ESCMID MANAGING INFECTIONS PROMOTING SCIENCE

# ECCMID 2017
# SY052 Year in Infection Control
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Speakers:
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## References

## Traditional infection control measures to control emerging resistance and old foes (focus on hand hygiene, PPE, disinfection/cleaning…)

### Hand hygiene

1.1 Stewardson AJ, Sax H, Gayet-Ageron A, et al. Enhanced performance feedback and patient participation to improve hand hygiene compliance of health-care workers in the setting of established multimodal promotion: a single-centre, cluster randomised controlled trial. Lancet Infect Dis, 2016;16:1345-55.

BACKGROUND: Hand hygiene compliance of health-care workers remains suboptimal despite standard multimodal promotion, and evidence for the effectiveness of novel interventions is urgently needed. We aimed to assess the effect of enhanced performance feedback and patient participation on hand hygiene compliance in the setting of multimodal promotion.

METHODS: We did a single-centre, cluster randomised controlled trial at University of Geneva Hospitals (Geneva, Switzerland). All wards hosting adult, lucid patients, and all health-care workers and patients in these wards, were eligible. After a 15-month baseline period, eligible wards were assigned by computer-generated block randomisation (1:1:1), stratified by the type of ward, to one of three groups: control, enhanced performance feedback, or enhanced performance feedback plus patient participation. Standard multimodal hand hygiene promotion was done hospital-wide throughout the study. The primary outcome was hand hygiene compliance of health-care workers (according to the WHO Five Moments of Hand Hygiene) at the opportunity level, measured by direct observation (20-min sessions) by 12 validated infection control nurses, with each ward audited at least once every 3 months. This trial is registered with ISRCTN, number ISRCTN43599478.

FINDINGS: We randomly assigned 67 wards to the control group (n=21), enhanced performance feedback (n=24), or enhanced performance feedback plus patient participation (n=22) on May 19, 2010. One ward in the control group became a high-dependency unit and was excluded from analysis. During 1367 observation sessions, 12 579 hand hygiene opportunities were recorded. Between the baseline period (April 1, 2009, to June 30, 2010) and the intervention period (July 1, 2010, to June 30, 2012), mean hand hygiene compliance increased from 66% (95% CI 62-70) to 73% (70-77) in the control group (odds ratio [OR] 1·41, 95% CI 1·21-1·63), from 65% (62-69) to 75% (72-77) in the enhanced performance feedback group (1·61, 1·41-1·84), and from 66% (62-70) to 77% (74-80) in the enhanced performance feedback plus patient participation group (1·73, 1·51-1·98). The absolute difference in compliance attributable to interventions was 3 percentage points (95% CI 0-7; p=0·19) for the enhanced performance feedback group and 4 percentage points (1-8; p=0·048) for the enhanced performance feedback plus patient participation group. Hand hygiene compliance remained significantly higher than baseline in all three groups (OR 1·21 [1·00-1·47] vs 1·38 [1·19-1·60] vs 1·36 [1·18-1·57]) during the post-intervention follow-up (Jan 1, 2013, to Dec 31, 2014).

INTERPRETATION: Hand hygiene compliance improved in all study groups, and neither intervention had a clinically significant effect compared with control. Improvement in control wards might reflect cross-contamination, highlighting challenges with randomised trials of behaviour change.
FUNDING: Swiss National Science Foundation.

## 1.2 Scheithauer S, Batzer B, Dangel M, et al. Workload even affects hand hygiene in a highly trained and well-staffed setting: a prospective 365/7/24 observational study. J Hosp Infect, 2017; pii: S0195-6701(17)30110-X.

INTRODUCTION: Compliance with hand hygiene (HH) has often not proved satisfactory; high workload is a commonly self-reported reason. Previous studies comparing workload and compliance have not measured workload precisely and have focused on certain times of day. This study aimed to investigate the association between HH compliance and workload, both electronically defined 365/7/24 (primary endpoint). In addition, the quality of commonly used compliance defining methods (hand disinfectant usage, direct observation) was investigated (secondary endpoint).
MATERIALS AND METHODS: Correlation of electronically measured HH compliance (hand-rub activities (HRA)/HH opportunities) with electronically determined workload (nursing time output/nursing time input) was undertaken over one year at a stem cell transplant unit at University Hospital Basel, Switzerland. HRA and procedures requiring HRA according to the five World Health Organization indications were recorded continuously (365/7/24) using electronic dispensers and electronic documentation, and compliance was calculated accordingly. Hand disinfectant usage was calculated using spending records for one year; direct observation was performed for approximately 1800 HH opportunities.
RESULTS: During the investigation, 208,184 HRA, translating into 57 [standard deviation (SD) 10] HRA/patient-day (PD), were performed. Electronically determined compliance ranged from 24% to 66% [mean 42.39% (SD 8%)]. The higher the workload, the lower the compliance (R=-0.411; P<0.001). HRA/PD (r=-0.037), hand disinfectant usage (mean 160mL/PD) and observed compliance (95%; 1734 HRA/1813 HH opportunities) were not found to be associated with workload.
CONCLUSION: Calculated compliance was inversely associated with nurses' workload. HRA/PD, observer-determined compliance and amount of disinfectant dispensed were used as surrogates for compliance, but did not correlate with actual compliance and thus should be used with caution.

## 1.3 Stahmeyer JT, Lutze B, von Lengerke T, et al. Hand hygiene in intensive care units: a matter of time? J Hosp Infect, 2017;95:338-343.

BACKGROUND: Healthcare-associated infections are a frequent threat to patient safety and cause significant disease burden. The most important single preventive measure is hand hygiene (HH). Barriers to adherence with HH recommendations include structural aspects, knowledge gaps, and organizational issues, especially a lack of time in daily routine.
AIM: To determine the number of hand hygiene opportunities (HHOs), compliance rates, and time spent on hand hygiene in intensive care units (ICUs).
METHODS: We conducted an observational study in two ICUs to determine the average number of HHOs per patient. Documentation was based on the World Health Organization concept of 'five moments for hand hygiene'. HHOs were collected in 12 patient rooms for 12h each.
FINDINGS: On average, 134 (internal ICU) and 182 (surgical ICU) HHOs per patient were observed during the 12h observation period. Overall HH compliance was 42.6%. Considering additional HHOs during the night shift, we estimated 218 (internal ICU) and 271 (surgical ICU) HHOs per patient-day. The average duration of hand disinfection was 7.6s. The time spent on HH was 8.3 (internal ICU) and 11.1 (surgical ICU) min during the day shift for each patient for all healthcare workers (nurses: 6.9min in the internal ICU and 8.3min in the surgical ICU). If nurses fully complied with guidelines, 58.2 (internal ICU) and 69.8 (surgical ICU) min would be spent on HH for each patient during the day shift.
CONCLUSION: Complying with guidelines is time-consuming. Sufficient time for HH should be considered in staff planning.

## 1.4 Pires D, Soule H, Bellissimo-Rodrigues F, et al. Hand Hygiene With Alcohol-Based Hand Rub: How Long Is Long Enough? Infect Control Hosp Epidemiol, 2017; 7:1-6.

BACKGROUND Hand hygiene is the core element of infection prevention and control. The optimal hand-hygiene gesture, however, remains poorly defined. OBJECTIVE We aimed to evaluate the influence of hand-rubbing duration on the reduction of bacterial counts on the hands of healthcare personnel (HCP). METHODS We performed an experimental study based on the European Norm 1500. Hand rubbing was performed for 10, 15, 20, 30, 45, or 60 seconds, according to the WHO technique using 3 mL alcohol-based hand rub. Hand contamination with E. coli ATCC 10536 was followed by hand rubbing and

sampling. A generalized linear mixed model with a random effect on the subject adjusted for hand size and gender was used to analyze the reduction in bacterial counts after each hand-rubbing action. In addition, hand-rubbing durations of 15 and 30 seconds were compared to assert non-inferiority (0.6 log10). RESULTS In total, 32 HCP performed 123 trials. All durations of hand rubbing led to significant reductions in bacterial counts (P<.001). Reductions achieved after 10, 15, or 20 seconds of hand rubbing were not significantly different from those obtained after 30 seconds. The mean bacterial reduction after 15 seconds of hand rubbing was 0.11 log10 lower (95% CI, -0.46 to 0.24) than after 30 seconds, demonstrating non-inferiority. CONCLUSIONS Hand rubbing for 15 seconds was not inferior to 30 seconds in reducing bacterial counts on hands under the described experimental conditions. There was no gain in reducing bacterial counts from hand rubbing longer than 30 seconds. Further studies are needed to assess the clinical significance of our findings. Infect Control Hosp Epidemiol 2017;1-6.

## 1.5 Tschudin-Sutter S, Rotter ML, Frei R, et al. Simplifying the WHO 'how to hand rub' technique: three steps are as effective as six-results from an experimental randomized crossover trial. Clin Microbiol Infect, 2017; pii: S1198-743X(16)30664-4.

OBJECTIVES: The World Health Organization (WHO) issued guidelines on hand hygiene recommending a six-step 'how to hand rub' technique for applying alcohol-based hand rub. However, adherence to all six steps is poor. We assessed a simplified three-step technique and compared it to the conventional WHO six-step technique in terms of bacterial count reduction on healthcare workers' hands.
METHODS: Thirty-two participants were randomly assigned to clean their hands following the six-step 'how to hand rub' technique (WHO reference group) or a simplified three-step technique (intervention group). Assignments were reversed after 1 day. The degree of bacterial killing was assessed following the European norm for testing hand hygiene products. Hands were contaminated with Escherichia coli, and the mean logarithmic reduction in bacterial counts was compared between both techniques.
RESULTS: Bacterial density before hand hygiene performance did not differ between the WHO reference group (median 6.37 log10 CFU, interquartile range (IQR) 6.19-6.54) and the intervention group (median 6.34 log10 CFU, IQR 6.17-6.60, p 0.513). After hand hygiene, the logarithmic reduction factor was higher in the intervention group (median 4.45, IQR 4.04-5.15) compared to the WHO reference group (median 3.91, IQR 3.69-4.62, p 0.021).
CONCLUSIONS: The WHO six-step 'how to hand rub' technique can be simplified to a 3-step procedure based on the reduction of bacterial counts on healthcare workers' hands achieved under experimental conditions. The proposed technique is easier to perform and could improve adherence to the execution of hand hygiene action.

## 1.6 Kerbaj J, Toure Y, Soto Aladro A, et al. Smartphone text message service to foster hand hygiene compliance in health care workers. Am J Infect Control, 2017;45:234-239.

BACKGROUND: Health care-associated infections are a major worldwide public health issue. Hand hygiene is a major component in the prevention of pathogen transmission in hospitals, and hand hygiene adherence by health care workers is low in many studies. We report an intervention using text messages as reminders and feedback to improve hand hygiene adherence.
MATERIALS AND METHODS: The study is a historical comparison proof-of-concept study. Eighteen health care workers were monitored during 12 months by a radiofrequency identification system. Afterward we sent 2 types of text messages, congratulation or encouragement, and we studied the evolution of hand hygiene adherence.
RESULTS: We recorded 15,723 hand hygiene opportunities, 8,973 before intervention and 6,750 during and after the intervention. Using a multilevel logistic regression analysis, we found a significant increase in hand hygiene adherence during the intervention (odds ratio, 1.68) compared with the historical period.
DISCUSSION: Despite limitations due to the type of study, a text message encouraging personnel to be more vigilant is effective in increasing hand hygiene adherence in health care workers.
CONCLUSIONS: Text message feedback should be incorporated into multimodal approaches for improving hand hygiene compliance.

