Table B.35: MDRO, Surveillance—Single Studies

Note: Full references are available in the [Section 5.3 reference list](#Section5point3refs).

| Author, Year | Description of Patient Safety Practice | Study Design; Sample Size; Patient  Population | Setting | Outcomes: Benefits | Outcomes: Harms | Implementation Themes/Findings | Risk of Bias (High,  Moderate, Low) | Comments |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ahern & Alston, 200958** | Longitudinal surveillance data to assess the impact of infection control interventions and antibiotic use. Implementation of a resistance index.  The surveillance system was used to measure associations of multiple interventions on health care-associated infection (HAI) rates. Only isolates recovered more than 48 hours after hospital admission are included. | Descriptive implementation case study that examined two 4-year periods before and after implementation of the interventions.  The resistance index (a measure of nosocomial infection and colonization) and the rate of antimicrobial use were compared using the Poisson distribution. Two-sided p values of less than 0.05 were considered to be statistically significant. | 562-bed academic medical center, United States  Hospital with a 26- bed surgical ICU (SICU) and 22-bed medical ICU (MICU), each with a five-bed open ward, and a four-bed pediatric ICU in the SICU | The resistance index was developed to quantify nosocomial infection and colonization. The index, calculated monthly, consists of a numerator of the number of nosocomial isolates and a denominator of the number of patient-days for each nursing unit and for the hospital.  Surveillance data suggest that infection control initiatives successfully reversed an upward trend in the six study MDROs, despite increasing antibiotic use. During the pre-intervention period, the resistance index was increasing in both units. The overall resistance index decreased in both units during the post-intervention period. The overall rate of antimicrobial use in the SICU was higher during the post-intervention period than during the pre-intervention period (366 vs. 352 defined daily doses per 1,000 patient-days; p<0.01). The overall rate of antimicrobial use in the MICU was higher during the post-intervention period than during the pre-intervention period (603 vs. 436 defined daily doses per 1,000 patient-days). | None assessed. | The paper describes a surveillance method to measure associations between multicomponent intervention and HAI rates. Keeping track of MDRO isolates over time and between different units allows hospitals to evaluate the effectiveness of their infection control protocols and to show reduction in MDROs despite increased rates of antibiotic prescription. | Moderate to high  Authors did not differentiate between infection and colonization. Also, unable to determine which infection control strategy was most effective.  The resistance index database required 8–12 hours of maintenance per month. | Organisms/ Outcomes  MRSA, *C. difficile,* VRE*, P. aeruginosa,* MDR-GNB *Stentro-phomonas matlophilia*  *Infections related to these six pathogens* |
| **Almyroudis et al., 201621** | Discontinuation of systematic surveillance (weekly perianal swabs) for VRE and contact isolation of colonized patients on the incidence of VRE bacteremia | Pre-post study (comparing two 3-year periods) to assess the incidence of VRE bacteremia and the incidence of bacteremia due to MRSA and *C. difficile* | 125-bed hospital hematology/ oncology unit with high prevalence of VRE coloniza-tion, United States | The incidence of VRE bacteremia remained stable after discontinuation of VRE surveillance and contact precautions (reduction of 2.32 to 1.87 per 1,000 patient-days; p>0.05). The use of levofloxacin prophylaxis during neutropenia and daily chlorhexidine bathing had no effect on the incidence of VRE bacteremia (p>0.05). The incidence of MRSA bacteremia and *C. difficile* infection for which the facility continued contact precautions also remained stable. Aggregated antibiotic utilization and nursing hours per patient-days were similar between the two study periods.  Antibiotic use also remained stable during the two periods (p>0.05, not significant). Nursing hours per patient per day decreased from 13.99 during the control period to 12.86 during the second period (p>0.05, not significant). | None assessed. | The authors found that MRSA bacteremia, *C. difficile* infection, and VRE bacteremia rates remained stable after discontinuation of an active surveillance and contact isolation protocol. Active surveillance and contact precautions for VRE colonization did not appear to prevent VRE bacteremia in patients with hematologic malignancies and recipients of hematopoietic stem cell transplantation with high prevalence of VRE. Based on the inefficiency of the contact isolation and the molecular epidemiology data, a decision was made to discontinue the systematic surveillance for VRE and contact isolation of colonized patients. | Moderate | Organism/ Outcomes:  VRE, MRSA, *C. difficile*  Colonization, bacteremia due to MRSA or VRE, *C. difficile* infection (CDI) |
