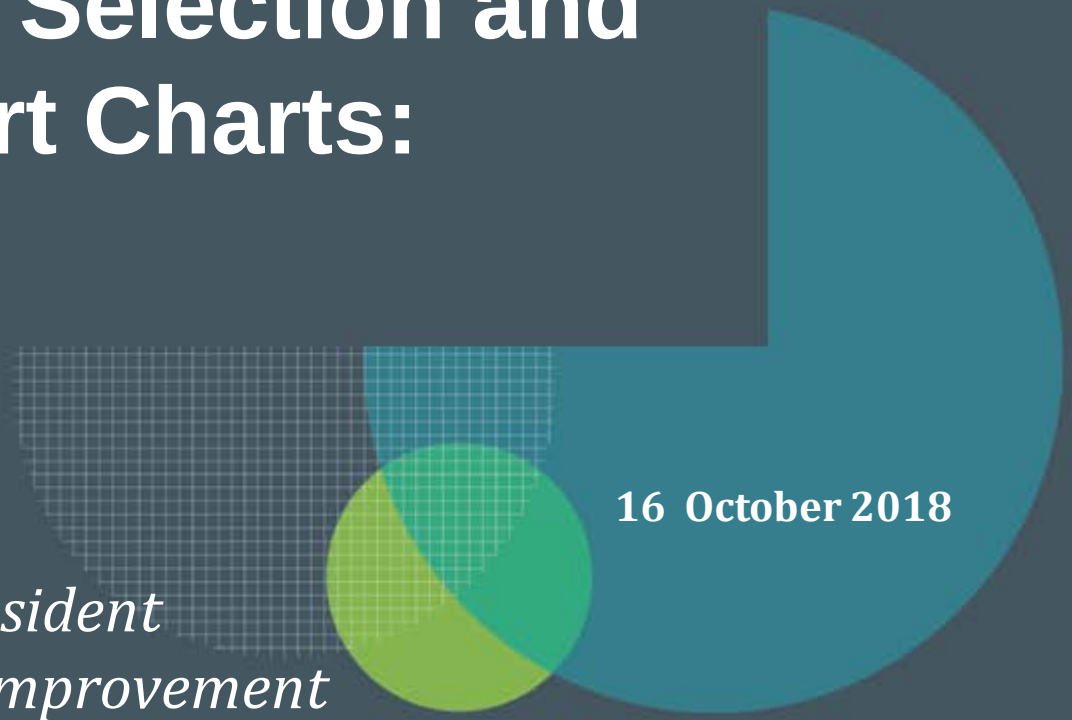
Institute for Healthcare Improvement

QUALITY IMPROVEMENT PROGRAMME

East London Foundation Trust

Simplifying the Selection and Use of Shewhart Charts: Worksheets



16 October 2018

IHI Faculty

Dr. Robert Lloyd, Vice President

Institute for Healthcare Improvement

Measurement Self-Assessment

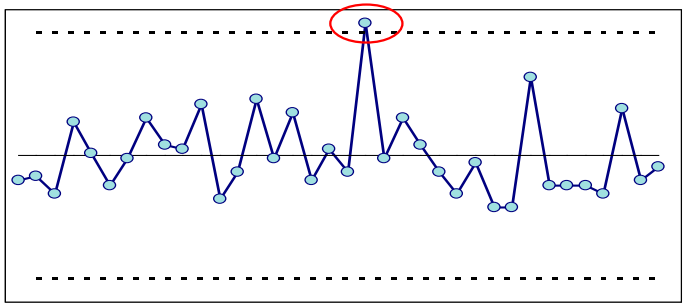
Source: R. Lloyd, Quality Health Care: A Guide to Developing and Using Indicators. 2nd edition, Jones & Bartlett Publishers, 2017.

