

MRSA Active Surveillance Testing

357. Reversion of Methicillin-resistant *Staphylococcus aureus* (MRSA) (+) Patients in the VA MRSA Directive: The Forgotten Cohort

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Background: In January 2007, the VA issued the MRSA Directive to reduce the transmission of MRSA in VA hospitals. The Directive utilizes active surveillance through nasal screening, Contact Precautions, and hand hygiene. While most of the attention has been on preventing transmission to MRSA (-) admissions by tracking conversion rates, we sought to characterize patients whose swabs were initially MRSA (+) but were negative at discharge.

Objective: To determine the reversion rate and predictors for reversion among MRSA (+) patients at the Atlanta VAMC.

Methods: Upon implementation of the initiative in March 2007, both admission and discharge swabs were cultured on CHROMagar MRSA (BBL). From July-August 2007, we compared the Xpert MRSA PCR assay with the CHROMagar MRSA for 177 admission screens yielding a sensitivity of 97.3% and a specificity of 96.5%. Based upon these findings, on August 1, 2007, we began using the Xpert MRSA PCR assay (Cepheid) only for admission screening, using culture for discharge swabs. For the PCR assay, the cycle threshold (CT) determines a positive, with lower CTs appearing to correspond to higher bacterial burden. We determined the CT for all MRSA (+) admission screens from August 1 - November 30, 2007. We defined a reversion as a patient with a positive screen on admission and a negative screen upon discharge. For any discharge swab from a reversion patient we retested both PCR and culture, when the swab was available. We used the t-test for the comparison of CT means.

Results: Through November 30, 2007, we performed a total of 3,254 screens: 1878 admissions and 1376 discharges. The prevalence of MRSA (+) patients upon admission was 16.5% (310/1878). For patients with both admission and discharge swabs (N=1257), the conversion rate (from negative to MRSA positive) was 3% (29/1060) and the reversion rate (from MRSA positive to negative) was 23% (46/197). When we analyzed all MRSA (+) admissions from PCR, the mean CTs of those that remained MRSA(+) at discharge differed significantly from those that reverted (25.6 vs. 29.6, $p=0.0001$, t-test). Twenty-three of the 46 reversion patients had available discharge swabs that were retested using the PCR assay. Of these 23 reversions, 13 were negative on both PCR and culture; 10 were positive on PCR but negative on culture. The mean CTs for those reversions that were PCR retest positive differed from those whose PCR retest was negative (26.9 vs. 31.7, $p=0.013$, t-test).

Conclusion: Among patients who were MRSA (+) on admission, nearly one quarter reverted to culture-negative on discharge. Half of these reversions may be explained by the use of two different detection methods -- PCR on admission and CHROMagar culture on discharge. For the remaining reversions, a low admission MRSA bacterial burden, measured by a high CT, may predict reversion to a negative discharge screen by either PCR or culture.

358. Continued Reduction in Device-Related MRSA Infections in the Critical Care Setting without the Use of Active Surveillance Cultures

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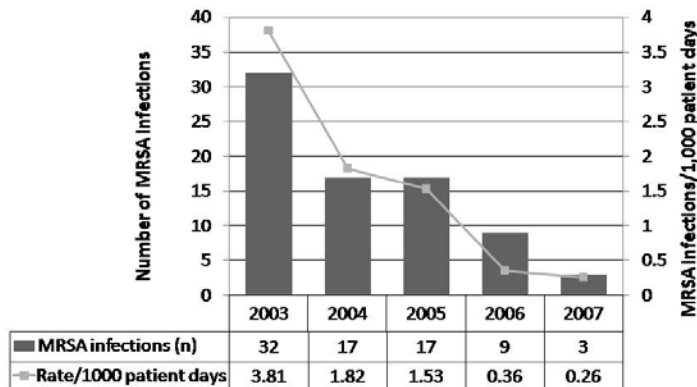
Background: In 2007, MRSA mania accelerated in the US as the issue exploded in the media, schools in at least 8 states closed due to students with skin infections, an increasing number of hospitals implemented active surveillance with contact precautions, and some states mandated screening programs for inpatients. Previous analyses by our group suggested that MRSA could be reduced in the critical care setting without active surveillance cultures; however, the sustainability of such an approach was uncertain.

Objective: To assess trends in device-related MRSA infections in the critical care setting.

Methods: Beginning in 2004, numerous broad-based, non-pathogen specific initiatives were implemented to reduce healthcare associated infections (HAIs) in our 820-bed, urban, teaching hospital. These included an increasingly aggressive hand hygiene program, a central line bundle, and a ventilator bundle, all with active compliance monitoring and feedback via unit-specific posters. Active surveillance cultures were not performed. Rates of central line associated bloodstream infections (BSI), catheter associated urinary tract infections (UTI) and ventilator associated pneumonia (VAP) due to MRSA were determined via concurrent surveillance by trained infection control practitioners utilizing CDC definitions in a 16-bed medical ICU (MICU) and an 18-bed surgical ICU (SICU).

Results: Over the 5-year period, a 93% reduction in the incidence of device-related MRSA infections was observed in these 2 ICUs (see figure). In 2007, only 3 MRSA infections occurred in 11,330 patient days. The proportion of HAIs due to MRSA fell from 14.3% in 2003 to 4.3% in 2007.

Conclusions: Our data demonstrate that continued reduction in MRSA device-related infections can be achieved without resorting to active surveillance cultures. We recommend interventions that focus broadly on reducing all HAIs via compliance with optimal infection control practices rather than a resource intensive strategy of questionable effectiveness targeted against a single pathogen that accounts for a small fraction of HAIs.



359. Sensitivities of Nasal and Rectal Swabs for MRSA Detection in a Large Community Teaching Hospital Active Surveillance Program

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Background: Active surveillance for timely detection of patients colonized with methicillin-resistant *Staphylococcus aureus* (MRSA) and institution of contact precautions is recommended for prevention of healthcare-associated MRSA. A swab of the anterior nares is most commonly recommended but some suggest the addition of other specimens to improve yield. Sensitivities of non-nasal body site swabs are not well documented.

Objective: To determine the sensitivity of nasal and rectal swabs individually and combined for detecting MRSA colonization in adult patients.

Methods: North York General Hospital is a 430 bed community teaching hospital in Toronto, Canada. From January 2004 to June 2007, all patients admitted to medicine, admitted surgical patients with hospital-associated MRSA risk factors and contacts of MRSA-positive patients were screened for MRSA colonization. Weekly unit prevalence screens were also conducted with preference given to units where transmission had recently occurred. Swabs of the anterior nares, rectum and any open skin or device exit sites were collected, placed in clear Amies gel with charcoal and inoculated on mannitol salt agar with oxacillin (MSA-Ox, Jan/04 to Jul/05), mannitol salt agar with cefoxitin (MSA-Fox, Aug/05-Jan/06) or MRSA Select® (MRSA-Select, Feb/06 to Jun/07). We defined colonized patients as those with culture-positive swabs from any body site. Screening swabs taken on patients already known to be positive and pediatric patients were excluded.

Results: Between January 2004 and June 2007, 23,404 patients submitted 91,876 specimens for MRSA screening averaging 7,697 patients and 26,250 specimens

annually. Nasal and rectal swabs comprised 47% each of annual specimens and 6% of swabs were from other body sites. Overall, 3.0% of patients were MRSA positive. Sensitivities of nasal, rectal and other body site swabs for detecting MRSA colonization are shown in Table 1. The sensitivity of rectal swabs improved from 59% using MSA-Ox to 67% using MRSA-Select ($p=0.05$). This improvement had no significant effect on the sensitivity of nasal and rectal swabs combined.

Table 1. Sensitivity of body sites for detection of MRSA among colonized adult patients identified by a culture-based active surveillance program, January 2004 to June 2007

Swab type	No. of colonized patients tested (n=627)	No. positive patients	Sensitivity	
			%	95% CI
Nares	616	419	68	(64 - 72)
Rectum	616	382	62	(58 - 66)
Other body site	121	88	73	(64 - 80)
Nares and rectum	612	586	96	(94 - 97)

Conclusions: Rectal swabs provided a similar level of sensitivity for detecting MRSA colonization as nasal swabs. Approximately 30% of colonized patients would have been missed if patients were screened by nasal or rectal swabs alone. Sensitivity was enhanced to 96% by the use of nasal and rectal swabs combined.

360. The Necessity of Screening Multiple Anatomical Sites as a Component of Active Surveillance for Methicillin-Resistant *Staphylococcus aureus*

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Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) is an important nosocomial pathogen and unrecognized colonized patients are a major reservoir for patient-to-patient transmission. Active surveillance for MRSA at hospital admission is important in identifying carriers and is one element required for effective control of nosocomial transmission. The optimal anatomical site(s) for MRSA screening are uncertain.

Objective: The objective of the study was to determine what proportion of carriers of MRSA identified through admission screening were colonized at each anatomical site and the corresponding potential exposure-days resulting from carriers not being cared for in Contact Precautions if an anatomical site was eliminated from the surveillance protocol.

Methods: All patients admitted to a 1,200-bed tertiary-care teaching hospital from Jan. 2004-Dec. 2006 were evaluated for the presence of MRSA risk factors within 24 hours of admission. Risk factors included direct transfer from or admission to a healthcare facility in the preceding year, receipt of home healthcare, living in a communal setting, and previous identification as a carrier of an antibiotic resistant organism. Swabs for MRSA were obtained from the anterior nares, perianal area, open wounds/lesions/incisions, and the exit sites of indwelling medical devices and

catheters. Swabs were inoculated onto selective chromogenic agar (MRSAScreen, Bio-Rad Laboratories, Inc.) and incubated at 37°C for up to 48 hours. MRSA was identified using standard methods. The yield from various anatomic sites cultured was determined.