| **Banach et al., 201423** | Active surveillance for carbapenem-resistant Enterobacteriaceae (CRE) using stool samples collected for CDI | Pre-post study for two hospitals. Before the study period, hospital A performed active surveillance for CRE among patients on high-risk units using perianal swab sampling at admission and weekly thereafter. There was no active surveillance program at hospital B prior to the intervention.  Nested case-control study design was used to identify risk factors for CRE. | Two large academic hospitals, United States | CRE was isolated from 27 (2.6%) of 1,047 specimens. CRE prevalence was 2.9% (25/854 unique patients), with 4.0% (11/272 patients) at hospital A and 2.4% (14/582 patients) at hospital B (p=0.18). Among patients with CRE-positive samples, 10 (40%) had been previously identified as carriers (64% at hospital A, 21% at hospital B). CRE isolates included *Klebsiella pneumoniae* (n=23), *K. oxytoca* (n=1), and *Enterobacter cloacae* (n = 1). The KPC gene was detected in 21 (84%) isolates and 21 (91%) *K. pneumoniae* isolates. CRE-colonized patients were older (median age, 66 vs. 59 years; p=0.05). Rates of CRE positivity did not differ by negative and positive *C. difficile* tests (2/90 [2.2%] and 25/955 [2.6%], respectively; p=0.82) or by patient sex (p=0.97). Bivariate analyses of case-control study data identified characteristics associated with colonization: length of stay >1 week (p=0.04), admission from a skilled nursing facility (p=0.01), percutaneous tube feeding (p<0.01), prior ICU admission (p<0.01), and mechanical ventilation (p=0.01). | This intervention may not be as cost-effective in hospitals with lower prevalence of CRE (more testing required to identify an unrecognized case).  Also does not include patients who are not displaying signs ofCDI (and thus would not have a stool sample collected). | CRE colonization and CDI share risk factors. In this study, active surveillance for CRE using stool specimens submitted for *C. difficile* testing detected previously unrecognized CRE carriage. Although not comprehensive, this active surveillance strategy may be of value because of its convenience and relative low cost.  The estimated average cost of surveillance testing was $8.53 per specimen, including technical support and supplies but not molecular testing. At the study prevalence, 76 and 68 specimens had to be tested at hospitals A and B, respectively, in order to identify one previously undetected CRE carrier. Total cost of detecting one CRE-colonized patient ranged from $580 (hospital B) to $649 (hospital A). | Low to  moderate | Organisms/ Outcomes:  CRE, *C. difficile* (as a risk factor) |
| **Barbadoro et al., 201711** | Active surveillance to identify patients colonized/infected with MDROs for isolation. Skin, blood, respiratory, and urine samples were taken, and compared for relative efficacy in identifying MDRO colonization/ infection.  Feedback: Reporting MDRO incidence (number of isolates/ 1,000 days of stay).  Other components of the intervention included: operational planning on contact precaution strategies; educational/training initiative on infection prevention practices; checklist for contact precautions; routine surveillance; and reporting of incidence rates. | Time series analysis before and after a multicomponent infection prevention intervention at a single, 900-bed teaching hospital in Italy  149,251 patients totaling 909,706 patient-days included in 2011-2013 study period | Hospital, Italy | Sampling from skin (β=0.08, p=0.001, 95% CI 0.06 to 0.10), blood (β=0.05, p=0.001, 95% CI 0.03 to 0.07), and respiratory samples (β=0.02, p=0.031, 95% CI 0.02 to 0.06) were significantly likely to initially identify MDRO-positive status; sampling from urine was not (β=-0.01, p=0.413, 95% CI -0.03 to -0.01).  Overall, the study period after the implementation of a multicomponent intervention showed a month-over-month decrease in MDRO rates. | The authors speculate that results may be more pronounced (i.e., a greater reduction) in hospitals with high transmission rates, compared to hospitals where transmission rates are already low. | In widespread surveillance, skin, blood, and respiratory samples performed better at initially identifying the presence of an MDRO than did urine samples. | Moderate  One study site, limited detail about the surveillance methods or how feedback was conducted. Patient case mix over the course of the study was not assessed. | Organisms/ Outcomes:  *K. pneumoniae*  *K. pneumoniae* infection/ colonization |