Measurement Topic or Skill	Response Scale				
	1	2	3	4	5
Help people in my organization determine why they are measuring (improvement, judgment or research)					
Move teams from concepts to specific quantifiable measures					
Building clear and unambiguous operational definitions for our measures					
Develop data collection plans (including stratification and sampling strategies)					
Explain why plotting data over time (dynamic display) is preferable to using aggregated data and summary statistics (static display)					
Explain the differences between random and non-random variation					
Construct run charts (including locating the median)					
Explain the reasoning behind the run chart rules					
Interpret run charts by applying the run chart rules					
Explain the statistical theory behind Shewhart control charts (e.g., sigma limits, zones, special cause rules)					
Describe the basic 7 Shewhart charts and when to use each one					
Help teams select the most appropriate Shewhart chart for their measures					
Describe the rules for special cause variation on a Shewhart chart					
Help teams link measurement to their improvement efforts					

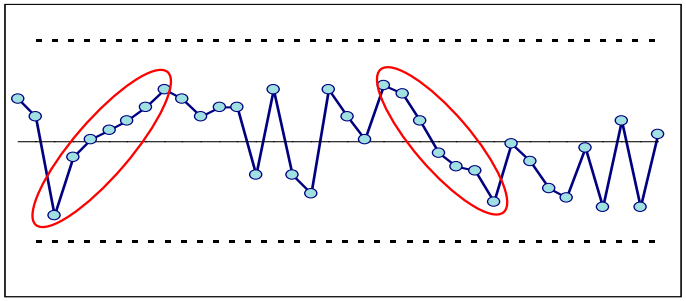
1. **I'd definitely have to call in an outside expert to explain and apply this topic/method.**
2. **I'm not sure I could apply this appropriately to a project.**
3. **I am familiar with this topic but would have to study it further before applying it to a project.**
4. **I have knowledge about this topic, could apply it to a project but would not want to be asked to teach it to others.**
5. **I consider myself an expert in this area, could apply it easily to a project and could teach this topic/method to others.**

Rules for Detecting Special Causes on Shewhart Charts

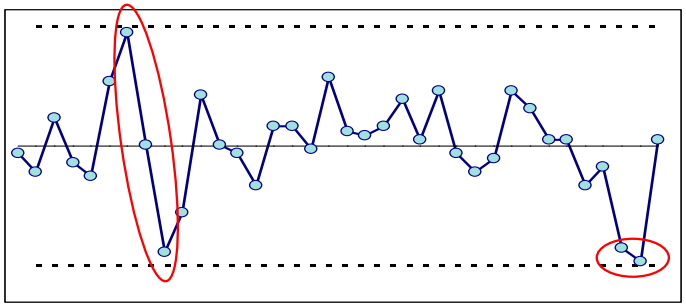
A single point outside the control limits



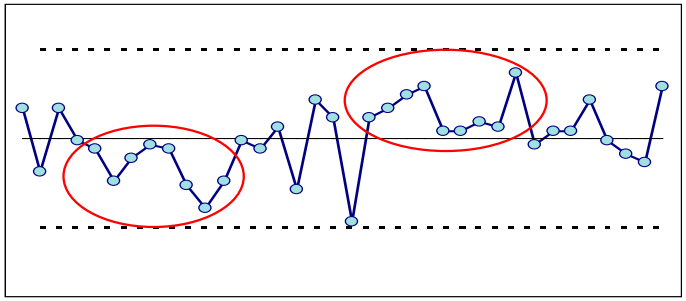
Six consecutive points increasing (trend up) or decreasing (trend down)



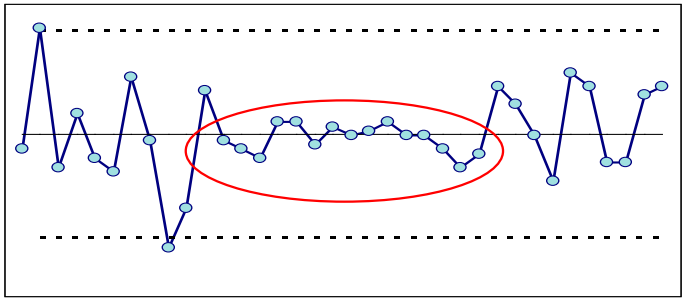
Two our of three consecutive points near a control limit (outer one-third)



Eight or more consecutive points above or below the centerline



Fifteen consecutive points close to the centerline (inner one-third)



Notes on Shewhart Charts
Special Cause Rules

Rule #1: 1 point outside the +/- 3 sigma limits
Note: A point exactly on a control limit is not considered outside the limit . When there is not a lower or upper control limit Rule 1 does not apply to the side missing the limit.

