The Healthcare-Associated Infections Community Interface (HAIC), launched in 2009, is the newest major activity of the Emerging Infections Program. The HAIC activity addresses population- and laboratory-based surveillance for *Clostridium difficile* infections, candidemia, and multidrug-resistant gram-negative bacilli. Other activities include special projects: the multistate Healthcare-Associated Infections and Antimicrobial Use Prevalence Survey and projects that evaluate new approaches for improving surveillance. The HAIC activity has provided information about the epidemiology and adverse health outcomes of health care–associated infections and antimicrobial drug use in the United States and informs efforts to improve patient safety through prevention of these infections.

Health care–associated infections (HAIs) and inappropriate antimicrobial drug use are major threats to patient safety in US health care facilities. For several years, the elimination of infections associated with health care has been a priority of the US Department of Health and Human Services and a “winnable battle” for the Centers for Disease Control and Prevention (CDC) (7). Essential to the development and implementation of effective HAI prevention and antimicrobial stewardship policies and practices is a current and comprehensive understanding of the epidemiology of HAIs and drug-resistant pathogens that commonly cause such infections.

The Emerging Infections Program (EIP) network, a CDC-supported, public health surveillance and research network, has conducted population-based surveillance for severe bacterial infections since 1995 through the Active Bacterial Core surveillance (ABCs). This program has successfully characterized the magnitude of infections, the patient populations affected, and risk factors for infections. Until 2004–2005, when the ABCs initiated surveillance for invasive methicillin-resistant *Staphylococcus aureus* (MRSA) infections, pathogens tracked by EIP were primarily associated with communities rather than with health care. In 2005, CDC’s National Nosocomial Infections Surveillance System, a longstanding, hospital-based surveillance system for HAIs, was integrated into the new National Healthcare Safety Network (NHSN). With the rapid expansion of NHSN during 2006–2010, additional complementary approaches were needed to define more fully the epidemiology of HAIs, drug-resistant pathogens, and antimicrobial drug use in US health care settings. Consequently, the Healthcare-Associated Infections Community Interface (HAIC) activity was launched to address this need; to bring together existing EIP HAI-related work into a single organizational structure (except for invasive methicillin-resistant *S. aureus* surveillance, which remained part of the ABCs); and to develop further the EIP’s involvement and expertise in HAI epidemiology. The HAIC activity was initiated because of a growing need for a flexible infrastructure in which to conduct HAI-related surveillance and applied research activities and because of the increasing role of state health departments in the implementation of reporting and preventing HAIs through regional and statewide collaboration.

Over the past 5 years, the HAIC activity has become a national public health resource for data on urgent and emerging infectious diseases related to health care. The HAIC activity seeks to promote patient safety and health care quality through 2 main initiatives: 1) evaluation of the epidemiology and public health effects of HAIs to understand emerging pathogens and populations at risk; and 2) exploration of innovations to improve national surveillance and evaluation of HAI prevention and control strategies.

**Current HAIC Activities and Methods**

HAIC activity projects are divided into 2 major categories: 1) pathogen-specific, population- and laboratory-based surveillance (for which 2 projects predated the formation...
of the HAIC activity); and 2) epidemiologic innovations. The HAIC activity currently conducts population-based surveillance aimed at defining the effects of disease and the epidemiology of infections caused by Clostridium difficile, Candida species (bloodstream infections only), and carbapenem-resistant Enterobacteriaceae (CRE) and Acinetobacter baumannii cultured from urine and sterile body sites (2). Although each of these 3 surveillance projects has its own case definition, catchment area, and data collection, all use laboratory-based criteria to identify cases. In addition, all 3 projects collect and submit isolates to CDC for further characterization, and they all collect data from medical records to confirm patient eligibility as a case, obtain demographics, and classify cases as either community associated or health care associated. When disease burden is high and surveillance catchment areas are large, CDC can work with specific EIP sites to develop medical records reviews and isolate sampling strategies that reduce resources needed for surveillance.