| **Beneson et al., 201335** | Active surveillance: Weekly fecal cultures for extended-spectrum beta-lactamase-producing *K. pneumoniae* (ESBL-KP). Rectal swab if stool sample not available.  Molecular typing of samples performed to identify strains. | Observational study of 1,763 neonate admissions (7 days or longer) during the 4-year study period across two neonatal ICUs (10-bed and 25-bed) in two academic hospitals | Hospital neonatal ICU, Israel | Surveillance cultures were obtained from 1,482/1,763 (84%) neonates over 4 years. ESBL-KP acquisition decreased continuously from 94/397 (24%) neonates in 2006 to 33/304 (11%) in 2009 (p<0.001, hazard ratio 0.75, 95% CI 0.66 to 0.85, p<0.001 for comparison of years). Hospitalwide ESBL-KP acquisition did not decrease outside the NICU. Pulsed-field gel electrophoresis identified identical ESBL-KP strains from multiple neonates on six occasions and different strains from single neonates on seven occasions.  Continuous long-term surveillance with cohorting of neonates with positive cultures was associated with a significant decrease in ESBL-KP acquisition within the NICU. | Weekly screening would not include neonates whose admissions were <7 days, and so may miss some patients who are colonized (either before or after admission). | Neonates with positive cultures were managed with contact precautions by dedicated nurses separately from other neonates. ESBL-KP acquisition among neonates staying 17 days was compared for the consecutive years. In addition to demonstrating the impact of surveillance on MDRO acquisition, this study shows the importance of molecular testing to identify whether the MDROs identified are being spread within a unit or imported from outside. | Low to  moderate  Only two sites; no control group. The study did control for the effects of current infection control practices by adding active surveillance to an already established infection prevention protocol. | Organisms/ Outcomes:  ESBL-KP  ESBL-KP acquisition |
| **Bryce et al., 201538** | Risk-based, active weekly screening of patients (and contact precautions) in high-risk units for VRE (as opposed to VRE screening in *all* units at baseline) to make screening more cost-neutral.  Risk-based surveillance was added to a horizontal implementation of environmental cleaning (decluttering) and antimicrobial stewardship program. | Pre-post study and economic analysis of targeted screening and contact precautions for VRE in a 728-bed adult acute care facility, starting in the 2012–2013 year | 728-bed adult tertiary care hospital, Canada | In high-risk units, VRE bacteremia decreased significantly the first year after a spike in VRE infection cases in 2013 (p=0.009), as did facilitywide *C. difficile* and MRSA infection cases (by 46% [p<0.001] and 25% [p=0.02], respectively). VRE bacteremia rates outside the high-risk units remained unchanged after switching to risk-management surveillance approach.  Cost avoidance for targeted surveillance comes in the form of reduction in VRE isolations (costs for gloves and gowns and hospital linen, as well as lost revenue due to reserving private rooms) and decreased laboratory reagent consumption. Although the project experienced net costs in the first 2 years of implementation (2012–2013 and 2013–2014), by the third year (2014–2015), the project had saved an estimated $14,655. | None assessed. | Risk-management surveillance can be as effective in reducing the target MDRO (as well as others) although it was unclear what the unique impact was of each intervention: risk management surveillance, antimicrobial stewardship, and environmental cleaning. | Low to  moderate  Single-site study; efficacy results may differ depending on VRE prevalence and risk factors. | Organisms/ Outcomes:  VRE, MRSA, *C. difficile*  VRE prevalence and bacteremia, CDI, MRSA infection |
| **D’Agata et al., 201239** | Active surveillance: screening for asymptomatic MRSA and VRE colonization  Other PSPs included in model: hand hygiene, contact precautions, reducing antimicrobial exposure | Mathematical model simulation  Modeled on a 600-bed tertiary care hospital | Hospital | Screening patients for asymptomatic colonization reduces the overall prevalence of MDRO, but only among patients already receiving antimicrobials. Improving screening has less effect on the prevalence of MDRO compared to improving compliance with hand hygiene or contact precautions, since a smaller population size is targeted. In addition, the model only incorporates screening for VRE and MRSA. | This model also highlights the importance of vulnerability to infection: even modest increases (5-10%) in MDRO infection rate among colonized patients can negate all the beneficial effects of infection prevention interventions. | Universal screening for asymptomatic colonization of MRSA and VRE did not reduce MDROs in this model; however, targeted screening for MRSA and VRE for patients already receiving antimicrobials (a known risk factor for MDRO acquisition) should theoretically reduce MDRO acquisition in the clinical setting. | Moderate  Mathematical study, not in situ; only included screening for MRSA and VRE (other MDROs may have different results). | Organisms/ Outcomes:  MRSA, VRE, MDR Gram-negative bacteria (MDR-GNB)  MDRO colonization |
