YALE-NEW HAVEN HOSPITAL

Using Web-Based Instruction Modules to Improve Practitioner Knowledge at Yale New Haven Hospital on the Prevention of Antimicrobial Resistance and Health-Care Associated Infections

Overall Goals & Objectives:

This proposal seeks to address two key problems in the prevention and mitigation of antimicrobial resistance and healthcare device associated infections through the use of Web-based instruction modules.

For the goal of preventing and mitigating antimicrobial resistance, clinicians require an overview of epidemiologic changes in antimicrobial resistance in the last decade; the mechanisms of antimicrobial resistance, both newly evolved as well as endemic prior mechanisms; the risk factors for antimicrobial resistance in both patient-specific factors and antimicrobial exposure risk factors; and the appropriate treatment of infectious organism to prevent for the selection of resistance.

For the second goal for the prevention and mitigation of healthcare device associated infections, clinician require an understanding of how such devices place patients at risk for infection, evidence-based methods to prevent such infections, and appropriate treatment of such infections if they do indeed occur.

Providing in-depth education for physicians and mid-level providers in these specific areas historically has been difficult due to the need for multiple lectures administered to many departments and at many sites within in a single institution. Housestaff duty hour requirements, mid-level providers with discrete work shifts, and competing time demands for attending physicians make a lecture based educational system untenable in terms of reaching clinicians. Circulating written materials for education is another approach for clinician education. However, although clinicians may sign attestations that they have reviewed and understand such materials, there is assessment of mastery or competency, let alone, that the education materials were actually reviewed.

Web-based instruction modules or tutorials have been used to provide specific targeted education to clinicians over the last decade to meet regulatory requirements such as OSHA required bloodborne pathogen training, fire safety, and isolation precautions for Infection Control. However, such modules are often not updated routinely nor impact a clinician's knowledge in terms of improving patient care and outcomes. The other use of web-based modules in medicine has been for CME activities for clinicians. However, such modules are not universally applied to an entire medical staff and the targeting of clinicians is usually based on specialty type.

To make web-based instruction modules useful both in terms of educational value in meeting the above objectives and clinician time, the following attributes are desirable:

1) Pre-test to assess current knowledge base.
2) Didactic instruction with interactivity to engage the end user.
3) Clinical cases to allow clinicians to practice what they have mastered from the module.
4) Feedback on answers for the clinical cases.
5) Post-test to assess mastery of material.

Technical Approach:

1) Needs Assessment

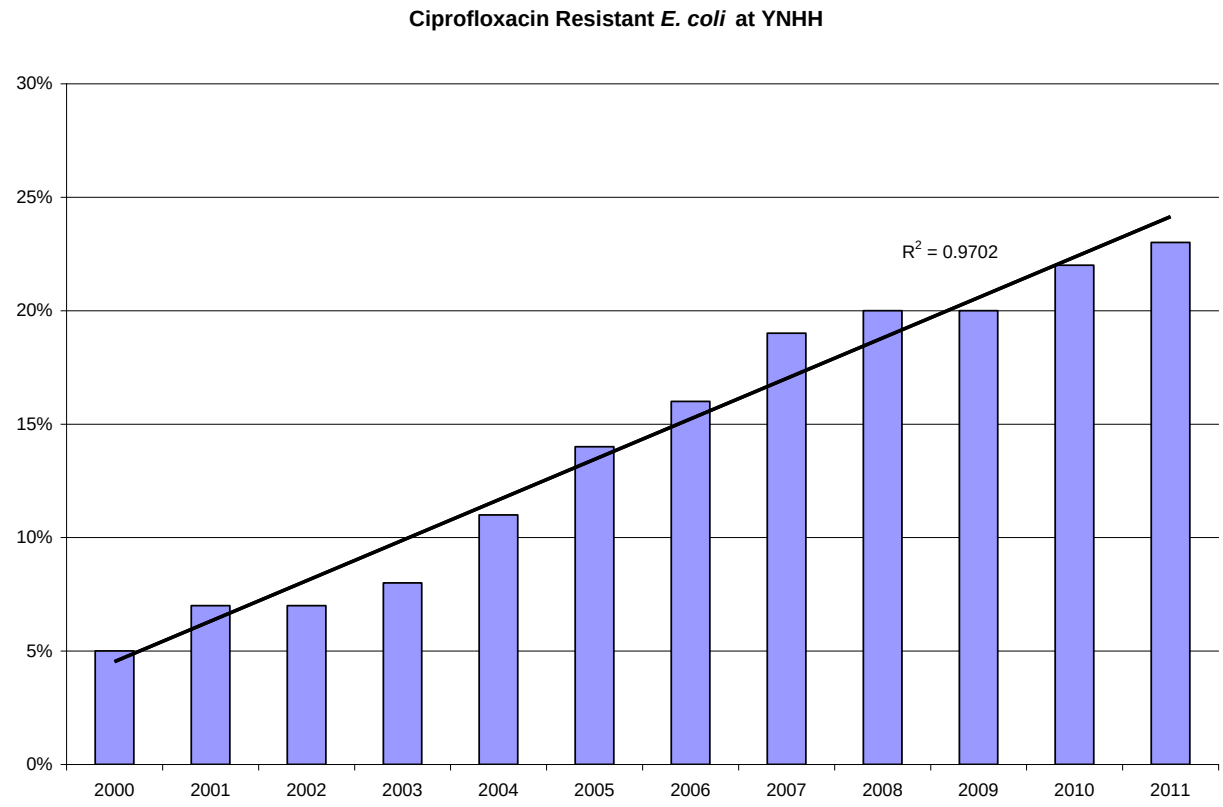
In the last decade in the US, more attention than before has been focused on the dual problems of increasing antimicrobial resistance and healthcare device associated infections by the CDC, CMS, the Joint Commission and IHI to name some of the most prominent groups. Although such emphasis has helped to identify these issues, the difficulty has been and continues to be how do we equip clinicians with the requisite knowledge to change their practice patterns and behavior to address the problems of antimicrobial resistance and healthcare device associated infections?

The focus on Infection Prevention at the hospital level has been driven most earnestly by CMS with their denial of reimbursement for healthcare device associated infections, the public reporting of infection rates on the Hospital Compare web site, and the Hospital Value Based Purchasing Program. However, although many institutions track these measures closely and feedback data, the clinician who directly cares for the patient on a daily basis is often not involved in such processes. Either the requisite information does not get to the clinician or the data is months old by the time feedback has been provided. Finally, educational efforts to address these issues of antimicrobial resistance and healthcare device associated infections still utilize the traditional routes of departmental lectures, as well as, sending out written materials to the medical staff to review. Consequently, educational efforts to address these issues often do not reach the appropriate audience or achieve measurable goals.

In terms of objective measures of the knowledge deficit by clinicians, CMS via its Hospital Compare website (*http://www.hospitalcompare.hhs.gov*) provides standardized data on healthcare device associated infections. Although Yale-New Haven Hospital (YNHH) has focused on evidence-based measures efforts to reduce its Central Line Associated Bloodstream Infection (CLABSI) over the last 2 years, the current YNHH CLABSI rate is 0.865 infections per 1000 patient discharges. This rate of infection is 2.3 fold higher than the US National rate. Reaching all clinicians who make the clinical decision to insert a central venous access device, as well as insert such devices, and make the decision when such devices are no longer needed has been a difficult task given the nearly 4000 clinicians who provide care at YNHH (this number includes attending physicians, housestaff, fellows, Physician Assistants, and Advance Practice Registered Nurses). Similarly, the Catheter-Associated Urinary Tract Infection rate at YNHH is 0.680 infections per 1000 discharges which is nearly 2 fold higher than the US National rate using the CMS Hospital Compare benchmark. Again, the clinician who directly cares for the patient is the one who decides on the indication for insertion of a urinary catheter as well as the duration of use, both of which are the main risk factors for this device associated infection.