## Cleaning and disinfection/Hospital ward design

### 1.7 Anderson DJ, Chen LF, Weber DJ, et al. Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and Clostridium difficile (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study. Lancet, 2017;389:805-814.

BACKGROUND: Patients admitted to hospital can acquire multidrug-resistant organisms and Clostridium difficile from inadequately disinfected environmental surfaces. We determined the effect of three enhanced strategies for terminal room disinfection (disinfection of a room between occupying patients) on acquisition and infection due to meticillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, C difficile, and multidrug-resistant Acinetobacter.
METHODS: We did a pragmatic, cluster-randomised, crossover trial at nine hospitals in the southeastern USA. Rooms from which a patient with infection or colonisation with a target organism was discharged were terminally disinfected with one of four strategies: reference (quaternary ammonium disinfectant except for C difficile, for which bleach was used); UV (quaternary ammonium disinfectant and disinfecting ultraviolet [UV-C] light except for C difficile, for which bleach and UV-C were used); bleach; and bleach and UV-C. The next patient admitted to the targeted room was considered exposed. Every strategy was used at each hospital in four consecutive 7-month periods. We randomly assigned the sequence of strategies for each hospital (1:1:1:1). The primary outcomes were the incidence of infection or colonisation with all target organisms among exposed patients and the incidence of C difficile infection among exposed patients in the intention-to-treat population. This trial is registered with ClinicalTrials.gov, NCT01579370.
FINDINGS: 31 226 patients were exposed; 21 395 (69%) met all inclusion criteria, including 4916 in the reference group, 5178 in the UV group, 5438 in the bleach group, and 5863 in the bleach and UV group. 115 patients had the primary outcome during 22 426 exposure days in the reference group (51·3 per 10 000 exposure days). The incidence of target organisms among exposed patients was significantly lower after adding UV to standard cleaning strategies (n=76; 33·9 cases per 10 000 exposure days; relative risk [RR] 0·70, 95% CI 0·50-0·98; p=0·036). The primary outcome was not statistically lower with bleach (n=101; 41·6 cases per 10 000 exposure days; RR 0·85, 95% CI 0·69-1·04; p=0·116), or bleach and UV (n=131; 45·6 cases per 10 000 exposure days; RR 0·91, 95% CI 0·76-1·09; p=0·303) among exposed patients. Similarly, the incidence of C difficile infection among exposed patients was not changed after adding UV to cleaning with bleach (n=38 vs 36; 30·4 cases vs 31·6 cases per 10 000 exposure days; RR 1·0, 95% CI 0·57-1·75; p=0·997).
INTERPRETATION: A contaminated health-care environment is an important source for acquisition of pathogens; enhanced terminal room disinfection decreases this risk.
FUNDING: US Centers for Disease Control and Prevention.

### 1.8 Stiller A, Salm F, Bischoff P, Gastmeier P. Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. Antimicrob Resist Infect Control, 2016; 5:51.

BACKGROUND: The influence of the hospital's infrastructure on healthcare-associated colonization and infection rates has thus far infrequently been examined. In this review we examine whether healthcare facility design is a contributing factor to multifaceted infection control strategies.
METHODS: We searched PubMed/MEDLINE, EMBASE and Cochrane Central Register of Controlled Trials (CENTRAL) from 1990 to December 31st, 2015, with language restriction to English, Spanish, German and French.
RESULTS: We identified three studies investigating accessibility of the location of the antiseptic hand rub dispenser. Each of them showed a significant improvement of hand hygiene compliance or agent consumption with the implementation of accessible dispensers near the patient bed. Nine eligible studies evaluated the impact of single-patient rooms on the acquisition of healthcare-associated colonization and infections in comparison to multi-bedrooms or an open ward design. Six of these studies showed a significant benefit of single-patient bedrooms in reducing the healthcare-associated colonization and infection rate, whereas three studies found that single-patient rooms are neither a protective nor risk factor. In meta-analyses, the overall risk ratio for acquisition of healthcare-associated colonization and infection was 0.55 (95% CI: 0.41 to 0.74), for healthcare-associated colonization 0.52 (95% CI: 0.32 to 0.85) and for bacteremia 0.64 (95% CI: 0.53 to 0.76), all in favor of patient care in single-patient bedrooms.

CONCLUSION: Implementation of single-patient rooms and easily accessible hand rub dispensers located near the patient's bed are beneficial for infection control and are useful parts of a multifaceted strategy for reducing healthcare-associated colonization and infections.

## Contact precautions

### 1.9 Martin EM, Russell D, Rubin Z, et al. Elimination of Routine Contact Precautions for Endemic Methicillin-Resistant Staphylococcus aureus and Vancomycin-Resistant Enterococcus: A Retrospective Quasi-Experimental Study. Infect Control Hosp Epidemiol, 2016;37:1323-1330.

OBJECTIVE To evaluate the impact of discontinuation of contact precautions (CP) for methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococcus (VRE) and expansion of chlorhexidine gluconate (CHG) use on the health system. DESIGN Retrospective, nonrandomized, observational, quasi-experimental study. SETTING Two California hospitals. PARTICIPANTS Inpatients. METHODS We compared hospital-wide laboratory-identified clinical culture rates (as a marker of healthcare-associated infections) 1 year before and after routine CP for endemic MRSA and VRE were discontinued and CHG bathing was expanded to all units. Culture data from patients and cost data on material utilization were collected. Nursing time spent donning personal protective equipment was assessed and quantified using time-driven activity-based costing. RESULTS Average positive culture rates before and after discontinuing CP were 0.40 and 0.32 cultures/100 admissions for MRSA (P=.09), and 0.48 and 0.40 cultures/100 admissions for VRE (P=.14). When combining isolation gown and CHG costs, the health system saved $643,776 in 1 year. Before the change, 28.5% intensive care unit and 19% medicine/surgery beds were on CP for MRSA/VRE. On the basis of average room entries and donning time, estimated nursing time spent donning personal protective equipment for MRSA/VRE before the change was 45,277 hours/year (estimated cost, $4.6 million). CONCLUSION Discontinuing routine CP for endemic MRSA and VRE did not result in increased rates of MRSA or VRE after 1 year. With cost savings on materials, decreased healthcare worker time, and no concomitant increase in possible infections, elimination of routine CP may add substantial value to inpatient care delivery. Infect Control Hosp Epidemiol 2016;1-8.

### 1.10 Widmer AF, Frei R, Erb S, et al. Transmissibility of Clostridium difficile Without Contact Isolation: Results From a Prospective Observational Study With 451 Patients. Clin Infect Dis, 2017;64:393-400.

Background: Contact precautions are recommended by health authorities in Europe and the United States for patients with Clostridium difficile infection (CDI). Recently, the significance of nosocomial transmission has been challenged by screening on admission studies and whole-genome sequencing, providing evidence for an endogenous source of C. difficile. We discontinued contact precautions for patients with CDI, except for patients infected with hypervirulent ribotypes or with stool incontinence, to determine the rate of transmission.

Methods: From January 2004 to December 2013, contacts of each index case with CDI were screened for toxigenic C. difficile by culturing rectal swabs. Transmission was defined as possible if toxigenic C. difficile was detected in contacts, as probable if the identical polymerase chain reaction ribotype was identified in index–contact pairs, and as confirmed if next-generation sequencing (NGS) revealed clonality of strains.

Results: Four hundred fifty-one contacts were exposed to 279 index patients nursed in 2-to 4-bed rooms. Toxigenic C. difficile was detected in 6.0% (27/451) after a median contact time of 5 days. Identical ribotypes were identified in 6 index–contact pairs, accounting for probable transmission in 1.3% (6/451). NGS was performed for 4 of 6 pairs with identical strains, and confirmed transmission in 2 contact patients.

Conclusions: The rate of transmission of toxigenic, predominantly nonhypervirulent C. difficile, was low and no outbreaks were recorded over a 10-year period after discontinuing contact precautions for patients with CDI who were not severely incontinent and who used dedicated toilets. As contact precautions may lead to lower levels of care, their implementation needs to be balanced against the risk of nosocomial transmission.

## *C. difficile* – ongoing challenges

### 1.11 Lawes T, Lopez-Lozano JM, Nebot AC, et al. Effect of a national 4C antibiotic stewardship intervention on the clinical and molecular epidemiology of Clostridium difficile infections in a region of Scotland: a non-linear time-series analysis. Lancet Infect Dis, 2017;17:194-206.

BACKGROUND: Whereas many antibiotics increase risk of Clostridium difficile infection through dysbiosis, epidemic C difficile ribotypes characterised by multidrug resistance might depend on antibiotic selection pressures arising from population use of specific drugs. We examined the effect of a national antibiotic stewardship intervention limiting the use of 4C antibiotics (fluoroquinolones, clindamycin, co-amoxiclav, and cephalosporins) and other infection prevention and control strategies on the clinical and molecular epidemiology of C difficile infections in northeast Scotland.

METHODS: We did a non-linear time-series analysis and quasi-experimental study to explore ecological determinants of clinical burdens from C difficile infections and ribotype distributions in a health board serving 11% of the Scottish population. Study populations were adults (aged ≥16 years) registered with primary carer providers in the community (mean 455 508 inhabitants) or admitted to tertiary level, district general, or geriatric hospitals (mean 33 049 total admissions per month). A mixed persuasive-restrictive 4C antibiotic stewardship intervention was initiated in all populations on May 1, 2009. Other population-specific interventions considered included limiting indications for macrolide prescriptions, introduction of alcohol-based hand sanitiser, a national hand-hygiene campaign, national auditing and inspections of hospital environment cleanliness, and reminders to reduce inappropriate use of proton-pump inhibitors. The total effect of interventions was defined as the difference between observations and projected scenarios without intervention. Primary outcomes were prevalence density of C difficile infection per 1000 occupied bed-days in hospitals or per 100 000 inhabitant-days in the community.

FINDINGS: Between Jan 1, 1997, and Dec 31, 2012, we identified 4885 cases of hospital-onset C difficile infection among 1 289 929 admissions to study hospitals, and a further 1625 cases of community-onset C difficile infection among 455 508 adults registered in primary care. Use of 4C antibiotics was reduced by 50% in both hospitals (mean reduction 193 defined daily doses per 1000 occupied bed-days, 95% CI 45-328, p=0·008) and the community (1·85 defined daily doses per 1000 inhabitant-days, 95% CI 0·23-3·48, p=0·025) during antibiotic stewardship. Falling 4C use predicted rapid declines in multidrug-resistant ribotypes R001 and R027. Hospital-onset C difficile infection prevalence densities were associated with fluoroquinolone, third-generation cephalosporin, macrolides, and carbapenem use, exceeding hospital population specific total use thresholds. Community-onset C difficile infection prevalence density was predicted by recent hospital C difficile infection rates, introduction of mandatory surveillance in individuals older than 65 years, and primary-case use of fluoroquinolones and clindamycin exceeding total use thresholds. Compared with predictions without intervention, C difficile infection prevalence density fell by 68% (mean reduction 1·01 per 1000 occupied bed-days, 0·27-1·76, p=0·008) in hospitals and 45% (0·083, 0·045-0·121 cases per 100 000 inhabitant-days, p<0·0001) in the community, during antibiotic stewardship. We identified no significant effects from other interventions.

INTERPRETATION: Limiting population use of 4C antibiotics reduced selective pressures favouring multidrug-resistant epidemic ribotypes and was associated with substantial declines in total C difficile infections in northeast Scotland. Efforts to control C difficile through antibiotic stewardship should account for ribotype distributions and non-linear effects.

FUNDING: NHS Grampian Microbiology Endowment Fund.

### 1.12 Dingle KE, Didelot X, Quan TP, et al. Effects of control interventions on Clostridium difficile infection in England: an observational study. Lancet Infect Dis, 2017;17:411-421.

