

# Predicting Delays in the Operating Room

Team 7

Chris Low • Igor Nakshin • Xinyang Zou

December 11, 2007

# Agenda

- **The Question**
- **Data**
- **Data Details**
- **Exploration**
- **Model**
- **Results**

# The Question

## ➤ Situation

- Surgery appointments at the hospital are taking longer than expected (scheduled) thus creating schedule overruns in the O.R.
- Schedule satisfactory
- This happens *mean* length based
- O.R. Manager can't predict what will happen more than expected

## ➤ Why is this

- Press Ganey
  - "...happens because of patient wait times when the O.R. is busy (e.g. emergency, un-planned). Scheduling personnel need to know which appointments are likely to run late in order not to "over"-schedule a room

Time	Abrev	Name	Char	Time	Abrev	Name	Char
1	INRS	INTO RS	10	6	IPACU	INTO PACU	10
2	INOR	INTO OR	10	7	OPACU	OUT OF PACU	10
3	SURGS	SURGERY START	15	8	IP/IRA	INTO POSTOP/AMBSURG	10
4	SURGE	SURGERY END	15	9	OPOST	OUT OF POSTOP	10
5	OUTOR	OUT OF OR	10	10			10

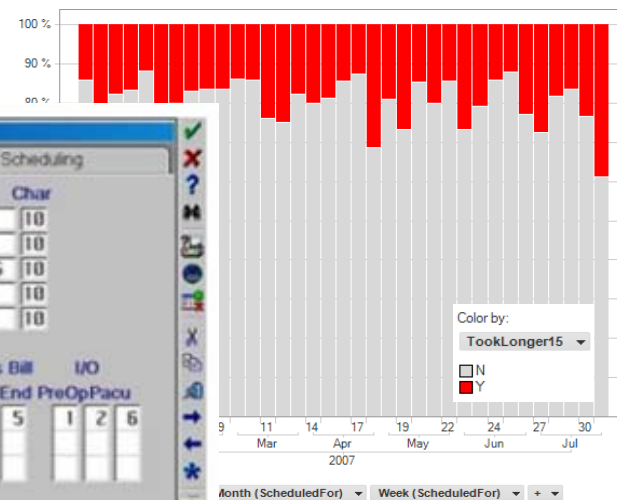
Facility	# Req	End	Last	Surgn	Recov	Sched	OR Bill	Anes Bill	I/O					
HMC	2	5	5	3	4	6	7	2	5	2	5	1	2	6

Cases	Sched	Proc
History	4	4
Drop Low	6	6
Drop High	1	1

Staff	Name	Char	Staff	Name	Char	Activity Shifts
PreOP	Preop Nurse	10	4	X Ray Tech	10	0629 NIGHT
1	Circulator	10	5	Other	10	0630 MORNING
2	Scrub	10	6			1500 MORNING
3	Perfusionist	10	Recovery	PACU Nurse	10	1501 DAY



Trimmed Mean ?

- Question
- Data
- Data Details
- Exploration
- Model
- Results

<sup>1</sup><http://www.pressganey.com/galleries/default-file/outpatient-report.pdf>

# Data

- Obtained remote access to hospital's Data Warehouse
  - Microsoft SQL Server 2000
  - Feeds from MEDITECH Magic Hospital Information System
- Worked with hospital's Decision support personnel to identify and extract the data
  - Scheduling, surgery, dictionaries (Physician, Surgery type, etc)
- Initially considered 3 years of data ( > 15,000 cases), eventually trimmed the data set to January to Aug 2007
- Considered only those variables that are “known” on the day prior to the scheduled appointment
- Calculated averages based on 6-months surgery/surgeon performance (not until later in the process)

- Question
- Data
- Data Details
- Exploration
- Model
- Results

# Data Details

- Sample
- Time-series
- Mostly categorical data
- 3,417 observations
- Calculated variables came later during modeling

Jan 2007 to Aug 2007  
 Total 3,417 cases  
 Cases Per Month:  
 $\mu = 439, \sigma = 26$   
 Cases Per Day:  
 $\mu = 19, \sigma = 7.41$   
 Appointment Length (minutes):  
 $\mu = 86, \sigma = 65$   
 383 types of Surgeries  
 47 Surgeons