For the goal of preventing and mitigating antimicrobial resistance, clinicians often learn of changing antimicrobial resistance patterns when their individual patient is infected by such an organism. Local trends in antimicrobial resistance may or may parallel national trends

depending on a hospital's location and patient mix. In the last decade, ciprofloxacin resistant E. coli has become a significant issue as easily demonstrated in the graph below:



In a review of YNHH patients (n= 100) admitted with suspected urinary tract infections, 22% were treated with ciprofloxacin even though the patient had a risk factor for ciprofloxacin resistance such as residing at a skilled nursing facility, prior recent hospitalization, or presence of an indwelling Foley catheter. Although, the YNHH Antibiotic Susceptibility Report (antibiogram) is updated annually, distributed to medical staff as pocket care, and available on the hospital intranet, changes in the patterns of antimicrobial resistance are not easily seen nor is there a breakdown of antimicrobial resistance by patient type/risk factors.

Not only are clinician deficit in changing antimicrobial resistance patterns, they often have not been educated to fully appreciate how antimicrobial use selects for resistance and how asymptomatic reservoirs of patients colonized with resistant organisms are part of the chain of transmission. While patient care is appropriately focused on an individual patient, it is at the population level where the selection for and the transmission of resistance is found. Teaching clinicians to think epidemiologically about how their use of antimicrobials impacts the hospital population at large is an unmet need in medical education.

Finally, another example of where there is an unmet need in education is how the selection of a specific antimicrobial impacts the risk for the development of resistance. It is well known that such organisms like *Enterobacter cloacae* or *Citrobacter freundii* will induce the chromosomal

beta-lactamase AmpC if the patient is treated with a third generation cephalosporin. In fact, the Clinical Standards Laboratory Institute which governs the rules for antimicrobial susceptibility testing in the US advises a comment for such inducible resistance to place on the microbiology result. At YNHH, as the comment did not help reduce the inappropriate use of third generation cephalosporins for the treatment of such organisms, the reported susceptibility list of antimicrobials was changed to suppress results for penicillins and cephalosporins. Although as in the LOI, the rate of appropriate antibiotic selection improved by 20%, we still had 40% of patients with such organisms still being treated with third generation cephalosporins.

As revealed in the examples above, clinicians need the requisite information to enable them to make the appropriate bedside decisions in order to reduce the risk of healthcare device associated infections as well as the to ensure the most appropriate therapy to both treat the patient's infection and to mitigate the development of antimicrobial resistant organisms. Educational efforts have to be targeted to a very wide range of clinicians: the medical team who provides the direct patient care, the subspecialists who consult on the patient, as well as the surgeons and/or interventional radiologists who may perform procedures. All are linked by the patient and their collective decision making is the driver of patient care. It is not enough to just to educate the attending staff or just the housestaff or just the physician assistant staff. Given the changing nature of how medicine is provided via team by multiple providers who may have discrete work shifts, educational efforts must be easily accessible and available 24/7. The use of Web-based instruction modules provides the logistical support for such an endeavor.

Intervention Design and Methods:

The educational intervention will be the use of Web-based instruction modules. Such instruction modules can be easily incorporated into the mandatory training for housestaff, physician assistants, and APRN's. For the medical attending staff, the education modules would be required as part of the YNHH credentialing process through the Chief of Staff's Office. Currently, written education materials are provided as part of the credentialing process but the attending physician only initials that he or she has read the provided material.

Each Web-based instruction module will have a pre-test to assess the current knowledge base of the clinician for a given topic. Then, instructional web pages will be provided using a case-based approach. Mandating interactive components such as asking questions or having interactive graphics will aid in the educational process. A post-test will be mandated in order to complete the specific module.

