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# Do admissions and discharges to long-term care facilities influence hospital burden of *Clostridium difficile* infection?

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## SUMMARY

**Background—**Substantial geographical clustering of *Clostridium difficile* infection (CDI) outbreaks in hospitals in the USA have previously been demonstrated.

**Aim—**To test the hypothesis that hospital burden of CDI is associated with admission from and discharge to long-term care facilities (LTCFs).

**Methods—**Hospital discharge data from 19 states in the USA were used to identify all patients discharged with a diagnosis of CDI from 1 January 2002 to 31 December 2004. For every hospital, the proportion of discharges with a diagnosis of CDI was calculated, and those above the 90th percentile were classified as 'high CDI' hospitals. We tested the association between this measure of hospital burden of CDI and the rates of admission from and discharges to LTCFs. We adjusted for other hospital level characteristics, case-complexity and local population characteristics.

**Findings—**We identified 38,372,951 discharges during the three-year study period. Of all discharges, 274,311 (0.71%) had a primary or secondary diagnosis of CDI. Hospitals had a mean CDI burden of 7.8 cases per 1000 discharges. High CDI hospitals ($N$ = 610; 10.0%) had a mean CDI burden of 34.8 cases per 1000 discharges. Compared to other hospitals, high CDI hospitals were more likely to have a high proportion of admissions from or discharges to LTCFs. This association persisted after adjustments for other hospital characteristics, case-complexity, and area population characteristics.

**Conclusion—**A high rate of admission from or discharge to LTCFs is associated with an increased hospital burden of CDI.

### Keywords

*Clostridium difficile* infection; Hospital discharge data; Long-term care facilities



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**Conflict of interest statement** None declared.

## Introduction

*Clostridium difficile* infection (CDI) commonly causes hospital-acquired diarrhoea and is associated with substantial morbidity and mortality.[1] Data from the United States Nationwide Inpatient Sample reveal an increase in the prevalence and severity of CDI.[1] A number of patient characteristics predispose patients to CDI.[2–10] However, given that most patients develop CDI during inpatient treatment at an acute care facility, attempts have been made to identify factors associated with high hospital rates and outbreaks of CDI.[11] Substantial geographic clustering of CDI outbreaks at US hospitals has been demonstrated.[12] These analyses did not identify factors that could explain the outbreaks. We therefore postulated that hospital burden of CDI was associated with patient transfer practices between facilities, particularly between acute care hospitals and long-term care facilities (LTCFs). The aim of this study was to test the hypothesis that a high rate of admission from or discharge to LTCFs is associated with a high hospital burden of CDI.

## Methods

### Healthcare Cost and Utilization Project data

Hospital inpatient discharge data were obtained from 19 states that reported to the Healthcare Cost and Utilization Project between 2002 and 2004.[13] These data included >99% of all discharge abstracts of non-government inpatient facilities in the reporting states. They provided information on patient demographics, socioeconomic factors, admission profiles, hospital profiles, hospital location, discharge diagnoses, procedure codes, total charges, and vital status at hospital discharge. A data use agreement is held with the Agency for Healthcare Research and Quality for all states except California, for which there is a separate data use agreement. The Lahey Clinic and Tufts University institutional review boards both approved the study.

Diagnostic codes from the International Classification of Diseases (ICD-9) were used to identify patients who were discharged with a diagnosis of CDI (ICD-9 code 8.45).[1] Counting patients with either a primary or secondary diagnosis of CDI, annual rates per 1000 discharges for each hospital were calculated. For each year, hospitals were divided into two groups: those hospitals with annual rates above the 90th percentile (‘high CDI’ hospitals) and the remaining hospitals.[12] The proportions of admissions from and discharges to LTCFs and other hospitals were identified. Hospitals with proportions of admissions from or discharges to LTCFs above the 90th percentiles were categorized as ‘high LTC admission’ and ‘high LTC discharge’ hospitals respectively. Length of stay was coded as the proportion of patients staying in hospital for four or more days. Median patient age at discharge was analysed as a continuous variable. Insurance payer information was also extracted and aggregated at the hospital level to measure the proportion of inpatient stays that were paid by government insurers (Medicare and Medicaid), private insurance and other sources.