BACKGROUND: The control of Clostridium difficile infections is an international clinical challenge. The incidence of C difficile in England declined by roughly 80% after 2006, following the implementation of national control policies; we tested two hypotheses to investigate their role in this decline. First, if C difficile infection declines in England were driven by reductions in use of particular antibiotics, then incidence of C difficile infections caused by resistant isolates should decline faster than that caused by susceptible isolates across multiple genotypes. Second, if C difficile infection declines were driven by improvements in hospital infection control, then transmitted (secondary) cases should decline regardless of susceptibility.

METHODS: Regional (Oxfordshire and Leeds, UK) and national data for the incidence of C difficile infections and antimicrobial prescribing data (1998-2014) were combined with whole genome sequences from 4045 national and international C difficile isolates. Genotype (multilocus sequence type) and fluoroquinolone susceptibility were determined from whole genome sequences. The incidence of C

difficile infections caused by fluoroquinolone-resistant and fluoroquinolone-susceptible isolates was estimated with negative-binomial regression, overall and per genotype. Selection and transmission were investigated with phylogenetic analyses.
FINDINGS: National fluoroquinolone and cephalosporin prescribing correlated highly with incidence of C difficile infections (cross-correlations >0·88), by contrast with total antibiotic prescribing (cross-correlations <0·59). Regionally, C difficile decline was driven by elimination of fluoroquinolone-resistant isolates (approximately 67% of Oxfordshire infections in September, 2006, falling to approximately 3% in February, 2013; annual incidence rate ratio 0·52, 95% CI 0·48-0·56 vs fluoroquinolone-susceptible isolates: 1·02, 0·97-1·08). C difficile infections caused by fluoroquinolone-resistant isolates declined in four distinct genotypes (p<0·01). The regions of phylogenies containing fluoroquinolone-resistant isolates were short-branched and geographically structured, consistent with selection and rapid transmission. The importance of fluoroquinolone restriction over infection control was shown by significant declines in inferred secondary (transmitted) cases caused by fluoroquinolone-resistant isolates with or without hospital contact (p<0·0001) versus no change in either group of cases caused by fluoroquinolone-susceptible isolates (p>0·2).
INTERPRETATION: Restricting fluoroquinolone prescribing appears to explain the decline in incidence of C difficile infections, above other measures, in Oxfordshire and Leeds, England. Antimicrobial stewardship should be a central component of C difficile infection control programmes.
FUNDING: UK Clinical Research Collaboration (Medical Research Council, Wellcome Trust, National Institute for Health Research); NIHR Oxford Biomedical Research Centre; NIHR Health Protection Research Unit on Healthcare Associated Infection and Antimicrobial Resistance (Oxford University in partnership with Public Health England [PHE]), and on Modelling Methodology (Imperial College, London in partnership with PHE); and the Health Innovation Challenge Fund.

## Unusual outbreaks and new challenges in infection control (focusing on mycobacteria, *Candida auris)*

### 1.13 Sommerstein R, Schreiber PW, Diekema DJ, et al. Mycobacterium chimaera Outbreak Associated With Heater-Cooler Devices: Piecing the Puzzle Together. Infect Control Hosp Epidemiol, 2017;38:103-108.

An outbreak of invasive Mycobacterium chimaera infections associated with heater-cooler devices (HCDs) has now affected patients in several countries on different continents. Clinical infections are characterized by delayed diagnosis, inadequate treatment response to antimicrobial agents, and poor prognosis. Outbreak investigators found M. chimaera in HCD water circuits and air samples while HCDs were running, suggesting that transmission from the HCD to the surgical site occurs via the airborne route. New HCDs at the manufacturing site were also contaminated with M. chimaera, and recent whole-genome sequencing data suggest a point source. Some guidance on screening for M. chimaera colonization in HCD water and exhaust air is available. In contrast, reliable disinfection procedures are not well described, and it is not yet known whether eradication of M. chimaera from a contaminated HCD can be achieved. Meanwhile, strict separation of the HCD from operating room air is necessary to ensure patient safety, and these efforts may require engineering solutions. While our understanding of the causes and the extent of the M. chimaera outbreak is growing, several aspects of patient management, device handling, and risk mitigation still require clarification. Infect Control Hosp Epidemiol 2016;1-6.

### 1.14 Chand M, Lamagni T, Kranzer K, et al. Insidious Risk of Severe Mycobacterium chimaera Infection in Cardiac Surgery Patients. Clin Infect Dis. 2017;64:335-342.

BACKGROUND: An urgent UK investigation was launched to assess risk of invasive Mycobacterium chimaera infection in cardiothoracic surgery and a possible association with cardiopulmonary bypass heater-cooler units following alerts in Switzerland and The Netherlands.
METHODS: Parallel investigations were pursued: (1) identification of cardiopulmonary bypass-associated M. chimaera infection through national laboratory and hospital admissions data linkage; (2) cohort study to assess patient risk; (3) microbiological and aerobiological investigations of heater-coolers in situ and under controlled laboratory conditions; and (4) whole-genome sequencing of clinical and environmental isolates.
RESULTS: Eighteen probable cases of cardiopulmonary bypass-associated M. chimaera infection were identified; all except one occurred in adults. Patients had undergone valve replacement in 11 hospitals between 2007 and 2015, a median of 19 months prior to onset (range, 3 months to 5 years). Risk to patients increased after 2010 from <0.2 to 1.65 per 10000 person-years in 2013, a 9-fold rise for

infections within 2 years of surgery (rate ratio, 9.08 [95% CI, 1.81-87.76]). Endocarditis was the most common presentation (n = 11). To date, 9 patients have died. Investigations identified aerosol release through breaches in heater-cooler tanks. Mycobacterium chimaera and other pathogens were recovered from water and air samples. Phylogenetic analysis found close clustering of strains from probable cases. CONCLUSIONS: We identified low but escalating risk of severe M. chimaera infection associated with heater-coolers with cases in a quarter of cardiothoracic centers. Our investigations strengthen etiological evidence for the role of heater-coolers in transmission and raise the possibility of an ongoing, international point-source outbreak. Active management of heater-coolers and heightened clinical awareness are imperative given the consequences of infection.

1.15 Williamson D, Howden B, Stinear T Mycobacterium chimaera Spread from Heating and Cooling Units in Heart Surgery. N Engl J Med. 2017;376:600-602.
(No abstract available)

1.16 Lockhart SR, Etienne KA, Vallabhaneni S, Simultaneous Emergence of Multidrug-Resistant Candida auris on 3 Continents Confirmed by Whole-Genome Sequencing and Epidemiological Analyses. Clin Infect Dis. 2017;64:134-140.
BACKGROUND: *Candida auris*, a multidrug-resistant yeast that causes invasive infections, was first described in 2009 in Japan and has since been reported from several countries.
METHODS:To understand the global emergence and epidemiology of C. auris, we obtained isolates from 54 patients with *C. auris* infection from Pakistan, India, South Africa, and Venezuela during 2012-2015 and the type specimen from Japan. Patient information was available for 41 of the isolates. We conducted antifungal susceptibility testing and whole-genome sequencing (WGS).
RESULTS:Available clinical information revealed that 41% of patients had diabetes mellitus, 51% had undergone recent surgery, 73% had a central venous catheter, and 41% were receiving systemic antifungal therapy when *C. auris* was isolated. The median time from admission to infection was 19 days (interquartile range, 9-36 days), 61% of patients had bloodstream infection, and 59% died. Using stringent break points, 93% of isolates were resistant to fluconazole, 35% to amphotericin B, and 7% to echinocandins; 41% were resistant to 2 antifungal classes and 4% were resistant to 3 classes. WGS demonstrated that isolates were grouped into unique clades by geographic region. Clades were separated by thousands of single-nucleotide polymorphisms, but within each clade isolates were clonal. Different mutations in ERG11 were associated with azole resistance in each geographic clade.
CONCLUSIONS:*C. auris* is an emerging healthcare-associated pathogen associated with high mortality. Treatment options are limited, due to antifungal resistance. WGS analysis suggests nearly simultaneous, and recent, independent emergence of different clonal populations on 3 continents. Risk factors and transmission mechanisms need to be elucidated to guide control measures.

1.17 Schelenz S, Hagen F, Rhodes JL, et al. First hospital outbreak of the globally emerging Candida auris in a European hospital. Antimicrob Resist Infect Control, 2016;5:35.
BACKGROUND: Candida auris is a globally emerging multidrug resistant fungal pathogen causing nosocomial transmission. We report an ongoing outbreak of C. auris in a London cardio-thoracic center between April 2015 and July 2016. This is the first report of C. auris in Europe and the largest outbreak so far. We describe the identification, investigation and implementation of control measures.
METHODS: Data on C. auris case demographics, environmental screening, implementation of infection prevention/control measures, and antifungal susceptibility of patient isolates were prospectively recorded then analysed retrospectively. Speciation of C. auris was performed by MALDI-TOF and typing of outbreak isolates performed by amplified fragment length polymorphism (AFLP).
RESULTS: This report describes an ongoing outbreak of 50 C. auris cases over the first 16 month (April 2015 to July 2016) within a single Hospital Trust in London. A total of 44 % (n = 22/50) patients developed possible or proven C. auris infection with a candidaemia rate of 18 % (n = 9/50). Environmental sampling showed persistent presence of the yeast around bed space areas. Implementation of strict infection and prevention control measures included: isolation of cases and their contacts, wearing of personal protective clothing by health care workers, screening of patients on affected wards, skin decontamination with chlorhexidine, environmental cleaning with chorine based reagents and hydrogen peroxide vapour. Genotyping with AFLP demonstrated that C. auris isolates from the same geographic region clustered.

CONCLUSION: This ongoing outbreak with genotypically closely related C. auris highlights the importance of appropriate species identification and rapid detection of cases in order to contain hospital acquired transmission.

### 1.18 Vallabhaneni S, Kallen A, Tsay S. Investigation of the First Seven Reported Cases of Candida auris, a Globally Emerging Invasive, Multidrug-Resistant Fungus - United States, May 2013-August 2016. MMWR Morb Mortal Wkly Rep, 2016;65:1234-1237.

Candida auris, an emerging fungus that can cause invasive infections, is associated with high mortality and is often resistant to multiple antifungal drugs. C. auris was first described in 2009 after being isolated from external ear canal discharge of a patient in Japan (1). Since then, reports of C. auris infections, including bloodstream infections, have been published from several countries, including Colombia, India, Israel, Kenya, Kuwait, Pakistan, South Africa, South Korea, Venezuela, and the United Kingdom (2-7). To determine whether C. auris is present in the United States and to prepare for the possibility of transmission, CDC issued a clinical alert in June 2016 informing clinicians, laboratorians, infection control practitioners, and public health authorities about C. auris and requesting that C. auris cases be reported to state and local health departments and CDC (8). This report describes the first seven U.S. cases of C. auris infection reported to CDC as of August 31, 2016. Data from these cases suggest that transmission of C. auris might have occurred in U.S. health care facilities and demonstrate the need for attention to infection control measures to control the spread of this pathogen.

## Infection control in the age of sequencing

### 1.19 Mulvey MR, Haraoui LP, Longtin Y. Multiple Variants of Klebsiella pneumoniae Producing Carbapenemase in One Patient. N Engl J Med, 2016;375:2408-2410.