Results: During the 3 year study period 641 new acute care inpatients were identified as carriers of MRSA, an incidence of 16.6 per 1,000 admissions. 328 (51%) of new MRSA carriers were identified through admission screening, and 236 (72%) of these were found to be colonized in the nares; 69 (21%) had positive perianal cultures without MRSA being cultured from the nares, and 23 (7%) had MRSA detected from only wound or exit site swabs. The 28% of carriers who would have been missed if only nasal swabs had been obtained, represented 1,029 potential exposure-days without the implementation of Contact Precautions. Swabbing both the nares and perianal area would have identified 93% of carriers, and would have decreased the number of exposure-days without Contact Precautions to 190.

Conclusions: Active surveillance for MRSA in high-risk patients on admission to hospital is an important component of MRSA infection prevention and control. The results of this study confirm that nasal cultures alone are insufficient, and that in order to optimize identification of colonized patients, MRSA screening should also include other anatomical sites, particularly the perianal area.

361. Targeted Surveillance Combined with Preemptive Isolation Can Reduce Methicillin-resistant *Staphylococcus aureus* Rates

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Background: Methicillin-resistant *Staphylococcus aureus* (MRSA) rates have been increasing over several years with MRSA accounting for 50-70% of *Staphylococcus aureus* (SA) isolates in many hospitals nationwide; similar increase in rates was noted in our institution from 17% in 2001 to 33% in 2003. The MRSA surgical site infection (SSI) rate also increased from 17% in 2001 to 30% in 2003.

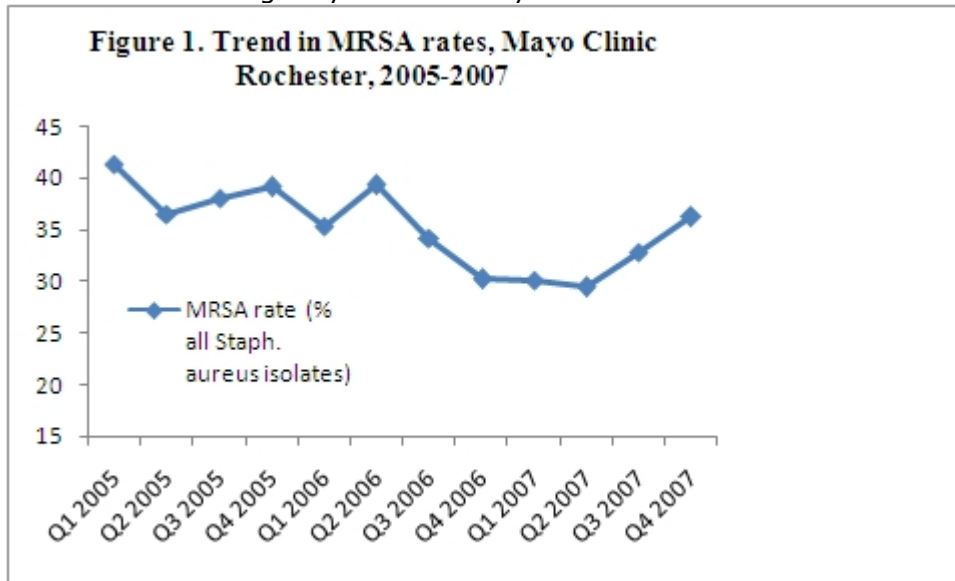
Objective: To evaluate the effect of targeted surveillance with preemptive isolation on MRSA rates.

Methods: In July 2004 we established a targeted active surveillance program to screen for MRSA colonization. In a pilot study, we screened all admissions to selected units, and found that patients from long term care facilities (LTCF) were 7 times more likely to be colonized with MRSA than other patients. We picked this group for continued admission screening. All LTCF residents were identified at admission, admitted to private rooms and placed on contact precautions which included gowns and gloves for all patient contact. Nasal and wound swabs were obtained; patients were removed from isolation only if their screening cultures were negative. All MRSA culture-positive patients were flagged electronically for automatic placement in isolation on subsequent admissions. Screening for MRSA was performed using conventional culture from July 2004-June 2006, and CHROM-agar testing July 2006 onwards. Data on MRSA positive cultures from 2002-2007 was obtained from the microbiology lab database and routine surveillance performed by Infection Control

practitioners. MRSA rates were calculated as percentage of MRSA isolates among all SA isolates for all clinical isolates, and separately for surgical site infections (SSIs).

Results: Our overall institution-wide MRSA rate was noted to increase till 2005 and peaked at 41% in the first quarter of 2005, 6-9 months after institution of the screening and isolation program, after which the rates declined to an average of 35% in 2006 and 31% for the first 3 quarters of 2007 (Figure 1). A similar trend was noted in the SSI rate with MRSA SSI rates of 35.4% in 2004, 37.2% in 2005, and 32% in 2006. The total number of healthcare associated MRSA blood stream infections (BSIs) and the number of ICU MRSA BSIs also decreased by 36% in 2006 compared to 2005. MRSA rates began to rise in the last quarter of 2007 (Figure 1).

Conclusions: Targeted screening combined with preemptive isolation of patients at high risk of MRSA colonization was successful at reducing overall MRSA rates, SSI rates and BSIs at our institution through 2006. Rising MRSA rates at the end of 2007 may signal a change in risk factors for MRSA carriage at admission to our institution and wider screening may be necessary to maintain our initial success.



362. Simulation-Based Assessment of the Effectiveness of Active Surveillance Strategies for Methicillin-Resistant *Staphylococcus aureus* (MRSA)

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Background: The use of a prediction rule to ascertain patients at high risk of MRSA carriage offers the potential for an efficient approach to active surveillance.

Objectives: We created a detailed computer simulation of MRSA infection in hospitalized patients to explore the effect of an active surveillance strategy based on detection of high risk patients.

Methods: An agent-based simulation of individual patients, nurses, physicians, and rooms was designed to allow interactive use. Transient health care worker hand carriage occurred consequent to contact with infected patients or with contaminated environmental surfaces. Patients, in turn, acquired MRSA via contact with health care workers or the room environment. Simulated nurse-patient contact was assumed to be ward-specific whereas simulated physicians contacted patients throughout the hospital.

For comparison, two hospitals were simulated, each containing two 15-bed ICUs and seven 40-bed non-ICU wards; 50% of the rooms on non-ICU wards were semi-private. In one hospital, patients who were classified as high risk at the time of admission were flagged for rapid MRSA testing and placed on contact precautions if positive. Patients who had been in the hospital for more than one week were also tested when transferred. The sensitivity of the criteria for detecting MRSA carriers on admission randomly varied from run-to-run, holding other parameters and assumptions constant. The effect of the active surveillance program was measured by calculating the difference in incidence of MRSA acquisition between hospitals for each run.

Assumptions in the base case included: prevalence of MRSA carriage on admission of 5%; hand hygiene compliance of physicians before contact of 20%; hand hygiene compliance of nurses before contact of 50%; adherence to contact precautions of 95%.

Results: The mean rate of acquisition of MRSA was ~5.4 events per 1,000 bed days in the absence of active surveillance, using base case parameters. As the sensitivity of the prediction rule increased, the difference in incidence of MRSA acquisition between the two hospitals rose continuously. Threshold behavior was not observed; the effect was evident even at low levels of sensitivity of the prediction rule. During the first 3 months following implementation of the intervention, the MRSA acquisition rate declined linearly by ~1.2 events per 1,000 bed days per month, when the sensitivity of the prediction rule was 90%. The value of the estimated effective reproductive number was substantially less than one, even in the absence of active surveillance.

Conclusions: MRSA acquisition rates began to decline within the first month after implementation of active surveillance based on identification of high risk patients. A key assumption was that infection control practices in rooms of patients on contact precautions were better than in other rooms.

Hand Hygiene

363. Evaluation of an Electronic Device for Real-Time Measurement of Use of Alcohol-Based Hand Rub (ABHR)

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Background: Observational surveys are currently the gold standard method for measuring hand hygiene compliance among healthcare workers (HCWs), but are

very time-consuming. Measuring product consumption is an alternative method of assessing the frequency of hand hygiene episodes (HHE) among HCWs.

Objective: To evaluate the utility of using an electronic device to record the frequency of ABHR use and to establish patterns of use of product dispensers.

Methods: Access of an ABHR dispenser was defined as a HHE. Electronic devices that record each time a dispenser is accessed were placed inside existing ABHR dispensers located in corridors and inside patient rooms on a general medical ward (GMW) and in a surgical intensive care unit (SICU). Duplicate accessions occurring within a few seconds are recorded as a single HHE. Each device, which has a unique identification number, records the date and time each dispenser is used in an enclosed electronic database. Data were periodically downloaded using wireless technology to a hand-held data transfer unit (data logger). Data were transferred from the data logger to a laptop computer and to a secured website for analysis.

Results: During the first 3 months of the trial period, there were 17,304 HHE using ABHR on the GMW and 50,874 HHE in the SICU. The number of HHE/patient-day was 9.44 on the GMW and 47.7 in the SICU. Dispensers located inside patient rooms accounted for 47.1% of all HHE performed with ABHR on the GMW and 48.1% of HHE in the SICU. By mapping the location of each device, ward maps indicating the highest and lowest areas of usage can be created. On the GMW, the number of HHE in rooms used primarily for patients on Contact Precautions was significantly lower than in other rooms on the ward (Mann-Whitney U test, $p = 0.006$). Average usage by hour was highest between 10 AM and 7 PM, and lowest at 5 AM. Because usage data for each dispenser can be obtained without opening the dispenser, time required to obtain product usage data is minimal. The number of HHE recorded did not reflect exactly the total number of HHE occurring on the two units since electronic devices were not placed in soap dispensers, and 3 rooms on the GMW did not have electronic devices in in-room dispensers during the entire trial period. Such devices cannot distinguish between HHE performed by HCWs from those performed by visitors.

Conclusions: Wireless electronic devices installed in ABHR (and/or soap) dispensers provide an efficient method of determining the number of HHE performed, by ward, shift, and dispenser location and over time. The system should be useful for documenting the impact on product usage of various interventions designed to improve the frequency of HHE, and for studying the effects of dispenser location on usage patterns. Further studies are indicated to determine how the data provided correlates with observational surveys and if feedback of data to HCWs can improve hand hygiene compliance.

