Dedication

This presentation is dedicated to the memory of Jean-Raoul Scherrer, MD, PhD, one of the greatest European informaticians of the last century, who passed away last month. He was the ultimate example of a gentleman and a scholar.

Jean-Raoul was in part responsible for the Vanderbilt WizOrder project, because he encouraged his student, Antoine Geissbuhler, MD, to train in Informatics with Vanderbilt faculty in the USA.

Antoine was the “father” of WizOrder at VUMC; he wrote over 90% the original WizOrder code while a Fellow and junior faculty member in Biomedical Informatics.

Antoine left VUMC in July, 1999 to assume Professor Scherrer’s academic position as Director of the Informatics Program in Geneva, at the time of Jean-Raoul’s retirement.
Two and one-half Millennia And Four Decades of Clinical Decision Support: From Standalone “Oracles” to “Assistance Integrated into Clinical Workflow”

Randolph A. Miller, MD ’71 P ‘03

Professor & Chairman, Department of Biomedical Informatics, Professor of Medicine, and Associate Director, Informatics Center, Vanderbilt University Medical Center, Nashville, TN, USA

Contributors to the work described include:
Jack D. Myers MD, Harry Pople Jr, PhD, Fred E. Masarie Jr MD, Antoine Geissbuhler MD, William W. Stead MD, Douglas A. Talbert PhD, Jonathan Grande BS, S. Trent Rosenbloom MD MPh, William Dupont PhD, Karen Hughart RN, David Sanders MD, Dario Giuse, DrIng, Eric Neilson, MD & the VUMC Resource Utilization Committee, and Numerous VUMC employees in the Informatics Center and School of Medicine

Work supported by Vanderbilt University Medical Center and grants from the U.S. National Library of Medicine

Copyright © 2002, Vanderbilt University Medical Center
Disclosure of (Non) Conflicts of Interest

Dr. Miller receives royalties from the University of Pittsburgh for his work there in authoring the Internist-I and Quick Medical Reference programs and knowledge bases for diagnostic decision support in Internal Medicine; donated to charity.

Dr. Miller receives royalties through Vanderbilt University based on Vanderbilt’s commercialization of the WizOrder clinician order entry system, which he helped to develop and support. The majority of income from WizOrder goes directly to Vanderbilt School of Medicine, per se.
Definition

Biomedical Informatics is the study of the generation, utilization, structure, transformation, and application of data, information and knowledge to basic biological research, clinical sciences, health care delivery, and health services research.
The first 2000 years of observations by earliest Biomedical Informaticians

ON THE NEED FOR DECISION SUPPORT:
1. Life is short, the art long, opportunity fleeting, experience treacherous, judgment difficult. Hippocrates. *Aphorisms*, ~460-400 BC

ALSO ON THE NEED FOR DECISION SUPPORT:

ON THE NEED TO EVALUATE DECISION SUPPORT SYSTEMS:
(also interpreted as avoidance of medical informatics vaporware)
3. The proof of the pudding is in the eating.
Miguel de Cervantes. *Don Quixote*, 1605
Rationale for Clinical Decision Support: More Recent Observations by Clinicians & Educators

1. Information in biomedical science is expanding exponentially (count/weigh pages in biomedical journals annually).


2. The half-life of biomedical information is approximately 5 years (repeat medical school after graduation recursively).

3. After completing residency training, a physician’s knowledge of medicine tends to decline over time.

4. Analyses of unmet clinical information needs, from academic centers to small clinics, indicate 0.12 to 5.2 unanswered questions occur per clinician half-day.


5. The effect of unmet information needs on patient outcomes is unknown. Williamson surveyed primary care practitioners in the U.S. and found “…physicians face a serious problem in their effort to keep current with recent medical advances.”