| **Friere et al., 201710** | Screening cultures from inguinal-rectal area, axilla, and throat swabs immediately before liver transplant, and weekly thereafter for carbapenem-resistant *P. aeruginosa* (CR-PA), carbapenem-resistant *A. baumannii* (CR-AB), ESBL-producing *K. pneumoniae.* | Sensitivity study of different methods for collecting surveillance cultures  Prospective cohort study of all patients who underwent liver transplant from November 2009 through November 2011 (n=181); 4,110 samples collected | Hospital transplant ward, Brazil | The MDRO positivity rate was highest among the inguinal-rectal collection site samples. However, if only samples collected from this area were considered, surveillance would fail to identify 34.9% of the cases of CR-AB colonization. The sensitivity of active surveillance for EBSL-KP was 92.5%. The performance of screening cultures was poorest for CR-AB (sensitivity, 80.6%). | Routine screening has costs associated with materials, time, and patient isolation (once carriage is identified). | The sensitivity and specificity of a sample collection site or type varies by type of MDRO. Given the costs associated with surveillance and subsequent patient isolation, universal surveillance may make the most sense in facilities where the incidence of MDROs is moderate to high, and for patients for whom the rate of conversion from colonization to infection is high (e.g., transplant patients). | Moderate  Single study, observational study design | Organisms/ Outcomes:  CR-PA, CR-AB, ESBL-producing *K. pneumoniae,* and EBSL-producing *Escherichia coli*  MDRO colonization, MDRO infection, health care-associated infections |
| **Fujitani et al., 201120** | Active surveillance of VRE colonization in patient stool samples positive for *C. difficile* colonization | Prospective laboratory analysis of stool samples from all inpatients with CDI in a single hospital from July 2006– October 2006, comprising 158 CDI cases. | Hospital, United States | Of the 158 cases of CDI evaluated, 88 (55.7%) involved VRE colonization. Independent risk factors for VRE colonization were admission from long-term care facilities (p<0.013), dementia (p=0.001), and hospitalization in the previous 2 months (p=0.002).  No statistically significant difference between CDI cases with and without VRE colonization in terms of previous receipt (within 1 month) of antibiotics, including metronidazole and vancomycin, was found on multivariate analysis. CDI cases with VRE colonization had a higher prevalence of coinfection with MRSA (p=0.002) and *Acinetobacter* species (p=0.006). | None assessed. | Given the high rate of CDI associated with VRE colonization, active surveillance of VRE in patients with CDI is reasonable in high-risk settings. | Moderate | Organisms/ Outcomes:  VRE*, C. difficile,* MRSA, *Acinetobacter* species  VRE colonization |
| **Huskins et al., 201122** | Active surveillance for MRSA (nasal swabs) and VRE (perianal swabs and stool cultures) within 2 days of admission to ICU and 2 days before or after discharge  Control ICUs used existing hospital procedures (not specified) to identify MRSA and VRE.  Results were reported to health care personnel in the intervention ICUs, but not the control ICUs. | Cluster-randomized trial of an active surveillance and reporting intervention in 10 intervention ICUs (5,434 admissions) and 8 control ICUs (3,705 admissions) | Hospital ICUs, United States | Patients who were colonized or infected with MRSA or VRE were assigned to contact precautions more frequently in intervention  ICUs than control ICUs (median of 92% of ICU days with either contact precautions or universal gloving [51% with contact precautions and 43% with universal gloving] in intervention ICUs vs. a median of 38% of ICU days with contact precautions in control ICUs, p<0.001).  