

Persons using assistive technology might not be able to fully access information in this file. For assistance, please send e-mail to: mmwrq@cdc.gov. Type 508 Accommodation and the title of the report in the subject line of e-mail. Please note: An erratum has been published for this article. To view the erratum, please click [here](#). On March 6, 2012, this report was posted as an MMWR Early Release on the MMWR website (<http://www.cdc.gov/mmwr>). Background: Clostridium difficile infection (CDI) is a common and sometimes fatal health-care-associated infection; the incidence, deaths, and excess health-care costs resulting from CDIs in hospitalized patients are all at historic highs. Meanwhile, the contribution of nonhospital health-care exposures to the overall burden of CDI, and the ability of programs to prevent CDIs by implementing CDC recommendations across a range of hospitals, have not been demonstrated previously. Methods: Population-based data from the Emerging Infections Program were analyzed by location and antecedent health-care exposures. Present-on-admission and hospital-onset, laboratory-identified CDIs reported to the National Healthcare Safety Network (NHSN) were analyzed. Rates of hospital-onset CDIs were compared between two 8-month periods near the beginning and end of three CDI prevention programs that focused primarily on measures to prevent intrahospital transmission of C. difficile in three states (Illinois, Massachusetts, and New York). Results: Among CDIs identified in Emerging Infections Program data in 2010, 94% were associated with receiving health care; of these, 75% had onset among persons not currently hospitalized, including recently discharged patients, outpatients, and nursing home residents. Among CDIs reported to NHSN in 2010, 52% were already present on hospital admission, although they were largely health-care related. The pooled CDI rate declined 20% among 71 hospitals participating in the CDI prevention programs. Conclusions: Nearly all CDIs are related to various health-care settings where predisposing antibiotics are prescribed and C. difficile transmission occurs. Hospital-onset CDIs were prevented through an emphasis on infection control. Implications for Public Health: More needs to be done to

prevent CDIs; major reductions will require antibiotic stewardship along with infection control applied to nursing homes and ambulatory-care settings as well as hospitals. State health departments and partner organizations have shown leadership in preventing CDIs in hospitals and can prevent more CDIs by extending their programs to cover other health-care settings. Introduction *Clostridium difficile* is an anaerobic, spore-forming bacillus that causes pseudomembranous colitis, manifesting as diarrhea that often recurs and can progress to toxic megacolon, sepsis, and death. Infection is spread by the fecal-oral route; spores, the infective form, can persist on fomites and environmental surfaces for months. *Clostridium difficile* infection (CDI) often occurs in patients in health-care settings, where antibiotics are prescribed and symptomatic patients, an important source for transmission, are concentrated. From 2000 to 2009, the number of hospitalized patients with any CDI discharge diagnoses more than doubled, from approximately 139,000 to 336,600, and the number with a primary CDI diagnosis more than tripled, from 33,000 to 111,000 (1). Although the incidence of other health-care-associated infections has declined (2), CDIs have increased and only recently plateaued (1). Evidence-based guidelines for the prevention of CDIs in hospitals have been published (3). However, because the evidence for many of these recommendations is weak (4) the degree to which they can prevent CDIs effectively across a range of hospitals is unknown, as is the relative burden of CDIs in nonhospital and hospital health-care settings.

Methods In this investigation, three data sources were used to identify health-care exposures for CDIs, determine the proportion of CDIs occurring outside hospital settings, and assess whether prevention programs can effectively reduce CDIs. CDC's Emerging Infections Program conducted active, population-based surveillance for CDIs from eight diverse geographic areas in 2010 (5). Program surveillance coordinators received laboratory reports of positive stool *C. difficile* tests from residents of catchment areas. Cases were defined by a positive *C. difficile* test in a person without a positive test during the previous 8 weeks (repeat