Rationale for Clinical Decision Support: Recent Observations by Clinical Researchers

Institute of Medicine, National Academy of Sciences, 1999 Report: To Err is Human

interpreted by lay press to imply:

“doctors and nurses incompetent, cause errors through lack of knowledge, kill ~100,000 annually”
Medical Diagnostic Decision Support Systems (MDDSS)

1. MDDSS old as medical informatics as a discipline: 1950-present, > 3000 MDDSS articles in peer-reviewed medical literature

2. Majority of concepts and methods relevant to MDDSS described/anticipated prior to 1985

3. As an academic activity, development of MDDSS has been successful, as reflected by the literature

4. However, only MDDSS in widespread use are small, focused applications for EKG, ABG, PFT interpretation, despite attempts to create general applications
Review of MDDSS Development: Current Understanding of Humans' Diagnostic Reasoning

1. Clinicians make diagnoses by “pattern recognition”, Using compiled knowledge, based on reading, experience

2. Expert diagnostic reasoning is based on:
   • Recognition of key or pivotal findings
   • Refinement of hypotheses as more is learned
   • Early diagnostic hypothesis formation
   • Quasi-probabilistic reasoning using prevalence
   • Pathophysiological reasoning (“first principles”) in unfamiliar settings

3. Experts reason more efficiently than novices:
   • Greater store of compiled knowledge, and array of strategic approaches
   • Awareness of diagnostic "weight of evidence" in hypothesis formation
Early MDDS system development: 1954-1985
Ledley and Lusted, *Science*, 1959

Physicians have imperfect self-knowledge of their own diagnostic problem solving methods.

Protocol analysis is an important tool for understanding diagnostic reasoning.

Both logic (as embodied in set theory and Boolean algebra in computer systems) and probabilistic reasoning (as embodied in Bayes' rule on computers) are essential components of medical reasoning.

Computers can assist in diagnosis.

MDDSS using decision-analytic approach are possible.
Early MDDS system development: 1954-1985

Systems using discriminating questions, models, and mathematical techniques:

1967+ Bleich and colleagues -- branching logic “20 questions”
acid-base and electrolyte disorders

1970+ Statistical Clustering / Probabilistic Models: many

1970+ Semiquantitative & quantitative deterministic
physiological & mathematical models: Guyton,
Kuipers & others

1980+ Expert systems using pathophysiologial models:
ABEL
Early MDDS system development: 1954-1985

Work on Bayesian systems:

1960+ HR Warner & Colleagues, JAMA 1961 -- Diagnosis of congenital heart diseases

1968+ Sequential diagnostic strategies
   by Gorry and Barnett

1970+ Abdominal pain program & UK clinical trials
   by de Dombal and colleagues
Early MDDS system development: 1954-1985

Early Heuristic MDSS employing criteria tables

1956+ Lipkin, Hardy, Engle: HEME
1966+ Lindberg et al: CONSIDER (CMIT)
1979+ Blois et al: RECONSIDER (CMIT)
1980+ Kulikowski & Weiss: EXPERT shell, AI/Rheum
Early MDDS system development: 1954-1985

Early Rule-based medical expert systems

1969+ DENDRAL - Feigenbaum & Buchanan
1974+ MYCIN - Shortliffe 1976
1976+ SEEK-I and SEEK-2 - Politakis and Weiss
Early MDDS system development: 1954-1985

Early Heuristic MDDSS Utilizing Symbolic Reasoning ("AI")
Gorry 1968: General principles for expert system MDDSS

Formal definition of the diagnostic problem
Analysis of relationships among:
  Generic inference function
    (used to generate diagnoses from observed findings)
  Generic test-selection function
    (dynamically selects the best test to order)
  Generic pattern-sorting function
    (determines which diagnoses belong to a "problem area")
Difference between the information value, the economic cost, and the morbidity/mortality risk of performing tests
Cost of misdiagnosis of life-threatening or disabling disorders
Potential influence of "red-herring" findings described
“Multiple diagnosis" problem described
Early MDDS system development: 1954-1985