### Centers for Medicare and Medicaid Services hospital case-complexity data

Hospital case-complexity information was obtained from the United States Centers for Medicare and Medicaid Services for the years 2002–2004.[14] We used the ‘case-mix index’ for each hospital, which is the average complexity for all Medicare diagnoses. A hospital’s case-complexity provides an estimate of the range of diagnoses, complexity of cases, and resource needs. This case-complexity information was merged with the hospital inpatient discharge data.

## American Hospital Association Annual Survey data

To determine hospital factors associated with high rates of CDI, we also obtained the American Hospital Association (AHA) Annual Survey of Hospitals database for the years 2002–2004.[15] The AHA database covers >6000 hospitals and >450 healthcare systems.[15] AHA data have been used extensively to study hospital-based outcomes, hospital policies, and reimbursement practices.[16–18] Features of interest were selected on the basis of previous analyses and included: human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) service, burns service, emergency department, haemodialysis, cardiac surgery, palliative care service, separate nursing home unit, transplant services, designation as a trauma centre, designation as a community hospital, accreditation by the Joint Commission on Accreditation of Healthcare Organizations, cancer programme approved by the American College of Surgeons, affiliation with a medical school, affiliation within a healthcare system or group, and average daily hospital census.[12] These variables were merged with the hospital inpatient discharge data.

## Census data

United States Census 2000 data were used to identify characteristics of the neighbourhood surrounding each hospital, including information on metropolitan (urban) status, population sex ratio, proportion of foreign-born residents, proportion of residents aged >65 years and proportion of households earning less than twice the federal poverty level.[19] We defined the hospital neighbourhood as the area within 90 miles of the hospital. Data management, spatial data overlay, and aggregation of census data were performed using ESRI's ArcView 9.3 software.

## Merged hospital-neighbourhood dataset

Data were merged from Health Care Cost and Utilization Project, Centers for Medicare and Medicaid, American Hospital Association, and the United States Census to create a hospital-neighbourhood dataset for use in this and future analyses. The merged dataset contained information at the hospital level on inpatient claims, patient case-mix, payers, ownership, medical school affiliation, service offerings and accreditation characteristics. The merged dataset also included the neighbourhood demographic information.

## Statistical analyses

To assess univariate group differences between high CDI and other acute care hospitals, linear and logistic regression with adjusted standard errors was used to account for clustering due to repeated measures on hospitals over the three-year period. Multiple imputation methods were used to impute missing data for hospital case-complexity information (22.4% missing) and number of hospital beds (15.3% missing). Following the approach detailed by Little and Rubin and adapted by Schafer, a Markov chain–Monte Carlo simulation for non-monotone missing variables was used to multiply impute the missing values.[20,21] Ten complete data sets were created.

Continuous variables are reported using means and standard deviations. Categorical variables are reported as counts and percentages. We constructed a multivariable regression model to evaluate the relationship between hospitals above the 90th percentile of CDI burden and all other characteristics. Variables were selected for inclusion in the full model based on our previous research and results from the univariate analyses. In successive model iterations, variables with weak multivariate associations were removed unless forced into the model based on hypotheses. The final iteration provided the best overall model fit. A model was thus estimated within each of the 10 imputed data sets. We combined models across the 10 data sets by taking the average of coefficients and standard errors and inflating the errors with an estimate of between-model variation.[20] Results of the combined multivariable regression model are presented as odds ratios. All statistical analyses were performed with SAS 9.2.