The investigation of outbreaks of Enterobacteriaceae that produce Klebsiella pneumoniae carbapenemases (KPCs) is hampered by the mobility of the blaKPC gene, which is spread by the Tn4401 transposon that carries the gene or by the plasmids that harbor the transposon, resulting in intraindividual or interindividual nonclonal dissemination.1,2 Here we report on nine organisms from a single patient that contain blaKPC-3 (with a shared nucleotide identity of 100%). Analyses were conducted as described previously.3,4

An 82-year-old man with heart failure and chronic obstructive pulmonary disease was admitted to the same hospital 21 times between 2011 and 2015, where he was most often grouped with other patients colonized or infected with KPC-producing Enterobacteriaceae (KPE). The patient received numerous courses of antibiotics (beta-lactams, vancomycin, linezolid, quinolones, aminoglycosides, and tetracyclines) for cellulitis, bacteremia, and aspiration pneumonia, none of which involved KPE…

### 1.20 Wang Y, Zhang R, Li J, et al. Comprehensive resistome analysis reveals the prevalence of NDM and MCR-1 in Chinese poultry production. Nat Microbiol, 2017;2:16260.

By 2030, the global population will be 8.5 billion, placing pressure on international poultry production, of which China is a key producer1. From April 2017, China will implement the withdrawal of colistin as a growth promoter, removing over 8,000 tonnes per year from the Chinese farming sector2. To understand the impact of banning colistin and the epidemiology of multi-drug-resistant (MDR) Escherichia coli (using blaNDM and mcr-1 as marker genes), we sampled poultry, dogs, sewage, wild birds and flies. Here, we show that mcr-1, but not blaNDM, is prevalent in hatcheries, but blaNDM quickly contaminates flocks through dogs, flies and wild birds. We also screened samples directly for resistance genes to understand the true breadth and depth of the environmental and animal resistome. Direct sample testing for blaNDM and mcr-1 in hatcheries, commercial farms, a slaughterhouse and supermarkets revealed considerably higher levels of positive samples than the blaNDM- and mcr-1-positive E. coli, indicating a substantial segment of unseen resistome-a phenomenon we have termed the 'phantom resistome'. Whole-genome sequencing identified common blaNDM-positive E. coli shared among farms, flies, dogs and farmers, providing direct evidence of carbapenem-resistant E. coli transmission and environmental contamination.

2.1 Arcilla MS, van Hattem JM, Haverkate MR, Bootsma MCJ, van Genderen PJJ, Goorhuis A et al. Import and spread of extended-spectrum β-lactamase-producing Enterobacteriaceae by international travellers (COMBAT study): a prospective, multicentre cohort study. Lancet Infect Dis. 2017;17(1):78-85. doi:http://doi.org/10.1016/S1473-3099(16)30319-X.

Background International travel contributes to the dissemination of antimicrobial resistance. We investigated the acquisition of extended-spectrum β-lactamase-producing Enterobacteriaceae (ESBL-E) during international travel, with a focus on predictive factors for acquisition, duration of colonisation, and probability of onward transmission. Methods Within the prospective, multicentre COMBAT study, 2001 Dutch travellers and 215 non-travelling household members were enrolled. Faecal samples and questionnaires on demographics, illnesses, and behaviour were collected before travel and immediately and 1, 3, 6, and 12 months after return. Samples were screened for the presence of ESBL-E. In post-travel samples, ESBL genes were sequenced and PCR with specific primers for plasmid-encoded β-lactamase enzymes TEM, SHV, and CTX-M group 1, 2, 8, 9, and 25 was used to confirm the presence of ESBL genes in follow-up samples. Multivariable regression analyses and mathematical modelling were used to identify predictors for acquisition and sustained carriage, and to determine household transmission rates. This study is registered with ClinicalTrials.gov, number NCT01676974. Findings 633 (34·3%) of 1847 travellers who were ESBL negative before travel and had available samples after return had acquired ESBL-E during international travel (95% CI 32·1–36·5), with the highest number of acquisitions being among those who travelled to southern Asia in 136 of 181 (75·1%, 95% CI 68·4–80·9). Important predictors for acquisition of ESBL-E were antibiotic use during travel (adjusted odds ratio 2·69, 95% CI 1·79–4·05), traveller's diarrhoea that persisted after return (2·31, 1·42–3·76), and pre-existing chronic bowel disease (2·10, 1·13–3·90). The median duration of colonisation after travel was 30 days (95% CI 29–33). 65 (11·3%) of 577 remained colonised at 12 months. CTX-M enzyme group 9 ESBLs were associated with a significantly increased risk of sustained carriage (median duration 75 days, 95% CI 48–102, p=0·0001). Onward transmission was found in 13 (7·7%) of 168 household members. The probability of transmitting ESBL-E to another household member was 12% (95% CI 5–18). Interpretation Acquisition and spread of ESBL-E during and after international travel was substantial and worrisome. Travellers to areas with a high risk of ESBL-E acquisition should be viewed as potential carriers of ESBL-E for up to 12 months after return. Funding Netherlands Organisation for Health Research and Development (ZonMw).

2.2 Bernasconi OJ, Kuenzli E, Pires J, Tinguely R, Carattoli A, Hatz C et al. Travelers Can Import Colistin-Resistant Enterobacteriaceae, Including Those Possessing the Plasmid-Mediated mcr-1 Gene. Antimicrob Agents Chemother. 2016;60(8):5080-4. doi:10.1128/AAC.00731-16.

Stool samples from 38 travelers returning from India were screened for extended-spectrum cephalosporin- and carbapenem-resistant Enterobacteriaceae implementing standard selective plates. Twenty-six (76.3%) people were colonized with CTX-M or DHA producers, but none of the strains was colistin resistant and/or mcr-1 positive. Nevertheless, using overnight enrichment and CHROMagar Orientation plates supplemented with colistin, four people (10.5%) were found to be colonized with colistin-resistant Escherichia coli. One cephalosporin-susceptible sequence type 10 (ST10) strain carried a 4,211-bp ISApl1-mcr-1-ISApl1 element in an IncHI2 plasmid backbone.

2.3 Bitterman R, Geffen Y, Rabino G, Eluk O, Warman S, Greenblatt AS et al. Rate of colonization of health care workers by carbapenem-resistant Enterobacteriaceae in an endemic hospital: A prospective study. Am J Infect Control. 2016;44(9):1053-4. doi:http://doi.org/10.1016/j.ajic.2016.02.027.

The role of health care workers in transmission of carbapenem-resistant Enterobacteriaceae (CRE) has not been evaluated thoroughly. We sought to determine the rate of fecal carriage of CRE among health care workers in our hospital, which is endemic for CRE (prevalence of 19 out of 800 beds and incidence of 128 out of 49,325 hospital admissions). We found no carriers among the 177 health care workers that participated in the study, suggesting that transmission does not occur through personnel gastrointestinal carriage of the bacteria.

2.4 Davey P, Marwick CA, Scott CL, Charani E, McNeil K, Brown E et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database Syst Rev. 2017(2). doi:10.1002/14651858.CD003543.pub4.

BACKGROUND: Antibiotic resistance is a major public health problem. Infections caused by multidrug-resistant bacteria are associated with prolonged hospital stay and death compared with infections caused by susceptible bacteria. Appropriate antibiotic use in hospitals should ensure effective treatment of patients with infection and reduce unnecessary prescriptions. We updated this systematic review to evaluate the impact of interventions to improve antibiotic prescribing to hospital inpatients.
OBJECTIVES: To estimate the effectiveness and safety of interventions to improve antibiotic prescribing to hospital inpatients and to investigate the effect of two intervention functions: restriction and enablement.
SEARCH METHODS: We searched the Cochrane Central Register of Controlled Trials (CENTRAL) (the Cochrane Library), MEDLINE, and Embase. We searched for additional studies using the bibliographies of included articles and personal files. The last search from which records were evaluated and any studies identified incorporated into the review was January 2015.
SELECTION CRITERIA: We included randomised controlled trials (RCTs) and non-randomised studies (NRS). We included three non-randomised study designs to measure behavioural and clinical outcomes and analyse variation in the effects: non- randomised trials (NRT), controlled before-after (CBA) studies and interrupted time series (ITS) studies. For this update we also included three additional NRS designs (case control, cohort, and qualitative studies) to identify unintended consequences. Interventions included any professional or structural interventions as defined by the Cochrane Effective Practice and Organisation of Care Group. We defined restriction as 'using rules to reduce the opportunity to engage in the target behaviour (or increase the target behaviour by reducing the opportunity to engage in competing behaviours)'. We defined enablement as 'increasing means/reducing barriers to increase capability or opportunity'. The main comparison was between intervention and no intervention.
DATA COLLECTION AND ANALYSIS: Two review authors extracted data and assessed study risk of bias. We performed meta-analysis and meta-regression of RCTs and meta-regression of ITS studies. We classified behaviour change functions for all interventions in the review, including those studies in the previously published versions. We analysed dichotomous data with a risk difference (RD). We assessed certainty of evidence with GRADE criteria.
MAIN RESULTS: This review includes 221 studies (58 RCTs, and 163 NRS). Most studies were from North America (96) or Europe (87). The remaining studies were from Asia (19), South America (8), Australia (8), and the East Asia (3). Although 62% of RCTs were at a high risk of bias, the results for the main review outcomes were similar when we restricted the analysis to studies at low risk of bias.More hospital inpatients were treated according to antibiotic prescribing policy with the intervention compared with no intervention based on 29 RCTs of predominantly enablement interventions (RD 15%, 95% confidence interval (CI) 14% to 16%; 23,394 participants; high-certainty evidence). This represents an increase from 43% to 58% .There were high levels of heterogeneity of effect size but the direction consistently favoured intervention.The duration of antibiotic treatment decreased by 1.95 days (95% CI 2.22 to 1.67; 14 RCTs; 3318 participants; high-certainty evidence) from 11.0 days. Information from non-randomised studies showed interventions to be associated with improvement in prescribing according to antibiotic policy in routine clinical practice, with 70% of interventions being hospital-wide compared with 31% for RCTs. The risk of death was similar between intervention and control groups (11% in both arms), indicating that antibiotic use can likely be reduced without adversely affecting mortality (RD 0%, 95% CI -1% to 0%; 28 RCTs; 15,827 participants; moderate-certainty evidence). Antibiotic stewardship interventions probably reduce length of stay by 1.12 days (95% CI 0.7 to 1.54 days; 15 RCTs; 3834 participants; moderate-certainty evidence). One RCT and six NRS raised concerns that restrictive interventions may lead to delay in treatment and negative professional culture because of breakdown in communication and trust between infection specialists and clinical teams (low-certainty evidence). Both enablement and restriction were independently associated with increased compliance with antibiotic policies, and enablement enhanced the effect of restrictive interventions (high-certainty evidence). Enabling interventions that included feedback were probably more effective than those that did not (moderate-certainty evidence).There was very low-certainty evidence about the effect of the interventions on reducing Clostridium difficile infections (median -48.6%, interquartile range -80.7% to -19.2%; 7 studies). This was also the case for resistant gram-negative bacteria (median -12.9%, interquartile range -35.3% to 25.2%; 11 studies) and resistant gram-positive bacteria (median -19.3%, interquartile range -50.1% to +23.1%; 9 studies). There was too much variance in microbial outcomes to reliably assess the effect of change in antibiotic use. Heterogeneity of intervention effect on prescribing outcomes. We analysed effect modifiers in 29 RCTs and 91 ITS studies. Enablement and restriction were independently associated with a larger effect size (high-certainty evidence). Feedback was included in 4 (17%) of 23 RCTs and 20 (47%) of 43 ITS studies of enabling interventions and was associated with greater

intervention effect. Enablement was included in 13 (45%) of 29 ITS studies with restrictive interventions and enhanced intervention effect.

