Monitoring Antimicrobial Use with Free or Widely Available Software

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Disclosures

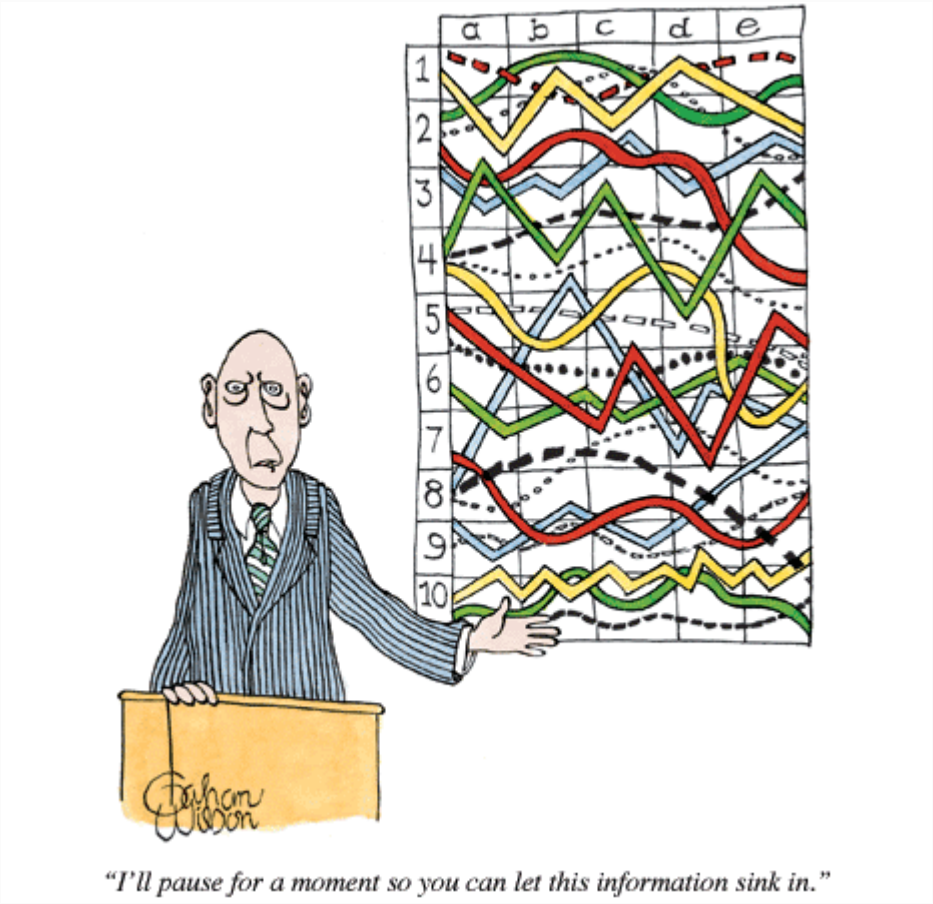
- I, Jonathan Beus, have no commercial relationships relevant to this presentation.
- While I make reference to and demonstrate specific software, I have no vested interested in these programs and endorse them only to the extent that they achieve the desired goals.

Objectives

- 1) Understand and define common measures of antimicrobial use
- 2) Identify data models for calculating antimicrobial use measures
- 3) Create simple graphs of trends in antimicrobial use from raw data
- 4) Understand basic principles of statistical process control

Outline

- Measurement in antimicrobial stewardship
- Preparing and formatting data
- Follow-along demonstration of calculating and plotting antimicrobial use data
- Statistical process control in antimicrobial use monitoring



"I'll pause for a moment so you can let this information sink in."

Gahon Wilson. The New Yorker. 2010.

ANTIMICROBIAL STEWARDSHIP AND ANTIMICROBIAL USE

Institute for Healthcare Improvement (IHI) and CDC

- "**Monitor**, feedback, and make visible data regarding **antibiotic utilization**, antibiotic resistance, ..."
- "**Establish real-time monitoring and measurement systems.**"

"Antibiotic Stewardship Driver Diagram and Change Package." Institute for Healthcare Improvement and Centers for Disease Control. July 2012. Available at: http://www.cdc.gov/getsmart/healthcare/implementation.html. Accessed 8/29/2014.

Why Measure?

- Identify areas for targeted intervention
- Assess response to an intervention
- Provide information/feedback to prescribers
- Justify importance of stewardship to administration and funders
- Future requirement to receive healthcare dollars?

Measuring Antimicrobial Use is Most Useful to Me to…

- A) Identify areas for intervention
- B) Assess the effectiveness of an intervention
- C) Provide feedback to prescribers
- D) Justify importance of stewardship to administration
- E) Other

Measuring Antimicrobial Use

- Is an important component of stewardship
- Does not constitute a stewardship program

Antimicrobial Stewardship

- "Antimicrobial stewardship refers to coordinated interventions designed to improve and measure the appropriate use of antimicrobial agents by promoting the selection of the **optimal antimicrobial drug regimen** including dosing, duration of therapy, and route of administration."

Fishman, N. Infect Control Hosp Epidemiol 2012;33(4):322-327

MEASURES OF ANTIMICROBIAL USE

How comfortable are you with interpreting measures of antimicrobial use?

- A) I don't know what DOT or LOT is
- B) I have heard of DOT and/or LOT, but am not sure what they mean
- C) I can interpret DOT and/or LOT
- D) I can probably explain DOT and/or LOT to other people
- E) I sometimes create my own metrics

Two Major Components to Measuring Antimicrobial Use

- Numerator:
  - DOT (days of therapy)
  - LOT (length of therapy)
  - DDD (defined daily dose)
- Denominator:
  - Number of admissions
  - Number of patient days