In 2008, population-based candidemia surveillance began in 2 EIP sites (Georgia and Maryland) to follow up previous surveillance conducted in the 8-county metropolitan area of Atlanta, Georgia, and in San Francisco, California, during 1992–1993 (3) and in Baltimore City and Baltimore County, Maryland, and in Connecticut during 1998–2000 (4). The primary objective of the ongoing surveillance is to assess changes in the incidence and epidemiology of these infections, including changes in antifungal resistance. Cases are identified through blood cultures that are positive for Candida species in residents of catchment areas. Submission and study of isolates enables a better understanding of antifungal susceptibility patterns among invasive Candida isolates; this information is not usually available from hospital clinical microbiology laboratories. Analysis of data collected during 2008–2011 in Georgia and Maryland showed marked declines in candidemia in infants, the group that had the highest rates of infection in the 1990s (5). The data also showed relatively stable levels of fluconazole resistance among Candida bloodstream isolates (6). Subsequent analyses identified increases in echinocandin-resistant and multidrug-resistant Candida infections during 2008–2012 (7). After sites in Oregon and Tennessee were added in 2011, candidemia surveillance is now conducted in 4 EIP sites, covering a population of 7.7 million persons. Data from this expanded surveillance are used to describe candidemia in these populations and to evaluate the emergence of echinocandin resistance in C. glabrata (8).

Surveillance for C. difficile infections (CDIs) began in 2009 and expanded by 2011 to include all of the 10 EIP sites and a population of ≈11.5 million persons. The objectives of CDI surveillance are to compile national estimates for CDIs associated with the community and with health care, to describe the epidemiology of these CDIs, and to characterize C. difficile strains. CDI surveillance captures the broad spectrum of CDI cases that occur in all community and health care settings (including nursing homes and facilities for rehabilitation and acute care) and collects extensive clinical and microbiologic data. CDI cases are defined on the basis of C. difficile–positive toxin or molecular assays for catchment area residents ≥1 year of age. Clinical data are used to confirm that patients had symptoms consistent with CDI, and epidemiologic data are used to classify cases into 1 of 3 categories: community associated; community-onset, health care facility associated; and health care facility onset. C. difficile isolates are collected from a convenience sample of laboratories and sent to CDC for molecular characterization, which enables comparative analysis of disease characteristics by strain type. Outcome data such as recurrence, hospitalization, and death are also captured.

This surveillance project has contributed substantially to the current understanding of CDI epidemiology in the United States. A recently published analysis of CDI surveillance data estimated that ≈453,000 CDI cases and 29,000 deaths occurred among patients with CDI in the United States in 2011 (9). Data from this surveillance project have also been used to evaluate differences in CDI incidence across EIP sites and have illustrated the importance of adjusting for patient factors (e.g., age, gender, and race) and hospital factors (e.g., inpatient days and use of nucleic acid amplification tests [NAAT]) for comparisons among populations (10). Data from EIP CDI surveillance have also shown substantial increases in CDI detection because laboratories have adopted NAAT for CDI diagnosis (11). EIP surveillance data have also enabled additional advances in the characterization of CDI: identification of outpatient health care exposures (e.g., doctor or dentist visits) among patients with community-associated CDI (12); description of the epidemiology of CDI in children, in whom most disease is community associated (13); evidence of the association between the North American pulsed-field gel electrophoresis type 1 epidemic C. difficile strain and more severe CDI outcomes (14); and description of the association between adoption of NAAT by clinical laboratories and implementation of stricter criteria for submitting stool specimens for testing (15). The CDI surveillance data are also used to estimate potential effects of reducing antimicrobial drug use on CDI rates (16), to estimate the incidence and outcome of CDI infection in nursing home populations (17), and to evaluate risk factors for community-associated infection. Ongoing surveillance will also enable measurement of outcomes of prevention efforts associated with inpatient antimicrobial drug stewardship or, potentially, with a CDI vaccine.

The third HAIC activity surveillance project targets multidrug-resistant gram-negative bacilli (MDR GNB).
This project, known as the Multisite Gram-Negative Ba-
cilli Surveillance Initiative (MuGSI), began in Georgia and
Minnesota in 2010 as pilot projects and expanded to Or-
ecgon in 2011. The impetus for initiating population-based
EIP surveillance for MDR GNB was the emergence of CRE
in the United States. Patients infected with these organisms
have few or sometimes no antimicrobial drug treatment op-
tions. The incidence and characteristics of MDR GNB are
in flux, so a flexible yet specific surveillance program is
needed. The program must be able to adapt to changing
laboratory breakpoints and case definitions when needed to
better define the impact of these infections, determine the
populations at risk, and inform prevention efforts.