The change in incidence of MDRO colonization varied widely between ICUs, but mean ICU incidence (of events of MDRO colonization/infection per 1,000 patient-days at risk), adjusted for baseline incidence, did not differ significantly between intervention and control ICUs (40.4 ± 3.3 and 35.6 ± 3.7, respectively; p=0.35). MDRO colonization/infection incidence was not significantly associated with the percentage of patient-days of contact precautions for colonized/ infected patients (p=0.26) or correct hand hygiene compliance (including gloves when recommended) (p=0.61). | In intervention ICUs, health care providers used clean gloves (82% of the time), gowns (77%), and hand hygiene (69%) less frequently than required for contacts with patients assigned to barrier precautions. | Although active surveillance identified a number of colonized patients who had previously been missed, the intervention did not reduce MRSA and VRE colonization or infection compared to usual care. The authors hypothesize that this unexpected result may be due to the lag between culture results and assignment to contact precautions, and the gaps in compliance with the required components of contact precautions and universal gloving. “Identify and isolate” approaches alone may not be enough, since closing one gap in surveillance did not close the gap in compliance. | Low | Organisms/ Outcomes:  MRSA, VRE  MRSA and/or VRE colonization or infection |
| **Jones et al., 201517** | Active screening at hospital admission for MDR-GNB: nasal screening, screening of clinical cultures  Cultures tested for relatedness using PCR | Retrospective cohort study of all patients with both a nasal screen and clinical culture, admitted to a Veterans Affairs (VA) facility between January 2009 and December 2012 (759,759 total). Assessed how often patients with MDR-GNB in clinical cultures obtained within 30 days following admission would have been in contact precautions because of a positive MRSA admission screen | All VA acute care medical facilities, United States | Of patients with MDR-GNB-positive cultures within 30 days following admission, up to 44.3% (dependent on bacterial species) would have been in contact precautions because of a clinical positive admission MRSA nasal screen. Admissions with a positive MRSA screen had odds for MDR-GNB in a culture 2.5 times greater than those with a negative screen (95% confidence interval [CI], 2.4 to 2.6). Odds ratios were 2.4 (95% CI, 2.3 to 2.5) for MDR Enterobacteriaceae, 2.7 (95% CI, 2.5 to 2.9) for MDR *P. aeruginosa*, and 4.3 (95% CI, 3.8 to 4.8) for MDR *Acinetobacter* species. | None assessed. | Evidence supports an association between MRSA status at admission and later discovery of MDRO colonization. This association was strongest for *Acinetobacter* species. Therefore, when patients are placed in contact precautions because of a positive MRSA screen, there may be a collateral benefit of isolating patients at increased risk for transmitting MDR-GNB to others within the hospital. However, it is not clear from this study if the MDR-GNB were present on admission or acquired in the facility. Still, in places where universal MRSA screening is already in place, a positive result may be considered a risk factor for other MDROs. | Moderate  VA population may not be representative of general population (more likely to be older, male); unable to determine if MDR-GNB were present on admission or acquired. | Organisms/ Outcomes:  MDR-GNB(Enterobacter-iaceae*, P. aeruginosa, Acinetobacter* species), MRSA  Positive screening for any of the above organisms |
| **Karampatakis et al., 201824** | Active surveillance was added to an infection prevention study also consisting of hand hygiene; contact precautions, patient and staff cohorting; environmental cleaning; antimicrobial stewardship; staff education; compliance monitoring audits and feedback.  Active surveillance consisted of (1) weekly rectal swabs; and (2) environmental surface samples. | Quasi-experimental study of all patients (300 total) in a 9-bed ICU with CR-GNB infection (n=34, retrospectively studied for 6 months) and those in an active surveillance program (n=266, prospectively studied for 22 months) | Hospital ICUs, Greece | The downward trend of average incidence, prevalence, and colonization pressure for all CR-GNB during the active surveillance program mostly occurred due to the reduction of CR-*K. pneumoniae* (CR-KP) and CR-*P. aerguinosa* (CR-PA) infections and resistance rates. Despite enhanced infection control, CR-*A.* *baumannii* infections were not reduced.  Total CR-GNB infections decreased from 29.9 to 25.2 infections per 1,000 bed-days  (p>0.05). CR-KP infections decreased from 19.6 to 8.1 per 1,000 bed-days (p=0.001), and CR-PA infections decreased from 5.1 to 1.8 per 1,000 bed-days (p=0.043). | None assessed. | A multicomponent intervention including active surveillance successfully reduced certain rates of CR-GNB (*K. pneumoniae* and *P. aeruginosa*) but not others (*A. baumannii).* | Low to moderate  Single-site study but quasi-experimental design with case mix analyzed | Organisms/ Outcomes  CR-KP, CR-PA, CR-AB  CR-GNB infection and colonization |