Numerator Measures

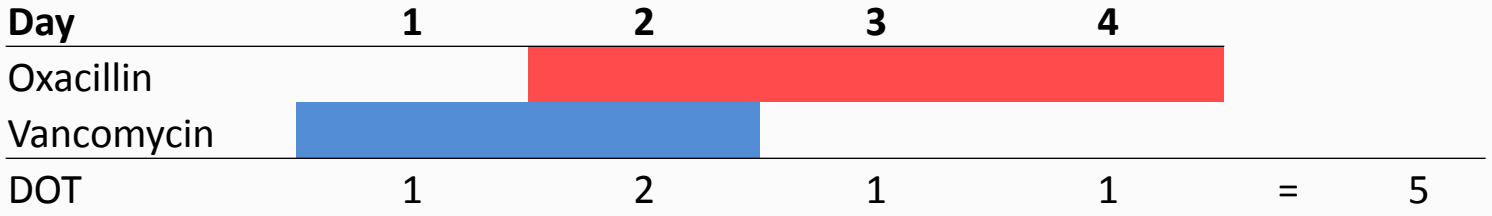
Days of therapy (DOT)

- Total number of days of individual antibiotics

Day	1	2		
Cefepime				
Vancomycin				
DOT	2	2	=	4

Days of therapy (DOT)

- Total number of days of individual antibiotics



Length of therapy (LOT)

- Number of days that a patient receives **any antimicrobial**

Day	**1**	**2**		
Cefepime				
Vancomycin				
DOT	2	2	=	4
LOT	1	1	=	2

Length of therapy (LOT)

- Number of days that a patient receives **any antimicrobial**

Day	**1**	**2**	**3**	**4**		
Oxacillin						
Vancomycin						
DOT	1	2	1	1	=	5
LOT	1	1	1	1	=	4

Defined daily dose (DDD)

- Take total mass of drug used by pharmacy and divide by WHO standard daily maintenance dose for an adult
  - http://www.whocc.no/atc_ddd_index/

Month	Vancomycin Use	IV Vancomycin DDD	# DDDs
1	200 g	2 g	100
2	176 g	2 g	88
3	224 g	2 g	112

Defined daily dose (DDD)

- May be easier to calculate
- Less preferable, particularly in specific populations (i.e. children)

"Core Elements of Hospital Antibiotic Stewardship Programs." Centers for Disease Control. March 2014. Available at: http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html. Accessed 8/29/2014.

Denominator Measures

- Include all patients, not just those who received an antimicrobial
- Common Measures
  - # of admissions
  - Patient days
    - Aggregate LOS
    - Hospital/unit census at the same time each day

Less Common, but Sometimes Helpful Metrics

- Median or mean length of therapy (by patient)
  - Doesn't necessarily represent contiguous days
- DOT/LOT ratio
  - Essentially mean # of antimicrobials/day

PREPARING AND FORMATTING ANTIMICROBIAL USE DATA

The Biggest Hurdle to Monitoring Antimicrobial Use at My Institution is…

- A) Getting access to data
- B) Reliability of data
- C) Cleaning data
- D) Presenting data
- E) Lack of Time, Resources, or Expertise
- F) Other

My Common Data Model

- Include both denominator data (patient days) and numerator data (medication use) in the same table
- Include patients whether or not they received an antibiotic
- Able to calculate DOT and LOT from the same table
- Able to calculate DOT correctly when medication administered multiple times in the same day (i.e. q8h)
- Easily partition by dates, patient location, antimicrobial, etc.

Basic Elements of Data Required

- Unique patient or visit identifier
- Dates (each day patient admitted, each time a medication is given)
- Medication name

Need to Standardize Antimicrobial Names

- Will be dependent on your EMR and its data structure
- Ampicillin might be recorded in a number of ways
  - "Ampicillin"
  - "Ampicillin Sodium"
  - "Ampicillin in Sterile Water"

Basic Elements of Data Required

Patient ID	Date	Medication

Basic Elements of Data Required

Patient ID	Date	Medication
1000	8/1/15	(none)
1000	8/2/15	(none)
1000	8/3/15	(none)

Example Patient with no antimicrobial

Basic Elements of Data Required

Patient ID	Date	Medication
1000	8/1/15	(none)
1000	8/2/15	(none)
1000	8/3/15	(none)
2000	8/10/15	(none)
2000	8/11/15	(none)
2000	8/12/15	(none)
2000	8/13/15	(none)
2000	8/10/15	Clindamycin
2000	8/11/15	Clindamycin
2000	8/11/15	Oxacillin
2000	8/12/15	Oxacillin
2000	8/13/15	Oxacillin

Example Patient with antimicrobials

Basic Elements of Data Required

Patient ID	Date	Medication	Patient Days ID	DOT ID	LOT ID

Combine - “Patient ID” & “Date”
1234 & 8/1/15 = 12348/1/15

Blank or “null” if no medication
Otherwise:
Combine - “Patient ID” & “Date” & “Medication”
1234 & 8/1/15 & ampicillin = 12348/1/15ampicillin

Blank or “null” if no medication
Otherwise:
Combine - “Patient ID” & “Date”
1234 & 8/1/15 = 12348/1/15

Basic Elements of Data Required

Patient ID	Date	Medication	Patient Days ID	DOT ID	LOT ID
1000	8/1/15	(none)	10008/1/2015	#N/A	#N/A
1000	8/2/15	(none)	10008/2/2015	#N/A	#N/A
1000	8/3/15	(none)	10008/3/2015	#N/A	#N/A
2000	8/10/15	(none)	20008/10/2015	#N/A	#N/A
2000	8/11/15	(none)	20008/11/2015	#N/A	#N/A
2000	8/12/15	(none)	20008/12/2015	#N/A	#N/A
2000	8/13/15	(none)	20008/13/2015	#N/A	#N/A
2000	8/10/15	Clindamycin	20008/10/2015	20008/10/2015 Clindamycin	20008/10/2015
2000	8/11/15	Clindamycin	20008/11/2015	20008/11/2015C lindamycin	20008/11/2015
2000	8/11/15	Oxacillin	20008/11/2015	20008/11/2015 Oxacillin	20008/11/2015
2000	8/12/15	Oxacillin	20008/12/2015	20008/12/2015 Oxacillin	20008/12/2015
2000	8/13/15	Oxacillin	20008/13/2015	20008/13/2015 Oxacillin	20008/13/2015

Calculations Based on Data Model

- Patient Days = count of unique “Patient Days ID”
  - Example data = 7
- DOT = count of unique “DOT ID”
  - Example data = 5
- LOT = count of unique “LOT ID”
  - Example data = 4