Rule #2: 8 successive consecutive points above (or below) the centerline
Note: A point exactly on the centerline does not cancel or count towards a shift.

Rule #3: 6 or more consecutive points steadily increasing or decreasing
Note: Ties between two consecutive points do not cancel or add to a trend. When control charts have varying limits due to varying numbers of measurements within subgroups, then rule #3 should not be applied.

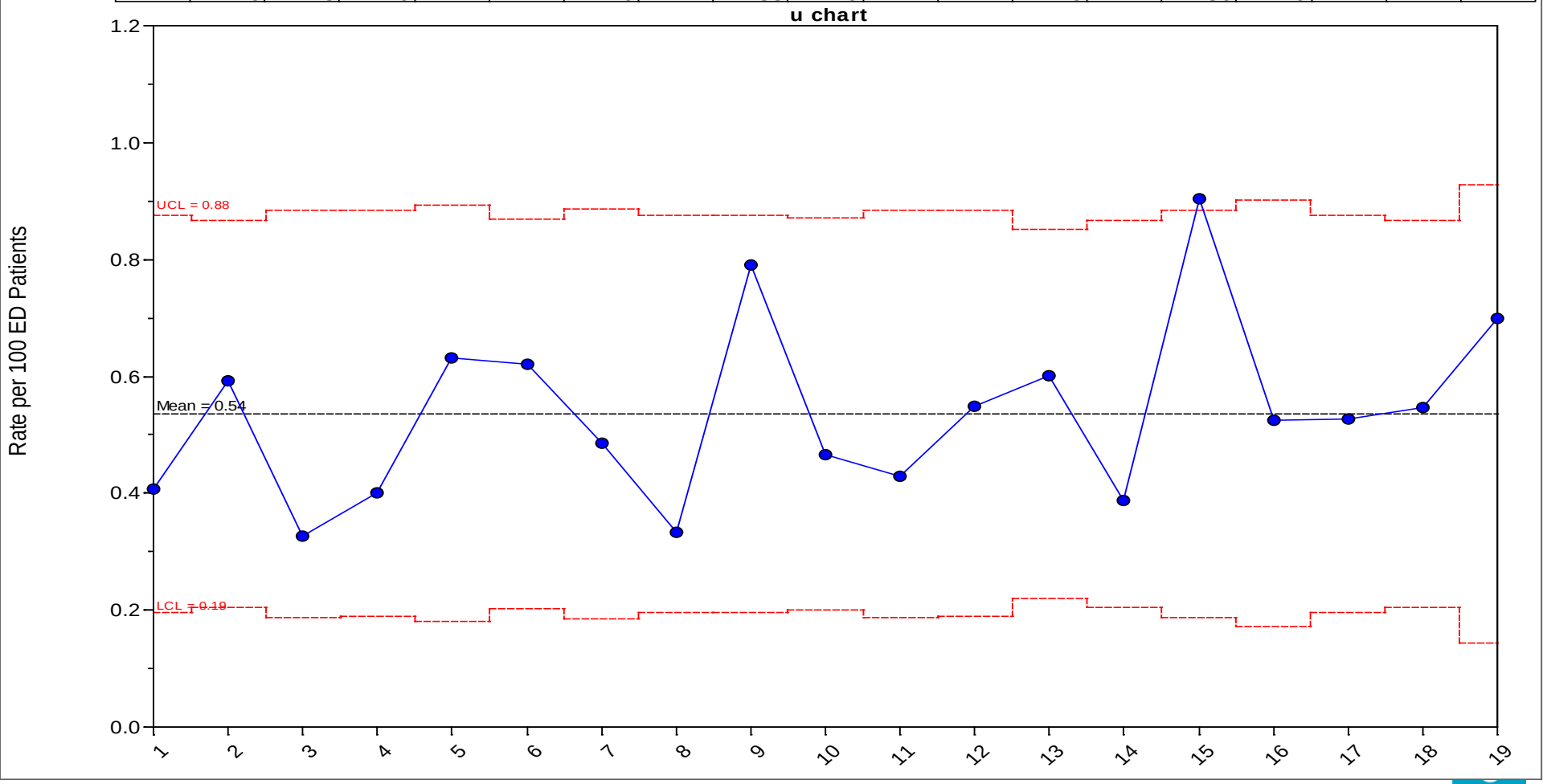
Rule #4: 2 out of 3 successive points in Zone A or beyond
Note: When there is not a lower or upper control limit Rule 4 does not apply to the side missing a limit.