## Results

We assessed 38,372,951 inpatient discharges from 6097 hospitals over the three-year study period. Of this total, 274,311 discharges were reported with a diagnosis of CDI. Characteristics of all acute-care facilities are listed in Table I. For all hospitals, the mean number of CDIs per 1000 inpatient discharges was 7.8 (SD: 16.4). Hospitals with a CDI rate above the 90th percentile ('high CDI' hospitals) had a mean rate of 34.8 cases per 1000 discharges.

### Univariate analysis

High CDI hospitals had a substantially higher rate of CDI as compared to all other acute-care hospitals. High CDI hospitals had higher hospital case-complexity and were more likely to offer more complex services relating to transplantation, HIV/AIDS treatment, burn care, and palliative medicine. In addition, high CDI hospitals were more likely to admit patients to the hospital for four or more days and to admit patients with Medicare insurance, higher age, and Black race (Table I). These high CDI hospitals were also more likely to be located within a metropolitan area and have a higher proportion of foreign-born residents living in the neighbourhood. Table II presents univariate models of admission and discharge characteristics. High CDI hospitals were more likely to have a high rate of admissions from and discharges to LTCFs. High CDI hospitals also had a higher rate of admission from and discharge to other acute care hospitals.

### Multivariate analysis

Logistic regression revealed that hospitals with a proportion above the 90th percentile of patients originating from LTCFs were more likely to be classified as a high CDI hospital (odds ratio: 1.49; $P = 0.034$). Hospitals with a proportion above the 90th percentile of patients discharged to LTCFs also had a higher risk of classification as a high CDI hospital (odds ratio: 1.72; $P = 0.02$). Several variables were also associated with an increased risk of classification as a high CDI facility, including hospital case-complexity, medical school affiliation, patient median age, length of stay, and location in a metropolitan area. An increased proportion of males in the hospital neighbourhood and provision of open heart cardiac surgery was associated with a decreased risk of classification as a high CDI facility. The full model is detailed in Table III.

## Discussion

This study found substantially higher rates of CDI, representing clusters of disease, in some hospitals. Several features of the hospitals and the neighbourhoods they serve were identified are associated with this clustering. The data reveal a substantial CDI burden at acute care facilities with higher rates of admission from and discharge to LTCFs. New clinical interventions and public policies may be needed to prevent and control CDI clusters in hospitals with a high proportion of patients receiving long-term care. High CDI hospitals had a mean of 34.8 cases of CDI per 1000 discharges, six times greater than the median. This variability in hospital burden of CDI is consistent with our contention that *C. difficile* clusters occur throughout the USA.[12] A number of studies have reported that outbreaks of disease may lead to significant morbidity and mortality.[22–24] We and others maintain that these outbreaks of CDI occur with regular periodicity, are predictable, and may therefore be preventable.

Identifying hospitals with a propensity for CDI clusters may be helpful in efforts to prevent future disease outbreaks. In the past, it has been demonstrated that hospitals with transplant programmes and other complex services have high CDI case burden.[12] In this analysis, it was found that hospitals with high rates of admissions from and discharges to LTCFs were at particular risk for CDI clusters. Similarly, in a point prevalence study of Association for Professionals in Infection Control and Epidemiology members, the authors found that 35% of patients with CDI had been admitted to a LTCF within 30 days and that 47% had been hospitalized within 90 days.[25] Hospitals with proportionately more admissions from LTCFs have a higher risk of CDI outbreaks. Possible reasons for this association include spread of the pathogen between facilities via symptomatic patients or via asymptomatic carriers, as is known to occur with meticillin-resistant *Staphylococcus aureus*.[26] Asymptomatic carriage among patients and healthcare workers has been implicated as a source *C. difficile* transmission in hospitals and LTCFs.[27,28] The differential health status of patients in LTCFs is a possible source of bias in the results of this study, but we adjusted for health status with measures of hospital case-complexity, insurance payer status, age, sex and other covariates. The present study has a number of strengths and limitations that are specific to the use of administrative data. First, because the data are administrative in nature, hospital billers or coders need to base the code for CDI diagnosis on physician report or laboratory assay, raising the potential for miscoding. Also, hospital inpatient discharge files do not provide clinical details commonly found in the medical record, such as laboratory results and treatment details, and we had no information on antibiotic prescription practices in hospitals. More information regarding culture and assay results and treatment patterns would allowed verification of diagnostic codes and examination of other associations. Some patients may have been admitted and discharged more than once with the same infection, but the data available did not allow identification of these. Despite these limitations, the study includes a large representative cohort of hospitalized patients with CDI in 19 states in different geographic regions of the USA.