| **Lin et al., 201816** | Active surveillance for MRSA (nasal and inguinal swabs, pulsed-field gel electrophoresis to distinguish community-associated strains from others) followed by contact precautions for any patients whose culture tested positive, as mandated by Illinois legislation at the start of the study period.  Hospitals also reported if daily chlorhexidine bathing and mupirocin were used. | Observational study of 25 hospitals, including 51 ICUs and 3,909 patients in point prevalence surveys; 5-year study period | Hospital ICUs, United States | In this study, 93% of patients in received active surveillance for MRSA on hospital admission. The overall admission prevalence of MRSA colonization as reported was 9.7% (95% CI, 8.8% to 10.8%) and did not change over time (p=0.95 for trend). The number of hospitals using daily chlorhexidine bathing in at least one ICU grew from 5 to 17 over the study period. The percentage of study patients who were in an ICU using chlorhexidine bathing grew from 28% to a peak of 59% by year 3 (p<0.001 for trend). No hospital ICUs routinely used mupirocin for decolonization.  No significant change in MRSA colonization (as measured by the point prevalence survey) was observed after legislation of mandatory active MRSA. MRSA colonization prevalence was unchanged during the study period: year-over-year relative risk for colonization was 0.97 (95% CI, 0.89 to 1.05; p=0.48). This trend remained nonsignificant after adjusting for chlorhexidine bathing and rapid results testing use over time. | Only 54% of patients with MRSA-positive cultures during the point prevalence surveys (n=184) were on contact precautions. Fifteen (8%) were not screened at admission; 16 (9%) had a positive admission MRSA screen but contact precautions had not yet been initiated; 27 (15%) had a pending admission culture that eventually became MRSA positive; and 126 (69%) had a negative admission MRSA culture, representing either admission MRSA screen insensitivity or ICU acquisition. | Despite high compliance with mandatory active surveillance, almost 4 of 10 patients identified as MRSA-colonized by the point prevalence survey were not on contact precautions. In addition, few hospitals were using recommended decolonization protocols (chlorhexidine bathing and nasal mupirocin) at the start of the study, limiting the effectiveness of active surveillance to reduce MRSA colonization.  For patients with results available for both nose and groin sites, nasal culturing alone identified 84% (327/ 388) of MRSA-positive patients; 61 patients (16%) were nasal culture negative and groin culture positive. Nasal MRSA screening had a negative predictive value of 98% (95% CI, 97.6% to 98.5%). | Low  No control group, as the legislation affected all hospitals in the State of Illinois | Organisms/ Outcomes:  MRSA  MRSA colonization |
| **Mawdsley et al., 201042** | Active surveillance: process surveillance for compliance with contact precautions for MDRO-flagged patients  Infection preventionists conducted weekly rounding to identify whether patients whose electronic medical record (EMR) had electronically flagged them as MDRO-positive (i.e., positive clinical cultures for MRSA, VRE, and MDR-GNB) were put on appropriate contact precautions. | Case study: Surveillance rounding project for a 22-week period | 500-bed academic medical center, United States | The program significantly improved the percentage of patients with appropriate isolation (p<0.001). Overall point prevalence of appropriate implementation of precautions was 70% on the first day of the program rollout period, 74% for the first month, and 82% overall for the entire period. The percentage of patients isolated at the first surveillance encounter ranged from 40% to 77%. For those patients still hospitalized 1 week later (for a second surveillance encounter), 97% were appropriately isolated.  Patients with MDR-GNB were significantly less likely to be isolated appropriately at the first surveillance encounter than those with MRSA or VRE (p=0.03), with VRE patients having the highest percentage appropriately isolated (66%). Non-ICU patients were less likely to be isolated (p<0.001). | None assessed. | Weekly surveillance rounding alone was successful in improving compliance with contact isolation initiation and required minimal resources (two person-hours of work per week, split among six infection preventionists). However, this approach does not ensure that contact precautions will be consistently followed, and MDROs may require surveillance apart from measure compliance. | Moderate  Single-site case study | Organisms/ Outcomes:  MRSA, VRE, MDR-GNB  Compliance with contact precautions based on EMR flagging |