The main objective of MuGSI is to describe the epi-
demiology and population-based incidence of carbapenem-
 nonsusceptible Enterobacteriaceae species and Acinetobac-
ter baumannii. The project also seeks to characterize
isolates and describe resistance mechanisms among a sub-
set of carbapenem-nonsusceptible Enterobacteriaceae iso-
lates submitted to CDC. This surveillance has expanded
in recent years to cover a surveillance area of \( \approx 15 \) million
persons in 8 states: Georgia, Oregon, Minnesota, Colorado,
Maryland, New Mexico, New York and Tennessee. Ini-
tially, cases were defined by carbapenem-nonsusceptible
(excluding ertapenem) and extended-spectrum cephalospo-
rin-resistant Escherichia coli, Enterobacter aerogenes, and
E. cloacae, Klebsiella pneumoniae and K. oxytoca, and
carbapenem-nonsusceptible (excluding ertapenem) Acinetobac-
ter baumannii complex isolated from normally sterile
sites or from urine of residents in the surveillance areas.
In MuGSI surveillance, most cases are identified through
queries of automated susceptibility-testing instruments in
clinical laboratories that serve the catchment areas rather
than through routine output of summarized test results (of-
ten called line listings) generated by laboratory information
systems (18). This method enables the application of case
definitions based on antimicrobial drug susceptibility test
results that may be suppressed from routine reports entered
into the patient’s medical record. Also, depending on the
concentration range of drugs tested, the method enables
application of the latest breakpoints from the Clinical Labo-
atory Standards Institute (http://www.clsi.org/) before they
have been widely implemented by clinical laboratories.
Isolates from EIP sites are being used to evaluate differ-
ent phenotypic definitions used to identify carbapenemase-
producing CRE (19). Data from this evaluation have as-
sisted in modifying CRE definitions used for reporting to
NHSN and for updating the MuGSI case definition. Final-
ly, MuGSI is uniquely positioned to describe persons with
community-associated CRE.

Since its inception, the HAIC activity has also con-
ducted several projects in epidemiology innovations, a ma-
ajor area of growth for the HAIC activity. The largest of
these projects is a multicenter HAI and antimicrobial drug
use prevalence survey project. This multiphase effort is de-
signed to fill gaps in data collected through NHSN by de-
veloping and conducting a national-scale point prevalence
survey that estimates the scope and magnitude of all HAI
 affecting acute-care hospital patients. This project also
describes the nature of and rationale for antimicrobial use
in acute care hospitals. The project development began in
2009 with a single-city pilot survey (20). A limited roll-out
survey was conducted in 22 hospitals in the 10 EIP sites
in 2010, followed by the full-scale survey in 183 hospi-
tals across the 10 sites in 2011. Data from the full-scale
survey were used to establish the current annual estimates
of HAIIs in US acute-care hospitals: \( \approx 722,000 \) infections in
648,000 patients (21). The survey showed that surgical site
infections and pneumonias were the most common HAI
and also that device-associated infections, which have for
many years been the focus of most HAI prevention efforts,
accounted for only 26% of all HAIIs. C. difficile was the
most common pathogen causing HAIIs; considering the
importance of antimicrobial drug use in the epidemiology
of CDI, this finding supports CDC’s increasing focus on
 antimicrobial stewardship programs in acute-care hospi-
tals. The antimicrobial drug use component of the survey
showed that half of all patients included in the survey were
receiving antimicrobial drugs at the time of the survey;
furthermore, broad-spectrum antimicrobial drug use was
very common, even among patients with community-onset
infections and among patients who were not in critical
care units (22).

The next phase of the prevalence survey, scheduled
for 2015, includes a hospital infection control and antimi-
crobial stewardship practices questionnaire; it also has as-
 sessments of the quality of antimicrobial drug prescribing
for selected clinical scenarios. The prevalence survey is an
effective approach for obtaining broad, situational aware-
ness of HAIIs and antimicrobial drug use in different health
care settings, particularly those settings where robust, pro-
spective surveillance is not yet available or widely used.
These surveys have been used in many other countries, in-
cluding a European Union survey conducted in 2011–2012
(23). The methods for the US survey effort were developed
with input from European colleagues, including those in
the European Centre for Disease Prevention and Control,
in an attempt to enable comparative metrics. We also re-
lied on European colleagues’ considerable experience in
conducting HAI and antimicrobial use prevalence surveys
in long-term care facilities (24). We consulted them for
input on a pilot EIP HAIC antimicrobial drug use preva-
 lence survey for nursing home HAIIs. This pilot was con-
ducted in 9 nursing homes in 4 EIP sites, and expansion
to a larger-scale, US nursing home survey in the future is
being considered.
Other innovations projects have sought to field-test streamlined, simplified methods for conducting HAI surveillance in NHSN. One example of these short-term innovations projects is a device-associated HAI denominator data simplification project to identify streamlined sampling methods that can replace daily collection of patient- and device-day data (25,26). Other innovations projects include field-testing of a new surveillance component for CDI and urinary tract infections (UTIs) in long-term care facilities and field-testing of a definition modification of bloodstream infections associated with central lines (27). Another innovations project is surveillance for bloodstream infections in dialysis facilities (28). EIP sites have also completed work to validate data submitted to NHSN. For example, the Connecticut and New Mexico EIP sites have compared MRSA bacteremia and CDI data collected through EIP’s population-based surveillance with MRSA and CDI Laboratory-Identified Event data (http://www.cdc.gov/nhsn/labid-calculator/index.html) submitted to NHSN (29). Knowledge gained through these EIP projects has directly affected several NHSN surveillance operations: in 2015, implementation of central line–associated bloodstream infection and catheter-associated urinary tract infection denominator sampling methods (http://www.cdc.gov/nhsn/acute-care-hospital/clabsi/index.html); also in 2015, the addition of selected variables to Laboratory-Identified Event reporting to improve the completeness of case information capturing; in 2014, implementation of the Mucosal Barrier Injury-Laboratory Confirmed Bloodstream Infection definition; and in 2013, clarification of UTI surveillance methods for long-term care facilities.