positive tests during this period suggest recurrence) (6). Medical records were reviewed to confirm the presence of symptoms consistent with CDI and to record all health-care exposures during the 12 weeks preceding specimen collection (i.e., minimum duration of antibiotic-induced susceptibility to CDI). CDIs were classified by the patient's location at the time of stool specimen collection and divided into three groups: 1) hospital-onset CDI, occurring in a hospitalized patient with a positive stool specimen collected more than 3 days after admission; 2) nursing home-onset CDI, occurring in a nursing home resident with a positive stool specimen collected at any time during their stay; and 3) community-onset CDI, occurring in an outpatient or an inpatient of any health-care facility with a positive stool specimen collected within 3 days (the median incubation period of *C. difficile*) after admission. Community-onset CDI cases were subcategorized based on previous health-care exposures during the 12 weeks preceding specimen collection; previous inpatient exposures took precedence over outpatient exposures when classifying cases. A second data source was the National Healthcare Safety Network (NHSN) Multidrug-Resistant Organism and *Clostridium difficile* Infection module for laboratory-identified (LabID)-CDI events, which became available in March 2009 (7). Incident LabID-CDI events in NHSN are based on positive *C. difficile* test results from hospital patients who did not have a previous positive test result reported within that facility during the preceding 8 weeks. LabID-CDI events present on admission were defined by a positive stool specimen collected within the first 3 days of admission; a subset was delineated further if patients were discharged from the reporting hospital in the preceding 4 weeks, during which time previous hospitalization is most likely to influence the risk for CDI (6,7). Rates of hospital-onset CDI cases were calculated per 10,000 patient-days. The third set of data included early results from three state-led programs (Illinois, Massachusetts, and New York) similar to other programs in which hospitals collaborated with one another to prevent health-care-associated infections (8) (in this case, hospital-onset CDIs). The three programs included a total of 71 hospitals

focused on preventing CDIs during three different periods ranging from 19 to 22 months.* Although the systems for data collection and behavioral change strategies varied among programs, all three used CDC surveillance definitions (6) and focused primarily on infection control interventions to prevent transmission of *C. difficile*; the Massachusetts program did include antibiotic stewardship as a minor component. Using a negative binomial model, rates of hospital-onset CDI from hospitals participating in the three programs were compared between two same-calendar-month, 8-month periods (to control for seasonal variation in rates), one earlier and the other later in the conduct of each program.

Results

The Emerging Infections Program population under surveillance included persons in the catchment areas of 111 acute-care hospitals and 310 nursing homes. A total of 10,342 CDIs were identified; 44% of patients were aged <65 years. CDIs were classified by inpatient or outpatient status at time of stool collection and type/location of exposures (Figure 1). Overall, 94% of all CDIs were related to various precedent and concurrent health-care exposures; of these, 75% had their onset outside of hospitals. In addition, some cases occurred in patients who were exposed to multiple settings. For example, 20% of hospital-onset CDIs occurred in recent (i.e., <12 weeks) residents of a nursing home, and 67% of nursing home-onset CDI cases occurred in patients recently discharged from an acute-care hospital. A total of 711 acute care hospitals in 28 states conducted facility-wide inpatient LabID-CDI event reporting to NHSN in 2010 (Table 1). A total of 42,157 incident LabID-CDI events were reported (Figure 2). Overall, 52% of LabID-CDI events were already present on admission to hospitals. The pooled rate of hospital-onset CDI was 7.4 per 10,000 patient-days, with a median hospital rate of 5.4 per 10,000 and an interquartile range of 6.2. The pooled hospital-onset CDI rate across the three prevention programs declined 20%, from 9.3 per 10,000 patient-days during the early comparison period to 7.5 during the later comparison period (rate ratio: 0.80) (Table 2).