| **Mayer et al., 201626** | Mandatory surveillance reporting, which was initiated in New York State in July 2013 | Retrospective validation of CRE cases reported to the National Healthcare Safety Network using retrospective laboratory report audit of all CRE infections between July 2013 and December 2014 in acute care hospitals in New York State; 1,151 CRE laboratory reports were audited. | 178 acute care hospitals, New York, United States | None assessed. | Of CRE laboratory reports audited, 13.6% were not reported (as required by New York State law) and 4.6% were reported in error. Some underreporting was due to lapses in surveillance. Other, systematic underreporting was due to misinterpretation of surveillance definitions. | Lapses in surveillance, misunderstanding or misinterpretation of surveillance definitions can result in under- or overreporting of CRE cases. In this study, underreporting was far more frequent than overreporting.  Cases of misinterpretation of surveillance definitions included: not reporting community-onset cases, not reporting specimens from all body sites, not reporting intermediate susceptibilities, changing overall carbapenem susceptibility interpretation based on ertapenem results, and only reporting carbapenemase- producers. | Low to moderate  Retrospective study | Organisms/ Outcomes:  CRE  Mandatory surveillance reporting rates |
| **Palmore et al., 201143** | Infection control adherence monitors were placed in MDR*-*AB cohort areas to observe and correct staff infection control behavior.  Surveillance reporting was done in weekly stakeholder meetings.  Other PSPs in outbreak response included active surveillance cultures, hand hygiene, enhanced contact isolation, patient cohorting with dedicated staff, and enhanced environmental cleaning. | Outbreak response (two outbreaks) in an 18-bed medical-surgical ICU | Hospital, ICU, United States | All but two of the patients included in the outbreak had overlapping stays with other MDR-ABpatients. Nearly all (90%) of case patients were infected or colonized with outbreak strains. Post-ICU-discharge screenings had low yield rates, and thus were discontinued in the second outbreak. Few of the environmental samples in either outbreak (three and five, respectively) had positive culture results, and all but one were from patient rooms.  Based on the evidence from environmental sampling and adherence monitoring, the authors concluded that MDR-AB in these outbreaks were spread by transmission from health care worker to patient (due to insufficient adherence to contact precautions). Collaborative team meetings were critical to halting the outbreak. | Physicians were responsible for more infection control violations than other staff categories, although most all-staff observations showed compliance (95.7% of 4,781 observations). | Extensive surveillance of patients and environment, combined with adherence monitoring, can home in on the transmission patterns of MDR-GNB and expose areas for improvement (in this case, hand hygiene and gown and glove compliance among physicians). | Moderate  Single-site outbreak response. Unable to assess the relative effectiveness of each of the components. | Organisms/ Outcomes:  MDR-AB  Infection prevention practice adherence |
| **Quan et al., 201553** | Automatic surveillance system for flagging patients for contact precautions, with physician-ordered discontinuation. | Case study of a single hospital  The system automatically reviewed daily positive laboratory results for 110,212 patient-days involving 20,000 historical admissions. | 410-bed academic hospital, United States | In this case study, an automated system surveyed microbiology results for positive cultures for MRSA, VRE, CRE, ESBL pathogens, MDR-AB, and *C. difficile.* Physicians could order discontinuation of contact precautions as appropriate (e.g., negative cultures). Automation saved 43 infection preventionist hours per 1,000 admissions, as well as unmeasured hours spent reviewing MDRO history for each admission. | Discontinuation protocols were too complex to be fully automated. | Automated systems can support enforcement of contact precautions and save considerable infection preventionist time in identifying MDROs. Point prevalence assessment showed that all precautions were appropriate. | Moderate  Single-site case study; time savings may vary at other sites. | Organisms/ Outcomes:  MRSA, VRE, CRE, ESBL-producing pathogens, MDR-AB, *C. difficile.*  Appropriateness of automatic flagging for initiating and discontinuing contact precautions |