Rule #5: 15 consecutive points in Zone C on either side of the centerline
This is known as "hugging the centerline"

Is there a Special Cause on this chart?

Unplanned Returns to Ed w/in 72 Hours

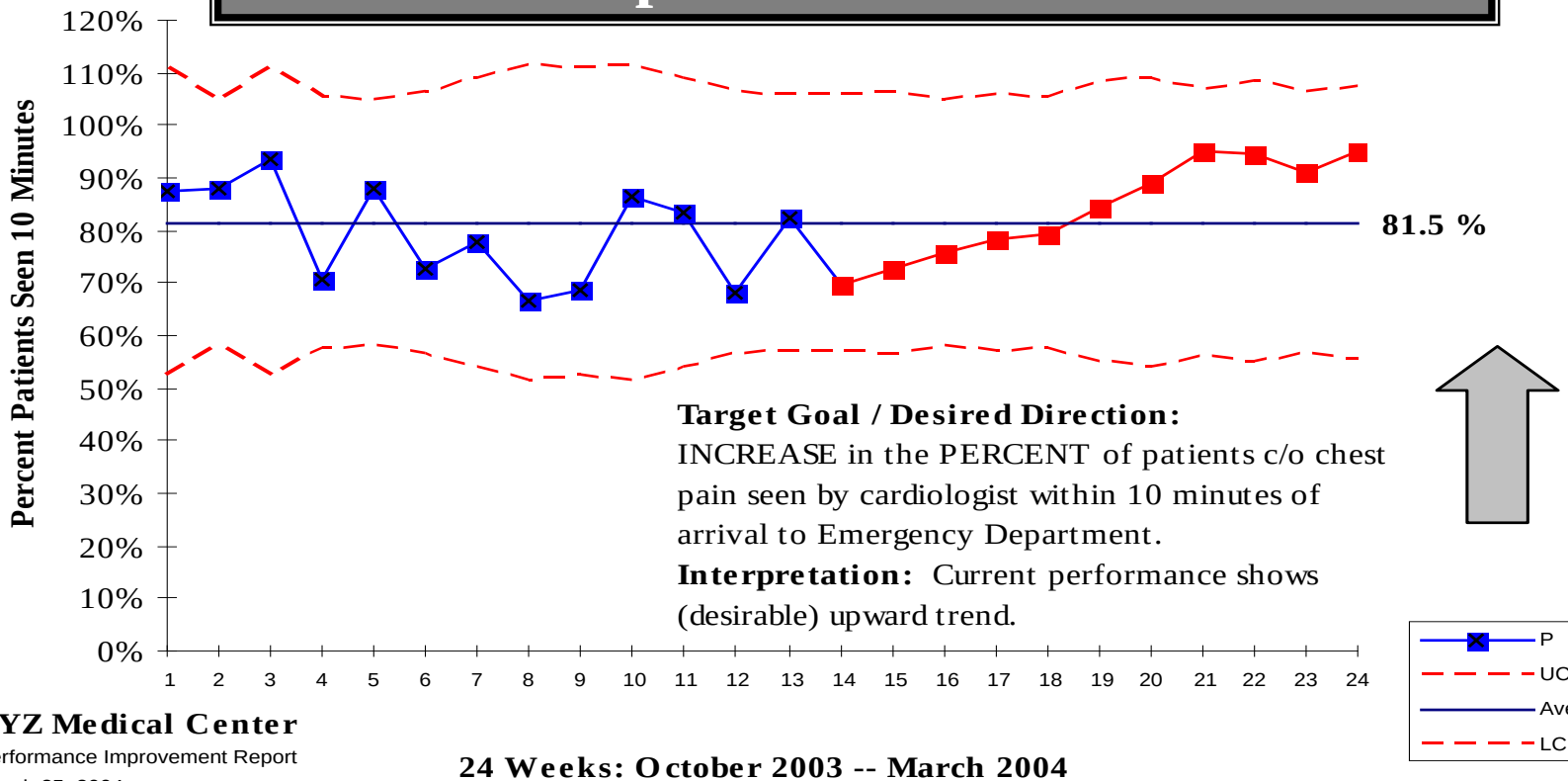
Month	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
ED/100	41.78	43.89	39.86	40.03	38.01	43.43	39.21	41.90	41.78	43.00	39.66	40.03	48.21	43.89	39.86	36.21	41.78	43.89	31.45
Returns	17	26	13	16	24	27	19	14	33	20	17	22	29	17	36	19	22	24	22