Descendants of Gorry's schemata: expert systems

1973+ PIP (the Present Illness Program) - Pauker, Gorry et al

1973+ INTERNIST-I developed by Myers, Pople, and Miller

1984+ QMR, developed by Miller, Masarie, and Myers

1986+ DXplain, developed by Barnett and colleagues

1986+ ILIAD, developed by Warner and colleagues
INTERNIST-I Project 1973-1985
J.D. Myers, M.D., H.E. Pople, Jr. Ph.D., R.A. Miller (then med student)

Goals and Objectives

Develop algorithm & KB that could support expert consultations for diagnosis in general internal medicine
Create program whose input would be patient's history, physical exam, and laboratory data;
Produce output consisting of either concluded diagnoses or differential diagnosis
Endow program with ability to lead physician through cost-effective patient "work-up"
Develop and maintain knowledge base for clinical diagnosis
INTERNIST-I Project 1973-1985
Sample case analysis

Positive Findings..... NEJM V324P527 1991
SEX Male
AGE Gtr Than 55
ABDOMEN Pain Epigastrium
ABDOMEN Pain Severe
UNCONSCIOUSNESS Recent Hx
HYPERTENSION Hx
MYOCARDIAL Infarction Hx
ANGINA Pectoris Hx
HEART Catheterization Recent Hx
CORONARY Arteriography Fixed Luminal Narrowing 70 Percent Or Gtr
HEART Angiocardiography Left Ventricle Adynamic Area <S>
HEART Surgery Recent Hx
PRESSURE Arterial Diastolic Gtr Than 125
DYSPNEA At Rest
BOWEL Sound <S> Decreased
INTERNIST-I Project 1973-1985
Sample case analysis

CONSIDERING: SEX Male, AGE Gtr Than 55, ABDOMEN Pain Epigastrium, ABDOMEN Pain Severe, UNCONSCIOUSNESS Recent Hx, HYPERTENSION Hx, MYOCARDIAL Infarction Hx, ANGINA Pectoris Hx, HEART Catheterization Recent Hx, HEART Surgery Recent Hx, PRESSURE Arterial Diastolic Gtr Than 125, DYSPNEA At Rest

DISCRIMINATE: AORTIC DISSECTION, MYOCARDIAL INFARCTION ACUTE

DIABETES MELLITUS HX?

MARFANS SYNDROME FAMILY HX?

MYOCARDIAL INFARCTION FAMILY HX?
INTERNIST-I Project 1973-1985
Lessons learned

1) “Greek Oracle” model of MDSS flawed

Quick Medical Reference (QMR) 1984-85 embodied change in philosophy in MDSS: abandoned "Greek Oracle" (INTERNIST-I) model for new “catalyst” model: build toolkits to address potential rate-limiting end-user problems

A → B → C → … L → M → … Y → Z

Goal is to improve performance of both the user and the MDSS over their native (unassisted) states

Unit of intervention for evaluation studies is man plus MDSS, not MDSS analyzing cases in isolation
INTERNIST-I Project 1973-1985
Lessons learned

2) Standard model for building expert systems non-sustainable: collaboration of domain expert and knowledge engineer

Recommendation: Use of the Biomedical Literature as a “Gold Standard” for Clinical Knowledge Bases

For what are the classics but the noblest thoughts of man? They are the only oracles which are not decayed, and there are such answers to the most modern inquiry in them as Delphi and Dodona never gave.

Henry David Thoreau, *Walden,* “Reading” (1854).
INTERNIST-I Project 1973-1985
Lessons learned

3) “Feedback loop” of running system required to build and maintain high-quality KB –
Beware of KBs built by committees of experts sitting in armchairs

Goals

Recognize expertise of clinician-user, in role as system "pilot"

Emphasize real-world diagnostic decision-making by physicians, rather than by “AI” algorithm

Replace "Greek Oracle" approach to diagnosis with Catalyst/Toolkit model

Exploit the INTERNIST-1/QMR knowledge base for diagnostic reasoning

Change to microcomputer-based, ubiquitous platform
Disease: PERINEPHRIC ABSCESS Number: 3.10.6 Author: Randolph A. Miller, M.D.