EXAMPLE USING “GOOGLE SHEETS”

Simulated Data

- Open Google Doc “Antimicrobial Use Demo”
  - https://goo.gl/RcNpck
- Sign in with a google account
- Click “File” -> “Make a copy…”
- Name the file whatever you would like

Caution About PHI

- Note that if you enter real PHI into google docs, this could be considered a HIPAA violation
- Would need to recode or encrypt patient ID and date fields prior to proceeding with real data

Simulated Data

- Should see 3 fields:
  - Patient ID
  - Medication
  - Date

Simulated Example

- Name the next 4 columns:
  - Patient Days ID
  - DOT ID
  - LOT ID
  - Year Month

Patient Days ID

- Will use to calculate patient days
- In cell D2, type:
  - "=A2&C2"
- Double click box in lower right corner of cell to copy to remaining cells

DOT ID

- Will use to calculate DOT
- In cell E2, type:
  - “=if(B2="",NA(),A2&B2&C2)”
- Copy to remaining rows

LOT ID

- Will use to calculate LOT
- In cell F2, type:
  - “=if(B2="",NA(),A2&C2)”
- Copy to remaining rows

Year Month

- Will use to summarize data by month
- In cell G2, type:
  - “=text(C2,"YYYY-MM")”
- Copy to remaining rows

Questions or Problems?

Start Summarizing Your Data!

- Select columns A through G while holding the "Shift" key
- Click "Data" -> "Pivot Table"
- (This should create a new sheet)
- On the right, find "Rows" and click "Add field" next to it
- Select the "Year Month" field you created

Calculate Patient Days

- Find “Values” on the right and click “Add field” next to it
- Select “Patient Days ID”
- Click the arrow next to “Summarize by” and select “COUNTUNIQUE”
- Repeat these steps for “DOT ID” and “LOT ID”

Calculate DOT Per 1000 Patient Days

- This standardization (1000 Patient Days) is simply by convention
- Steps
  - Name the next column “DOT Per 1000 Days”
  - In the cell, type the formula corresponding to:
    - 1000*(COUNTUNIQUE of DOT ID)/(COUNTUNIQUE of Patient Days ID)
    - e.g. “1000*C2/B2”
  - Copy this to the remaining rows
- Repeat for LOT

Create a Plot of Your Values

- Select these columns by holding down the "Ctrl" key
  - Year Month, DOT Per 1000 Days, LOT Per 1000 Days
- Click "Insert" -> "Chart
- Select the first line chart (on the left)
- Click the blue "Insert" box
- Customize the chart as you like

Find The Most Used Antibiotics

- Go back to the data sheet
- Make sure that columns A through G are selected
- Again, click “Data” -> “Pivot table…”

Find The Most Used Antibiotics

- On the right, find “Rows” and click “Add field” next to it
- Select the “Medication” field
- Next to “Values”, click “Add field” and select “DOT ID”
- Change “Summarize by” to “COUNTUNIQUE”
- Under “Rows/Medication” select “Sort by:” and choose “COUNTUNIQUE of DOT ID”
- Change the order to “Descending”

Plot the Most Used Antibiotics

- Select the antibiotic names and newly calculated DOT next to them
- Click “Insert” -> “Chart”
- Select either the horizontal or vertical bar chart (not histogram)
- Click the blue “Insert” button
- You may not see all of the drug names due to the number of bars on the chart

Alternate Options

- MS Excel
  - Using PowerPivot for Excel 2010 and later
- QlikView
  - Make your own QlikView apps
  - Can't open apps that others have created
  - http://www.qlik.com/us/explore/products/qlikview/free-download

DEMONSTRATION OF ADVANCED ANALYSIS TOOLS

Interactive Data Visualization Example

- Carbapenems are broad spectrum and frequently “last-line” agents
  - What is our usage trend?
  - Which service(s) are responsible?

Antimicrobial Use at CHOP

Antibiotic Search

Calendar

Year
Quarter
Month

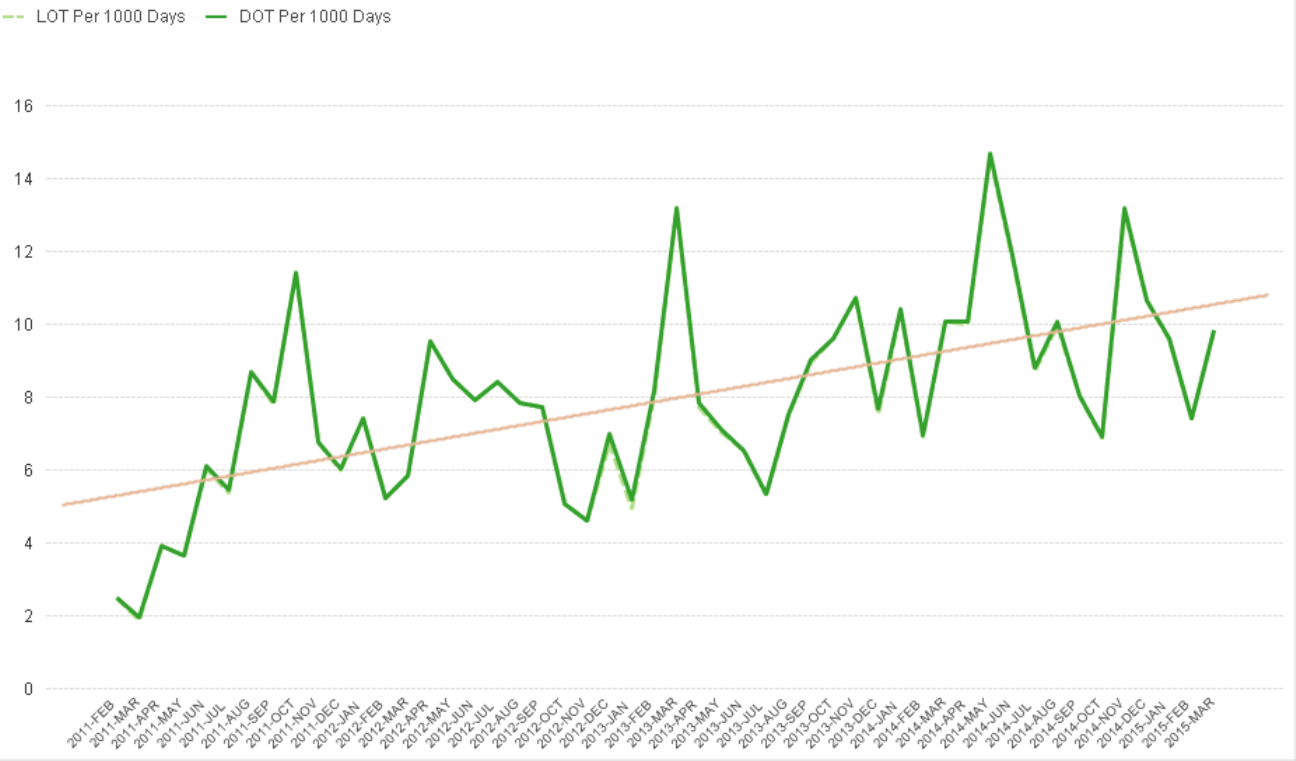
Targeted Drugs	Carbapenem
Drug Category	Cefepime
Drug Class	Fluoroquinolone
Drug Name	Linezolid
Anti-Pseudomonal	Piperacillin-Tazobactam
ASP Restricted?	Vancomycin
Anaerobic Coverage	
Route	
Clinical Service	
Clinical Unit	
Patient Age	