PERCENT PATIENTS C/O CHEST PAIN SEEN BY CARDIOLOGIST WITHIN 10 MINUTES OF ARRIVAL TO ED

EXAMPLE CHART

Are there special causes on this chart?



Target Goal / Desired Direction:
INCREASE in the PERCENT of patients c/o chest pain seen by cardiologist within 10 minutes of arrival to Emergency Department.

Interpretation: Current performance shows (desirable) upward trend.

XYZ Medical Center
Performance Improvement Report
March 25, 2004
Fictitious data for educational purposes

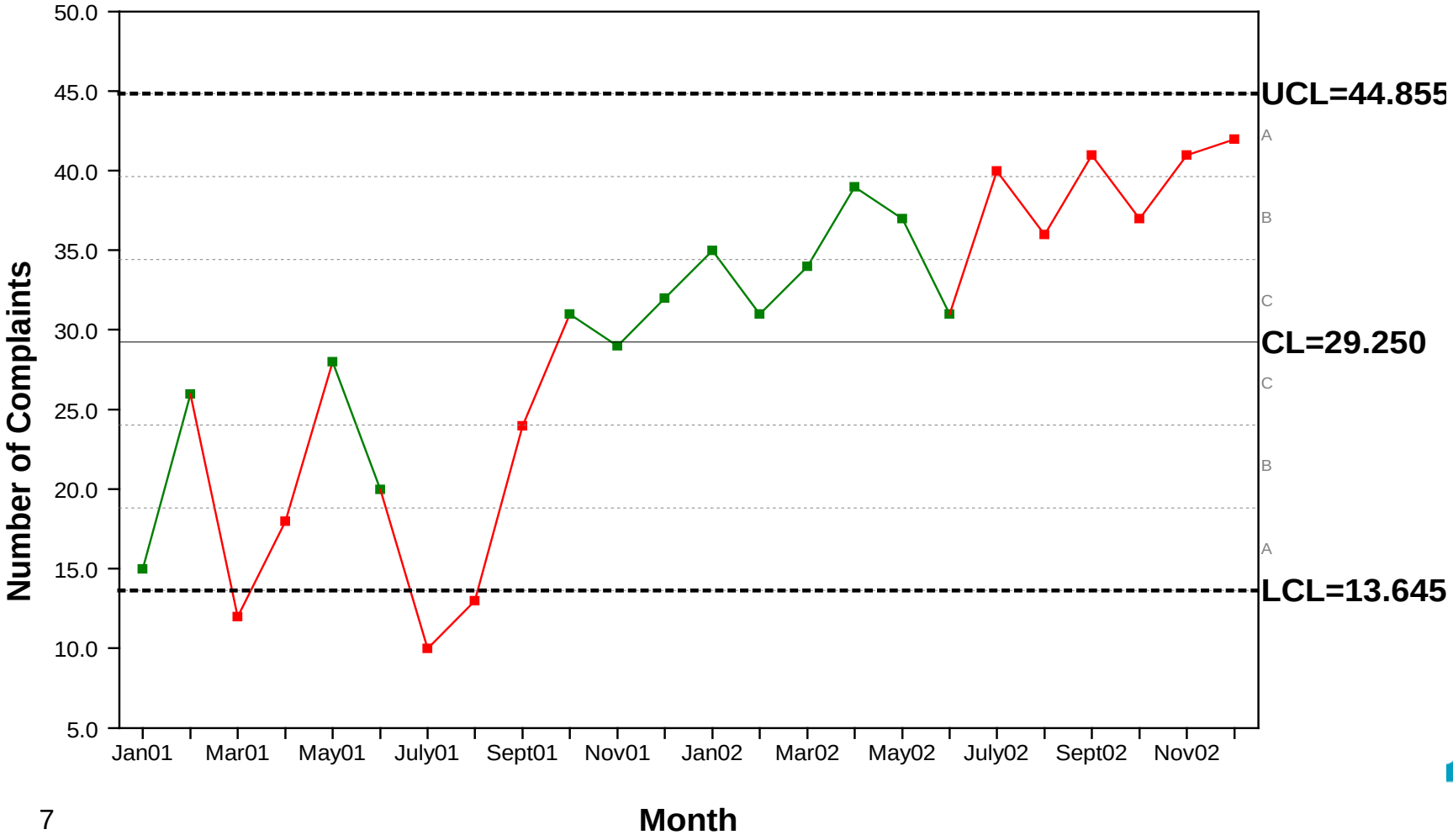
24 Weeks: October 2003 -- March 2004

p-chart, possible range 0-100%

Number of Patient Complaints by Month

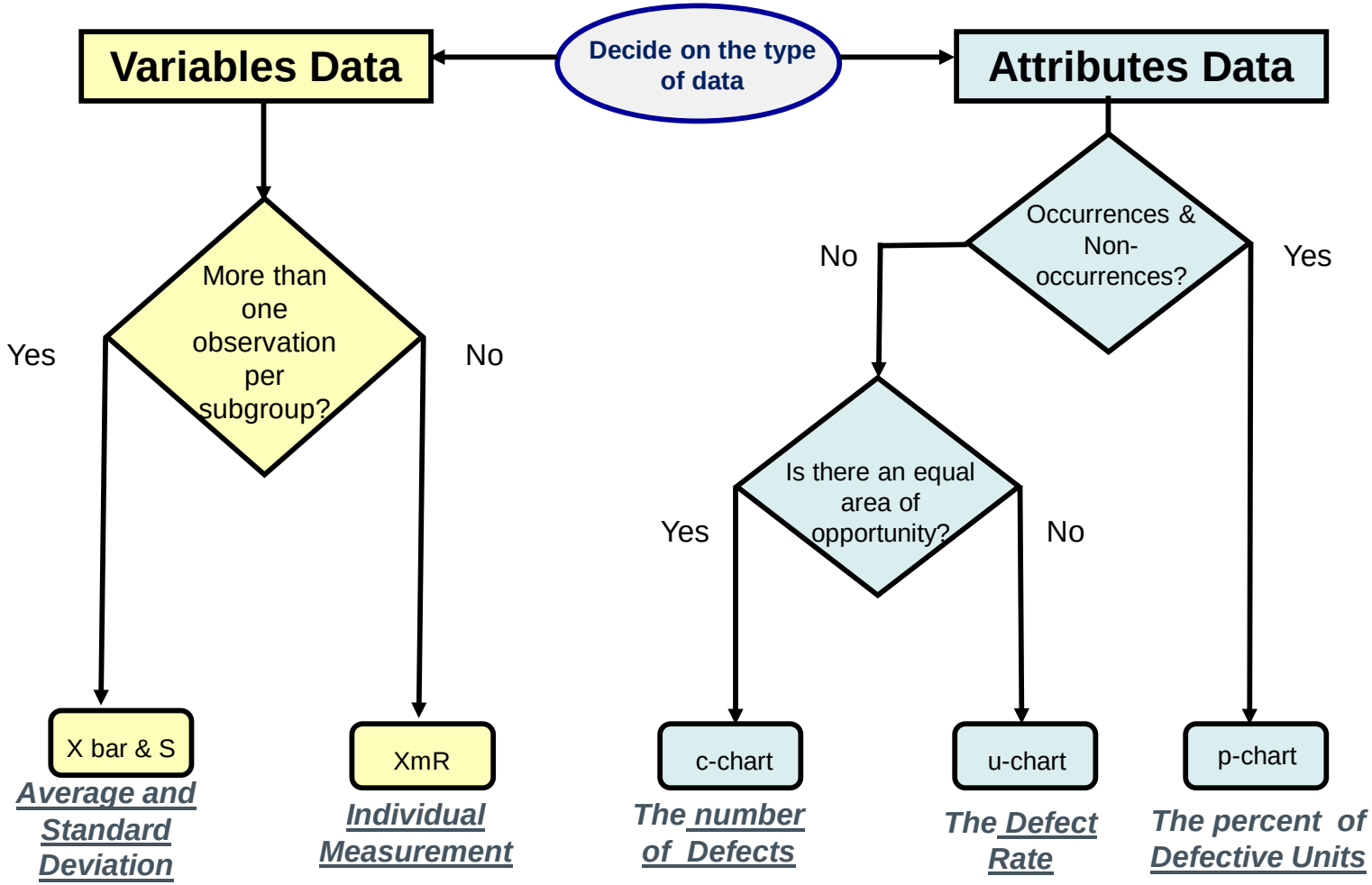
(XmR chart)