Findings:

1.1 ABDOMEN TRAUMA RECENT HX

[1] 1 Mentioned as predisposing factor, p. 72
[5] 1 Mentioned as common antecedent, 1925-1940
[7] 2 Case report
[9] 2 Case reports of trauma leading to renoalimentary fistulae
[13] 2 Several cases due to trauma, 1920-1930
[10] 3 2/46 cases had flank trauma 1-2 weeks earlier
[25] 2 2/49 had history of trauma
[30] 2 67 cases, 1896-1902, in series of 230 reportedly due to trauma
[62] 1 Mentioned as cause 1910; cited as reason for male dominance of illness and age in "years of greatest physical activity"

[82] 3 2 of 55 cases had recent trauma (1931)

97] 2 Motorcycle accident 11 days before admission in case report

[12] Brust RW, Morgan AL
Renocolic fistula secondary to carcinoma of the colon.
J Urol 1974;111:439

[13] Campbell MF
Perinephric abscess.
Surg Gynecol & Obstetrics 1930;51:674.
Quick Medical Reference (QMR) : 1984-1994

<table>
<thead>
<tr>
<th>EV-FR</th>
<th>Contains 130 Hypotheses arranged by relative score (1-100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 4</td>
<td>Fever and Splenomegaly Moderate and Heart Murmur Present and Hemoglobin Blood Less Than 12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukemia Acute Lymphoblastic</td>
<td>86</td>
</tr>
<tr>
<td>Rheumatoid Arthritis</td>
<td>85</td>
</tr>
<tr>
<td>Causes Anemia Of Chronic Disease</td>
<td></td>
</tr>
<tr>
<td>Endocarditis Acute Infective Left Heart</td>
<td>83</td>
</tr>
<tr>
<td>Rheumatoid Arthritis is the Systemic Component of Felty's Syndrome</td>
<td>82</td>
</tr>
<tr>
<td>Causes Anemia Of Chronic Disease</td>
<td></td>
</tr>
</tbody>
</table>

Line 1 of 416
### Quick Medical Reference (QMR) : 1984-1994

#### Relationships

Contains 130 Hypotheses arranged by relative score (1-100)

- Fever and Splenomegaly Moderate and Heart Murmur Present and Hemoglobin Blood Less Than 12

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autoimmune Hemolytic Anemia Involving Warm Reacting Antibody</td>
<td>81</td>
</tr>
<tr>
<td>Endocarditis Infective Right Heart</td>
<td>81</td>
</tr>
<tr>
<td>Pernicious Anemia</td>
<td>81</td>
</tr>
<tr>
<td>Myeloid Metaplasia (Primary Myelofibrosis)</td>
<td>80</td>
</tr>
<tr>
<td>Anemia Of Decreased Vitamin B12 Absorption</td>
<td>79</td>
</tr>
<tr>
<td>Crohns Disease Of Small Intestine Causes Iron Deficiency Anemia</td>
<td>79</td>
</tr>
</tbody>
</table>

---

**Line 14 of 416**

**Focus-ENTER**

**Menu-ALT**
Quick Medical Reference (QMR) : 1984-1994

Disease hypotheses (DX)

Observed Findings (MX)
Early Case Report:  
The Imperfectability of Man  
Shakespeare, W. *The Merchant of Venice*. 1597; Act I, Scene ii

If to do were as easy as to know what were good to do,  
chapels had been churches, and  
poor men's cottages princes' palaces.  
... I can easier teach twenty what were good to be done than  
to be one of the twenty  
to follow my own teaching.
1 Patient-Specific Information
Core “Portable” Patient Summary:
Problems, Allergies, Meds
Local Electronic Patient Record
Orders: Active/Inactive

2 Local Knowledge
“Best of Care” Pathways
Institutional policies & costs
Drug interactions & formulary
Physician preferences

3 Global Knowledge
Medical literature
Diagnostic databases regarding diseases
National guidelines
Patient databanks with outcome data