Data from HAIC activity population-based surveillance projects and from the HAI and antimicrobial drug use prevalence survey have been critical to the development of recent high-profile reports. Of the 18 pathogens or pathogen groups included as serious, urgent, or concerning threats to public health in CDC’s first report on antimicrobial threats in the United States, discussions of 7 used estimates from HAIC activity data (30). HAIC activity data have also been used to illustrate concepts in public health calls to action in CDC reports: on CDIs (75% of cases had infection occurring outside of hospitals) (31), on CREs (92% of CRE episodes occurred in patients with health-care exposures) (32), and on the public health problem of incorrect inpatient antimicrobial drug use (37% of antimicrobial drug prescribing in selected scenarios could be improved) (16). In addition, data from candidemia surveillance were used in the World Health Organization’s first global report on antimicrobial resistance (33).

**Future of the EIP HAIC Activity**

The accomplishments of the EIP HAIC activity have been numerous over a relatively short period of time, including delivery of data that have affected federal policy, programs, and operational approaches of HAI surveillance and prevention. However, as the landscape of HAI and antimicrobial drug–resistant infection prevention changes, the HAIC activity must constantly reassess priorities and direction. Reporting requirements related to HAIs as part of the Centers for Medicare and Medicaid Services quality reporting programs have expanded in recent years; data from the HAI and antimicrobial drug use prevalence survey show that ≈28% of all acute care hospital–related HAIs are now part of the Hospital Inpatient Quality Reporting Program of the Centers for Medicare and Medicaid Services (http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/HospitalRHQDAPU.html). The flexibility of the HAIC activity makes it well suited to fill gaps in facility-specific reporting as part of those programs, to contribute data on hospital HAIs not included in reporting programs, and to provide data on the large proportion of infections caused by health care–associated pathogens that occur outside acute care hospital settings. For example, as reporting to NHSN becomes increasingly robust for particular hospital-onset infections, the HAIC activity can adapt its surveillance approach to focus on cases in nonacute care or community settings, locations where high quality data would otherwise be lacking. Thus, the HAIC activity can provide an infrastructure that enables evaluation of progress of prevention efforts.

As reporting requirements become part of nonacute care settings, including long-term care or ambulatory care, the EIP HAIC activity will be well positioned to help determine selection of the highest-priority infection metrics in those settings. Periodic assessment of the spectrum of HAIs through time-limited activities, such as the point-prevalence surveys, will help CDC reassess priority infections for prevention efforts and determine needed modifications to reporting requirements for various types of health care facilities. Over the next decade, the HAIC activity can serve to identify new and emerging challenges involving HAIs occurring across the spectrum of health care delivery.

The HAIC activity can also continue to develop new techniques and respond to emerging and urgent issues related to HAI surveillance and antimicrobial resistance. With knowledgeable, state-based staff and existing networks in health care facilities and clinical microbiology laboratories, the HAIC activity can explore novel approaches to HAI tracking, accommodate shifting case definitions and approaches to defining antimicrobial resistance, and contribute valuable data to inform development and implementation of optimal definitions through ongoing collection and study of isolates linked to well-defined cases of infection.