Conclusions and Comment

The incidence, mortality, and medical care costs of CDIs have reached

historic highs (1,3,9,10). The estimated number of deaths attributed to CDI, based on multiple cause-of-death mortality data, increased from 3,000 deaths per year during 1999–2000 to 14,000 during 2006–2007, with more than 90% of deaths in persons aged ≥ 65 years (10). Recent excess health-care costs of hospital-onset CDI are estimated to be \$5,042–\$7,179 per case with a national annual estimate (limited to the subset of hospital-onset CDIs only) of \$897 million to \$1.3 billion (11). Much of the recent increase in the incidence and mortality of CDIs is attributed to the emergence and spread of a hypervirulent, resistant strain of *C. difficile* that produces greater quantities of principal virulence toxins A and B and has additional factors enhancing its virulence (9,12). Nonetheless, many of these infections can be prevented, as demonstrated by the 20% reduction in incidence of hospital-onset CDI among three state prevention programs conducted over approximately 21 months. In England, where a national campaign to publicly report and prevent CDIs was implemented in 2007 through an emphasis on antibiotic stewardship as well as infection control (13), pooled hospital-onset CDI rates declined 56% during a 3-year period (2008–2011) (14). In the United States, the National Action Plan for Prevention of HAIs has targeted a 30% reduction of CDIs in acute-care hospitals by 2015 (15). Principal recommendations to prevent CDI include improving antibiotic use, early and reliable detection of CDI, isolation of symptomatic patients, and reducing *C. difficile* contamination of health-care environmental surfaces (3). Good antibiotic stewardship is an important aspect of quality health care that prevents CDI. Antibiotic use increases the risk for developing CDI by seven- to 10-fold while the patient is taking the antibiotic and for 1 month after discontinuation, and by approximately three-fold for the subsequent 2 months (16). CDC provides tools for facilities to develop antibiotic stewardship programs.† To prevent transmission of *C. difficile*, early detection and isolation of patients with CDI is essential. Nucleic acid amplification tests can be as much as twice as sensitive as enzyme immunoassays and can detect CDI more accurately when used in populations

with an appropriate pretest probability (i.e., patients with more than three unformed stools in a 24-hour period without an identified cause) (3,17). Because of their increased sensitivity, nucleic acid amplification tests will yield higher hospital-onset CDI rates. Currently, 35% of NHSN hospitals are using nucleic acid amplification tests (Table 1); risk adjustment will be necessary to compare rates accurately where diagnostic testing practices vary. *C. difficile* frequently is transmitted between patients via hands of health-care personnel transiently contaminated after contact with symptomatic patients or their surrounding environment. Glove use, with strict adherence to changing between patient contacts, is the best proven method for preventing hand contamination with *C. difficile* from symptomatic patients (3,4). Health-care environmental services have a key role in reducing contamination that can directly transmit to patients or contaminate the hands of health-care personnel.§ Because *C. difficile* spores resist killing by usual hospital disinfectants, an Environmental Protection Agency-registered disinfectant with a *C. difficile* sporicidal label claim¶ should be used to augment thorough physical cleaning. These findings emphasize how the risk for CDI from antibiotic exposure and transmission moves with patients across multiple health-care settings, leading to the interdependence of health-care settings in a region to lower their CDI rates. Because antibiotics disrupt the normally protective bacterial populations of the lower intestine in a manner that increases risk for CDI for 3 or more months, antibiotics received in one setting often predispose a patient to develop CDI in another. In contrast, because the incubation period is a median of only 2–3 days (3), acquisition of *C. difficile* is overall more likely to have occurred in the setting where symptoms have their onset and CDI is diagnosed. Meanwhile, CDIs present on hospital admission are most often related to the care delivered in other inpatient or outpatient facilities; because they are an important source for intrahospital transmission, CDIs present on admission are a risk factor for higher hospital-onset CDI rates (18). The findings of this report are subject to at least six limitations. First, data on antibiotic