4 Algorithms to enhance care
Reminders, Alerts
Quality checks
Self-Generated Monitors
Decision support programs

Copyright © 2002, Vanderbilt University Medical Center
Recent Case Report: 
The Imperfectability of Man

Protocol-based computer reminders, the quality of care, and the non-perfectability of man

McDonald CJ, New England Journal of Medicine
1976; 295(24):1351-5

“Using controlled crossover design, nine physicians given computer suggestions from 390 protocols related to conditions managed (e.g., elevated blood pressure) or caused (e.g., liver toxicity) by drugs. Physicians responded to 51 per cent of 327 events when given, and 22 per cent of 385 events when not given computer suggestions.”

“It appears that the prospective reminders do reduce errors, and that many of these errors are probably due to man's limitations as a data processor rather than to correctable human deficiencies.”
Background: History of Integrated Clinical Decision Support


“A computerized medical record system detected and reminded responsible clinicians about clinical events requiring possible corrective action. Reminders significantly increased the clinician response rate. *Addition of relevant medical literature citations to the reminders did not significantly increase the response rate, nor did it stimulate the physicians to read any of the cited articles kept in an immediately available "library" of reprints.*”


“The number of study tests ordered [by academic primary care group] decreased significantly for intervention patients (16.8%) and for controls (10.9%). *Presenting physicians with previous test results reduced the ordering of those tests.*”
Background: History of Integrated Clinical Decision Support


“Effect of informing physicians of the charges for outpatient diagnostic tests on their ordering of such tests in an academic primary care medical practice studied. **During 26-week intervention period, the physicians in the intervention group ordered 14 percent fewer tests per patient visit than did those in the control group (P less than 0.005), and the charges for tests were 13 percent ($6.68 per visit) lower (P less than 0.05).”


“Computerized infectious disease monitor automatically generates surveillance "alerts" for patients with hospital-acquired infections, not receiving antibiotics to which their pathogens are susceptible, who could be receiving less expensive antibiotics, or who are receiving prophylactic antibiotics too long. Over 2 months, surveillance personnel using system found more hospital-acquired infections, while requiring only 35% of the time. Alerts identified 37 patients not receiving appropriate antibiotics, 31 patients who could have been receiving less expensive antibiotics, and 142 patients, during one month, receiving prolonged cephalosporin prophylaxis. **Computer screening can help focus the activities and improve the efficiency of hospital surveillance personnel.**
Background: History of Integrated Clinical Decision Support


“We prospectively monitored the timing of antibiotic prophylaxis and studied the occurrence of surgical-wound infections in 2847 patients undergoing elective clean or "clean-contaminated" surgical procedures at a large community hospital.

Of the 1708 patients who received the prophylactic antibiotics preoperatively, 10 (0.6 percent) subsequently had surgical-wound infections. Of the 282 patients who received the antibiotics perioperatively, 4 (1.4 percent) had such infections (P = 0.12; relative risk as compared with the preoperatively treated group, 2.4; 95 percent confidence interval, 0.9 to 7.9). Of 488 patients who received the antibiotics postoperatively, 16 (3.3 percent) had wound infections (P less than 0.0001; relative risk, 5.8; 95 percent confidence interval, 2.6 to 12.3).

We conclude that in surgical practice there is considerable variation in the timing of prophylactic administration of antibiotics and that [computer-prompted] administration in the two hours before surgery reduces the risk of wound infection.”
Background: History of Integrated Clinical Decision Support


We performed a prospective randomized controlled trial that included all inpatients at a large teaching hospital during a 15-week period. The intervention consisted of computerized reminders at the time a test was ordered that appeared to be redundant. Main outcome measures were the proportions of clinical laboratory orders that were canceled and the proportion of the tests that were actually performed. During the study period, there were 939 apparently redundant laboratory tests among the 77,609 study tests that were ordered among the intervention (n = 5,700 patients) and control (n = 5,886 patients) groups. In the intervention group, 69% (300 of 437) of tests were canceled in response to reminders. Of 137 overrides, 41% appeared to be justified based on chart review. In the control group, 51% of ordered redundant tests were performed, whereas in the intervention group only 27% of ordered redundant tests were performed (P <0.001). However, the estimated annual savings in laboratory charges was only $35,000.