In conclusion, this study has revealed significant associations between hospitals with high levels of CDI and both admissions from and discharges to LTCFs. Prevention strategies would benefit from better information about transmission patterns both within and between healthcare facilities.

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## Table I

Characteristics for all included hospitals

| Characteristic | All hospitals (*N* = 6097) | High CDI hospitals (*N* = 610) | All others (*N* = 5487) | *P*-value |
|---|---|---|---|---|
| CDI (cases per 1000 discharges) | 7.8 (16.4) | 34.8 (42.1) | 4.8 (3.5) | 0.0001 |
| CMS variables Case-complexity mean | 1.3 (0.3) | 1.4 (0.2) | 1.3 (0.3) | 0.0001 |
| AHA variables Average daily inpatient census | 152.5 (206.8) | 182.6 (272.2) | 149.2 (198.2) | 0.2 |
| Medical/surgical beds | 104.5 (129.6) | 119.4 (151.9) | 103.1 (127.1) | 0.7 |
| Intensive care unit beds | 11.1 (15.6) | 13.3 (18.4) | 10.9 (15.3) | 0.7 |
| Designation as community hospital | 5721 (94.9%) | 515 (87.3%) | 5206 (95.7%) | 0.07 |
| Emergency department | 5141 (90.0%) | 381 (72.4%) | 4760 (91.8%) | 0.2 |
| Accreditation by joint commission | 4894 (81.3%) | 512 (87.4%) | 4382 (80.7%) | 0.02 |
| Approved cancer program | 1877 (31.2%) | 162 (27.6%) | 1715 (31.6%) | 0.3 |
| Residency training programme | 1264 (21.0%) | 132 (22.5%) | 1132 (20.8%) | 0.9 |
| Membership within hospital system | 3986 (66.1%) | 456 (77.3%) | 3530 (64.9%) | 0.001 |
| Affiliation with a medical school | 1545 (25.7%) | 178 (30.4%) | 1367 (25.2%) | 0.8 |
| Burn care services | 383 (6.7%) | 23 (4.4%) | 360 (6.9%) | 0.2 |
| Cardiac catheter laboratory services | 2588 (45.2%) | 219 (42.0%) | 2369 (45.5%) | 0.6 |
| Trauma centre servives | 2122 (36.8%) | 124 (23.7%) | 1988 (38.1%) | 0.8 |
| HIV/AIDS services | 2079 (36.3%) | 198 (38.2%) | 1881 (36.2%) | 0.01 |
| Open heart services | 1455 (25.4%) | 107 (20.5%) | 1348 (25.9%) | 0.2 |
| Transplant services | 611 (10.6%) | 71 (13.6%) | 540 (10.3%) | 0.04 |
| Long-term acute-care services | 394 (6.9%) | 85 (16.2%) | 309 (5.9%) | 0.0001 |
| Palliative care services | 1606 (28.2%) | 159 (30.8%) | 1447 (28.0%) | 0.04 |
| Haemodialysis services | 2333 (40.7%) | 231 (43.6%) | 2102 (40.4%) | 0.001 |
| Separate nursing home facilities | 1435 (23.8%) | 115 (19.5%) | 1320 (24.3%) | 0.07 |
| HCUP variables Length of stay ≥4 days | 45.1% (15.7) | 62.7% (21.3) | 43.2% (13.6) | 0.0001 |
| Admit from another hospital | 6.4% (16.8) | 24.1% (37.8) | 4.4% (10.8) | 0.0001 |
| Admission source | 2.5% (6.9) | 5.0% (13.4) | 2.2% (5.7) | 0.001 |