364. Correlation between Direct Observation of Hand Hygiene Compliance And Electronically Monitored Used Of Hand Sanitizer

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Background: Proper hand hygiene (HH) is an effective means of reducing health-care associated infections but monitoring HH in health-care settings is challenging. Direct observation of health-care workers' HH is generally considered the best performance

indicator however, this method is very labor intensive and alternative methods should be sought.

Objective: To evaluate the correlation between hand hygiene product consumption data, as measured by electronic counters installed in alcohol-based hand sanitizer dispensers, and hand hygiene compliance as measured by direct observation.

Methods: Trained members of the Hospital Epidemiology Department at Yale-New Haven Hospital have monitored health care workers' compliance with hand hygiene by direct observation in patient-care areas since 2002. 10 observations before, and 10 after patient contact are recorded per unit per month. Proportion of alcohol-based hand sanitizer vs. soap/water HH is recorded. For this study electronic counters were placed in each hand sanitizer dispenser located in two general medical units (A, B) and a medical intensive care unit (MICU). The counter records dispenser lever depressions and electronically registers dispenser location, date and time of every event. Observations of hand hygiene opportunities/hr. were performed in each study unit to determine the optimal number of HH episodes per patient bed-day. The study period was September-November, 2007.

Results: During the study period, mean events per month were 21,432 (MICU), 20,872 (unit A) and 29,317 (unit B), which corresponded to 43.8, 18.9 and 22.6 HH events per bed-day respectively. There was no statistically significant difference in events per bed-day when each unit was evaluated in terms of night and weekend vs. day and weekday dispenser use. Observed HH compliance as measured by direct observation was 88%, 80%, and 70%, for MICU, unit A and B respectively. Calculated HH compliance by electronically determined events per bed-day was 38 %, 14 % and 15 % respectively.

Conclusions: Significant use of alcohol-based hand sanitizer was detected in all units. Compliance with HH as measured by electronic surveillance and calculated based on an optimal average of events per bed-day was much lower than that determined by direct observation. The difference in results between the two methods could relate to low precision of direct observation (low number of observations per unit per month) or to error in determination of the optimum number of mean opportunities for HH per unit per day used to calculate HH compliance using the electronic method, or a combination of both. Further evaluation of both methods continues at our hospital.

365. The Effect of Recognized Observers on Measurement of Hand Hygiene Compliance in High and Low Performing Inpatient Units

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Background: Hand hygiene (HH) has long been recognized as a core element of all infection prevention programs. As health care facilities strive to achieve 100% HH compliance among patient care staff, accurate measurement has become more important.

Objective: We tested the hypothesis that HH compliance rates among hospital staff differ depending on whether the observer is known or unknown to the observed.

Methods: Beginning in 2006, 3 well-known infection control practitioners (ICP) have performed regular observations of HH in their designated inpatient units as part of the infection prevention program at our 382 bed academic medical center. In April - May 2007, a student (S) unknown to hospital staff also performed HH observations in 3 units selected on the basis of past HH compliance: Unit A consistently had >90% HH compliance, Unit B averaged 45% compliance, and Unit C had recently improved its performance from <50% to approximately 60%. We defined HH compliance as the number of opportunities for HH taken/the number of opportunities for HH X100. We considered that there was one HH opportunity before and one HH opportunity after direct contact with a patient or the patient's immediate environment. Opportunities in which there was uncertainty about whether HH occurred were not counted in numerator or denominator. We compared compliance rates observed by the ICP designated to each unit to those observed by the unknown student.

Results: ICP observed 332 opportunities during 15 observation periods and S observed 355 opportunities during 19 observation periods. Overall HH compliance was 65% (ICP) and 58% (S, p=0.1). The table shows differences in observed compliance by unit.

	Compliance (ICP)	Compliance (S)	ICP vs S	p
Unit A	98% (53/54)	79% (89/112)	19% higher	0.003
Unit B	71% (90/126)	56% (74/132)	15% higher	0.01
Unit C	47% (72/152)	40% (44/111)	7% higher	0.3

Conclusions: Overall, measurements of HH compliance among hospital staff tend to be slightly higher when measured by an observer recognized by the staff. In our study, the positive influence on HH compliance was much greater in the high performing unit, and insignificant in the low-performing units; the unit with improving HH compliance appeared to respond similarly to the high performing unit to the presence of a recognized observer. Our data suggest that the use of unrecognized observers of HH compliance may be important in verifying high performance but is probably unnecessary in documenting poor performance.

366. A 3-Year Evaluation of the Consumption of Hydro-Alcoholic Handrub Solution (HAHS) as an Indicator for Compliance with Hand Hygiene (HH)

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Background: An endemic high prevalence of hospital acquired (HA) MRSA in a 900 bed teaching hospital. A hospital wide Infection Control (IC) program (VigiGerme®; University Hospitals of Geneva, Switzerland) was implemented in 2004 in order to contain the MDRO incidence.

Objective: To evaluate consumption of HAHS as an Indicator for compliance with HH.

Methods: Two indicators for the compliance with HH per hospital ward were compared: a) the number of handrub actions calculated from the volume of consumed HAHS in relation to the number of patient days and b) bed-side measurement by IC nurses with a standardized electronic registration system (©Sax Machines, Geneva, Switzerland) of the compliance with HH of nurses and doctors,

measuring the number of opportunities for HH and compliance rates. Each act is electronically registered and compliance with HH calculated using an IT expert system. The table shows the extent of bed-side measurements of HH compliance performed at baseline (2004) and the follow-up 3 year period.

Results: Implementation of the VigiGerme® program in 2004 and 2005 resulted in a highly significant increase ($p < 0.001$) of the consumption of HAHS by 58% (2006) and 64% (2007). HH compliance significantly increased ($P < 0.001$) from 13% in 2004 to 31% (2005), 47% (2006) and 70% (2007). Ward to ward analysis indicated a clear correlation between HAHS consumption and compliance with hand hygiene.

Conclusions: This study indicates that HAHS consumption is as a good indicator for long term follow-up of HH compliance.

Year	Duration of observations	HCWs observed	Patients observed	Opportunities for HH	Compliance observed	Average consumption of HAHS per patient day
2004	15h55	53	311	268	13%	11.3
2005	27h45	138	258	396	31%	16.5
2006	89h58	226	591	984	47%	17.7
2007	88h45	133	399	803	70%	18.4

367. An Evaluation of Organizational Culture and Perceptions of Hand Hygiene Following a Multi-Center Randomized Trial to Reduce the Transmission of Antimicrobial-Resistant Bacteria

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Background: Organizational culture (OC) is most often defined as a collection of shared values, assumptions, norms, and beliefs that are generally consistent throughout an organization and are demonstrated by the behaviors of the organization's members. OC has been hypothesized to be a determinant of adherence to infection control practices such as hand hygiene (HH).

Objective: To assess individual healthcare personnel (HCP) perceptions of OC and HH among intensive care units (ICUs) participating in the Strategies to Reduce Transmission of Antimicrobial Resistant Bacteria in Intensive Care Unit (STAR*ICU) trial (ClinicalTrials.gov number, NCT00342745) conducted by the Bacteriology and Mycology Study Group (BAMSG), a multi-center trial comparing two infection control strategies for preventing transmission of antimicrobial-resistant bacteria in ICUs.

Methods: An online survey of HCP in participating ICUs was conducted at the conclusion of the trial. The survey included items related to perceptions of the benefits of HH and unit-level HH practices, as well as items derived from the OC scales of Shortell, such as unit team work, individual HCP empowerment, and HCP job satisfaction (mean total score ranging from 11-55 with higher scores = more positive OC). Multivariable linear regression with adjustment for clustering was used to assess the relationship between perception of OC and HH practices.

Results: A total of 735 HCP completed the online survey from 13/19 ICUs; 71% were nurses, 15% physicians, 14% other HCP. Among all HCP, the mean OC score was 48.2 (SD: 6.76). There was a significant difference in mean OC score by HCP type (physicians 52.0 [SD: 5.52], nurses 47.3 [SD: 6.72], and other HCP 48.3 [SD: 6.76], $p < 0.0001$). In a multivariable analysis controlling for unit, HCP type, and intervention strategy, the following perceptions of HH practice were significantly correlated with a higher OC score: "HCP who work on my unit practice HH as recommended" ($p < 0.0001$), "Failure to practice HH as recommended will result in harm to my patients" ($p < 0.0001$), "It is my responsibility to provide immediate feedback to other HCP when HH recommendations are not followed" ($p = 0.0068$), "I work in a unit where I feel comfortable reminding other HCP when HH recommendations are not followed" ($p = 0.0082$), and "I work in a unit where practicing HH is encouraged" ($p = 0.0270$).

Conclusions: Perceptions of OC are strongly associated with perceptions of the benefits of HH and of ICU-level HH practices. This observation is strengthened by the fact that it was derived from 13 ICUs distributed across the US. Further study of the relationship between OC and the observed HH practices of HCP is planned and may lead to novel insights in how to improve HH practice.