“Computerised physician order entry and computerised physician decision support … have been found to improve drug safety

Other innovations, including using robots to fill prescriptions, bar coding, automated dispensing devices, and computerisation of the medication administration record, though less studied, should all eventually reduce error rates”
WizOrder purpose and demographics

WizOrder was developed at Vanderbilt by DBMI faculty and Informatics Center staff to help ensure the highest quality of care for our patients, reducing medical errors.

It provides “point-of-care” relevant information resources to enhance and support clinicians’ decision-making at the time of order entry.

It has been refined by ongoing clinical feedback from House staff, nurses, attending MDs, committees, others at VUMC for the past 6 years.

WizOrder is now used on 625 of 650 beds at VUH by: Medicine, Surgery, Pediatrics, and OB/GYN services.

Over 12,000 orders/day, 70% by MDs, rest by clinical staff.
WizOrder components include:

-- “Intelligent, Heads-up Display” Approach to Patient Care:
   What clinicians need to know when they need to know it
-- Electronic record sensitive to patients’ specific information
-- Medication prescription with safeguards
-- Flexible tools to present & activate guidelines
-- Implementation of “Best of Care” clinical pathways
-- Respect for individual physicians’ preferences
-- Hooks to web-based ‘just-in-time’ educational resources
-- Linkage of patient cases to literature-based evidence
-- Ability to implement cost-savings precisely & humanely
User types “gen 80 iv q8h”
Completer gives good matches

1. gentamicin injection: garamycin 80 mg iv q8h
2. gentamicin ophthalmic oint: q8h
3. gentamicin ophthalmic soln: q8h
4. gentamicin 0.1% topical soln (VUH SPECIAL PREPARATION) appl
5. gentamicin fortified eye drop (VUH SPECIAL PREPARATION) q8h
6. hypertension svc admission orders »
7. gentamicin peak & trough levels »
8. General Medicine (Scoville or Morgan) attending MD contact info
9. cyclosporine oral (Sandimmune, Neoral, Gengraf, Generic CYA)
10. general other ED labs (ED) »
11. generic chemotherapy »

Select an item from the list

or enter another order
or press END to return to the previous list

Copyright (C) 2001 Vanderbilt University Medical Center

User selects first item from above pick list
Completer shows part of order “understood”, asks for more below (also recent labs above)

GENTAMICIN INJ: GARAMYCIN
Estimated CrCl=112 ml/min based on Creat=0.8 on Jan 17 02:30
Information: recommended dose for single daily iv dosing: 4-7 mg/kg/24h

a) Dose: 80 MG
b) Route: IV
c) How often: Q8H

When to start (first dose): (with optional start date & time)

1. NEXT SCH (default) (next schedule)
2. NOW

or enter a start date, time and priority
or press ENTER = NEXT SCH

Copyright (C) 2001 Vanderbilt University Medical Center
WizOrder uses pharmacokinetic model to estimate drug distribution in this patient, based on parameters such as weight and renal function, and displays warning and suggested proper dose if MD’s dose out of range (too high or too low).
WizOrder: Pharmacy warning about potential drug interaction

1) MD prescribed “cyclosporine” with currently active “gentamicin” order; WizOrder displays drug interaction warnings

2) Clicking on drug interaction warning displays monograph from VUMC pharmacists about nature and severity of interaction

3) WizOrder NEVER stops MDs from doing what they want to (they know patients better than computer does), so option to override warning always offered; log is kept of MD being warned
MD requests advice for empirical treatment of intra-abdominal abscess (before culture & sensitivity results known)

WizOrder queries user about patient, then suggests cost-effective alternatives based on Infectious Disease experts’ approach. User selects best one for patient & orders.
1) Upon MD stating patient is eligible for protocol, WizOrder calculates heparin dose and makes it easy to order tests associated with guidelines.