Clear Selections

Current Selections

drug_name: Ertapenem, Imipenem, Mer
drug_class: Carbapenem

Overall Use | DOT/LOT Per 1... | Trend Significance | Mean LOT/Mean... | DOT By Antibiotic | DOT By Service | # Patients | % on Antibiotics



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Contacts: Jeff Gerber, MD, PhD; Jonathan Beus, MD, MS
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Antimicrobial Use at CHOP

Antibiotic Search

Calendar

Year
Quarter
Month

Overall Use | DOT/LOT Per 1... | Trend Significance | Mean LOT/Mean... | DOT By Antibiotic | DOT By Service | # Patients | % on Antibiotics

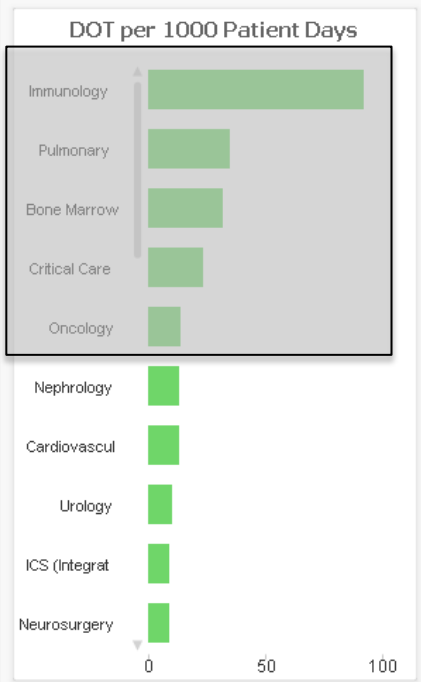
By Clinical Service | By Antimicrobial | By APR DRG

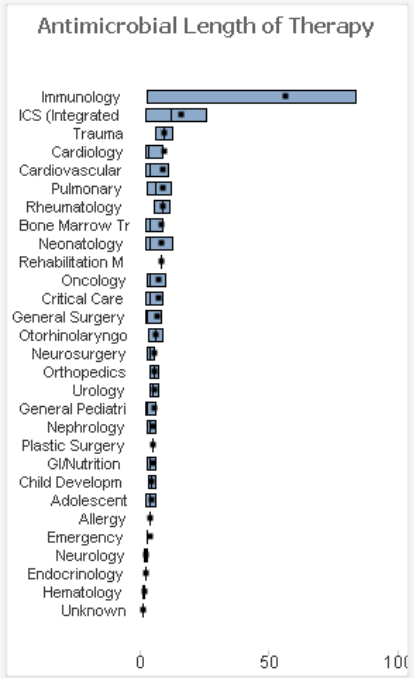
Targeted Drugs	Carbapenem
Drug Category	Cefepime
Drug Class	Fluoroquinolone
Drug Name	Linezolid
Anti-Pseudomonal	Piperacillin-Tazobactam
ASP Restricted?	Vancomycin
Anaerobic Coverage	
Route	
Clinical Service	
Clinical Unit	
Patient Age	

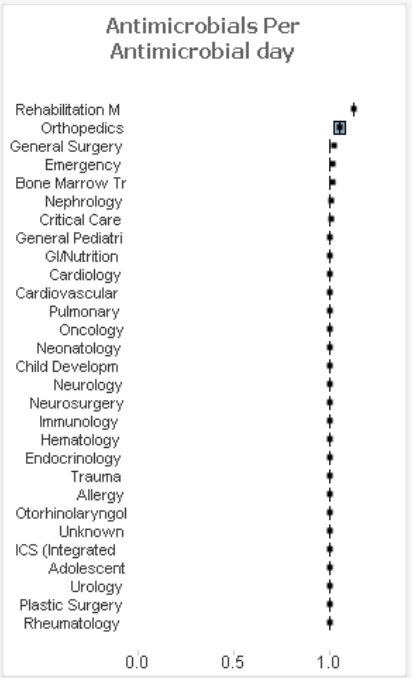
Clear Selections

Current Selections

drug_name: Ertapenem, Imipenem, Mer
drug_class: Carbapenem







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Antimicrobial Use at CHOP

Antibiotic Search

Calendar

Year
Quarter
Month

Targeted Drugs
Drug Category
Drug Class
Drug Name
Anti-Pseudomonal
ASP Restricted?
Anaerobic Coverage
Route
Clinical Service
Clinical Unit
Patient Age

Carbapenem
Cefepime
Fluoroquinolone
Linezolid
Piperacillin-Tazobactam
Vancomycin

Clear Selections

Current Selections

drug_name	Ertapenem, Imipenem, Mer
drug_class	Carbapenem
ADT_SERVICE	Bone Marrow Transplant, C Immunology, Oncology, Pul