368. A Global Perspective on Patient Empowerment and Hand Hygiene Compliance: A Realistic Goal for a Multifaceted WHO Strategy

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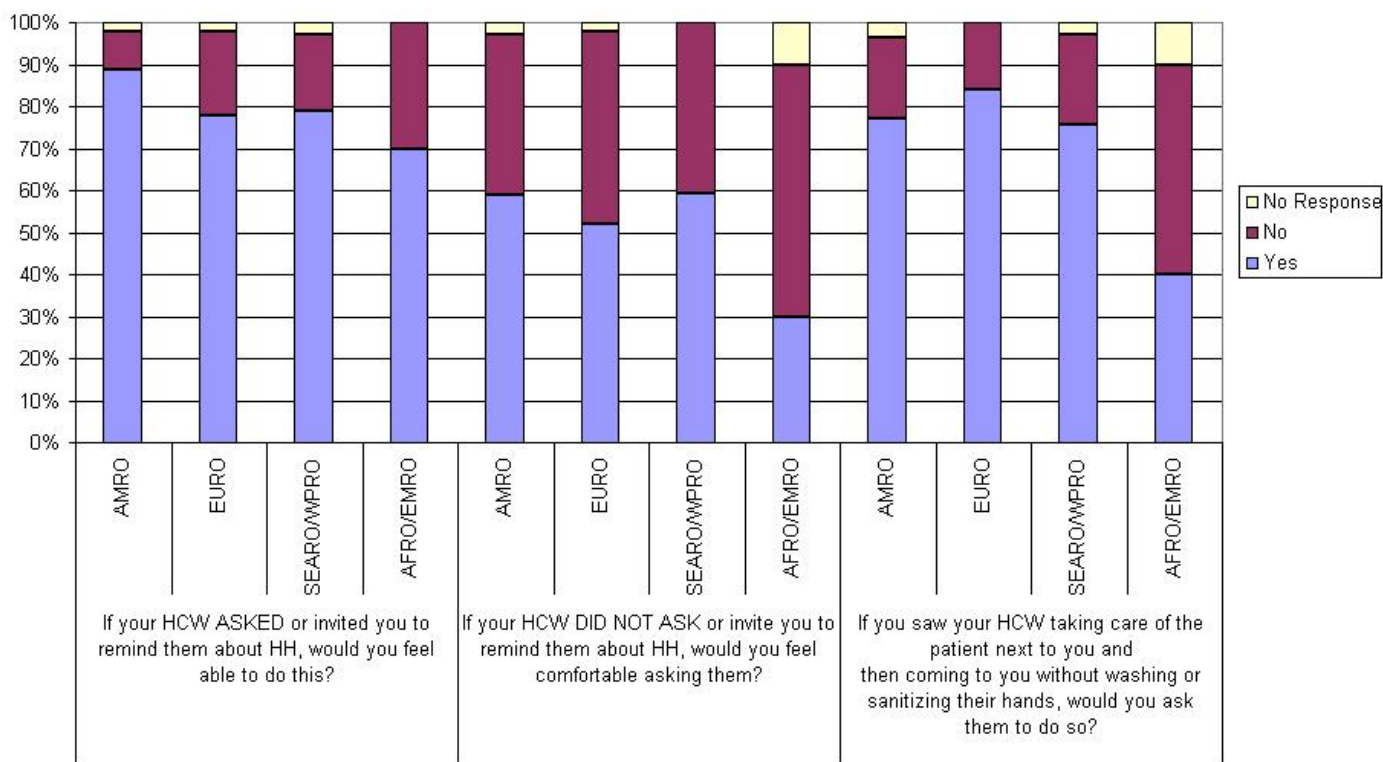
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Background: WHO statistics report that there are 59.2 million full-time health care workers (HCWs) worldwide. This represents over 100 million hands, touching and treating patients each day. The WHO Guidelines on Hand Hygiene in Health Care (Advanced Draft) recommend patient involvement as part of a multifaceted strategy for improving hand hygiene (HH). However, the Guidelines acknowledge limitations in current evidence concerning the acceptability of the concept of empowerment in different cultural contexts.

Objective: To identify patients' experiences and perceptions of what factors facilitate or impede their involvement in hand hygiene improvement and to integrate this evidence into WHO strategies.

Methods: Two-phase web-based surveys conducted between March 2007 and January 2008. Phase 1 collected data on: the availability of HH products; patient empowerment and perceptions; effectiveness of empowerment programs; and personal experiences with healthcare-associated infection (HAIs) through qualitative

Fig. 1: Responses to scenarios given by respondents from the WHO regions



case studies. Phase 2 closes in January 2008 and explores patient perceptions, how best to communicate risk, and will provide greater international diversity.

Results: 238 respondents, representing 43 countries across the six WHO regions, completed the phase I survey. Approximately half of all respondents worked in a health related profession. 33.5% of respondents had in the past asked a HCW to clean their hands: in 69% of cases the HCW proceeded to clean their hands, however 31% 'became angry'. Patients who had direct experience of a HAI were more likely to question the HCW 56% among those who had direct experience, as opposed to 22% among those who didn't. When presented with scenarios in which a HCW invited the patient to remind them to clean their hands 84% reported that they would feel comfortable doing so. This decreased to 56% when NOT invited, and increased to 76% when they observed failure to comply. Figure 1 shows the breakdown by WHO region.

Conclusions: Phase I results indicate that patient involvement in hand hygiene compliance should not be overlooked and it seems likely that such an approach may provide a useful adjunct to current strategies. Phase II data will bring further information on the importance of the cultural context, and the personal experiences of patients globally.

Antibiotic Use

369. Sustained Reduction in Inappropriate Treatment of Asymptomatic Bacteriuria and Decreased Total Antimicrobial Use in a Long-Term Care Facility through an Educational Intervention

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Background: In long-term care facilities, treatment of asymptomatic bacteriuria (ASB) is common. However, randomized, controlled trials suggest that such treatment offers no benefit, and may promote antimicrobial resistance. We previously reported that an educational intervention in a long-term care facility was associated with a reduction in inappropriate treatment of ASB during a 6-month follow-up period.

Objective: To assess whether an educational intervention could result in a sustained reduction in inappropriate treatment of ASB and decrease total antimicrobial use in a long-term care facility.

Methods: For 3 months before and 30 months after instituting an educational intervention, we monitored the appropriateness of urine culture collection and antibiotic treatment based on published guidelines, and examined the effect on total antimicrobial use. The intervention included education of nursing staff to discourage the collection of urine cultures in the absence of symptoms suggestive of urinary tract infection, and of primary care practitioners to not treat ASB. Poisson analysis was used to compare rates of inappropriate urine culture submission and treatment of asymptomatic bacteriuria the pre- and post-intervention periods and chi-square test was used to compare the proportions of antimicrobial days of therapy per 1,000 patient-days.

Results: In pre-intervention period, 23 of 38 (61%) antibiotic regimens prescribed for urinary tract indications were for ASB. In the 30 months after the intervention, inappropriate submission of urine cultures decreased from 2.6 to 0.6 per 1,000 patient-days ($p < 0.0001$) and the overall rate of treatment of ASB was reduced from 1.7 to 0.3 per 1,000 patient-days ($p < 0.0001$). Total antimicrobial days of therapy were reduced from 167.7 to 109 per 1,000 patient-days ($p < 0.001$).

Conclusions: Educational interventions requiring minimal resources can result in sustained reductions in inappropriate treatment of ASB in long-term care and decreased total antimicrobial use. Education of the nursing staff regarding appropriate criteria for requesting urine cultures should be a component of such interventions.

370. Variability in Antibiotic Use in Neonatal ICU Patients and Mortality

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Background: Antibiotic (AB) use in neonatal ICUs (NICU) is common. A point prevalence study showed 43% of infants in NICUs were receiving an AB. The excess of use of ABs has been linked with increased resistance among bacterial pathogens. Infections with resistant bacteria are associated with increased morbidity, mortality, hospital stay and cost. Outbreaks of resistant organisms in NICUs have been attributed to inappropriate AB use.

Objective: We performed a retrospective cohort study to determine the rates of antibiotic use among hospitalized children in NICUs and the impact of AB use on neonatal mortality.

Methods: We used the Pediatric Health Information System, a database of clinical and financial data from free-standing children's hospitals in the US. Exposure was defined as receipt of any AB, excluding antiviral and antifungal agents. Risk adjusted hospital rates of AB use were determined adjusting for hospital and patient (PT) factors, while controlling for hospital clustering. The association between AB use and mortality was determined using instrumental variable analysis. The rate of AB use by a given hospital in 2005 was put into a model with PT-level variables in PTs hospitalized in 2006 to determine the effect on in-hospital mortality.

Results: A total of 23,535 neonatal ICU hospitalizations from 38 hospitals were included. The majority of hospitals (79%) have > 200 beds. All census regions were represented. The mean adjusted number of PTs receiving at least one dose of an AB was 96.0 (IQR 95.2-97.0) /100 discharges. The median adjusted days of therapy (DOT) was 329/1000 (IQR 304, 361) PT-days. Adjusted hospital-specific rates of AB use varied between 259 DOT/1000 PT-days and 398 DOT/1000 PT-days. The variability in rates of AB use across hospitals was statistically significant ($p < 0.001$). The overall mean proportion of hospital days on antibiotics was 53.0% (49.9, 56.0) but varied by hospital from 35.5% to 68.9%. There was no evidence that decreased use of AB was associated with in-hospital mortality after adjusting for patient and hospital level variables ($p=0.92$) in fact, there was a statistically significant increase in mortality associated with increased AB use ($p=0.02$).

Conclusions: A wide variability of AB use is observed in NICUs among numerous children's hospitals across the US. On average NICU PTs received an AB for half of their NICU stay. Finally, hospitals with greater AB utilization had a statistically significant higher rate of mortality even after adjusting for patient and hospital level factors.

371. Variability in Antibiotic Use in Hospitalized Children and Mortality

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Background: Aggregate antibiotic (AB) use has been reported for hospitalized adults, however, variability in AB use among hospitalized children is not known. Furthermore, an estimated 50% of antimicrobial use is inappropriate and unnecessary. Inappropriate use is linked with increased selection of resistant pathogens and infection with resistant organisms results in increased morbidity, mortality, and healthcare costs. However, AB prescribers often perceive that clinical outcomes would be more adversely affected by not prescribing ABs than by the potential for harm posed by antimicrobial resistance.

Objective: To describe the variability in antibiotic use in hospitalized children and determine the association between antibiotic use and in-hospital mortality.

Methods: We performed a retrospective cohort study using the Pediatric Health Information System, a database of clinical and financial data from free-standing children's hospitals in the US. Exposure was defined as receipt of any AB, excluding antiviral and antifungal agents. Risk adjusted hospital rates of AB use were determined adjusting for hospital and patient (PT) factors, while controlling for hospital clustering. The association between AB use and mortality was estimated using instrumental variable analysis; specifically, the rate of AB use by a given hospital in 2005 was put into a model with PT-level variables in PTs hospitalized in 2006 to determine the effect on in-hospital mortality.