exposure, which are important for targeting prevention efforts, were not available. An NHSN option designed to address this problem is undergoing piloting with electronic health record vendors.** Second, data on potential underlying temporal trends in prevention program hospitals were not available. Third, the various methods used to implement prevention strategies in the prevention hospitals were not described (e.g., staff training, assessment and feedback of compliance with isolation precautions, or adequacy of environmental cleaning). Although the pooled rate toward the end of these programs (7.5 per 10,000 patient-days) was similar to the rate across all NHSN hospitals in 2010 (7.4), the three programs started and ended at different rates, suggesting that locally tailored approaches to prevention might be beneficial. Fourth, the impact of ongoing CDI prevention initiatives under way during the early phase of evaluation also was not assessed. Fifth, the potential impact of any shifts in test sensitivity between different methods used (e.g., nucleic acid amplification versus enzyme immunoassay) was not assessed. Finally, in both the Emerging Infections Program and NHSN, the setting of onset was based on where the patient was located at the time of stool specimen collection; therefore, there might have been misclassification of cases if a marked delay occurred between onset of symptoms and stool specimen collection. Because nearly 75% of all CDIs related to U.S. health care have their onset outside of hospitals, more needs to be done to prevent CDIs across all health-care settings. For its part, CDC is working to improve NHSN LabID-CDI event reporting for nursing homes as well as hospitals. Clinical document architecture specifications are available for electronic health record system vendors to use in enabling their systems to serve as electronic data sources for LabID-CDI event reporting to NHSN.†† The option to report electronically will take on greater importance as increasing numbers of hospitals are required to report LabID-CDI events to NHSN. Currently, six states (California, Illinois, New York, Oregon, Tennessee, and Utah) mandate public reporting of facility-wide LabID-CDI events. Beginning in 2013, all

hospitals participating in the Centers for Medicare and Medicaid Services' Inpatient Prospective Payment System Quality Reporting Program will be required to report facility-wide LabID-CDI events using NHSN to qualify for their 2015 annual payment update; public reporting of hospital rates will begin in 2014 at the Hospital Compare website (19). Clinicians and other health-care providers, as well as inpatient and outpatient health-care facilities, state and federal public health officials (e.g., the Partnership for Patients), and partner patient safety organizations, could benefit from increased collaboration in preventing CDIs. Such collaborations could broaden and enhance the use of prevention strategies and do so across the entire spectrum of U.S. health-care delivery. State health departments, working with regional quality improvement organizations, hospital associations, and other nongovernmental patient safety partners, are positioned uniquely to work across these multiple settings. §§ Given the emphasis of current health-care reform efforts to improve patient safety while reducing costs, now is an opportune time to begin to eliminate health-care-associated CDIs.

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Iowa Foundation for Medical Care-Illinois, Oakbrook; Illinois Dept of Public Health. Massachusetts Coalition for the Prevention of Medical Errors; the Massachusetts Dept of Public Health. Greater New York Hospital Association; United Hospital Fund; New York State Dept of Health. Hospitals and staff members reporting to the National Healthcare Safety Network. Amit Chitnis, MD, EIS Officer; principal investigators and surveillance staff members, Emerging Infections Program, CDC.

* The Illinois prevention program, led by the Department of Public Health and the Iowa Foundation for Medical Care-Illinois (a health-care quality improvement organization headquartered in West

Des Moines, Iowa), included 11 hospitals with complete data from the beginning of March 2010 through October 2011. The Massachusetts program, led by the Massachusetts Coalition for the Prevention of Medical Errors and the Massachusetts Department of Public Health, included 27 hospitals with complete data from January 2010 through September 2011. The New York program, led by the Greater New York Hospital Association and the United Hospital Fund in collaboration with the New York State Department of Health, included 33 hospitals with complete data from March 2008 through December 2009. † Additional information available at <http://www.cdc.gov/getsmart/healthcare/improve-efforts/clinicians.html>. § Additional information available at <http://www.cdc.gov/hai/toolkits/evaluating-environmental-cleaning.html>. ¶ Additional information available at <http://www.epa.gov/oppad001/cdif-guidance.html>. ** Additional information available at http://www.cdc.gov/nhsn/psc_ma.html. †† Additional information available at http://www.cdc.gov/nhsn/cda_esurveillance.html. §§ Additional information available at <http://www.cdc.gov/hai/stateplans/haistateplans-map.html>.