Variable	DataType	Description
CaseID	String	Unique Case Identifier
TookLonger15	Yes / No	Did this appointment take over 15 minutes longer than expected?
LongerMin	Minutes (int)	How many minutes longer over expected?
ActDur	Minutes (int)	Actual Duration of appointment in minutes
PlanDur	Minutes (int)	Expected Duration of appointment in minutes
ScheduledFor	DateTime	Date & Time appointment was scheduled for
PatientIn	DateTime	Date & Time appointment started
PatientOut	DateTime	Date & Time appointment ended
Room	Categorical	Operating Room ID
Serv	Categorical	Surgical Service ID
OpID	Categorical	Operation ID
Surgeon	Categorical	Surgeon ID
SurgeonGroup	Categorical	Surgeon Group ID
OnStaff	Yes / No	Is the surgeon a hospital staff surgeon?
AdmitPrivilege	Yes / No	Does the surgeon have admit privilege?
PtStatus	Categorical	Patient Type (Inpatient, Same Day Surgery)
HadAppt	Yes / No	Did the patient have appointment?
MultProcs	Yes / No	Did the appointment have multiple operations?
Gender	Categorical	Gender of the patient (M/F)
Race	Categorical	Race of the patient(AA, HIS, CA, OT, UNK)
Age	Numerical	Age of the patient in years
Severity	Categorical	Severity of the surgery (LEVEL1 to 7)

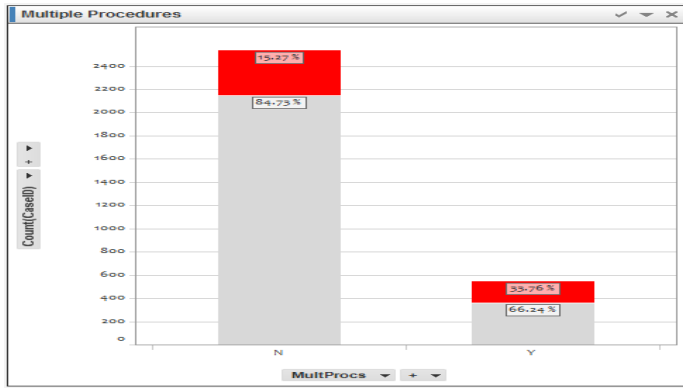
## CALCULATED

Variable	DataType	Description
AvgLength	Numerical	Calculated - 90-day moving average of # of minutes same surgery took done by same surgeon
StdevLength	Numerical	Calculated - 90-day moving stdev of # of minutes same surgery took done by same surgeon
NumPerformed	Numerical	Calculated - 90-day moving count of same surgeries performed by same surgeon

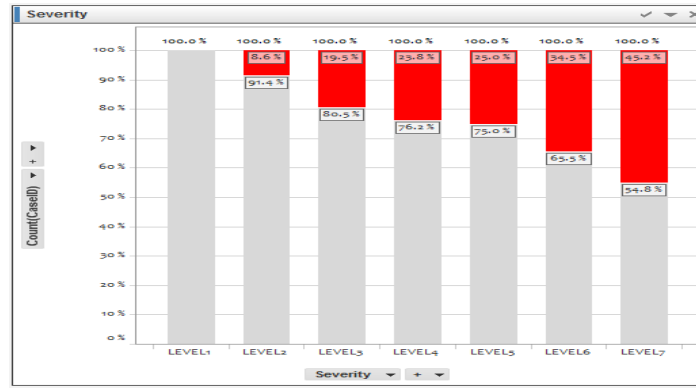
- Question
- Data
- **Data Details**
- Exploration
- Model
- Results