Results: A total of 479,202 pediatric hospitalizations from 38 hospitals were included. The majority of hospitals (79%) had > 200 beds. The median adjusted number of PTs receiving at least one dose of an AB was 68.7 (IQR 65.5-71.3) /100 discharges. The median adjusted days of therapy (DOT) was 392 (IQR 372, 426) /1000 PT-days. Adjusted hospital-specific rates of AB use varied significantly ($p < 0.001$) between 337 DOT/1000 PT-days and 486 DOT/1000 PT-days. The overall mean proportion of hospital days on antibiotics was 32.9% (95% CI: 32.2, 33.6) but varied by hospital from 23.7% to 42.8%. There was no evidence that hospitals with lower AB use had greater in-hospital mortality after adjusting for patient and hospital level variables ($p = 0.92$), in fact, there was a slight increase in mortality seen in hospitals with associated higher AB use ($p = 0.02$).

Conclusions: AB use in children's hospitals exhibits substantial excess variation not explained by observed patient or hospital characteristics. This suggests that AB prescription may be influenced by variation in the philosophy, psychology, or culture of care across different hospitals. Furthermore, reduction of AB use was not associated with increased mortality.

372. Effect of Antimicrobial Diversity on the Development of Antimicrobial Resistance

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Background: Antimicrobial use is a critical factor in the development and spread of antimicrobial resistance. Antimicrobial cycling has had mixed results on limiting antimicrobial resistance. Mathematical modeling studies suggest that completely heterogeneous use of antimicrobials, essentially a cycling period of zero, would be optimal to limit antimicrobial resistance.

Objective: To separately determine for *E. coli* and *P. aeruginosa* if increased diversity of antimicrobials typically used to treat each pathogen is associated with lower mean resistance of that pathogen to the studied antimicrobials

Methods: We performed a cross-sectional study design using the Pediatric Health Information System (PHIS), a database of clinical and financial data from 39 freestanding children's hospitals in the US in 2005. Each hospital was one unit of analysis. Antimicrobial diversity was calculated with the Simpson's Diversity Index $[1 - \sum (n / N)^2]$, where n =days of antimicrobial use for each antimicrobial class, and N =total antimicrobial days. The index ranges from zero (no diversity) to one (highest

possible diversity), and was separately calculated for anti-pseudomonals and anti-*E. coli* agents. The outcome was the mean proportion of *E. coli* or *P. aeruginosa* isolates resistant to pre-specified representative agents/classes used to treat them (one mean composite number for each pathogen). Number of staffed beds, 2005 admissions, and total antibacterial antimicrobial days were examined as potential confounding variables. We queried antimicrobial use data and the potential confounders from the PHIS database. Antimicrobial resistance data was obtained as pre-existing antibiogram data from participating hospitals. The statistical analysis was a non-parametric regression model (for continuous data). Potential confounders were individually examined in separate models.

Results: Adequate antimicrobial use and resistance data was available for *E. coli* from 14 hospitals and for *P. aeruginosa* from 17 hospitals. In many hospitals, the antibiograms included both inpatient and outpatient isolates. The range of Simpson's diversity index was 0.61 to 0.86 for anti-pseudomonals and 0.76 to 0.86 for anti-*E. coli* agents. The β coefficient and 95% confidence interval for the effect of Simpson's Diversity Index on mean resistance was 14 (-116 to 143) for *P. aeruginosa* and 60 (-118 to 240) for *E. coli*. The results were unchanged when controlling for any potential confounder.

Conclusions: We found no association between antimicrobial diversity and mean antimicrobial resistance for common gram-negative pathogens. Further studies are needed that include hospitals with greater differences in diversity, distinguish hospital from community-acquired isolates (since antibiogram data often combine isolates from community and hospital sources), and include unit-level data for hospitals are needed before definitive conclusions can be made.

373. Coadministration of Oral Fluoroquinolones with Agents That Impair Their Absorption: Impact on Emerging Antibiotic Resistance

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Background: Coadministration of oral fluoroquinolones (FQs) with oral divalent or trivalent cation containing compounds (DTCCs) (calcium, magnesium, etc), may impair the absorption of FQs. In vitro studies have shown that exposure to low serum levels of FQs may elicit FQ resistance.

Objective: To determine if coadministration of FQs and DTCCs is associated with subsequent FQ resistance.

Methods: In a retrospective cohort study, inpatients receiving oral FQ for at least 72 hours between January 1, 2001 and December 31, 2005 were identified. Patients whose entire course of oral FQ therapy was complicated by DTCC coadministration were considered exposed. Patients with courses not completely co-administered (<100% of doses) or never co-administered, were considered unexposed. The outcome was identification of a FQ resistant isolate in a clinical culture > 48 hours after the initiation of the FQ course. Patients with a FQ resistant isolate identified in the 3 months prior to FQ course were excluded. Bi-variable analyses were conducted to determine the association between coadministration and potential confounders and subsequent FQ resistance. Multivariable analysis evaluated the association

between coadministration and FQ resistance while controlling for potential confounders.

Results: 3134 individuals met study criteria. In 895, a DTCC was co-administered with 100% of FQ doses (exposed) and in 2239 a DTCC was co-administered with at least one dose of FQ (but not with all doses) or was never co-administered. A FQ-resistant isolate was identified in 198 (6.3%) patients. For bi-variable results see table. On multivariable analysis, after controlling for days of FQ therapy and hospital days prior to FQ initiation, 100% coadministration was associated with identification of a FQ-resistance in a clinical isolate [adjusted odds ratio (95% confidence interval) = 1.43 (1.04, 1.96); p=0.03]. Sub-analyses that varied the definition of exposure (e.g., > 75%, > 50% and > 25% coadministration) produced similar results.

Conclusions: The emergence of widespread FQ resistance is of great concern. Improper coadministration of oral FQs and DTCC is likely a risk factor for FQ resistance and represents an easily modifiable target for interventions. Educational efforts focusing on the ramifications of coadministration are warranted and systems intended to prevent co-administration in institutional settings should be investigated.

Unadjusted Association between Coadministration and FQ Resistance				
Definition of Co-Administration (% of doses co-administered)	Resistant Culture (n=198)	No Resistant Culture (n=2936)	Relative Risk (95%CI)	P Value
100% Coadministration	74 (37%)	821 (28%)	1.49 (1.13, 1.97)	0.005
≥75% Coadministration	81 (41%)	919 (31%)	1.48 (1.12, 1.94)	0.005
≥50% Coadministration	96 (49%)	1059 (36%)	1.61 (1.20, 2.11)	<0.001
≥25% Coadministration	104 (53%)	1256 (43%)	1.44 (1.10, 1.89)	0.007

Ventilator-Associated Pneumonia and Critical Care

374. Imipenem Resistance in *Acinetobacter baumannii*: Emergence, Epidemiology and Impact on Clinical and Economic Outcomes

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Background: *Acinetobacter baumannii* (AB) is a serious gram-negative pathogen in patients with healthcare-associated infections. Resistance of AB to imipenem complicates the treatment of these infections.

Objectives: To examine trends of AB resistance to imipenem, identify factors associated with imipenem-resistant AB (IRAB), and investigate the effect of IRAB on outcomes.

Methods: This study analyzed data from two medical centers at the University of Pennsylvania. Longitudinal trends in prevalence of IRAB were characterized from 1989 through 2004. For AB isolates obtained between 2001 and 2006, a case-control study was conducted to identify risk factors for IRAB and a cohort study was performed to determine the effect of IRAB on mortality, post-culture length of stay, and post-culture hospital charges.

Results: From 1989 to 2004, the annual prevalence of IRAB ranged from 5 to 21%. Among 386 unique patients with AB isolates between 2001-2006, 175 (45.3%) had polymicrobial cultures and 227 (58.8%) harbored multidrug resistant isolates. Of these patients, 89 (23.1%) had IRAB and 297 demonstrated imipenem-susceptible AB (ISAB). Prior use of a carbapenem or fluoroquinolone, and transfer from another facility were independent risk factors for IRAB (Table 1). In-hospital 30-day mortality was significantly greater for IRAB among blood isolates[RR (95%CI) = 3.05 (1.52, 6.13)] while there was no significant difference in mortality when comparing non-blood isolates of IRAB and ISAB[RR (95%CI) = 0.65 (0.35, 1.18)]. In multivariable analyses, there remained a borderline significant association between IRAB and mortality, but only among blood isolates[adjusted OR (95%CI) = 5.30 (0.81, 34.59); p=0.08] (Table 2). IRAB was also associated with longer post-culture hospital stay (21 vs 16 median days, p=.07) and greater post-culture charges (\$177,277 vs \$110,770, p=0.03), compared to ISAB. In multivariate analyses, IRAB did not remain an independent risk factor for increased post-culture hospital days or hospital charges. In both multivariable models, ICU location at the time of culture and duration of hospitalization prior to culture were the only independent predictors of increased post-culture hospital days and hospital charges.

Conclusions: IRAB has remained common in recent years with potential important implications for mortality, particularly among patients with bloodstream isolates. Further investigation of this association in future studies is warranted. There remains a clear need for strategies to optimize therapy.

Table 1. Final Multivariable Model of Risk Factors for IRAB

Variable	Adjusted OR (95%CI)	P value
Prior use of a carbapenem	3.48 (1.27, 9.54)	0.02
Prior use of a fluoroquinolone	1.75 (1.03, 2.98)	0.04
Transfer from another facility	1.79 (1.07, 2.98)	0.03
Duration of hospitalization prior to culture	0.99 (0.98, 1.01)	0.49

Table 2. Final Multivariable Model of Risk Factors for Mortality

Variable	Adjusted OR (95%CI)	P value
Imipenem resistance	0.56 (0.28, 1.15)	0.12
Bloodstream involvement	1.85 (0.82, 4.16)	0.14
Interaction between anatomic site of infection (blood vs. non-blood) and imipenem resistance	9.38 (1.26, 69.88)	0.03
ICU location at time of culture	2.61 (1.39, 4.89)	0.003

Duration of hospitalization prior to culture	1.01 (1.00, 1.02)	0.15
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375. Imipenem Resistance In *Pseudomonas aeruginosa*: Emergence, Epidemiology, and Impact on Clinical and Economic Outcomes

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Background: *Pseudomonas aeruginosa* (PA) is one of the most common gram-negative pathogens in patients with healthcare-associated infections. Emerging resistance of PA to imipenem, among other agents, increasingly complicates the treatment of these infections.