Are there any special causes present? If so, what are they?



The Control Chart Decision Tree

Source: R. Lloyd. *Quality Health Care: A Guide to Developing and Using Indicators. 2nd edition, Jones and Bartlett, 2017.*



You Make the Call!
Is it an XmR (I) or X bar & S?

Measure	Subgroup	XmR (I chart)	X bar & S chart
1. Time to clean an inpatient room (in minutes)			
2. Patient satisfaction scores for a sample of 15 outpatients collected every 2 weeks			
3. Avg. turnaround time for all STAT labs done each day and stratified by shift			
4. Cost for each normal delivery			
5. A diabetic patient's 3x a day blood sugar readings			
6. Length of stay for a sample of 20 ICU patients pulled each month			
7. The distance (in feet) that a sample of 10 knee replacement patients can walk in 15 seconds			

Summary Table for XmR and X bar & S charts

Source: R. Lloyd. *Quality Health Care: A Guide to Developing and Using Indicators. 2nd Edition, Jones and Bartlett, 2017.*

Type of Control Chart	Type of Data and data collection issues	Examples of Indicators used on this type of chart
X-bar & S chart This is known as the Average (X-bar) and Standard Deviation (S) chart. Most SPC software programs will give you two charts when you select this chart: one for the X-bar portion and one for the S portion. This is considered to be the most statistically powerful of all the charts.	**Continuous data** The X-bar & S chart usually involves drawing a small sample of observations that are organized into rational subgroups. The statistical principles behind this chart are based on the assumptions of the normal (Gaussian) bell-shaped distribution.	▪ Actual turnaround time for 5 lab tests or 3 pharmacy orders each day ▪ Blood pressure readings (e.g., 3 per day) ▪ Diabetes monitoring (mg/dl) ▪ Anesthesia time for selected procedures • Patient satisfaction scores
XmR chart This chart is known as the Individual values and moving range chart. Sometimes it will be referred to as the Individuals or I-chart. It does not have the statistical rigor or power of the X-bar & S chart. This chart is used to answer questions related to volume, "How many surgeries did we do this week?" The XmR chart does not address the question as to whether these surgeries were started on time (this would require a p-chart). Instead, the XmR chart is answering a neutral question, "How many?"	**Continuous data** The XmR chart is used when you have a single observation for each subgroup. Sampling typically is not done but might be if the process being monitored has an extremely large volume. Since this chart frequently uses aggregates as the plotted number (e.g., days in accounts receivable this month), it is important to make sure that the data are consistently collected from one time period to the next. This chart is used to evaluate questions related process outcomes (volumes), with no concern as to whether the outcomes of the process are acceptable or not acceptable.	▪ Patient wait time to see the physician or to be seen in the ED ▪ The number of days to mail a patient bill after discharge ▪ The number of calls coming into a clinic each day ▪ Average length of stay by week for a particular DRG ▪ The number of surgeries done each week ▪ Operating margin by month ▪ Pounds of laundry each day ▪ Average turnaround time by day ▪ The number of food trays produced

You Make the Call!
Is it a p, c or u-chart?