## 2.5 de Jong E, van Oers JA, Beishuizen A, Vos P, Vermeijden WJ, Haas LE et al. Efficacy and safety of procalcitonin guidance in reducing the duration of antibiotic treatment in critically ill patients: a randomised, controlled, open-label trial. Lancet Infect Dis. 2016;16(7):819-27. doi:10.1016/S1473-3099(16)00053-0.

Background: In critically ill patients, antibiotic therapy is of great importance but long duration of treatment is associated with the development of antimicrobial resistance. Procalcitonin is a marker used to guide antibacterial therapy and reduce its duration, but data about safety of this reduction are scarce. We assessed the efficacy and safety of procalcitonin-guided antibiotic treatment in patients in intensive care units (ICUs) in a health-care system with a comparatively low use of antibiotics. Methods: We did a prospective, multicentre, randomised, controlled, open-label intervention trial in 15 hospitals in the Netherlands. Critically ill patients aged at least 18 years, admitted to the ICU, and who received their first dose of antibiotics no longer than 24 h before inclusion in the study for an assumed or proven infection were eligible to participate. Patients who received antibiotics for presumed infection were randomly assigned (1:1), using a computer-generated list, and stratified (according to treatment centre, whether infection was acquired before or during ICU stay, and dependent on severity of infection [ie, sepsis, severe sepsis, or septic shock]) to receive either procalcitonin-guided or standard-of-care antibiotic discontinuation. Both patients and investigators were aware of group assignment. In the procalcitonin-guided group, a non-binding advice to discontinue antibiotics was provided if procalcitonin concentration had decreased by 80% or more of its peak value or to 0•5 μg/L or lower. In the standard-of-care group, patients were treated according to local antibiotic protocols. Primary endpoints were antibiotic daily defined doses and duration of antibiotic treatment. All analyses were done by intention to treat. Mortality analyses were completed for all patients (intention to treat) and for patients in whom antibiotics were stopped while being on the ICU (per-protocol analysis). Safety endpoints were reinstitution of antibiotics and recurrent inflammation measured by C-reactive protein concentrations and they were measured in the population adhering to the stopping rules (per-protocol analysis). The study is registered with ClinicalTrials.gov, number NCT01139489, and was completed in August, 2014. Findings: Between Sept 18, 2009, and July 1, 2013, 1575 of the 4507 patients assessed for eligibility were randomly assigned to the procalcitonin-guided group (761) or to standard-of-care (785). In 538 patients (71%) in the procalcitonin-guided group antibiotics were discontinued in the ICU. Median consumption of antibiotics was 7•5 daily defined doses (IQR 4•0-12•7) in the procalcitonin-guided group versus 9•3 daily defined doses (5•0-16•6) in the standard-of-care group (between-group absolute difference 2•69, 95% CI 1•26-4•12, p<0•0001). Median duration of treatment was 5 days (3-9) in the procalcitonin-guided group and 7 days (4-11) in the standard-of-care group (between-group absolute difference 1•22, 0•65-1•78, p<0•0001). Mortality at 28 days was 149 (20%) of 761 patients in the procalcitonin-guided group and 196 (25%) of 785 patients in the standard-of-care group (between-group absolute difference 5•4%, 95% CI 1•2-9•5, p=0•0122) according to the intention-to-treat analysis, and 107 (20%) of 538 patients in the procalcitonin-guided group versus 121 (27%) of 457 patients in the standard-of-care group (between-group absolute difference 6•6%, 1•3-11•9, p=0•0154) in the per-protocol analysis. 1-year mortality in the per-protocol analysis was 191 (36%) of 538 patients in the procalcitonin-guided and 196 (43%) of 457 patients in the standard-of-care groups (between-group absolute difference 7•4, 1•3-13•8, p=0•0188).Interpretation: Procalcitonin guidance stimulates reduction of duration of treatment and daily defined doses in critically ill patients with a presumed bacterial infection. This reduction was associated with a significant decrease in mortality. Procalcitonin concentrations might help physicians in deciding whether or not the presumed infection is truly bacterial, leading to more adequate diagnosis and treatment, the cornerstones of antibiotic stewardship.

## 2.6 Ferdinands JM, Fry AM, Reynolds S, Petrie JG, Flannery B, Jackson ML et al. Intraseason Waning of Influenza Vaccine Protection: Evidence From the US Influenza Vaccine Effectiveness Network, 2011–2012 Through 2014–2015. Clin Infect Dis. 2017;64(5):544-50.

Background: Recent studies suggest that influenza vaccine effectiveness (VE) may wane over the course of an influenza season, leading to suboptimal VE during late influenza seasons. Methods: We examined the association between influenza VE and time since vaccination among patients ≥9 years old with medically-attended acute respiratory illness in the US Influenza Vaccine Effectiveness Network using data pooled from the 2011-12 through 2014-15 influenza seasons. We used multivariate logistic

regression with PCR-confirmed influenza infection as the outcome and vaccination status defined by days between vaccination and symptom onset as the predictor. Models were adjusted for calendar time and other potential confounding factors. Results: We observed decreasing VE with increasing time since vaccination for influenza A(H3N2) (p=0.004), influenza A(H1N1)pdm09 (p=0.01), and influenza B viruses (p=0.04). Maximum VE was observed shortly after vaccination, followed by a decline in VE of about 7% (absolute) per month for influenza A(H3N2) and influenza B and 6% - 11% per month for influenza A(H1N1)pdm09 viruses. VE remained greater than zero for at least six months for influenza A(H1N1)pdm09 and influenza B and at least five months for influenza A(H3N2) viruses. Decline in VE was more pronounced among patients with prior season influenza vaccination. A similar pattern of increasing influenza risk with increasing time since vaccination was seen in analyses limited to vaccinees. Conclusions: We observed decreasing influenza vaccine protection with increasing time since vaccination across influenza types/subtypes. This association is consistent with intraseason waning of host immunity, but bias or residual confounding could explain these findings.

## 2.7 Flannery B, Reynolds SB, Blanton L, Santibanez TA, O'Halloran A, Lu P-J et al. Influenza Vaccine Effectiveness Against Pediatric Deaths: 2010–2014. Pediatrics. 2017. Not on PubMed yet.

## 2.8 Freedberg DE, Salmasian H, Cohen B, et al. Receipt of antibiotics in hospitalized patients and risk for Clostridium difficile infection in subsequent patients who occupy the same bed. JAMA Intern Med. 2016;176:1801-8.

Objective: To assess whether receipt of antibiotics by prior hospital bed occupants is associated with increased risk for CDI in subsequent patients who occupy the same bed.
Design, Setting, and Participants: This is a retrospective cohort study of adult patients hospitalized in any 1 of 4 facilities between 2010 and 2015. Patients were excluded if they had recent CDI, developed CDI within 48 hours of admission, had inadequate follow-up time, or if their prior bed occupant was in the bed for less than 24 hours.
Main Outcomes and Measures: The primary exposure was receipt of non-CDI antibiotics by the prior bed occupant and the primary outcome was incident CDI in the subsequent patient to occupy the same bed. Incident CDI was defined as a positive result from a stool polymerase chain reaction for the C difficile toxin B gene followed by treatment for CDI. Demographics, comorbidities, laboratory data, and medication exposures are reported.
Results: Among 100 615 pairs of patients who sequentially occupied a given hospital bed, there were 576 pairs (0.57%) in which subsequent patients developed CDI. Receipt of antibiotics in prior patients was significantly associated with incident CDI in subsequent patients (log-rank P < .01). This relationship remained unchanged after adjusting for factors known to influence risk for CDI including receipt of antibiotics by the subsequent patient (adjusted hazard ratio [aHR], 1.22; 95% CI, 1.02-1.45) and also after excluding 1497 patient pairs among whom the prior patients developed CDI (aHR, 1.20; 95% CI, 1.01-1.43). Aside from antibiotics, no other factors related to the prior bed occupants were associated with increased risk for CDI in subsequent patients.
Conclusions and Relevance: Receipt of antibiotics by prior bed occupants was associated with increased risk for CDI in subsequent patients. Antibiotics can directly affect risk for CDI in patients who do not themselves receive antibiotics.

## 2.9 Giufrè M, Monaco M, Accogli M, Pantosti A, Cerquetti M, Farina C et al. Emergence of the colistin resistance mcr-1 determinant in commensal Escherichia coli from residents of long-term-care facilities in Italy. J Antimicrob Chemother. 2016;71(8):2329-31.

No abstract

## 2.10 Grundmann H, Glasner C, Albiger B, Aanensen DM, Tomlinson CT, Andrasević AT et al. Occurrence of carbapenemase-producing Klebsiella pneumoniae and Escherichia coli in the European survey of carbapenemase-producing Enterobacteriaceae (EuSCAPE): a prospective, multinational study. Lancet Infect Dis. 2017;17(2):153-63.

BACKGROUND: Gaps in the diagnostic capacity and heterogeneity of national surveillance and reporting standards in Europe make it difficult to contain carbapenemase-producing Enterobacteriaceae. We report the development of a consistent sampling framework and the results of the first structured survey on the

occurrence of carbapenemase-producing Klebsiella pneumoniae and Escherichia coli in European hospitals. METHODS: National expert laboratories recruited hospitals with diagnostic capacities, who collected the first ten carbapenem non-susceptible clinical isolates of K pneumoniae or E coli and ten susceptible same-species comparator isolates and pertinent patient and hospital information. Isolates and data were relayed back to national expert laboratories, which made laboratory-substantiated information available for central analysis. FINDINGS: Between Nov 1, 2013, and April 30, 2014, 455 sentinel hospitals in 36 countries submitted 2703 clinical isolates (2301 [85%] K pneumoniae and 402 (15%) E coli). 850 (37%) of 2301 K pneumoniae samples and 77 (19%) of 402 E coli samples were carbapenemase (KPC, NDM, OXA-48-like, or VIM) producers. The ratio of K pneumoniae to E coli was 11:1. 1•3 patients per 10 000 hospital admissions had positive clinical specimens. Prevalence differed greatly, with the highest rates in Mediterranean and Balkan countries. Carbapenemase-producing K pneumoniae isolates showed high resistance to last-line antibiotics. INTERPRETATION: This initiative shows an encouraging commitment by all participants, and suggests that challenges in the establishment of a continent-wide enhanced sentinel surveillance for carbapenemase-producing Enterobacteriaeceae can be overcome. Strengthening infection control efforts in hospitals is crucial for controlling spread through local and national health care networks. FUNDING: European Centre for Disease Prevention and Control.

## 2.11 Haverkate MR, Weiner S, Lolans K, Moore NM, Weinstein RA, Bonten MJM et al. Duration of colonization with KPC-producing bacteria at long-term acute care hospitals in Chicago, USA. Open Forum Infect Dis. 2016. doi:10.1093/ofid/ofw178.

Background. High prevalence of Klebsiella pneumoniae carbapenemase (KPC)-producing Enterobacteriaceae has been reported in long-term acute care hospitals (LTACHs), in part because of frequent readmissions of colonized patients. Knowledge of the duration of colonization with KPC is essential to identify patients at risk of KPC colonization upon readmission and to make predictions on the effects of transmission control measures. Methods. We analyzed data on surveillance isolates that were collected at 4 LTACHs in the Chicago region during a period of bundled interventions, to simultaneously estimate the duration of colonization during an LTACH admission and between LTACH (re)admissions. A maximum-likelihood method was used, taking interval-censoring into account. Results. Eighty-three percent of patients remained colonized for at least 4 weeks, which was the median duration of LTACH stay. Between LTACH admissions, the median duration of colonization was 270 days (95% confidence interval, 91-∞). Conclusions. Only 17% of LTACH patients lost colonization with KPC within 4 weeks. Approximately half of the KPC-positive patients were still carriers when readmitted after 9 months. Infection control practices should take prolonged carriage into account to limit transmission of KPCs in LTACHs.