2) Links to educational materials available in protocol.

3) MD reviews relevant medications & labs.

4) MD selects actions and clicks buttton to activate guideline-related orders.
**New**

**Teaching rounds:**

Participants all have summarization "active" orders & current information

**Rounds focus on diagnosis & management, not on details**

---

**Active orders**

**Recent Labs**

---

**Wiz Current Meds & MARS Results**

---

**Copyright © 2000, Vanderbilt University Medical Center**
The PC-POETS Study:
Integrating
Patient Care-Provider
Order Entry with Tactical Support

Research Supported by NIH / NLM:
1 R01 LM06226

Copyright © 2002, Vanderbilt University Medical Center
The project tested a fundamental and long-held tenet in medical informatics, that:

medical decision support systems can gain widespread acceptance when a critical mass of functionality is delivered through a common interface on a readily available platform

“Good counselors lack no clients”

(Shakespeare, Measure for Measure, 1605; Act I, Scene ii)
PC-POETS: Evaluation - Methods

House staff teams: 1 resident (PGY 2 or 3) plus 1 or 2 interns (PGY 1); 1-3 teams per ward (Medicine only) – assigned to study wards

Study period: April 1999 through March 2000

House staff rotations determined monthly by Medicine Chief Resident, then processed by statisticians to assure each teams’ members either all control or all intervention

All MDs in “Control” status during July-August 1999

Switch from control to intervention in later rotations OK, but going from intervention to control forbidden; except, all statuses reset after “washout” (July/August) at year boundary
Problem: Follow-up, test ordering patterns
The VUMC Antibiotic Subcommittee recommends Cefepime (Maxipime®) over Ceftazidime (Fortaz®) for most indications where an anti-pseudomonal cephalosporin is needed.*

Cefepime 1000 mg q12h = Ceftazidime 1000 mg q8h

* Exception for neonates and selected pediatric patients. Safety and effectiveness of Cefepime in pediatric patients below the ages of 2 months have not been established.

Compared to ceftazidime, Cefepime has the following advantages:
- Similar coverage against *Pseudomonas*, improved coverage against *Enterobacter* species
- Enhanced stability against inducible/derepressed chromosomal beta-lactamases
- Better activity against Gram-positive pathogens, including *Staphylococci*, *S. viridans*, *pneumococci*
- Q12 hour dosing except for empiric therapy for febrile neutropenia

### Adults (Age > 16 years)

<table>
<thead>
<tr>
<th>Dose</th>
<th>Example of Infection being treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 mg IV q12h</td>
<td>Uncomplicated urinary tract infection</td>
</tr>
<tr>
<td>1000 mg IV q12h</td>
<td>Nosocomial pneumonia in ICU patient</td>
</tr>
<tr>
<td>1000 mg IV q8h</td>
<td>Empiric coverage of febrile neutropenic patient</td>
</tr>
</tbody>
</table>
| 2000 mg IV q8h      | **The FDA approved a dose of 2 gm IV q8h for febrile neutropenic patients and this is preferred over the 1gm IV q8h dose if cefepime is given as monotherapy for this indication.**
|                     | The 1 gm IV q8h dose has been used in the Bone Marrow Units and is appropriate for febrile neutropenic patients receiving other antibiotics with activity against Gram-negative aerobic pathogens such as aminoglycosides or quinolones. Documented infection with *Pseudomonas aeruginosa* should be treated with the higher (2 gm IV q8h) dose. |

### Other

- **Intramuscular**
  - order I.M. Cefepime (with Lidocaine)

- **Non-standard Dose**
  - order non-standard dose of Cefepime

"Click" the CLOSE button to return to WizOrder without ordering cefepime
CONCLUSION:

Early Advice on Ideal Behavior of Clinical Decision Support Systems And Their Developers

The essence of knowledge is, having it, to apply it;

not having it, to confess your ignorance

Confucius. ~2500 years ago