| **Characteristic** | **All hospitals (*N* = 6097)** | **High CDI hospitals (*N* = 610)** | **All others (*N* = 5487)** | ***P*-value** |
|---|---|---|---|---|
| is long-term care | | | | |
| Discharged to another hospital | 4.7% (4.8) | 7.2% (7.8) | 4.4% (4.3) | 0.0004 |
| Discharged to long-term care | 15.9% (8.9) | 22.1% (11.6) | 15.2% (8.2) | 0.0001 |
| Died in hospital | 3.0% (4.1) | 6.2% (9.2) | 2.6% (2.8) | 0.0001 |
| Proportion female | 60.9% (9.2) | 57.4% (8.9) | 61.3% (9.2) | 0.005 |
| Median age | 60.9 (12.1) | 68.1 (9.2) | 60.1 (12.1) | 0.005 |
| Proportion White | 58.2% (38.6) | 70.1% (30.6) | 56.9% (39.2) | 0.09 |
| Proportion Black | 7.7% (13.7) | 8.7% (12.0) | 7.6% (13.8) | 0.8 |
| Proportion Hispanic | 8.5% (16.7) | 7.0% (12.4) | 8.6% (17.1) | 0.1 |
| Proportion Asian | 1.5% (5.5) | 2.0% (5.3) | 1.5% (5.6) | 0.006 |
| Proportion Native American | 0.5% (4.2) | 0.2% (0.7) | 0.6% (4.5) | 0.006 |
| Medicare insurance | 49.2% (18.2) | 60% (18.2) | 48% (17.8) | 0.0001 |
| Medicaid insurance | 14.0% (13.3) | 8.4% (10.2) | 14.6% (13.5) | 0.0001 |
| Private insurance | 28.3% (15.5) | 25.6% (15.1) | 28.6% (15.5) | 0.004 |
| Self-pay | 4.5% (6.8) | 2.4% (3.0) | 4.7% (7.1) | 0.0001 |
| Census neighbourhood | | | | |
| Proportion male | 49.2% (0.8) | 48.9% (0.7) | 49.2% (0.8) | 0.0001 |
| Proportion foreignborn | 13.0% (9.9) | 15.7% (9.6) | 12.7% (9.8) | 0.0001 |
| Proportion aged ≥65 years | 12.8% (2.6) | 13.3% (3.2) | 12.8% (2.5) | 0.02 |
| Proportion below poverty level | 28.6% (5.7) | 28.6% (4.8) | 28.6% (5.8) | 0.9 |
| Proportion non-Hispanic White | 70.5% (17.1) | 65.7% (16.1) | 71.1% (17.2) | 0.0001 |
| Proportion living in metropolital area | 77.9% (24.7) | 88.6% (16.5) | 76.7% (25.2) | 0.0001 |

CDI, *Clostridium difficile* infection; CMS, Centers for Medicare and Medicaid Services; AHA, American Hospital Association; HIV/AIDS, human immunodeficiency virus/acquired immune deficiency syndrome; HCUP, Healthcare Cost and Utilization Project.

Univariate analyses compared ‘High CDI hospitals’ with ‘All other hospitals’.

Values are presented as means (SD) unless otherwise stated.

Based on clustered linear regression.