| **Rosenman et al., 201454** | Active surveillance using EMR evidence of positive culture for MRSA, VRE, CRE, ESBL-producing Enterobacteriaceae, or other MDR-GNB | Retrospective analysis of 80,180 patients (in 12 hospital systems) with microbiology data between October 1, 2013, and December 31, 2013; includes subsequent healthcare encounters (through February 6, 2014). | Hospitals in a shared geographic region, United States | This project created standardized data collection across 12 hospital systems that used clinical data to create MDRO alerts (based on a pre-existing MRSA/VRE alert system). For infection preventionists, the most important alerts were ones at other facilities (identifying which patients may be colonized with organisms and then transferred to other institutions). | Here, 2% of alerts were internally inconsistent (alert email titles did not match the results in the body of the email). | The authors created a regional surveillance system for MDROs, through which they observed several transmissions between institutions. | Moderate  Single case series | Organisms/ Outcomes:  MRSA, VRE, CRE, ESBL-producingEnterobacter-iaceae*,* MDR-GNB (*P. aeruginosa, A. baumannii,* and others)  Accurate MDRO alerts using positive culture results captured in EMRs |
| **Silwedel et al., 201632** | Routine microbiological screening, including: examination of ear swabs and gastric fluid immediately after birth. Surveillance of intestinal colonization of preterm infants comprised the weekly microbiological examination of anorectal swabs or stool samples in all infants. Infants admitted from external NICUs were screened on admission and isolated until receipt of results.  Other PSPs in outbreak response: hand hygiene; glove, gown, and apron use; shared equipment disinfection; patient isolation; dedicated staff. | Retrospective case study. All infants in a single neonatal ICU during a 35-day outbreak. Outbreak affected 13 infants. | Two neonatal ICUs at 113-bed children’s hospital, Germany | Routine stool sampling revealed MDR-*E. coli* detected in a total of 35 infants using active surveillance of anorectal or stool samples. Despite infection prevention precautions, ongoing transmission occurred in the NICU. Control was ultimately achieved by relocating all preterm infants from NICU-1 to NICU-2 and moving NICU-1 into a temporary ward. NICU-1 was reopened at the beginning of 2015 after thorough disinfection and extensive reconstruction work. | Although environmental surveillance revealed no MDR-*E. coli,* the outbreak only ended after closure of the original NICU for extensive decontamination and construction of isolation rooms. | Although the environmental sampling turned up no MDR-*E. coli*, the change of environment was what was needed to eventually end the outbreak. Relocation and reconstruction improved the NICU’s structural layout, focusing on isolation capacities. | Moderate  Outbreak study, single site. | Organisms/ Outcomes:  MDR-*E. coli*  MDR-*E. coli colonization* |
| **Zarpellon et al., 201845** | Active surveillance protocol consisting of:  (1) Rectal swab on admission for VRE/CP-*K. pneumonia* in adult and pediatric patients hospitalized for >48 hours in preceding 30 days, had stayed in ICU in preceding 6 months, or were on dialysis;  (2) Nasal swabs for MRSA for pediatric patients;  (3) Nasal and rectal swabs for all admitted neonates; and  (4) Weekly rectal swabs for all adults and nasal swabs for MRSA in pediatric and neonatal patients.  PCR molecular testing  Other PSPs: patient isolation, contact precautions, two terminal cleanings | Prospective study; all patients in a 123-bed teaching hospital | Hospital, Brazil | The study found significant decreases in infections from MDROs after implementing a multicomponent infection prevention program, including routine surveillance on admission. The overall hospital infection rate in the pre-intervention period (2005–2010) was 5.35% (range: 4.58% to 6.12%). The same rate in the post-intervention period (2011–2016) was 3.62% (range: 3.0% to 4.24%). The overall rate of HAIs decreased by 1.73%. Statistically significant differences in the HAIs rate were observed between the pre- and post-intervention periods (p=0.00198). | Implementing surveillance programs can be costly in both labor and materials, and the cost-benefit comparison of implementation should be considered. | This implementation was successful, but the authors note that this may not always be the case. Cost-effectiveness of surveillance interventions depends on how many infections are reduced (or are likely to be reduced) by the intervention, which varies by facility and even within facilities. For example: in this hospital, MRSA is considered endemic (except in pediatric and neonatal wards). Accordingly, the authors only screened for MRSA in patients where the MDRO was not yet endemic (and thus could be prevented from establishing). | Moderate  Single site, observational study design | Organisms/ Outcomes:  VRE, MRSA, *K. pneumoniae* carbapenemase-producing bacteria  All hospital infections, all health care-associated infections |