Measure	Subgroup	p-chart	c-chart	u-chart
1. The number of central line insertions each week during which all elements of the bundle were followed divided by the total number of central line insertions that week				
2. The weekly number of catheter-associated urinary tract infections per 1000 urinary catheter days				
3. The total number of patient falls each month (with or without injury to the patient and whether or not assisted by a staff member) is divided by the total patient days for the month				
4. An analyst pulls a sample of 50 orthopedic surgery charts each week and counts all discrepancies from standard documentation practice				
5. Each medication order is checked against five potential types of errors. You also have the total number of orders placed each week				
6. Each day the number of home healthcare visits that are more than 15 minutes late on arrival are recorded and compared with the total number of visits scheduled for that day.				
7. The number of outpatients not showing up for an appointment is recorded each week. The volume of outpatients varies each week by only 4-6 patients.				

Summary Table for p, c and u-charts

Source: R. Lloyd. *Quality Health Care: A Guide to Developing and Using Indicators. 2nd Edition, Jones and Bartlett, 2017.*

Type of Control Chart	Type of Data and data collection issues	Examples of Indicators used on this type of chart
p-chart The p-char t is used frequently in healthcare to compute the percent (or proportion) of defective products or services. The p-chart requires being able to count both the numerator and the denominator.	**Attributes data** These data are classified as defectives or nonconforming units because they reflect the percent (or proportion) of undesirable outcomes (the numerators). The denominators usually (but not always) are of varying sizes, which produce stair-step control limits. Data of this type reflect the binomial distribution. The denominators need to be sufficiently large (e.g., greater than 15) to enable a reasonable percentage to be calculated yet not too large (e.g., over 300).	▪ Percent of c-sections ▪ Percent of late food tray ▪ Percent of incomplete charts ▪ Percent of late surgery starts ▪ Percent of bills that are inaccurate ▪ Percent mortality ▪ Percent RN turnover ▪ Percent of patients responding "Very Good" to a survey question
c-chart The c-chart is used to count the number of defects that occur within an equal area of opportunity when the non-defects are unknown. In this case, each observed unit (e.g., a patient) can have multiple defects (e.g., falls). Generally speaking, these are considered to be "rare events."	**Attributes data** The key to using a c-chart is that there must be an equal opportunity for a defect to occur. This condition frequently makes it difficult to use this chart in healthcare because the conditions under which we provide care do not always remain constant. These data are based on the Poisson distribution.	▪ The number of falls ▪ The number of restraints ▪ The number of needle sticks ▪ The number of law suits filed ▪ The number of ventilator associated pneumonias ▪ The number of nosocomial infections ▪ The number of medication errors ▪ The number of returns to surgery

Summary Table for p, c and u-charts

Source: R. Lloyd. *Quality Health Care: A Guide to Developing and Using Indicators. 2nd Edition, Jones and Bartlett, 2017.*

Type of Control Chart	Type of Data and data collection issues	Examples of Indicators used on this type of chart
u-chart The u-chart is used to track defects when the area of opportunity is not equal. For this reason, the u-chart is use more often in healthcare than the c-chart. This chart is based on rates rather than simple counts.	**Attributes data** The Poisson distribution is also used as the frame of reference for this chart. The u-chart presents rates (e.g., so many falls per 1000 patient days). Knowledge of how to collect data to form rates is essential.	▪ Medication errors per 100 admissions ▪ Ventilator associated pneumonias per 1000 vent days ▪ Total falls per 1000 patient days ▪ Total readmits per 1000 discharges

POINT: Be clear on the type of chart, the type of data and the indicator you plan to place on a Control Chart!

Selecting the most appropriate chart for your measures

Measure Name	Outcome (O) Process (P) Balancing (B)	Subgroup ?	Type of Data?	Chart of Choice?
			V or A	
			V or A	
			V or A	
			V or A	
			V or A	