## 2.12 Patel TS, Kaakeh R, Nagel JL, Newton DW, Stevenson JG. Cost Analysis of Implementing MALDI-TOF plus Real-time Antimicrobial Stewardship Intervention for Bloodstream Infections. J Clin Microbiol. 2016. doi:10.1128/jcm.01452-16.

Studies evaluating rapid diagnostic testing plus stewardship intervention have consistently demonstrated improved clinical outcomes for patients with bloodstream infections. However, the cost of implementing new rapid diagnostic testing can be significant, and such testing usually does not generate additional revenue. There are minimal data evaluating the impact of adding matrix-assisted laser desorption ionization–time of flight mass spectrometry (MALDI-TOF MS) for rapid organism identification and dedicating pharmacy stewardship personnel time on the total hospital costs. A cost analysis was performed utilizing patient data generated from the hospital cost accounting system and included additional costs of MALDI-TOF equipment, supplies and personnel, and dedicated pharmacist time for blood culture review and of making interventions to antimicrobial therapy. The cost analysis was performed from a hospital perspective for 3-month blocks before and after implementation of MALDI-TOF plus stewardship intervention. A total of 480 patients with bloodstream infections were included in the analysis: 247 in the pre-intervention group and 233 in the intervention group. Thirty-day mortality was significantly improved in the intervention group (12% versus 21%, $P < 0.01$), and the mean length of stay was reduced, although the difference was not statistically significant (13.0 ± 16.5 days versus 14.2 ± 16.7 days, $P = 0.44$). The total hospital cost per bloodstream infection was lower in the intervention group ($42,580 versus $45,019). Intensive care unit cost per bloodstream infection accounted for the largest share of the total costs in each group and was also lower in the intervention group ($10,833 versus $13,727). Implementing MALDI-TOF plus stewardship review and intervention decreased mortality for patients with bloodstream infections. Despite the additional costs of implementing MALDI-TOF and of

dedicating pharmacy stewardship personnel time to interventions, the total hospital costs decreased by $2,439 per bloodstream infection, for an approximate annual cost savings of $2.34 million.

## 2.13 Pollack LA, Plachouras D, Sinkowitz-Cochran R, Gruhler H, Monnet DL, Weber JT. A Concise Set of Structure and Process Indicators to Assess and Compare Antimicrobial Stewardship Programs Among EU and US Hospitals: Results From a Multinational Expert Panel. Infect Control Hosp Epidemiol. 2016;37(10):1201-11. doi:10.1017/ice.2016.115.

Objectives: To develop common indicators, relevant to both EU member states and the United States, that characterize and allow for meaningful comparison of antimicrobial stewardship programs among different countries and healthcare systems. DESIGN Modified Delphi process. PARTICIPANTS A multinational panel of 20 experts in antimicrobial stewardship. Methods: Potential indicators were rated on the perceived feasibility to implement and measure each indicator and clinical importance for optimizing appropriate antimicrobial prescribing. Results: The outcome was a set of 33 indicators developed to characterize the infrastructure and activities of hospital antimicrobial stewardship programs. Among them 17 indicators were considered essential to characterize an antimicrobial stewardship program and therefore were included in a core set of indicators. The remaining 16 indicators were considered optional indicators and included in a supplemental set. Conclusions: The integration of these indicators in public health surveillance and special studies will lead to a better understanding of best practices in antimicrobial stewardship. Additionally, future studies can explore the association of hospital antimicrobial stewardship programs to antimicrobial use and resistance.

## 2.14 Skov RL, Monnet DL. Plasmid-mediated colistin resistance (mcr-1 gene): three months later, the story unfolds. Euro Surveill. 2016;21(9):30155. doi:10.2807/1560-7917.ES.2016.21.9.30155.

Editorial- no abstract

## 2.15 van Hattem JM, Arcilla MS, Bootsma MCJ, van Genderen PJ, Goorhuis A, Grobusch MP et al. Prolonged carriage and potential onward transmission of carbapenemase-producing Enterobacteriaceae in Dutch travelers. Future Microbiol. 2016;11(7):857-64.

Aim: The aim was to study acquisition and persistence of carbapenemase-producing Enterobacteriaceae (CPE) among travelers. Materials & methods: Stools from 2001 travelers and 215 nontraveling household members, collected before and immediately post-travel as well as 1, 3, 6 and 12 months upon return, were screened for CPE. Results: Five travelers, all visiting Asia outside the Indian subcontinent, acquired CPE. One traveler persistently carried the same OXA-244 CPE up to 6 months post-travel. Three months after travel, her co-traveling spouse also became positive for this OXA-244 CPE strain, suggesting clonal transmission within this household. Conclusion: Acquisition of CPE is not restricted to travelers to the Indian subcontinent and/or to travelers seeking healthcare during travel and can persist up to at least 6 months post-travel.

## CLABSI

### 3.1 Antimicrobial-Resistant Pathogens Associated With Healthcare-Associated Infections: Summary of Data Reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2011-2014. Weiner LM, Webb AK, Limbago B, Dudeck MA, Patel J, Kallen AJ, Edwards JR, Sievert DM, Clin Infect Dis, 2016:62(10):1203-09.

**OBJECTIVE:** To describe antimicrobial resistance patterns for healthcare-associated infections (HAIs) that occurred in 2011-2014 and were reported to the Centers for Disease Control and Prevention's National Healthcare Safety Network.
**METHODS**: Data from central line-associated bloodstream infections, catheter-associated urinary tract infections, ventilator-associated pneumonias, and surgical site infections were analyzed. These HAIs were reported from acute care hospitals, long-term acute care hospitals, and inpatient rehabilitation facilities. Pooled mean proportions of pathogens that tested resistant (or nonsusceptible) to selected antimicrobials were calculated by year and HAI type.
**RESULTS:** Overall, 4,515 hospitals reported that at least 1 HAI occurred in 2011-2014. There were 408,151 pathogens from 365,490 HAIs reported to the National Healthcare Safety Network, most of which were reported from acute care hospitals with greater than 200 beds. Fifteen pathogen groups accounted for 87% of reported pathogens; the most common included Escherichia coli (15%), Staphylococcus aureus (12%), Klebsiella species (8%), and coagulase-negative staphylococci (8%). In general, the proportion of isolates with common resistance phenotypes was higher among device-associated HAIs compared with surgical site infections. Although the percent resistance for most phenotypes was similar to earlier reports, an increase in the magnitude of the resistance percentages among E. coli pathogens was noted, especially related to fluoroquinolone resistance.
**CONCLUSION:** This report represents a national summary of antimicrobial resistance among select HAIs and phenotypes. The distribution of frequent pathogens and some resistance patterns appear to have changed from 2009-2010, highlighting the need for continual, careful monitoring of these data across the spectrum of HAI types.

### 3.2 Causative Organisms and Associated Antimicrobial Resistance in Healthcare-Associated, Central Line-Associated Bloodstream Infections From Oncology Settings, 2009-2012. Freifeld AG, Magill SS. Clin Infect Dis, 2016:62(10):1203-09.

**BACKGROUND:** Recent antimicrobial resistance data are lacking from inpatient oncology settings to guide infection prophylaxis and treatment recommendations. We describe central line-associated bloodstream infection (CLABSI) pathogens and antimicrobial resistance patterns reported from oncology locations to the Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN).
**METHODS:** CLABSI data reported to NHSN from 2009 to 2012 from adult inpatient oncology locations were compared to data from nononcology adult locations within the same hospitals. Pathogen profile, antimicrobial resistance rates, and CLABSI incidence rates per 1000 central line-days were calculated. CLABSI incidence rates were compared using Poisson regression.
**RESULTS:** During 2009-2012, 4654 CLABSIs were reported to NHSN from 299 adult oncology units. The most common organisms causing CLABSI in oncology locations were coagulase-negative staphylococci (16.9%), Escherichia coli (11.8%), and Enterococcus faecium (11.4%). Fluoroquinolone resistance was more common among E. coli CLABSI in oncology than nononcology locations (56.5% vs 41.5% of isolates tested; $P < .0001$) and increased significantly from 2009-2010 to 2011-2012 (49.5% vs 60.4%; $P = .01$). Furthermore, rates of CLABSI were significantly higher in oncology compared to nononcology locations for fluoroquinolone-resistant E. coli (rate ratio, 7.37; 95% confidence interval [CI], 6.20-8.76) and vancomycin-resistant E. faecium (rate ratio, 2.27, 95% CI, 2.03-2.53). However, resistance rates for some organisms, such as Klebsiella species and Pseudomonas aeruginosa, were lower in oncology than in nononcology locations.
**CONCLUSIONS:** Antimicrobial-resistant E. coli and E. faecium have become significant pathogens in oncology. Practices for antimicrobial prophylaxis and empiric antimicrobial therapy should be regularly assessed in conjunction with contemporary antimicrobial resistance data.

## 3.3 Central Line-Associated Bloodstream Infection Reduction and Bundle Compliance in Intensive Care Units: A National Study. Furuya EY, Dick AW, Herzig CT, Pogorzelska-Maziarz M, Larson EL, Stone PW, Infect Control Hosp Epidemiol 2016;37(7):805-10.

**OBJECTIVES:** To describe compliance with the central line (CL) insertion bundle overall and with individual bundle elements in US adult intensive care units (ICUs) and to determine the relationship between bundle compliance and central line-associated bloodstream infection (CLABSI) rates. DESIGN Cross-sectional study. PARTICIPANTS National sample of adult ICUs participating in National Healthcare Safety Network (NHSN) surveillance.
**METHODS:** Hospitals were surveyed to determine compliance with CL insertion bundle elements in ICUs. Corresponding NHSN ICU CLABSI rates were obtained. Multivariate Poisson regression models were used to assess associations between CL bundle compliance and CLABSI rates, controlling for hospital and ICU characteristics.
**RESULTS:** A total of 984 adult ICUs in 632 hospitals were included. Most ICUs had CL bundle policies, but only 69% reported excellent compliance (≥95%) with at least 1 element. Lower CLABSI rates were associated with compliance with just 1 element (incidence rate ratio [IRR] 0.77; 95% confidence interval [CI], 0.64-0.92); however, ≥95% compliance with all 5 elements was associated with the greatest reduction (IRR, 0.67; 95% CI, 0.59-0.77). There was no association between CLABSI rates and simply having a written CL bundle policy nor with bundle compliance <75%. Additionally, better-resourced infection prevention departments were associated with lower CLABSI rates.
**CONCLUSIONS:** Our findings demonstrate the impact of transferring infection prevention interventions to the real-world setting. Compliance with the entire bundle was most effective, although excellent compliance with even 1 bundle element was associated with lower CLABSI rates. The variability in compliance across ICUs suggests that, at the national level, there is still room for improvement in CLABSI reduction. Infect Control Hosp Epidemiol 2016;37:805-810.