Objectives: To examine trends of PA resistance to imipenem, identify factors associated with imipenem-resistant PA (IRPA), and investigate the impact of IRPA on outcomes.

Methods: This study analyzed data from two medical centers of the University of Pennsylvania. Longitudinal trends in prevalence of IRPA were characterized during 1989-2006. For PA isolates obtained between 2001 and 2006, a case-control study was conducted to identify risk factors for IRPA and a cohort study was performed to determine the impact of IRPA on mortality, post-culture length of stay, and post-culture hospital charges.

Results: From 1989 to 2006, the annual prevalence of IRPA increased from 13 to 20% ($p < 0.001$, trend). Among 2,542 unique patients with PA isolates between 2001-2006, 836 (32.9%) had polymicrobial cultures and 341 (13.4%) harbored multidrug resistant isolates. Of these patients, 253 had IRPA and 2,289 had imipenem-susceptible PA (ISPA). Prior use of a carbapenem or fluoroquinolone, and transfer from another facility were independent risk factors for IRPA (Table 1). IRPA patients had higher in-hospital 30-day mortality (17.4% vs 13.4%, $p = .01$). In multivariable analyses, imipenem resistance remained an independent risk factor for mortality among blood isolates [adjusted OR (95%CI) = 5.43 (1.72, 17.10); $p = .004$] but not among non-blood isolates [adjusted OR (95%CI) = 0.78 (0.51, 1.21); $p = 0.27$] (Table 2). Bloodstream involvement was also an independent risk factor for mortality [adjusted OR (95%CI) = 3.72 (2.59, 5.35); $p < 0.001$]. IRPA was associated with longer post-culture hospital stay (16 vs 9 median days; $p < .001$) and greater post-culture charges (\$104,300 vs \$48,191; $p < .001$). After controlling for ICU location, transfer from another facility, and duration of hospitalization prior to culture, IRPA remained an independent risk factor for both longer post-culture hospital stay [coeff (95%CI) = 0.20 (0.04, 0.36); $p = 0.02$] and post-culture hospital charges [coeff (95%CI) = 0.30 (0.06, 0.54); $p = 0.02$].

Conclusions: IRPA has risen significantly in recent years with important implications for both clinical and economic outcomes. Interventions to curb the continued increase of IRPA and strategies to optimize therapy are urgently needed.

Table 1. Final Multivariable Model of Risk Factors for IRPA

Variable	Adjusted OR (95%CI)	P value
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Prior use of a carbapenem	7.68 (4.50, 13.08)	<0.001
Prior use of a fluoroquinolone	2.16 (1.53, 3.03)	<0.001
Transfer from another facility	1.54 (1.14, 2.10)	0.005
ICU location at time of culture	1.28 (0.95, 1.72)	0.11
Duration of hospitalization prior to culture	1.00 (0.99, 1.01)	0.41

Table 2. Final Multivariable Model of Risk Factors for Mortality

Variable	Adjusted OR (95%CI)	P value
Imipenem resistance	0.78 (0.51, 1.21)	0.27
Bloodstream involvement	3.72 (2.59, 5.35)	<0.001
Interaction between anatomic site of infection (blood vs. non-blood) and imipenem resistance	6.92 (2.03, 23.55)	0.002
ICU location at time of culture	4.30 (3.27, 5.65)	<0.001
Transfer from another facility	1.68 (1.29, 2.19)	<0.001
Duration of hospitalization prior to culture	1.01 (1.00, 1.01)	0.09

376. Antibiotic Resistance among Important Gram-Negative Pathogens Causing Healthcare-Associated Infections Reported to the National Healthcare Safety Network, 2006-2007

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Background: Recent reports of multidrug resistant (MDR) gram-negative rods (GNR) are concerning; however, it is not clear how extensive this problem is nationally. The National Healthcare Safety Network (NHSN) collects information on select hospital-associated infections (HAIs) from about 600 hospitals throughout the U.S. and is a system that may be used to evaluate this problem.

Objective: To describe the prevalence of MDR among *K. pneumoniae*, *P. aeruginosa* and *A. baumannii* HAIs reported to NHSN.

Methods: HAIs due to the aforementioned pathogens reported to the NHSN device or procedure modules from January 1, 2006 to September 15, 2007 were evaluated. Isolates were included if they had susceptibility results for at least 1 agent in each of 4 classes of antimicrobials: aminoglycosides, quinolones, beta-lactams (penicillins and cephalosporins), and carbapenems. Isolates were classified as MDR if reported as resistant or intermediate to all drugs tested in all 4 classes. Other potentially important resistance phenotypes were also evaluated. Pooled mean (%) MDR were determined by pathogen and HAI type. To better characterize the national prevalence, results were stratified to control for facilities that reported large numbers of MDR-GNR (outlier facilities).

Results: Overall, 313 hospitals in 42 states reported 4,790 HAIs with selected GNR: 2,432 *P. aeruginosa* (bloodstream infection [BSI] 327, ventilator associated

pneumonia [VAP] 889, urinary tract infection [UTI] 866, surgical site infection [SSI] 350); 1,740 *K. pneumoniae* (BSI 490, VAP 417, UTI 650, SSI 183); and 791 *A. baumannii* (BSI 221, VAP 439, UTI 92, SSI 39). Among *P. aeruginosa*, 3% of isolates were MDR and 3% were non-susceptible (NS) to beta-lactams, quinolones and aminoglycosides. Among *K. pneumoniae*, 8% of isolates were MDR and 10% were NS to carbapenems. Among *A. baumannii*, 26% were MDR. MDR isolates were reported from 68 (30%) facilities in 21 states and were more commonly reported from larger hospitals (>500 beds, $p < 0.001$). The percent isolates that were MDR varied slightly by type of HAI (table). Pooled mean (%) MDR varied when states with outlier facilities were excluded (table).

	Number (%) Multidrug Resistant					
Organism	BSI	VAP	UTI	SSI	Pooled mean	Pooled mean without outlier
<i>P. aeruginosa</i>	3 (2%)	12 (3%)	18 (4%)	1 (1%)	34 (3%)	NA
<i>K. pneumoniae</i>	27 (10%)	9 (4%)	24 (9%)	5 (5%)	65 (8%)	16 (3%)
<i>A. baumannii</i>	37 (23%)	89 (29%)	12 (21%)	4 (17%)	142 (26%)	72 (16%)

Conclusions: As defined, MDR among GNR is not rare in U.S. hospitals reporting data to NHSN. MDR-GNR were not confined to one geographic region and are more common in, but not limited to, larger hospitals. The paucity of novel antimicrobial agents in development to treat these organisms places increasing emphasis on infection prevention efforts.

377. Randomized Study of a Silver-Coated Endotracheal Tube to Reduce the Incidence of Ventilator-Associated Pneumonia. The North American Silver-Coated Endotracheal Tube (NASCENT) Study

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Background: Ventilator-associated pneumonia (VAP) is an important public health problem that increases length of hospital stay and healthcare costs. Preventing VAP will become even more important if VAP becomes a benchmark for quality of care. An endotracheal tube (ETT) coated with silver ions micro dispersed in a proprietary polymer was designed to reduce VAP incidence by preventing bacterial colonization and biofilm formation.

Objective: To determine whether the silver-coated ETT would reduce the incidence of microbiologically-confirmed VAP.

Methods: In a multicenter study, patients expected to require mechanical ventilation for ≥ 24 hours were randomly assigned to intubation with one of two ETTs, similar except for the silver coating on the experimental ETT (Agento™ I. C., C. R. Bard, Inc.). Sites were allowed to follow (and encouraged to maintain) institutional practices for preventing VAP. Primary outcome was VAP incidence based on quantitative bronchoalveolar lavage fluid culture with $\geq 10^4$ colony-forming units/mL.

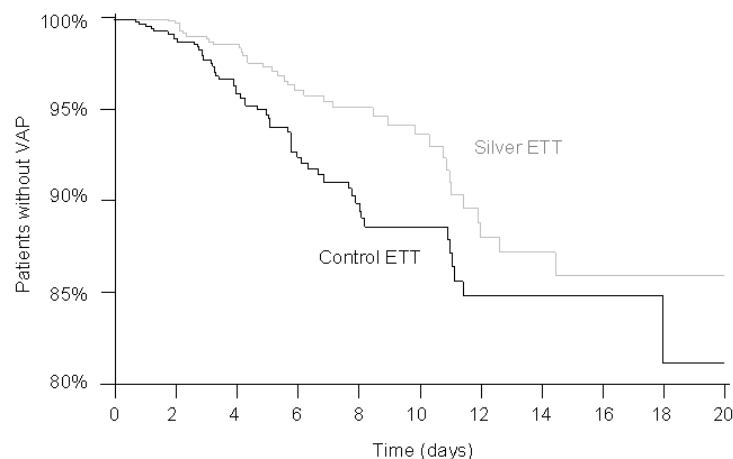
Other outcomes were VAP incidence within 10 days of intubation, time to VAP onset, length of intubation and stay, mortality, and adverse events.

Results: Microbiologically-confirmed VAP occurred in 4.8% of 766 patients in the silver group and 7.5% of 743 in the control group ($P=.03$; relative risk reduction [RRR], 35.9%). The silver-coated ETT was associated with a 47.6% RRR in VAP incidence within 10 days of intubation ($P=.005$) and delayed VAP occurrence ($P=.005$). No statistically significant between-group differences occurred in durations of intubation, intensive care unit stay, and hospital stay; mortality; and frequency and severity of adverse events.