Overall Use | DOT/LOT Per 1... | Trend Significance | Mean LOT/Mean... | DOT By Antibiotic | DOT By Service | # Patients | % on Antibiotics

Drug Name	Slope	Trend p	Pat/Mo...
			7
Imipenem	0.069	0.880	7
Meropenem	0.121	0.168	7
Ertapenem	-	-	1

Clinical Serv...	Slope	Trend p	Pat/Month
Pulmonary	-0.924	0.011	3
Critical Care	0.424	0.001	7
Oncology	-0.052	1	3
Bone Marrow Tra...	0.426	1	2
Immunology	10.040	0.084	1

Patient Age	Slope	Trend p	Pat/Month
10: >18Y	-0.027	1	2
6: 3Y-5Y	-0.005	1	2
1: 0Mo - 1Mo	-0.003	1	1
7: 5Y-8Y	-0.001	1	1
5: 1Y-3Y	0.017	1	3
3: 2Mo - 6Mo	0.037	1	1
4: 6Mo - 12Mo	0.044	1	2
9: 12Y-18Y	0.058	0.756	4
8: 8Y-12Y	0.075	1	2
2: 1Mo - 2Mo	0.145	1	1

DRG Name	Slope	Trend p	Pat/Month
ELECTROLYTE DIS...	0.351	0.014	1
NONEXTENSIVE PR...	0.425	0.038	1
HEART &/OR LUNG...	-0.242	1	1
OTHER HEPATOBIL...	-0.209	-	1
OTHER ENDOCRIN...	-0.150	-	2
OTHER RESPIRATO...	-0.133	-	1
VENTRICULAR SHU...	-0.110	1	1
SEIZURE	-0.108	1	1
MAJOR SMALL & LA...	-0.108	1	1
CYSTIC FIBROSIS -...	-0.080	1	2
CHEMOTHERAPY	-0.074	1	1
OTHER KIDNEY & U...	-0.068	1	1
OTHER ANEMIA &...	-0.065	1	1
TRACHEOSTOMY W...	-0.060	1	1
OTHER PROCEDUR...	-0.057	1	1
OTHER RESPIRATO...	-0.050	1	1

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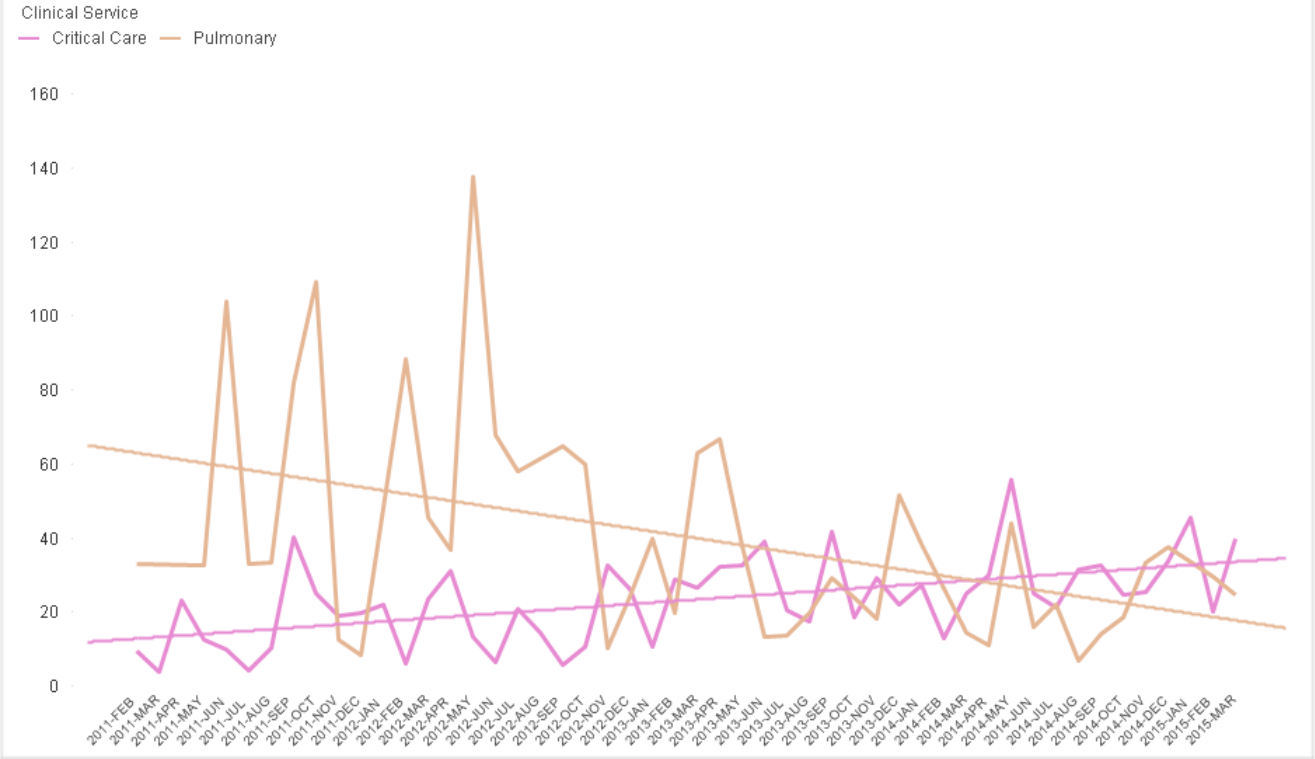
Targeted Drugs	Carbapenem
Drug Category	Cefepime
Drug Class	Fluoroquinolone
Drug Name	Linezolid
Anti-Pseudomonal	Piperacillin-Tazobactam
ASP Restricted?	Vancomycin
Anaerobic Coverage	
Route	
Clinical Service	
Clinical Unit	
Patient Age	

Clear Selections

Current Selections

drug_name	Ertapenem, Imipenem, Mer
drug_class	Carbapenem
ADT_SERVICE	Critical Care, Pulmonary

Overall Use | DOT/LOT Per 1... | Trend Significance | Mean LOT/Mean... | DOT By Antibiotic | DOT By Service | # Patients | % on Antibiotics



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- Increasing DOT Per 1000 Patient Days in Critical Care
  - Increasing duration of therapy?
  - vs.
  - Increasing percentage of patients on therapy?