## 3.4 Impregnated central venous catheters for prevention of bloodstream infection in children (the CATCH trial): a randomised controlled trial. Gilbert RE, Mok Q, Dwan K, Harron K, Moitt T, Millar M, Ramnarayan P, Tibby SM, Hughes D, Gamble C for the CATCH trial investigators, Lancet 2016;387:1732-42

**BACKGROUND:** Impregnated central venous catheters are recommended for adults to reduce bloodstream infections but not for children because there is not enough evidence to prove they are effective. We aimed to assess the effectiveness of any type of impregnation (antibiotic or heparin) compared with standard central venous catheters to prevent bloodstream infections in children needing intensive care.
**METHODS:** We did a randomised controlled trial of children admitted to 14 English paediatric intensive care units. Children younger than 16 years were eligible if they were admitted or being prepared for admission to a participating paediatric intensive care unit and were expected to need a central venous catheter for 3 or more days. Children were randomly assigned (1:1:1) to receive a central venous catheter impregnated with antibiotics, a central venous catheter impregnated with heparin, or a standard central venous catheter with computer generated randomisation in blocks of three and six, stratified by method of consent, site, and envelope storage location within the site. The clinician responsible for inserting the central venous catheter was not masked to allocation, but allocation was concealed from patients, their parents, and the paediatric intensive care unit personnel responsible for their care. The primary outcome was time to first bloodstream infection between 48 h after randomisation and 48 h after central venous catheter removal with impregnated (antibiotic or heparin) versus standard central venous catheters, assessed in the intention-to-treat population. Safety analyses compared central venous catheter-related adverse events in the subset of children for whom central venous catheter insertion was attempted (per-protocol population). This trial is registered with ISRCTN number, ISRCTN34884569.
**FINDINGS:** Between Nov 25, 2010, and Nov 30, 2012, 1485 children were recruited to this study. We randomly assigned 502 children to receive standard central venous catheters, 486 to receive antibiotic-impregnated catheters, and 497 to receive heparin-impregnated catheters. Bloodstream infection occurred in 18 (4%) of those in the standard catheters group, 7 (1%) in the antibiotic-impregnated group, and 17 (3%) assigned to heparin-impregnated catheters. Primary analyses showed no effect of impregnated (antibiotic or heparin) catheters compared with standard central venous catheters (hazard ratio [HR] for time to first bloodstream infection 0.71, 95% CI 0.37-1.34). Secondary analyses showed that antibiotic central venous catheters were better than standard central venous catheters (HR 0.43, 0.20-0.96) and heparin central venous catheters (HR 0.42, 0.19-0.93), but heparin did not differ from standard central venous catheters (HR 1.04, 0.53-2.03). Clinically important and statistically significant absolute risk differences were identified only for antibiotic-impregnated catheters versus standard catheters (-

2.15%, 95% CI -4.09 to -0.20; number needed to treat [NNT] 47, 95% CI 25-500) and antibiotic-impregnated catheters versus heparin-impregnated catheters (-1.98%, -3.90 to -0.06, NNT 51, 26-1667). Nine children (2%) in the standard central venous catheter group, 14 (3%) in the antibiotic-impregnated group, and 8 (2%) in the heparin-impregnated group had catheter-related adverse events. 45 (8%) in the standard group, 35 (8%) antibiotic-impregnated group, and 29 (6%) in the heparin-impregnated group died during the study.
**INTERPRETATION:** Antibiotic-impregnated central venous catheters significantly reduced the risk of bloodstream infections compared with standard and heparin central venous catheters. Widespread use of antibiotic-impregnated central venous catheters could help prevent bloodstream infections in paediatric intensive care units.

## 3.5 Generalisability and Cost-Impact of Antibiotic-Impregnated Central Venous Catheters for Reducing Risk of Bloodstream Infection in Paediatric Intensive Care Units in England. Harron K, Mok Q, Hughes D, Muller-Pebody B, Parslow R, Ramnarayan P, PLOS ONE 2016;11(3):e0151348.

**BACKGROUND:** We determined the generalisability and cost-impact of adopting antibiotic-impregnated CVCs in all paediatric intensive care units (PICUs) in England, based on results from a large randomised controlled trial (the CATCH trial; ISRCTN34884569).
**METHODS:** BSI rates using standard CVCs were estimated through linkage of national PICU audit data (PICANet) with laboratory surveillance data. We estimated the number of BSI averted if PICUs switched from standard to antibiotic-impregnated CVCs by applying the CATCH trial rate-ratio (0.40; 95% CI 0.17,0.97) to the BSI rate using standard CVCs. The value of healthcare resources made available by averting one BSI as estimated from the trial economic analysis was £10,975; 95% CI -£2,801,£24,751.
**RESULTS:** The BSI rate using standard CVCs was 4.58 (95% CI 4.42,4.74) per 1000 CVC-days in 2012. Applying the rate-ratio gave 232 BSI averted using antibiotic CVCs. The additional cost of purchasing antibiotic-impregnated compared with standard CVCs was £36 for each child, corresponding to additional costs of £317,916 for an estimated 8831 CVCs required in PICUs in 2012. Based on 2012 BSI rates, management of BSI in PICUs cost £2.5 million annually (95% uncertainty interval: -£160,986, £5,603,005). The additional cost of antibiotic CVCs would be less than the value of resources associated with managing BSI in PICUs with standard BSI rates >1.2 per 1000 CVC-days.
**CONCLUSIONS:** The cost of introducing antibiotic-impregnated CVCs is less than the cost associated with managing BSIs occurring with standard CVCs. The long-term benefits of preventing BSI could mean that antibiotic CVCs are cost-effective even in PICUs with extremely low BSI rates.

## 3.6 Chlorhexidine-impregnated transparent dressings decrease catheter-related infections in hemodialysis patients: a quality improvement project. Apata IW, Hanfelt J, Bailey JL, Niyyar VD, J Vasc Access 2017;18(2):103-8.

**PURPOSE:** Central venous catheters (CVC) are associated with increased infection rates, morbidity and mortality compared to other hemodialysis vascular access. Chlorhexidine-impregnated transparent (CHG-transparent) dressings allow for continuous antimicrobial exposure and easy visibility of the CVC insertion site. We conducted a quality improvement project to compare catheter-related infection (CRI) rates in two dressing regimens - CHG-transparent dressings and adhesive dry gauze dressing in hemodialysis patients with tunneled CVCs.
**METHODS:** The study was conducted in two phases. In phase 1, CHG-transparent dressing was introduced to EDC hemodialysis unit, while EDG and EDN hemodialysis units, served as the control sites and maintained adhesive dry gauze dressing. Phase 2 of the study involved replacing the adhesive dry gauze dressing with CHG-transparent dressing at EDG and EDN and maintaining CHG-transparent dressing at EDC. CRI rates at each hemodialysis unit during the 12-month intervention were compared to CRI rates for the 12-month pre-intervention period for each study phase. CRI rates were also compared between all three hemodialysis units.
**RESULTS:** In phase 1, CRI rates (per 1000 days) in EDC (intervention site) decreased by 52% (1.69 vs. 0.82, $p<0.05$) and increased by 12% (1.80 vs. 2.02, $p = 0.75$) at EDG, and 35% (0.91 vs. 1.23, $p = 0.40$) at EDN. In phase 2, CRI rates at EDG and EDN (intervention sites) decreased by 86% (1.86 vs. 0.26 $p<0.05$), and 53% (1.89 vs. 0.88, $p<0.05$), respectively, and decreased by 20% at EDC (0.73 vs. 0.58, $p = 0.65$).
**CONCLUSIONS:** Replacing adhesive dry gauze dressing with CHG-transparent dressing for hemodialysis patients with tunneled CVC was associated with decreased CRI rates.

## VAP

### 3.7 Tapered-cuff Endotracheal Tube Does Not Prevent Early Postoperative Pneumonia Compared with Spherical-cuff Endotracheal Tube after Major Vascular Surgery. Monsel A, Lu Q, Le Corre M, Brisson H, Arbelot C, Vezinet C, Fléron MH, Ibanez-Estève C, Zerimech F, Balduyck M, Dexheimer F, Wang C, Langeron O, Rouby JJ, Bodin L, Deransy R, Garçon P, Douiri H, Khalifa I, Pons A, Gu WJ, Koskas F, Gaudric J; TETRIS Study Group, Anesthesiol 2016;124:1041-52.

**BACKGROUND:** Patients undergoing major vascular surgery often develop postoperative pneumonia that impacts their outcomes. Conflicting data exist concerning the potential benefit of tapered-shaped cuffs on tracheal sealing. The primary objective of this study was to assess the efficiency of a polyvinyl chloride tapered-cuff endotracheal tube at reducing the postoperative pneumonia rate after major vascular surgery. Secondary objectives were to determine its impact on microaspiration, ventilator-associated pneumonia rate, and inner cuff pressure.

**METHODS:** This prospective randomized controlled study included 109 patients who were randomly assigned to receive either spherical- (standard cuff) or taper-shaped (tapered cuff) endotracheal tubes inserted after anesthesia induction and then admitted to the intensive care unit after major vascular surgery. Cuff pressure was continuously recorded over 5 h. Pepsin and α-amylase concentrations in tracheal aspirates were quantified on postoperative days 1 and 2. The primary outcome was the early postoperative pneumonia frequency.

**RESULTS:** Comparing the tapered-cuff with standard-cuff group, respectively, postoperative pneumonia rates were comparable (42 vs. 44%, P = 0.87) and the percentage (interquartile range) of cuff-pressure time with overinflation was significantly higher (16.1% [1.5 to 50] vs. 0.6% [0 to 8.3], P = 0.01), with a 2.5-fold higher coefficient of variation (20.2 [10.6 to 29.4] vs. 7.6 [6.2 to 10.2], P < 0.001). Although microaspiration frequencies were high, they did not differ between groups.

**CONCLUSION:** For major vascular surgery patients, polyvinyl chloride tapered-cuff endotracheal tubes with intermittent cuff-pressure control did not lower the early postoperative pneumonia frequency and did not prevent microaspiration.

### 3.8 Low Efficacy of Antibiotics against Staphylococcus aureus Airway Colonization in Ventilated Patients. Stulik L, Hudcova J, Craven DE, Nagy G, Nagy E, Clin Infect Dis 2017;64(8):1081-8.

**Background:** Airway-colonization by ***Staphylococcus aureus*** predisposes to the development of ventilator-associated tracheobronchitis (VAT) and ventilator-associated pneumonia (VAP). Despite extensive antibiotic treatment of intensive care unit patients, limited data are available on the efficacy of antibiotics on bacterial airway colonization and/or prevention of infections. Therefore, microbiologic responses to antibiotic treatment were evaluated in ventilated patients.

**Methods:** Results of semiquantitative analyses of ***S. aureus*** burden in serial endotracheal-aspirate (ETA) samples and VAT/VAP diagnosis were correlated to antibiotic treatment. Minimum inhibitory concentrations of relevant antibiotics using serially collected isolates were evaluated.

**Results:** Forty-eight mechanically ventilated patients who were ***S. aureus*** positive by ETA samples and treated with relevant antibiotics for at least 2 consecutive days were included in the study. Vancomycin failed to reduce methicillin-resistant ***S. aureus*** (MRSA) or methicillin-susceptible ***S. aureus*** (MSSA) burden in the airways. Oxacillin was ineffective for MSSA colonization in approximately 30% of the patients, and responders were typically coadministered additional antibiotics. Despite antibiotic exposure, 15 of the 39 patients (approximately 38%) colonized only by ***S. aureus*** and treated with appropriate antibiotic for at least 2 days still progressed to VAP. Importantly, no change in antibiotic susceptibility of ***S. aureus*** isolates was observed during treatment. ***Staphylococcus aureus*** colonization levels inversely correlated with the presence of normal respiratory flora.

**Conclusions:** Antibiotic treatment is ineffective in reducing ***S. aureus*** colonization in the lower airways and preventing VAT or VAP. ***Staphylococcus aureus*** is in competition for colonization with the normal respiratory flora. To improve patient outcomes, alternatives to antibiotics are urgently needed.

### 3.9 "Bundle" Practices and Ventilator-Associated Events: Not Enough, O'Horo JC, Lan H, Thongprayoon C, Schenck L, Ahmed A, Dziadzko M. Infect Control Hosp Epidemiol 2016; 37(12)1453-57.