Conclusions: The results of this large, randomized study demonstrated that the silver-coated ETT significantly reduced VAP incidence and had its greatest benefit during the peak time of VAP occurrence, without any notable adverse events. The silver-coated ETT offers a unique approach because it becomes user independent after intubation, requiring no further action by medical personnel. Moreover, the silver-coated ETT can be combined with other preventive measures to further reduce VAP incidence.

Funding/Support: This study was supported by a research grant from C. R. Bard, Inc.

Figure. Kaplan-Meier plot for time to occurrence of microbiologically-confirmed VAP ($P=.005$).



378. Preventing Ventilator-Associated Pneumonia in US Hospitals: A Mixed-Methods Study

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Background: Although ventilator-associated pneumonia (VAP) frequently affects critically ill patients, there is scant national data describing strategies used by U.S. hospitals to prevent this important patient safety problem.

Objective: We undertook a mixed-methods sequential explanatory study to determine, through a quantitative survey, the practices used by hospitals to prevent VAP, and then, using qualitative methods, to understand more fully why hospitals use certain practices and not others.

Methods: We conducted a written survey of infection control coordinators at all Department of Veterans Affairs (VA) hospitals (n = 119) and a national random sample of non-VA hospitals (n = 600). Using the survey responses and a stratified purposeful sampling strategy, we selected 14 hospitals for in-depth investigation, which included semi-structured interviews with 86 individuals and visits to 6 hospitals. We focused primarily on two VAP prevention practices: semi-recumbent positioning and subglottic secretion drainage.

Results: The survey response rate was 72%. Overall, 83% of hospitals (89% VA vs. 82% non-VA) reported regularly using semi-recumbent positioning; only 21% (22% VA vs. 21% non-VA) used subglottic secretion drainage. While participation in a collaborative was significantly associated with use of semi-recumbent positioning, multivariable analyses provided little guidance regarding use of subglottic secretion drainage. Our qualitative findings, however, revealed three themes that help explain why hospitals were using - or not using - these two practices: collaborative initiatives, nursing support, and perceived level of evidence. First, collaboratives, which often employ practice bundles, have had a strong influence on the use of semi-recumbent positioning but little effect on subglottic secretion drainage. Second, nurses have played a major role in the use of semi-recumbent positioning but are not strongly engaged in the use of subglottic secretion drainage. Finally, there is considerable debate about the evidence to support subglottic secretion drainage, despite five randomized trials and a supportive meta-analysis, but little discussion about the evidence supporting semi-recumbent positioning (two randomized trials, one negative).

Conclusions: Semi-recumbent positioning is commonly used to prevent VAP, while subglottic secretion drainage is used far less. A thorough understanding of the factors that influence uptake of evidence-based practices for preventing VAP is key to improving the care of critically ill patients.

379. Effect of a Ventilator-associated Pneumonia (VAP) Infection Control Bundle for the Prevention of VAP in a Long-term Care Acute Hospital (LTACH)

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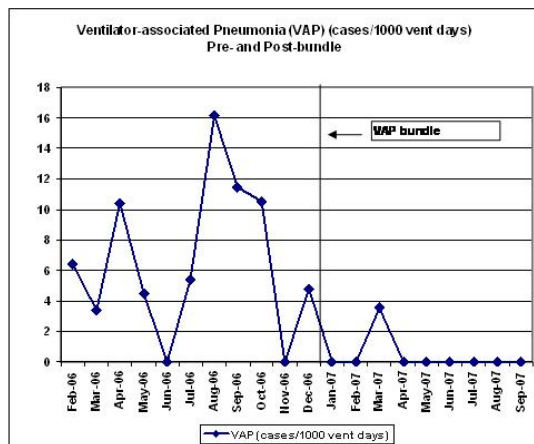
Background: LTACHs manage patients too acute to go home but not sick enough to remain in traditional acute care hospitals. Many LTACH patients require mechanical ventilation and are at significant risk for VAP. We characterized the effect of a group of interventions on VAP rates at an LTACH.

Methods: On January 1 2007 a group of interventions ("VAP bundle") was implemented for all mechanically-ventilated patients admitted to the LTACH. The VAP bundle consisted of daily multidisciplinary (nursing, respiratory and infection control)

rounds checking for head-of-bed positioning at 30 to 45 degrees, every 4 hour oral care using Toothette Oral Care Suction Toothbrush with Antiplaque solution (cetylpyridinium chloride 0.05%), Toothette Oral Care Suction Oral Swab (Hydrogen Peroxide 1.5%) and Toothette Oral Care Oropharyngeal Suction Catheter (Toothette, Sage) and administration of proton pump inhibitors. Definition for VAP was based on CDC's NNIS recommendation. We analyzed rates of VAP from February 2006 through September 2007. Rates were compared before and after implementation of the VAP bundle using Poisson regression models and interrupted time series analysis.

Results: We detected 16 VAPs during 20 months. A significant and sustained reduction in VAP rates was seen immediately after introduction of the VAP bundle: 6.16/1000 VAP-days vs. 0.52/1000 VAP-days (RR, 0.08; $p=0.02$). The case mix index was not significantly different among the pre- and post-intervention groups.

Conclusions: The introduction of this VAP bundle significantly and immediately decreased the rate of VAP at an LTACH. This bundle may be a useful strategy to reduce VAP risk among chronically-ventilated patients.



Late-Breaker Papers

380. Using Internet Search Query Logs to Predict Influenza Activity

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Background: Influenza occurs in regular cycles, but the beginning, peak and end of each season varies. Influenza is not reportable, but efforts, such as the Influenza Sentinel Provider Surveillance Network and 122 Cities Mortality Reporting System, contribute information to influenza surveillance in the U.S. Investigators have proposed syndromic surveillance approaches (e.g., over-the-counter drug sales) to augment influenza surveillance efforts. However, such approaches are difficult to

implement on a national basis. Because the Internet is an important source of health information for patients and providers, an analysis of the frequency of influenza searches may provide information in advance of other reports of influenza activity.

Objective: This study examines the temporal relationship between search terms for influenza and actual disease occurrence.

Methods: Search query logs were obtained from <http://search.yahoo.com> between March 2004 and August 2007, and unique queries, originating from the U.S. and containing influenza-related search terms, were counted daily. These daily counts of influenza-related searches were then divided by the total number of searches that day in the U.S., and the resulting daily fraction of searches was averaged over the week. We developed linear models, using searches with one- to nine-week lead times, to predict the onset of the incidence of positive influenza cultures and deaths due to pneumonia and influenza in the US.

Results: Using the frequency of the occurrence of search terms to predict when positive influenza cultures would peak, the best-fitting model contained a four-week lead of influenza searches ($p < 0.0001$) and explained 43% of the variation between positive influenza cultures. The best-fitting model of mortality from both pneumonia and influenza contained a seven-week lead of influenza searches ($p < 0.0001$); this model explained 41% of the variation in pneumonia and influenza mortality in the U.S.

Conclusions: We demonstrate that an increase in influenza-related search activities signals an increase in positive influenza cultures four weeks in advance and an increase in deaths from pneumonia and influenza seven weeks in advance. Our preliminary results suggest that search-term surveillance may represent a novel, powerful and inexpensive way of performing supplemental disease surveillance.

381. The NNIS Risk Index (RI) is a valid method for risk adjustment of invasive Surgical Site Infections (SSI)

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Background: Public reporting of SSI rates is occurring in many states and is likely to occur in others, yet the optimal methodology for reporting such rates remains unclear. Some groups have proposed only reporting invasive SSIs to external agencies; other experts, however, have argued that risk adjustment using methods derived from NNIS data cannot be reliably applied to this subgroup of SSIs. Indeed, the data used to validate the NNIS RI contained all categories of SSI; specifically, 47% of SSIs were categorized as superficial-incisional. Thus, further validation is required to ascertain if the NNIS RI can be reliably applied to SSIs exclusively categorized as invasive.

Purpose: To determine if increasing NNIS RI scores were correlated with increased risk of invasive SSI in a large cohort of hospitals and, thus, whether the NNIS RI could be used for risk-adjustment of rates of invasive SSIs.

Methods: We reviewed surgical procedures performed at 24 community hospitals from 1/1/2005 through 6/30/2007. SSIs were prospectively identified at these study hospitals by trained ICPs using standard CDC criteria and identical surveillance methods. Deep-incisional and organ/space infections were termed "invasive" SSIs. We determined procedure-specific rates of invasive SSI stratified by NNIS RI for the following procedures: cardiothoracic, colon, abdominal hysterectomy, hip prosthesis insertion, knee prosthesis insertion, and vascular. RI 2 and 3 were collapsed into one index for all procedures except colon. The Goodman-Kruskal (*G*) statistic was used to determine correlation. P-values ≤ 0.05 were considered to be statistically significant.

Results: In total, 2,257 SSIs were identified following 189,288 procedures performed at the 24 study hospitals during the 30 month period (overall rate of SSI = 1.19/100 procedures); 1,164 (51.6%) were superficial-incisional and 1,093 (48.4%) were invasive. As the NNIS RI score increased, the procedure-specific rates of invasive SSI increased in a step-wise fashion (Table). Procedure-specific rates of invasive SSI were significantly correlated with increasing NNIS RI scores, as the p-values for each *G* statistic were <0.05 .

Conclusion: Adjustment must be made for differences in case-mix among institutions in order to optimize meaningful comparisons for SSI rates. While no method is perfect, the NNIS RI is a logical choice as it is a procedure-specific, prospectively applied method for risk adjustment that is already widely used for internal reporting and benchmarking. In our cohort, procedure-specific rates of invasive SSI were significantly correlated with increasing NNIS RI scores. Thus, we conclude that the NNIS RI is a valid method for risk-adjustment of rates of invasive SSIs.