**Table II**

Dichotomized admission and discharge variables (based on the 90th percentile of admission or discharge status) for all included hospitals

| Characteristic | All hospitals (*N* = 6097) | High CDI hospitals (*N* = 610) | All other hospitals (*N* = 5487) | *P*-value |
|---|---|---|---|---|
| CDI (cases per 1000 discharges) | 7.8 (16.4) | 34.8 42.1 | 4.8 3.5 | 0.0001 |
| HCUP dichotomous variables | | | | |
| >90% admitted from other hospital | 609 (10%) | 181 (29.7%) | 428 (7.8%) | 0.002 |
| >90% admitted from long-term care | 609 (10%) | 117 (19.2%) | 492 (9.0%) | 0.0002 |
| >90% discharged to another hospital | 609 (10%) | 142 (23.3%) | 467 (8.5%) | 0.0001 |
| >90% discharged to long-term care | 609 (10%) | 173 (28.4%) | 436 (7.9%) | 0.0001 |

CDI, *Clostridium difficile* infection; HCUP, Healthcare Cost and Utilization Project.

Univariate analyses were performed comparing ‘High CDI hospitals’ with ‘All other hospitals’.

**Table III**

Multivariate regression evaluating factors associated with hospital identification as 'high CDI'

| Characteristic | Change in odds | Odds ratio | *P*-value |
|---|---|---|---|
| CMS variables | | | |
| One unit increase in case-mix index | 27.33 | 1.27 | 0.4 |
| AHA variables | | | |
| 100 unit increase in average inpatient census | 9.77% | 1.10 | 0.03 |
| Designation as community hospital | 104.99% | 2.05 | 0.03 |
| Emergency department | −10.09% | 2.05 | 0.03 |
| Accreditation by Joint Commission | 39.31% | 1.39 | 0.2 |
| Approved cancer programme | −2.25% | 0.98 | 0.9 |
| Membership within a hospital system | 64.92% | 1.65 | 0.003 |
| Affiliation with a medical school | 33.48% | 1.33 | 0.12 |
| Burn care services | −9.03% | 0.91 | 0.7 |
| Trauma centre services | −0.60% | 0.99 | 1 |
| HIV/AIDS services | 37.58% | 1.38 | 0.07 |
| Open heart services | −55.06% | 0.45 | 0.002 |
| Transplant services | 52.11% | 1.52 | 0.08 |
| Palliative care services | 18.29% | 1.18 | 0.29 |
| Haemodialysis services | −2.34% | 0.98 | 0.9 |
| HCUP variables | | | |
| Referent | | 1.00 | |
| >90% admitted from other hospital | −45.88% | 0.54 | 0.02 |
| Referent | | 1.00 | |
| >90% admitted from long-term care | 49.29% | 1.49 | 0.03 |
| Referent | | 1.00 | |
| >90% discharged to another hospital | 86.16% | 1.86 | 0.005 |
| Referent | | 1.00 | |
| >90% discharged to long-term care 10 unit increase | 72.47% | 1.72 | 0.02 |

| Characteristic | Change in odds | Odds ratio | *P*-value |
|---|---|---|---|
| in: | | | |
| Median age | 68.65% | 1.68 | 0.0001 |
| Length of stay ≥4 days | 75.93% | 1.76 | 0.0001 |
| Proportion female | −24.38% | 0.76 | 0.005 |
| Proportion White | 2.63% | 1.03 | 0.3 |
| Proportion Medicare | 4.79% | 1.05 | 0.5 |
| Proportion Medicaid | −29.06% | 0.71 | 0.0001 |
| US Census Information | | | |
| 10 unit increase in: | | | |
| Proportion male | −86.50% | 0.13 | 0.14 |
| Proportion foreign-born | −31.95% | 0.68 | 0.002 |
| Proportion aged ≥65 years | −29.16% | 0.71 | 0.3 |
| Proportion below poverty level | 98.22% | 1.98 | 0.0002 |
| Proportion in metropolitan area | 39.47% | 1.39 | 0.0001 |

CDI, *Clostridium difficile* infection; CMS, Centers for Medicare and Medicaid Services; AHA, American Hospital Association; HIV/AIDS, human immunodeficiency virus/acquired immune deficiency syndrome; HCUP, Healthcare Cost and Utilization Project.