Key Points FIGURE 1. Percentage of *Clostridium difficile* infection (CDI) cases (N = 10,342), by inpatient or outpatient status at time of stool collection and type/location of exposures* — United States, Emerging Infections Program, 2010 * CDIs were classified by the patient's location at the time of stool specimen collection and divided into three groups: 1) hospital-onset CDI, occurring in a hospitalized patient with a positive stool specimen collected more than 3 days after admission; 2) nursing home-onset CDI, occurring in a nursing home resident with a positive stool specimen collected at any time during their stay; and 3) community-onset CDI, occurring in an outpatient or an inpatient of any health-care facility with a positive stool specimen collected within 3 days (the median incubation period of *C. difficile*) after admission. Community-onset CDI cases were subcategorized based on previous health-care exposures during the 12

weeks preceding specimen collection; previous inpatient exposures took precedence over outpatient exposures when classifying cases. Alternate Text: The figure above shows the percentage of Clostridium difficile infection (CDI) cases (N = 10,342), by inpatient or outpatient status at time of stool collection and type/location of exposures, in the United States during 2010, based on data from the Emerging Infections Program. The population under surveillance included persons in the catchment areas of 111 acute-care hospitals and 310 nursing homes. A total of 10,342 CDIs were identified. CDIs were classified by inpatient or outpatient status at time of stool collection and type/location of exposures. Overall, 94% of all CDIs were related to various antecedent and concurrent health-care exposures; of these, 75% had their onset outside of hospitals. In addition, some cases occurred in patients who were exposed to multiple settings. For example, 20% of hospital-onset CDIs occurred in recent (i.e., <12 weeks) residents of a nursing home, and 67% of nursing home-onset CDI cases occurred in patients recently discharged from an acute-care hospital.

TABLE 1. Number and percentage of hospitals reporting laboratory-identified Clostridium difficile infections, by selected characteristics — United States, National Healthcare Safety Network, 2010

Characteristic	No.	(%)
Total	711	(100)
Bed size		
≤200	429	(61)
201–500	232	(33)
501–1000	46	(6)
>1000	1	(<0.5)
Medical school affiliation	226	(31)
Primary diagnostic assay used		
Enzyme immunoassay for toxin A and/or B	364	(51)
Nucleic acid amplification test	238	(33)
Other	88	(12)
Missing data	21	(3)

FIGURE 2. Percentage of laboratory-identified Clostridium difficile infections (N = 42,157), by hospitalization status at time of stool collection and type/location of exposure — United States, National Healthcare Safety Network, 2010 * From reporting hospital during the preceding 4 weeks. Alternate Text: The figure above shows the percentage of laboratory-identified Clostridium difficile infections (LabID-CDIs) (N = 42,157), by hospitalization status at time of stool collection and type/location of exposure in the United States, during 2010, based on data from the

National Healthcare Safety Network. Surveillance was conducted over approximately 27.6 million patient days. A total of 42,157 incident LabID-CDIs were reported. Overall, 52% of LabID-CDIs events were already present on admission to hospitals. The pooled rate of hospital onset CDI was 7.4 per 10,000 patient-days, with a median hospital rate of 5.4 per 10,000 and an interquartile range of 6.2.

TABLE 2. Reductions in hospital-onset Clostridium difficile infection rates — Illinois, Massachusetts, and New York, May 2008–October 2011* State Period Patient days Rate (95% CI*) Rate ratio (95% CI)

Illinois	Mar 2010–Oct 2010	637,135	11.6 (10.3–13.0)	0.84 (0.70–1.00)
Massachusetts	Mar 2011–Oct 2011	578,121	9.9 (8.4–11.4)	0.75 (0.63–0.90)
Massachusetts	Feb 2010–Sep 2010	823,939	7.6 (6.7–8.5)	0.75 (0.63–0.90)
Massachusetts	Feb 2011–Sep 2011	830,023	5.7 (4.9–6.5)	0.81 (0.73–0.89)
New York	May 2008–Dec 2008	2,607,464	9.2 (8.5–9.9)	0.81 (0.73–0.89)
New York	May 2009–Dec 2009	2,575,514	7.5 (7.0–8.0)	0.80 (0.73–0.86)
Overall	Pooled baseline	4,068,538	9.3 (8.7–9.8)	
Overall	Pooled post	3,983,658	7.5 (7.0–7.9)	

Abbreviation: CI = confidence interval. * Study periods vary by state. Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of

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