Besides these functions, the HAIC activity provides an infrastructure for evaluating approaches to the prevention of HAIs and the spread of antimicrobial resistance by
building on research and innovations tested and refined in smaller-scale or academic settings. The activity’s surveil-
ance projects have firmly established outcome metrics and
can therefore measure patient-centered outcomes after early
adoption of new standards in HAI prevention efforts in acute
or long-term care settings (e.g., the effects of hospital-based
programs to reduce CDI in postdischarge settings). One
challenge facing the HAIC activity in implementing these
evaluations is the population-based nature of many of its sur-
veillance projects. Currently, cases are defined in part on the
basis of residency in the designated catchment area, and new
approaches to enable capture of nonresident cases will be
needed, particularly for work focused in acute care hospitals.

During the past 5 years, the HAIC activity infrastructure
has adapted quickly to new challenges, additional pathogens,
and new methods to accomplish its mission. Given the scope of the antimicrobial resistance problem
and the aggressive timeline laid out in the US President’s
September 2014 Executive Order (https://www.white-
house.gov/the-press-office/2014/09/18/executive-order-
combating-antibiotic-resistant-bacteria), the pace of work
will need to be accelerated to make progress in reaching the
targets outlined in the National Strategy for Combating Anti-
biotic-Resistant Bacteria (34). These targets include large
reductions in incidence of multidrug-resistant Pseudomo-
nas aeruginosa, invasive MRSA, CDI, and CRE. Through
the EIP HAIC activity, CDC will be better and more rapidly
able to identify populations at risk for antimicrobial drug–
resistant infections associated with health care settings,
to evaluate and refine prevention approaches, and to define
critical links between disease severity or prevention and mi-
robe characteristics. Furthermore, this program will serve
as one of several that will assist the success of various com-
ponents of the National Strategy towards achieving targets
and providing data to empower public health and health
care sectors to make progress toward eliminating HAIs.

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References
1. Centers for Disease Control and Prevention. Winnable battles—
healthcare-associated infections [cited 2015 Mar 2].
http://www.cdc.gov/winnablebattles/healthcare-associatedinfections/
index.html

2. Centers for Disease Control and Prevention. Emerging Infections
Program—healthcare-associated infections projects. [cited 2015

3. Kao AS, Brandt ME, Pruitt WR, Conn LA, Perkins BA,
Stephens DS, et al. The epidemiology of candidemia in two United
States cities: results of a population-based active surveillance.

4. Hajjeh RA, Sofair AN, Harrison LH, Lyon GM,
Aarthington-Skaggs BA, Mirza SA, et al. Incidence of bloodstream
infections due to Candida species and in vitro susceptibilities of
isolates collected from 1998–2000 in a population-based active
http://dx.doi.org/10.1128/JCM.42.4.1519-1527.2004

5. Cleveland AA, Farley MM, Harrison LH, Stein B, Hollick R,
Lockhart SR. Changes in incidence and antifungal drug resistance
in candidemia: results from population-based laboratory

6. Lockhart SR, Iqbal N, Cleveland AA, Farley MM, Harrison LH,
Bolden CB, et al. Species identification and antifungal
susceptibility testing of Candida bloodstream isolates from
population-based surveillance studies in two U.S. cities from 2008
10.1128/JCM.01283-12

7. Alhquist AM, Harrison LH, Farley MM, Schaffner W, Beldavs Z,
Iqbal N, et al. The emergence of multidrug resistant Candida
species: results from a population-based laboratory surveillance in
of the International Society for Human and Animal Mycology;

8. Pham CD, Iqbal N, Bolden CB, Kuykendall RJ, Harrison LH,
Farley MM, et al. Role of FKS mutations in Candida glabrata:
MIC values, echinocandin resistance, and multidrug resistance.
10.1128/AAC.03253-14

9. Lessa FC, Mu Y, Bambarg W, Beldavs Z, Dumyati GK, Dunn JR,
et al. Burden of Clostridium difficile infection in the United States.
NEJMoa1408913

10. Lessa FC, Mu Y, Winston LG, Dumyati G, Farley MM,
Beldavs ZG, et al. Determinants of Clostridium difficile infection incidence
across diverse U.S. geographic locations. Open Forum

Farley MM, et al. Effect of nucleic acid amplification testing on
population-based incidence rates of Clostridium difficile infection.

12. Chitnis AS, Holzbauer SM, Belflower RM, Winston LG,
Bamberg WM, Lyons C, et al. Epidemiology of community-
associated Clostridium difficile infection, 2009 through 2011.
jamainternmed.2013.7056

13. Wendt JM, Cohen JA, Mu Y, Dumyati GK, Dunn JR, Holzbauer SM,
et al. Clostridium difficile infection among children across
http://dx.doi.org/10.1542/peds.2013-3049

et al. NAP1 strain type predicts outcomes from Clostridium
http://dx.doi.org/10.1093/cid/ciu125


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