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drug_class	Carbapenem
ADT_SERVICE	Critical Care

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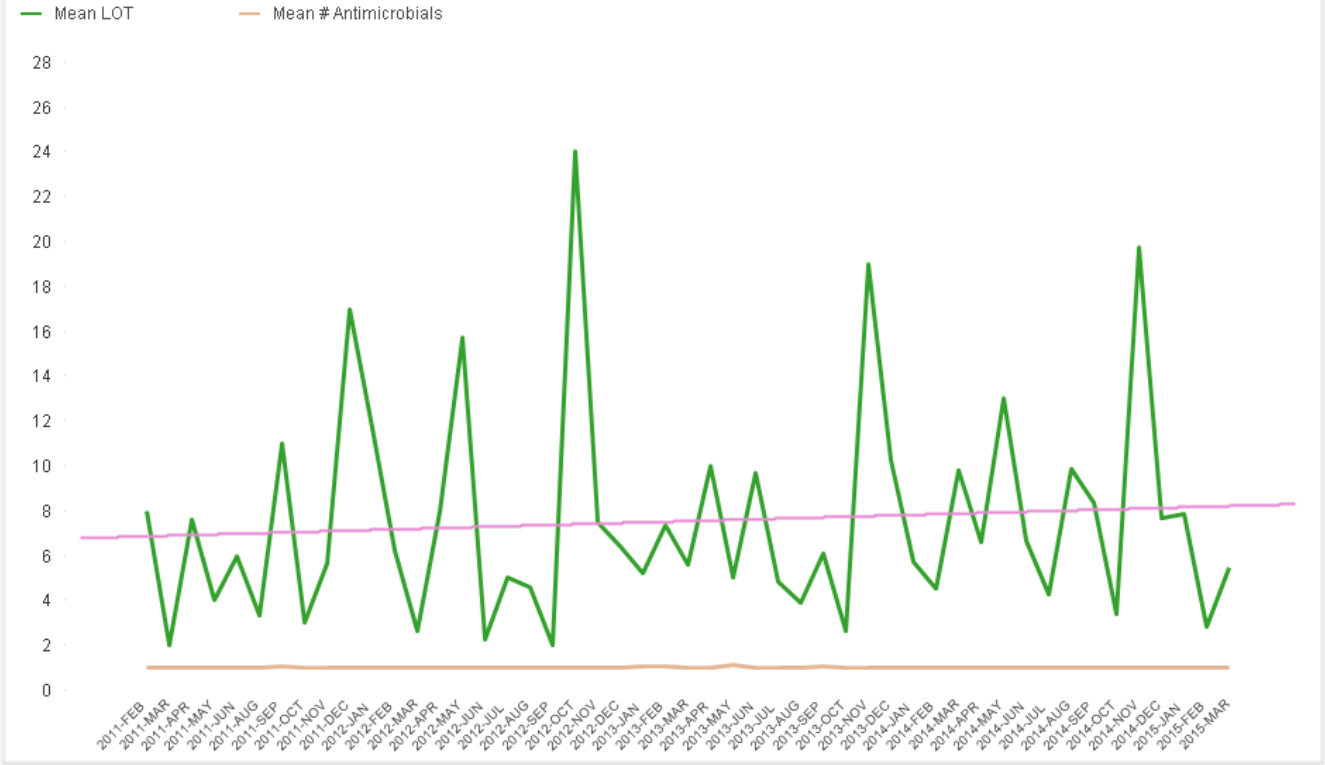

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ADT_SERVICE	Critical Care

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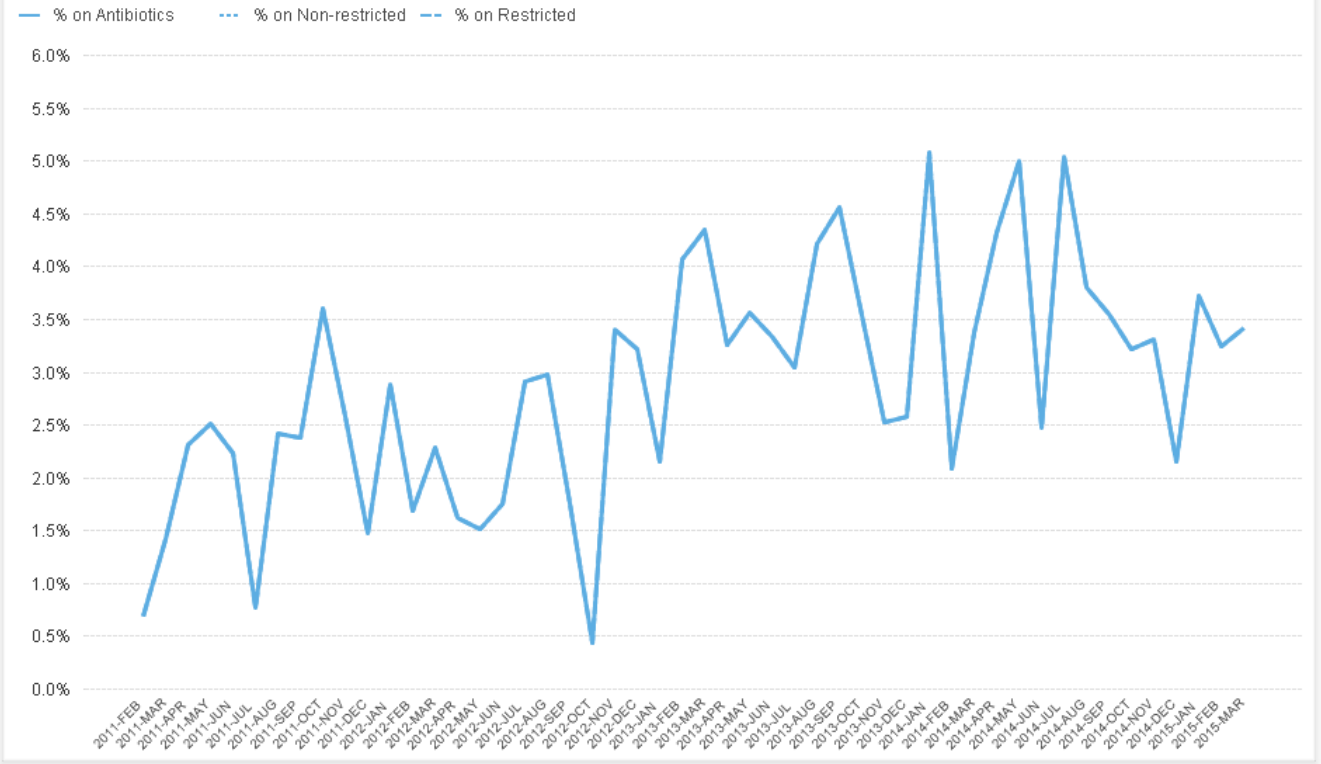