The proposed Web-based instruction modules would include:

1) Antimicrobial Resistance in Gram Negative Organisms:
   A) Amp C producing organisms (i.e., *Enterobacter spp. Citrobacter spp., etc.*)
      Clinical case: Patient with *Enterobacter cloacae* pneumonia treated with ceftriaxone
      Illustrate the mechanism for AmpC resistance
      Delineate the SPACE/SPICE organisms that may harbor AmpC chromosomal beta-lactamases
      Optimal treatment of AmpC infections to prevent development of resistance
      Denote the special cases of *Serratia marcescens* and *Acinetobacter baumannii*, both are potential AmpC producers that violate the usual rules for AmpC producers

   B) *E. coli* and *Klebsiella pneumoniae/oxytoca* with an Extended Spectrum Beta-lactamase (ESBL) phenotype
      Clinical case: Patient with UTI due to E. coli resistant to ceftriaxone.
      Illustrate how ESBL's developed from prior beta-lactamases through point mutations in the setting of antibiotic selection pressure
      Risk factors for and the epidemiology of ESBL organisms
      Delineate how to determine if an *E. coli* or *Klebsiella spp*. may be an ESBL producer --changes to ceftriaxone/ceftazidime susceptibility testing by CLSI
      Optimal treatment of ESBL infections
      Infection Control implications for patients with ESBL *E. coli/Klebsiella spp.*

   C) *Klebsiella spp.* Producing Carbapenemase (KPC); Carbapenemase Producing Enterobacteriacae
      Clinical case: Patient transferred from an ECF who previously received care in NYC.
      Illustrate the mechanisms for resistance

Possible treatment options for the pan-resistant Gram negative organisms by antibiotic, monotherapy or combination therapy and impact of site of infection on available antibiotics
Infection Control implications for a patient colonized or infected with a KPC.

D) *Pseudomonas aeruginosa*
Clinical case: Patient with pseudomonal pneumonia treated with multiple antibiotics
Illustrate the many mechanisms for antimicrobial resistance in *Pseudomonas aeruginosa*
Review the issue of "double coverage" and whether it improves clinical outcomes or prevents antimicrobial resistance
Review the risk of developing antibiotic resistance while on therapy as stratified by antibiotic class (i.e., carbapenems with greater risk for resistance on therapy compared to ceftazidime or Zosyn)

E) Ciprofloxacin-resistant *E. coli*
Clinical case: Patient with urinary tract infection due to ciprofloxacin resistant *E. coli*
Illustrate the changing epidemiology of ciprofloxacin resistance in *E. coli*
Delineate the many mechanisms for quinolone resistance including efflux pumps
Optimal empiric treatment of UTI's in setting of ciprofloxacin resistant *E. coli*

2) Antimicrobial Resistance in Gram Positive Organisms:
A) Methicillin-Resistant *Staphylococcus aureus* (MRSA)
Clinical case: Patient with refractory MRSA bacteremia
Clinical case: Patient with CA-MRSA skin/soft tissue infection
Delineate the mechanism of beta-lactam resistance in MRSA
Review the changing epidemiology of MRSA in the US and CT
Review the infection control implications of a patient colonized/infected with MRSA
Review treatment options for MRSA infections stratified by type of infection (e.g., Bacteremia, pneumonia, skin/soft tissue, etc.)

B) Vancomycin-Resistant Enterococci (VRE)
Clinical case: VRE bacteremia in a patient S/P stem cell transplant
Clinical case: Patient with VRE in a urine culture
Delineate the mechanism of vancomycin resistance in VRE
Review the epidemiology of VRE colonization and infection
Review the infection control implications of a patient colonized/infected with VRE
Review the treatment options for VRE infection stratified by site of infection

3) *Clostridium difficile* associated diarrhea (CDAD)
Clinical case: *C. difficile* infection in a patient not responding to metronidazole or oral vancomycin
Review the change in the incidence of *C. difficile* as well as increased rate of recurrent disease

Review risk factors for C. difficile infection by type of antibiotic exposure (some agents are more likely to predispose a patient to CDAD than others