**OBJECTIVE**: Ventilator-associated events (VAEs) are nosocomial events correlated with length of stay, costs, and mortality. Current ventilator bundle practices target the older definition of ventilator-associated pneumonia and have not been systematically evaluated for their impact on VAEs.
**DESIGN**: Retrospective cohort study.
**SETTING**: Tertiary medical center between January 2012 and August 2014.
**PARTICIPANTS**: All adult patients ventilated for at least 24 hours at our institution.
**INTERVENTIONS:** We conducted univariate analyses for compliance with each element; we focused on VAEs occurring within a 2-day window of failure to meet any ventilator bundle element. We used Cox proportional hazard models to assess the effect of stress ulcer prophylaxis, deep vein thrombosis (DVT) prophylaxis, oral care, and sedation breaks on VAEs. We adjusted models for gender, age, and Acute Physiology and Chronic Health Evaluation (APACHE) III scores.
**RESULTS:** Our cohort comprised 2,660 patients with 16,858 ventilator days and 77 VAEs. Adjusting for APACHE score and gender, only oral care was associated with a reduction in the risk of VAE (hazard ratio [HR], 0.44; 95% confidence interval [CI], 0.26-0.77). The DVT prophylaxis and sedation breaks did not show any significant impact on VAEs. Stress ulcer prophylaxis trended toward an increased risk of VAE (HR, 1.59; 95% CI, 1.00-2.56).
**CONCLUSION:** Although limited by a low baseline rate of VAEs, existing ventilator bundle practices do not appear to target VAEs well. Oral care is clearly important, but the impact of DVT prophylaxis, sedation breaks, and especially stress ulcer prophylaxis are questionable at best.

### 3.10 The effects of oral rinse with 0.2% and 2% chlorhexidine on oropharyngeal colonization and ventilator associated pneumonia in adults' intensive care units. Zand F, Zahed L, Mansouri P, Dehghanrad F, Bahrani M, Ghorbani M, J Crit Care 2017 March 1.

**BACKGROUND:** Ventilator Associated Pneumonia (VAP) is the most common nosocomial infection in Intensive Care Units (ICUs) which increases the length of ICU stay, duration of mechanical ventilation, and mortality. The present study used an oral care protocol and compared the effects of two different concentrations of chlorhexidine on reduction of oropharyngeal colonization and VAP.
**MATERIALS AND METHODS:** This study was performed on 114 patients from trauma, surgery, neurosurgery, and general ICUs randomly allocated to two groups under oral care with 0.2% and 2% chlorhexidine solution. A multidisciplinary team approved the oral care protocol. Data was collected using a demographic information form, APACHE IV form, Beck oral assessment scale, mucosal-plaque assessment scale, and oropharyngeal swab culture.
**RESULTS:** The results showed a significant reduction in VAP (p=0.007) and oropharyngeal colonization (p=0.007) in the group under oral care with 2% chlorhexidine solution compared with the other group. However, no significant difference was found between the two groups in terms of oropharyngeal adverse effects (p=0.361).
**CONCLUSION:** Oral decontamination with 2% compared to 0.2% chlorhexidine is a more effective method in the prevention of VAP and reduction of oropharyngeal colonization (especially gram-positive).

## SSI

### 3.11 Timing of surgical antimicrobial prophylaxis: a phase 3 randomised controlled trial. Weber WP, Mujagic E, Zwahlen M, Bundi M, Hoffmann H, Soysal SD, Kraljević M, Delko T, von Strauss M, Iselin L, Da Silva RX, Zeindler J, Rosenthal R, Misteli H, Kindler C, Müller P, Saccilotto R, Lugli AK, Kaufmann M, Gürke L, Oertli D, Bucheli-Laffer E, Landin J, Widmer AF, Fux CA, Marti WR, Lance Infect Dis 2017 April 3.

**BACKGROUND:** Based on observational studies, administration of surgical antimicrobial prophylaxis (SAP) for the prevention of surgical site infection (SSI) is recommended within 60 min before incision. However, the precise optimum timing is unknown. This trial compared early versus late administration of SAP before surgery.
**METHODS:** In this phase 3 randomised controlled superiority trial, we included general surgery adult inpatients (age ≥18 years) at two Swiss hospitals in Basel and Aarau. Patients were randomised centrally and stratified by hospital according to a pre-existing computer-generated list in a 1:1 ratio to receive SAP early in the anaesthesia room or late in the operating room. Patients and the outcome assessment team were blinded to group assignment. SAP consisted of single-shot, intravenous infusion of 1·5 g of cefuroxime, a commonly used cephalosporin with a short half-life, over 2-5 min (combined with 500 mg metronidazole in colorectal surgery). The primary endpoint was the occurrence of SSI within 30 days of

surgery. The main analyses were by intention to treat. The trial is registered with ClinicalTrials.gov, number NCT01790529.
**FINDINGS:** Between Feb 21, 2013, and Aug 3, 2015, 5580 patients were randomly assigned to receive SAP early (2798 patients) or late (2782 patients). 5175 patients (2589 in the early group and 2586 in the late group) were analysed. Median administration time was 42 min before incision in the early group (IQR 30-55) and 16 min before incision in the late group (IQR 10-25). Inpatient follow-up rate was 100% (5175 of 5175 patients); outpatient 30-day follow-up rate was 88·8% (4596 of 5175), with an overall SSI rate of 5·1% (234 of 4596). Early administration of SAP did not significantly reduce the risk of SSI compared with late administration (odds ratio 0·93, 95% CI 0·72-1·21, p=0·601).
**INTERPRETATION:** Our findings do not support any narrowing of the 60-min window for the administration of a cephalosporin with a short half-life, thereby obviating the need for increasingly challenging SAP timing recommendations.

## SSI

### 3.12 Comparison of Sterile vs. Nonsterile Gloves in Cutaneous Surgery and Common Outpatient Dental Procedures: A Systematic Review and Meta-analysis. Brewer JD, Gonzalez AB, Baum CL, Arpey CJ, Roenigk RK, Otley CC, Erwin PJ, JAMA Dermatology 2016;152(9):1008-1014

**IMPORTANCE:** Whether the use of sterile vs nonsterile gloves in outpatient cutaneous procedures affects the rate of postoperative wound infection is unknown.
**OBJECTIVE:** To explore rates of surgical site infection (SSI) with the use of sterile vs nonsterile gloves in outpatient cutaneous surgical procedures.
**DATA SOURCES:** This systematic review and meta-analysis identified studies from Ovid MEDLINE (1946 to present), Ovid Cochrane Central Register of Controlled Trials (1991 to present), Ovid EMBASE (1988 to present), EBSCO Cumulative Index to Nursing and Allied Health Literature (1980 to present), Scopus (1996 to present), and Web of Science (1975 to present).
**STUDY SELECTION:** Studies with information on sterile vs nonsterile gloves in outpatient surgical procedures were retrieved. Only randomized clinical trials and comparative studies were included for final analysis.
**DATA EXTRACTION:** Data of trial design, surgery characteristics, and outcomes from published manuscripts and unpublished data were independently extracted.
**MAIN OUTCOMES AND MEASURES:** Randomized clinical trials were considered high quality if randomization, allocation concealment, blinding, and follow-up completeness were appropriate. Relative risk and 95% CIs were derived for postoperative wound infections.
**RESULTS:** Fourteen articles met eligibility and inclusion criteria for systematic review; they included 12 275 unique patients who had undergone 12 275 unique outpatient procedures with sterile or nonsterile gloves and had follow-up regarding SSI. With the exclusion of 1 single-arm observational study of 1204 patients, 11 071 patients from 13 studies remained in the meta-analysis. Of these, 228 patients were documented as having postoperative SSI (2.1%), including 107 of 5031 patients in the nonsterile glove group (2.1%) and 121 of 6040 patients in the sterile glove group (2.0%). Overall relative risk for SSI with nonsterile glove use was 1.06 (95% CI, 0.81-1.39).
**CONCLUSIONS AND RELEVANCE:** No difference was found in the rate of postoperative SSI between outpatient surgical procedures performed with sterile vs nonsterile gloves.

## CAUTI

### 3.13 National survey of practices to prevent health care-associated infections in Thailand: The role of prevention bundles. Apisarnthanarak A, Ratz D, Greene MT, Khawcharoenporn T, Weber DJ, Saint S, Am J Infect Control 2017 Feb 28.

**BACKGROUND:** We evaluated the practices used in Thai hospitals to prevent catheter-associated urinary tract infection (CAUTI), central line-associated bloodstream infection (CLABSI), and ventilator-associated pneumonia (VAP).
**METHODS:** From January 1, 2014-November 30, 2014, we surveyed all Thai hospitals with an intensive care unit and at least 250 beds. The use of prevention practices for CAUTI, CLABSI, and VAP was assessed. High compliance (≥75%) with all components of the CLABSI and VAP prevention bundles were determined. CAUTI, CLABSI, and VAP infection rates before and after implementing infection control practices are reported. Multivariable regression was used to examine associations between infection prevention bundle compliance and infection rate changes.

**RESULTS:** Out of 245 eligible hospitals, 212 (86.5%) responded. A total of 120 (56.6%) and 115 hospitals (54.2%) reported ≥75% compliance for all components of the CLABSI and VAP prevention bundles, respectively, and 91 hospitals (42.9%) reported using ≥ 4 recommended CAUTI-prevention practices. High compliance with all of the CLABSI and VAP bundle components was associated with significant infection rate reductions (CLABSI, 38.3%; P < .001; VAP, 32.0%; P < .001). Hospitals regularly using ≥ 4 CAUTI-prevention practices did not have greater reductions in CAUTI (0.02%; P = .99).
**CONCLUSIONS:** Compliance with practices to prevent hospital infections was suboptimal. Policies and interventions promoting bundled approaches may help reduce hospital infections for Thai hospitals.

## OTHER: STETHOSCOPE

### 3.14 Predictors of Heavy Stethoscope Contamination Following a Physical Examination. Tschopp C, Schneider A, Longtin Y, Renzi G, Schrenzel J, Pittet D, Infect Control Hosp Epidemiol 2016;37(6):673-9.

**BACKGROUND:** The degree of bacterial contamination of stethoscopes can vary significantly following a physical examination.
**OBJECTIVE:** To conduct a prospective study to investigate the impact of various environmental and patient characteristics on stethoscope contamination.
**METHODS:** Following a standardized examination, the levels of bacterial contamination of 4 regions of the physicians' hands and 2 sections of the stethoscopes, and the presence of different pathogenic bacteria, were assessed. Predictors of heavy stethoscope contamination were identified through multivariate logistic regression.
**RESULTS:** In total, 392 surfaces were sampled following examination of 56 patients. The microorganisms most frequently recovered from hands and stethoscopes were Enterococcus spp. (29% and 20%, respectively) and Enterobacteriaceae (16% and 7%, respectively). Staphylococcus aureus (either methicillin susceptible or resistant), extended-spectrum β-lactamase-producing Enterobacteriaceae, and Acinetobacter baumannii were recovered from 4%-9% of the samples from either hands or stethoscopes. There was a correlation between the likelihood of recovering these pathogens from the stethoscopes vs from the physicians' hands (ρ=0.79; P=.04). The level of patient's skin contamination was an independent predictor of contamination of the stethoscope diaphragm (adjusted odds ratio [aOR], 1.001; P=.007) and tube (aOR, 1.001; P=.003). Male sex (aOR, 28.24; P=.01) and reception of a bed bath (aOR, 7.52; P=.048) were also independently associated with heavy tube contamination.
**CONCLUSIONS:** Stethoscope contamination following a single physical examination is not negligible and is associated with the level of contamination of the patient's skin. Prevention of pathogen dissemination is needed.

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