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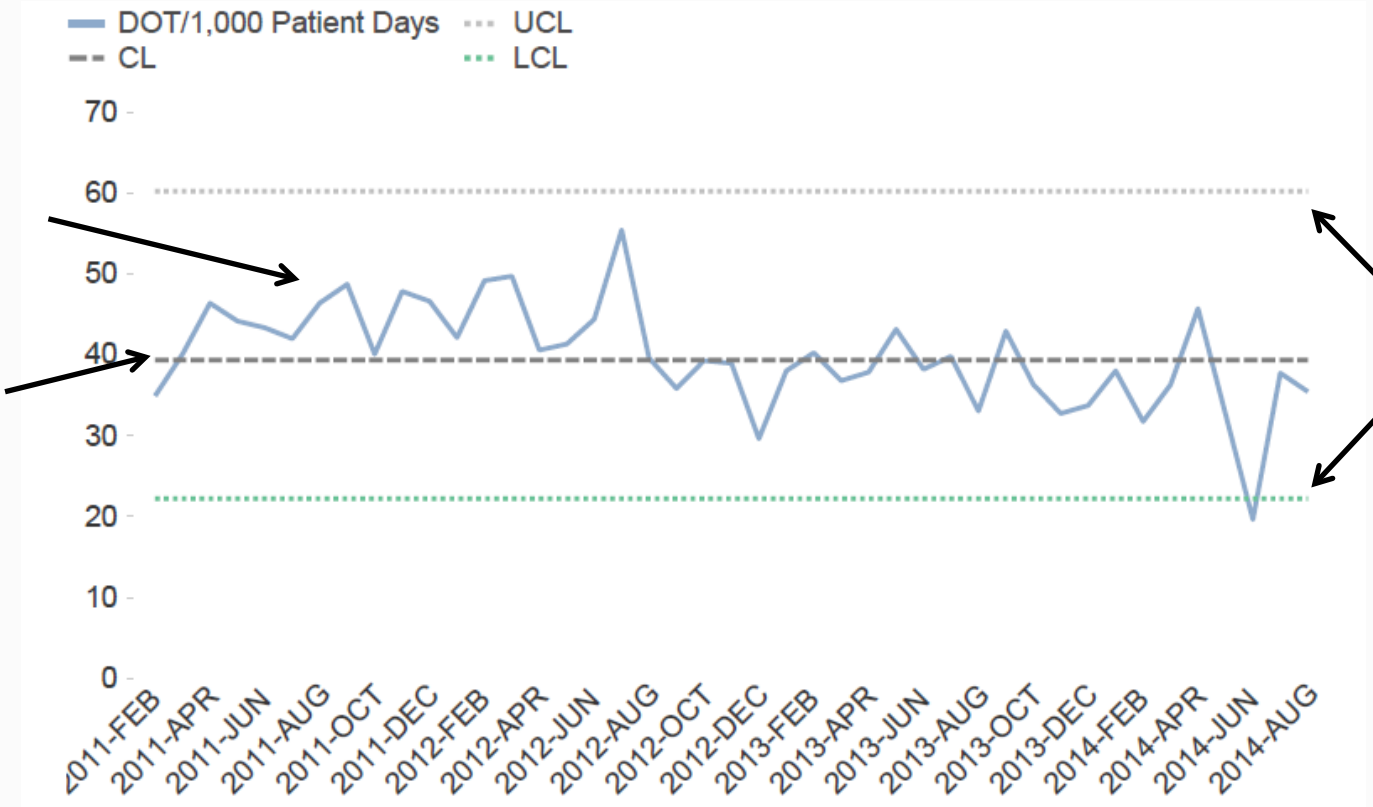
ANTIMICROBIAL USE AND STATISTICAL PROCESS CONTROL

Process Control Charts

- Approach to identifying significant variations in data
- Control limits typically set with +/- 3 standard deviations
  - Within control limits – “common cause variation”
  - Outside of control limits – “special cause variation”