Table. Procedure-specific invasive SSI rates by NNIS RI

Procedure	Rate of Invasive SSI				G-statistic; p-value
	RI 0	RI 1	RI 2*	RI 3	
Abdominal hysterectomy	0.47	0.71	2.15	-	0.36; p=0.0005
Cardiothoracic	0	1.02	1.72	-	0.26; p=0.04
Colon	1.95	2.79	3.52	3.85	0.18; p=0.01
Insertion of hip prosthesis	0.37	0.99	2.36	-	0.49; p<0.0001
Insertion of knee prosthesis	0.42	0.73	1.74	-	0.39; p<0.0001
Vascular	0.45	0.63	1.74	-	0.43; p=0.0003

382. Patients with Unsuspected Carriage of Methicillin-Resistant *Staphylococcus aureus* are an Important Source for Transmission in Hospitals

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Background: Controversy exists regarding the suggestion that all healthcare facilities perform active surveillance to detect patients colonized with methicillin-resistant *Staphylococcus aureus* (MRSA), as it is unclear whether patients identified only through active surveillance represent a significant risk for MRSA transmission in

hospitals.

Objective: 1) To test the hypothesis that MRSA carriers identified only by active surveillance have a low frequency of skin and environmental contamination when compared with patients with MRSA infection or positive clinical cultures, and 2) to identify risk factors for skin and environmental contamination.

Methods: We conducted a 7-month prospective study of patients with positive nares cultures for MRSA in a veterans affairs hospital where active surveillance is performed for all admissions. The frequency of skin (chest, abdomen, forearm, hands) and environmental (bedrail, bedside table, call button, phone) contamination with MRSA was compared among carriers identified only by active surveillance versus those with current or previous MRSA infection or positive clinical cultures. Hand imprint cultures were performed to assess acquisition of MRSA on hands. The density of nares colonization was measured. Logistic regression was performed to determine predictors of contamination, and pulsed-field gel electrophoresis (PFGE) was performed to determine relatedness of isolates.

Results: Of 82 patients studied, 38 (46%) were detected only by active surveillance and 44 (54%) had current or previous MRSA infection and/or positive clinical cultures. The frequency of skin and environmental contamination was equivalent among carriers detected by active surveillance versus those with MRSA infection and/or positive clinical cultures (47% versus 45%, $P=0.86$). For both groups, hand imprint cultures demonstrated that MRSA on skin was easily acquired on hands. By multivariate analysis, decreased mobility (OR 4.16, 95% CI 1.21-14.3) and increased density of nares MRSA defined as >100 colony-forming units (OR 7.36, 95% CI 1.42-38.2) were independently associated with skin and environmental contamination, whereas recent chlorhexidine bathing or use of antibiotics with activity against MRSA were protective (OR 0.26, 95% CI 0.08-0.86). By PFGE, more than 90% of skin and environmental isolates were identical to nares isolates from the same patients.

Conclusion: MRSA carriers identified only by active surveillance are as likely to disseminate MRSA as are those with infection or positive clinical cultures. Decreased mobility and increased density of nares colonization are predictors of increased skin and environmental contamination with MRSA. These results suggest that infection control strategies to limit the transmission of MRSA in hospital settings must address colonized as well as infected patients.

383. Evaluation of ICD-9 Codes as a Mechanism for Surveillance of Methicillin-resistant *Staphylococcus aureus* Infections in Illinois - United States, 2007

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Background: In August 2007, Illinois passed legislation requiring public reporting of Methicillin-resistant *Staphylococcus aureus* (MRSA) infections in all acute care hospitals using ICD-9-CM codes from hospital discharge data. Because there is no single ICD-9-CM code for MRSA infections, several combinations of codes have been

proposed.

Objective: To evaluate the accuracy of the currently recommended ICD-9-CM code combinations for identification of MRSA infection at one Illinois hospital.

Methods: We identified all potential MRSA infections at one Illinois hospital, during July and August of 2005, 2006 and 2007, through review of medical records that had at least one of the following: (1) MRSA detected by culture or PCR, or (2) Presence of an ICD-9-CM modifier code for penicillin resistance. Though only the first 9 codes are submitted for reimbursement, this hospital's discharge database maintains up to 15 ICD-9-CM codes per discharge. Medical records from discharges associated with potential infections were reviewed to confirm presence of MRSA infection based on assessment and documentation of the treating clinicians. Based on coding guidelines, ICD-9-CM-defined *S. aureus* infection was any discharge that included one of the following codes: *S. aureus* septicemia (038.11) or *S. aureus* pneumonia (482.41) or the *S. aureus* organism code (041.11). ICD-9-CM-defined MRSA infection was any discharge coded as *S. aureus* infection that also had the Penicillin-resistant modifier code (V09.0). Position of the V09.0 code, in relation to the other 15 discharge diagnoses was also recorded.

Results: During the 6 month study period, there were 571 discharges with a potential MRSA infection; 396 (69%) had confirmed MRSA infection based on chart review. Only 234 of the 396 (59%) confirmed MRSA infections were ICD-9 coded for MRSA infection. Of the 254 encounters ICD-9-CM coded as MRSA infection, 234 (92%) were confirmed MRSA infections (Positive Predictive Value: 92%); of these, 122 (54%) had the V09.0 modifier code listed amongst the top nine discharge codes, and never in the first or second position. Thus, if only the top nine codes were reviewed, only 122 of 396 (31%) of confirmed MRSA infections would have been identified by the recommended ICD-9-CM MRSA definitions.

Conclusions: Use of hospital discharge data as a mechanism to report MRSA infections in one Illinois hospital had high positive predictive value, but substantially underestimated the true number of infections. Our findings suggest there are important limitations to using ICD-9-CM codes for public reporting of MRSA infection rates.

384. Comparison of Measures of MRSA Related to Central Line-Associated Bloodstream Infections in Intensive Care Units – United States, 1997-2007

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Background: In recent years, surveillance data have shown increasing percent oxacillin/methicillin resistance among *Staphylococcus aureus* isolates (%MRSA) from intensive care unit (ICU) patients with hospital-associated infections. Since Fall 2007, legislative mandates regarding MRSA prevention have been prompted, in part, by interpretations of rising %MRSA as indicating a failure of current prevention programs. However, translating %MRSA to disease burden is not well understood.

Objective: We sought to determine whether increasing %MRSA in central line-associated bloodstream infections (CLABSIs) caused by *S. aureus* reflects an increasing rate of MRSA CLABSIs among ICUs reporting data during the most recent

10 years of national surveillance conducted by the Centers for Disease Control and Prevention (CDC).

Methods: Data were reported through CDC's National Nosocomial Infections Surveillance (NNIS) System from 1997-2004 and through CDC's National Healthcare Safety Network (NHSN) from 2006-2007. In both systems during the months and ICUs selected for surveillance, infection control professionals used standard methods and definitions to identify and report all central line days and CLABSIs attributed to the ICU stay; when available, antibiotic susceptibility data also were reported. Data from all facilities were aggregated to calculate pooled mean annual CLABSI rates per 1,000 central line days for MRSA and methicillin-susceptible *S. aureus* (MSSA) across major ICU types (including medical, medical/surgical, surgical, pediatric, coronary, and cardiothoracic). Pooled mean %MRSA was calculated over all units by year. Reported *P*-values were obtained by Chi-square tests.

Results: Overall, 4,076 *S. aureus* CLABSIs (with susceptibility data) were reported from 1,679 ICUs representing 8,575,848 central line days of surveillance. Over the study period, %MRSA for *S. aureus* isolates rose from 47.9 in 1997 to 64.7 in 2007, representing a relative 35.1% ($P < 0.0001$) increase (Figure). However, although MRSA CLABSI incidence appeared to increase between 1997 and 2001, it steadily declined over the remaining study period, resulting in an overall 44.4% ($P < 0.0001$) reduction in incidence. MSSA CLABSI incidence also declined over the study period, for an overall 72.4% ($P < 0.0001$) reduction in incidence.

Conclusions: The discordance between trends in %MRSA and MRSA incidence of CLABSIs reported over the past decade of national ICU surveillance demonstrates a limitation of using %MRSA to monitor changes in the burden of MRSA hospital-associated infections.

385. Multistate Outbreak of *Serratia Marcescens* Due to Contamination of Prefilled Heparin and Saline Syringes

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Background: In November and December 2007, Centers for Disease Control and Prevention (CDC) were notified of clusters of *Serratia marcescens* (SM) bloodstream infections (BSIs) at facilities in TX and IL.

Objective: To investigate potential causes and prevent further SM BSIs.

Methods: We performed a cohort study at a facility in TX (TX site A) and conducted active case finding for other clusters of SM BSIs. Information on cases was obtained and isolates were sent to CDC. Various lots of prefilled heparin and saline syringes were sent to CDC from these facilities (TX site A, RUMC) and from the manufacturer (company X) to test for the presence of SM. SM isolates from syringes and blood

cultures were compared by pulsed-field gel electrophoresis (PFGE).

Results: Twenty-one patients at TX site A and 22 patients at RUMC developed SM BSIs in November-December, 2007. One lot of prefilled heparin syringes made by company X was associated with case status at TX site A (Relative Risk >25.8, 95% Confidence interval 3.3-202.7). This lot was also used at RUMC. Cultures of unopened heparin syringes of the common lot done by RUMC laboratory and by CDC grew SM. PFGE demonstrated that patient and syringe isolates were genetically related. Company X voluntarily recalled the contaminated lot of prefilled heparin syringes on December 19, 2007. On January 14, 2008 CDC was notified of 20 cases of SM BSIs at a different facility in TX (MDACC). Eighteen of these cases were associated with use of prefilled saline syringes made by company X. The MDACC laboratory isolated SM from an unopened saline syringe. PFGE typing demonstrated that patient and syringe isolates from this cluster were genetically related to the strain recovered from prefilled heparin syringes. On January 18, 2008 the recall was expanded to include all products made by company X. To date, we have received reports of 142 BSIs in 10 states among patients at facilities using prefilled syringes made by company X. There were 5 SM BSI-associated deaths. Ninety-one percent (67 /73) of SM patient isolates submitted to CDC from 7 states were genetically related to the outbreak strain. An FDA inspection revealed that company X was not in compliance with quality system regulations.

Conclusions: A multistate outbreak of SM BSIs was associated with intrinsic contamination of prefilled heparin and saline syringes. This outbreak may have been prevented by adherence to quality system regulations for manufacturing sterile products.