# Exploration

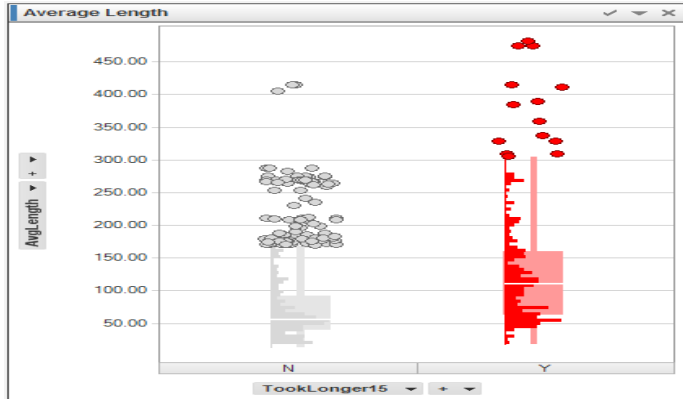
## Multiple Procedures



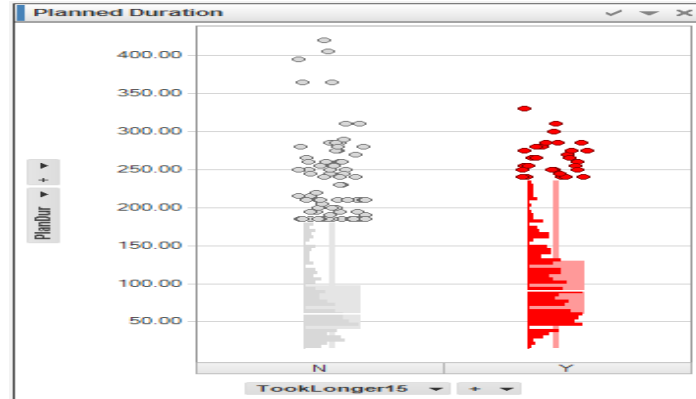
## Severity



## Average Length



## Planned Duration



TookLonger15 ▾

□ N  
 ■ Y

- ▾ Question
- ▾ Data
- ▾ Data Details
- ▾ Exploration
- ▾ Model
- ▾ Results

# Model

- Partitioning – Train, Validation, Test
- Various combination of dummy variables
- Introduced additional variables (historical averages) when nothing worked
- Logit model
  - Preferred because of ease of use in reporting tool (Microsoft Reporting Services)
  - Best performance (compared to DA on same predictors)
- Trees failed completely
- NB & KNN were much worse than logit and DA (on same predictors)
- Prefer higher specificity (conservative) cut-off

## The Regression Model

Input variables	Coefficient	Std. Error	p-value	Odds
Constant term	-2.80768847	0.14402305	0	*
PlanDur	-0.05720958	0.00517448	0	0.94439614
MultipleProcs_Y	1.35159361	0.17726205	0	3.86357784
AvgLength	0.06774805	0.00513235	0	1.07009566

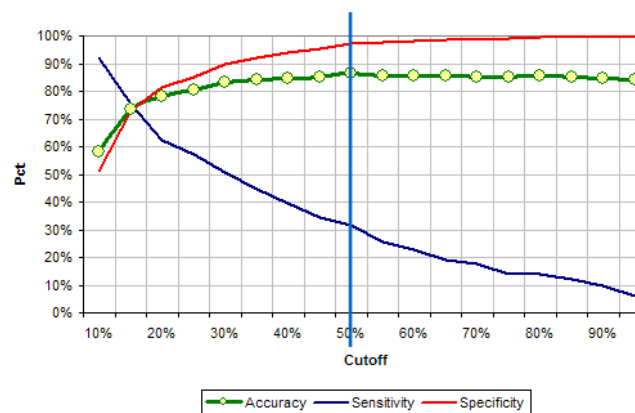
Residual df	1705
Residual Dev.	1279.245361
% Success in training data	20.71386776
# Iterations used	10
Multiple R-squared	0.26634535

### Test Data scoring - Summary Report

Cut off Prob.Val. for Success (Updatable) **0.5**

Classification Confusion Matrix		
	Predicted Class	
Actual Class	Y	N
Y	36	78
N	15	555

Error Report			
Class	# Cases	# Errors	% Error
Y	114	78	68.42
N	570	15	2.63
Overall	684	93	13.60



- Question
- Data
- Data Details
- Exploration
- **Model**
- Results

# Results

- We plan to report the results to HMC and, during the next several weeks, aid the hospital's decision support champion of our project in the implementation of the report and the presentation of its expected benefits to the Director of O.R. and other senior managers
- Proposed OR Daily Schedule Report:

OR Schedule for Aug 20, 2007										
Order	From	To	Case Number	Minutes Planned	Service	Operation	Surgeon	PtStatus	Severity	Multipl
<b>Room 01</b>										
1	8/20/07 08:00 AM	8/20/07 09:00 AM	33217	60	DENTAL	DENTREHAB	MINME	SDC	LEVEL3	No
2	8/20/07 09:00 AM	8/20/07 10:00 AM	33198	60	DENTAL	DENTREHAB	MINME	SDC	LEVEL3	No
3	8/20/07 10:00 AM	8/20/07 11:00 AM	33199	60	DENTAL	DENTREHAB	MINME	SDC	LEVEL3	No
4	8/20/07 11:00 AM	8/20/07 12:00 PM	33200	60	DENTAL	DENTREHAB	MINME	SDC	LEVEL3	No
5	8/20/07 12:00 PM	8/20/07 01:00 PM	33201	60	DENTAL	DENTREHAB	MINME	SDC	LEVEL3	No
<b>Room 02</b>										
1	8/20/07 08:00 AM	8/20/07 08:20 AM	32614	20	RHINOLARYNGOLOGY	BMT	REGCH	SDC	LEVEL2	No
2	8/20/07 08:20 AM	8/20/07 08:40 AM	32543	20	RHINOLARYNGOLOGY	BMT	REGCH	SDC	LEVEL2	No
3	8/20/07 08:40 AM	8/20/07 09:45 AM	33015	65	RHINOLARYNGOLOGY	T&A	REGCH	SDC	LEVEL2	Yes
4	8/20/07 09:45 AM	8/20/07 10:30 AM	32541	45	RHINOLARYNGOLOGY	T&A	REGCH	SDC	LEVEL2	No
5	8/20/07 10:30 AM	8/20/07 11:15 AM	32540	45	RHINOLARYNGOLOGY	T&A	REGCH	SDC	LEVEL2	No
<b>Room 03</b>										
1	8/20/07 08:00 AM	8/20/07 09:45 AM	33094	105	SURGERY	LAPCHOLE	STUHA	IN	LEVEL6	Yes
2	8/20/07 09:45 AM	8/20/07 12:50 PM	32783	185	ORAL MAXILLARY SURGERY	ORIFMANDIB	MARKU	SDC	LEVEL4	No
3	8/20/07 12:50 PM	8/20/07 03:00 PM	33216	130	SURGERY	AMPDIGITS	TSEZU	IN	LEVEL3	No
<b>Room 04</b>										
1	8/20/07 09:55 AM	8/20/07 02:05 PM	33264	250	SURGERY	LAPAROTOMY	SCHCHA	IN	LEVEL4	No
2	8/20/07 02:05 PM	8/20/07 03:10 PM	33244	65	OBSTETRICS/GYNECOLOGY	C-SECTION	HODLE	IN	LEVEL4	No
3	8/20/07 03:10 PM	8/20/07 04:00 PM	33204	50	OBSTETRICS/GYNECOLOGY	C-SECTION	LLOJO	IN	LEVEL4	No
<b>Room 05</b>										
1	8/20/07 08:00 AM	8/20/07 09:00 AM	32784	60	UROLOGY	HYDROCELEA	WERDA	SDC	LEVEL3	No
2	8/20/07 09:00 AM	8/20/07 10:50 AM	33104	110	UROLOGY	URETHSLING	WERDA	IN	LEVEL3	Yes
3	8/20/07 12:00 PM	8/20/07 01:30 PM	33016	90	UROLOGY	INGEXPLOR	MCDKE	SDC	LEVEL3	No
4	8/20/07 01:30 PM	8/20/07 02:40 PM	33234	70	UROLOGY	URESTONREM	MCDKE	SDC	LEVEL3	No
<b>Room 06</b>										
1	8/20/07 01:15 PM	8/20/07 03:15 PM	33241	120	ORTHOPEDICS	TENDREP	DECAL	SDC	LEVEL3	No
<b>Room 07</b>										
1	8/20/07 08:00 AM	8/20/07 09:55 AM	33108	115	ORTHOPEDICS	ARTHROSHLD	DECAL	SDC	LEVEL3	Yes
2	8/20/07 12:30 PM	8/20/07 01:25 PM	33203	55	ORTHOPEDICS	I&D	BASRO	IN	LEVEL3	Yes
3	8/20/07 01:25 PM	8/20/07 02:10 PM	33229	45	ORTHOPEDICS	FORBODRE	BASRO	SDC	LEVEL2	No
4	8/20/07 02:10 PM	8/20/07 03:30 PM	33240	80	ORTHOPEDICS	DORSROFLAP	BASRO	SDC	LEVEL3	Yes



Proposed Report Sample

- Question
- Data
- Data Details
- Exploration
- Model
- Results



# Important Takeaway

- **Domain experience can save a lot of time!**
  - **Early in the process O.R. personnel said that “nothing matters other than past performance”**
- **Some data sets are very difficult to model – look out of the box!**
- **Being able to go back to the data was tremendous help**
- **Learn to fit and develop a model within cost and practical constraints**

# Thanks!