Process Control Charts – Metronidazole Use



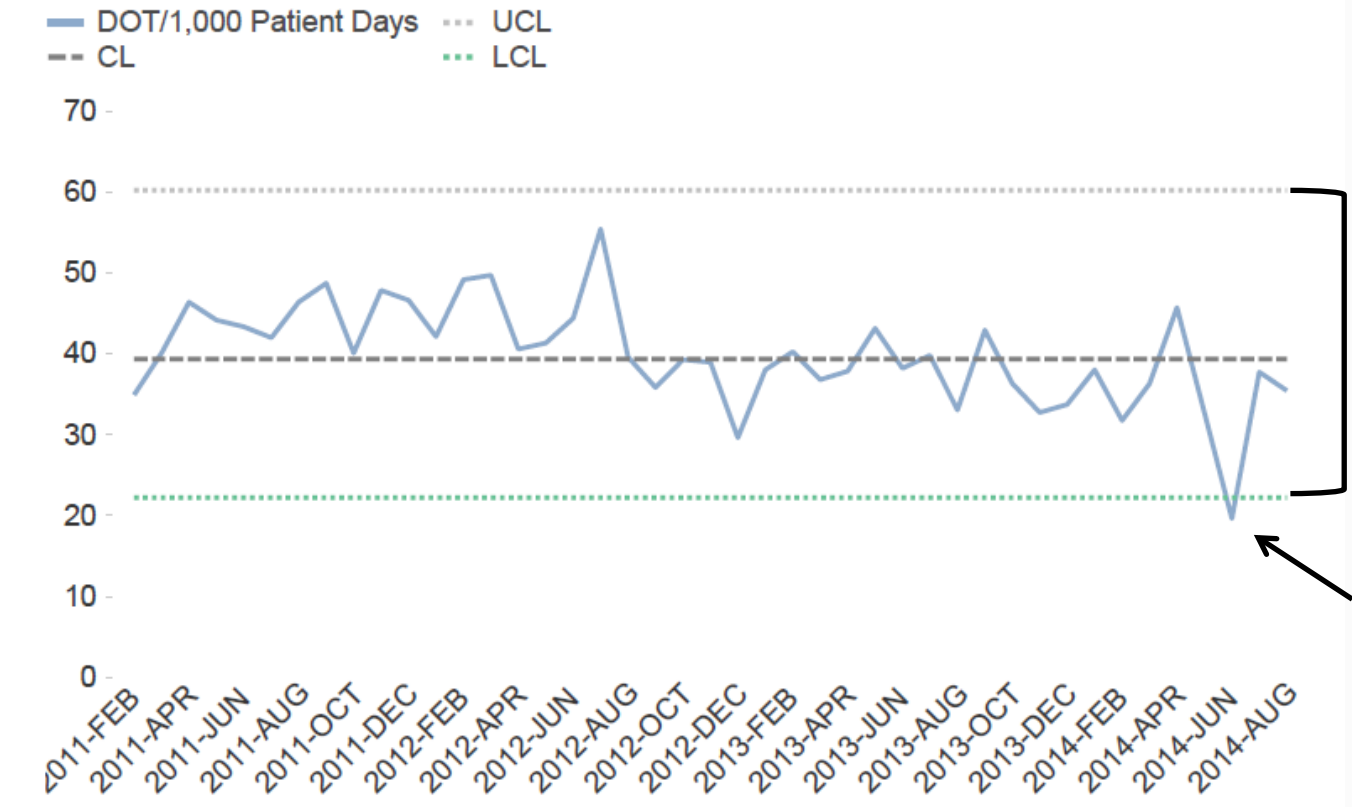
Outcome

Control Line

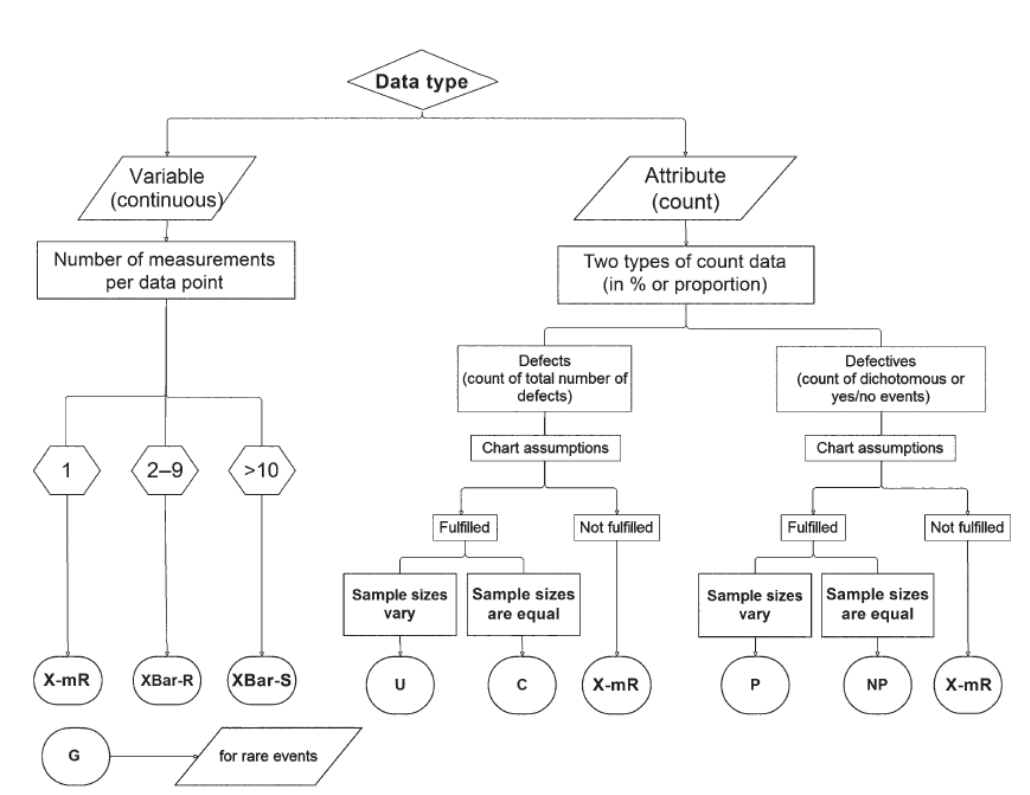
Process Control Limits

Time

Process Control Charts



Lots of Charts for Different Types of Measures



Cheung, Y, et. al. "Quality initiatives: statistical control charts: simplifying the analysis of data for quality improvement." Radiographics 2012;32:2113-26.

Statistical Process Control in Antimicrobial Use

- Don’t want to use blindly
  - “Special cause” variation in antimicrobial use might be appropriate – i.e. increasing antibiotic resistance or outbreak of specific pathogen

What Kind of SPC Chart Should I Use?

- Complicated question for antimicrobial use data
- QI algorithms and charts may suggest “C” or “U” charts for count data, but these tend not to be ideal for antimicrobial use data
- Anecdotally, best option seems to be X-mR chart

Conclusions

- Stewardship is more than monitoring data, but use measures provide important feedback
- Basic antimicrobial use monitoring does not have to be complicated
- Interactive data exploration can help identify stewardship opportunities
- Control charts provide a framework for monitoring trends over time

Thanks

- Questions?
- Contact Information:
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  - beusj@email.chop.edu

- CHOP ASP Team
  - Jeff Gerber, MD, PhD – Medical Director
  - Talene Metjian, PharmD – ASP Manager
  - Molly Hayes, PharmD – ASP Pharmacist