4) Central-Line Associated Bloodstream Infections (CLABSI's)
   Review the indications for central venous access
   ---can the use of a central venous catheter be avoided by using highly orally bioavailable antibiotics (e.g., TMP/SMX, metronidazole, doxycycline, clindamycin, fluconazole, etc.)?
   Review how the choice of a central venous access device impacts the risk of CLABSI
   Review the strategies to reduce the risk for CLABSI at time of insertion
   --Maximum Barrier Precautions, chlorhexidine for skin antisepsis, use of insertion checklist
   Review the strategies to reduce the risk for CLABSI during line maintenance
   --Use of the Biopatch, compliance with an intact dressing at the exit site, and daily assessment of need for central venous access
   Review the risk factors for CLABSI
   Review the diagnosis of CLABSI
   --Need for 2 sets of blood cultures, peripheral preferred; problem of single blood culture set it is positive for GPC's in clusters
   Review treatment of CLABSI by organism (*S. epi*, *S. aureus*, *Candida spp*.) and the need for central line removal

5) Catheter-Associated Urinary Tract Infections (CAUTI's)
   Review the indications for Foley catheterization
   --strategies to mitigate the use of a Foley catheter-bedside commode, prompting frequent toileting, use of a condom catheter, etc.
   Review the risk factors for CAUTI
   --daily review of the need for the indwelling urinary catheter
   Review the diagnosis of CAUTI
   --Need for urinalysis with a urine culture
   Review treatment of CAUTI
   --importance of trying to remove the indwelling urinary catheter as part of CAUTI treatment

Evaluation Design:

To assess if the target audience of clinicians has been reached, we will utilize the mandatory training platform at YNHH which is current called Healthstream®. This platform can host independent web-based modules as the bloodborne pathogens training module and the tuberculosis training module were developed by YNHH Infection Control in 2000 and then added to the Healthstream®, platform. This mandatory training platform has already in place the ability to produce reports if an individual has completed their designated training or not by a specific date. We will aim for at least 80% completion rate of the assigned Web-based instruction modules.

The following outcomes will assessed during a control period of 6 months prior to the planned intervention with Web-based education modules to establish the baseline data.

1) Percentage of infections due to AmpC producing organisms appropriately treated with non-cephalosporin, non-penicillin based antimicrobials.
2) Percentage of patients at risk for ciprofloxacin resistant E. coli UTI upon admission treated with an appropriate empiric antibiotic.
3) Rate of hospital acquired *C. difficile* colitis per 1000 inpatient-days.
4) Antimicrobial use rate of piperacillin-tazobactam, carbapenems, ceftazidime, daptomycin, vancomycin, and linezolid in divided daily doses per 1000 inpatient-days.
5) Utilization of Foley catheters as measured by number of catheter days per 1000 inpatient-days.

The above data will be culled from the existing microbiology database at YNHH and the use of Theradoc®, a data mining program utilized by YNHH Pharmacy services and YNHH Quality Improvement Support Services (*i.e*, Infection Control). This project will expand the use of Theradoc® to incorporate collection of data for the metrics above.

After a 2 month period where the mandatory education will be provided using the Web-based instructions, the above data will be re-collected. For outcomes 1 and 2, we would anticipate an at least a 15% improvement in the treatment of AmpC organisms and empiric therapy of patients at risk for ciprofloxacin resistant *E. coli* compared to baseline data. For outcomes 3 and 4, would anticipate a 10% reduction in the rate of *C. difficile* associated diarrhea as well as the same reduction in the antibiotic usage as denoted above. Finally, outcome 5, we would estimate a 20% reduction in the use of Foley catheters as measured above.

The outcome goals above will disseminated to the groups already in place at YNHH addressing these specific issues: the antibiotic surveillance team and pharmacy services (YNHH antibiotic stewardship program) for outcomes 1, 2, and 4; infection control for outcome 3, and the STOP-CAUTI committee for outcome 5. Finally, this project through the Chief of Staff office's focus on the issues above, will disseminated to the many quality councils at YNHH.

Project Timeline:

	1/2013	2/2013	3/2103	4/2013	5/2013	6/2013	7/2013	8/2013
Baseline Data Collection	X	X	X	X	X	X		
Creation of Web-Based Modules	X	X	X	X	X	X		
Implementation of Web-Based Modules							X	X

	9/2013	10/2013	11/2103	12/2013	1/2013	2/2013
Post Intervention Outcome Data Collection	X	X	X	X	X	X

	3/2014	4/2014	5/2014
Data Analysis and Reporting Results	X	X	X