

# Hospital Charges Attributable to a Primary Diagnosis of Infectious Diseases in Older Adults in the United States, 1998 to 2004

Aaron T. Curns, MPH,<sup>\*†</sup> Claudia A. Steiner, MD, MPH,<sup>‡</sup> James J. Sejvar, MD,<sup>\*</sup> and Lawrence B. Schonberger, MD, MPH<sup>\*</sup>

**OBJECTIVES:** To describe total and average hospital charges associated with infectious disease (ID) hospitalizations and specific ID categories and to estimate ID hospitalization rates in adults aged 65 and older in the United States from 1998 through 2004.

**DESIGN:** Retrospective analysis of hospital discharge data obtained from the Nationwide Inpatient Sample for 1998 through 2004.

**SETTING:** United States.

**PATIENTS:** Older adults hospitalized in the United States from 1998 through 2004.

**MEASUREMENTS:** Hospital charges and hospitalization rates for IDs described according to year, age group, sex, U.S. Census region, and ID category. Charges for non-ID hospitalizations were also described. Hospital charges were adjusted for inflation.

**RESULTS:** From 1998 through 2004, total charges for ID hospitalizations exceeded \$261 billion and accounted for 13% of all hospital charges for older adults. Total charges for ID hospitalizations increased from \$31.4 billion in 1998 to \$45.7 billion in 2004. The average annual ID hospital charge was lower than the average annual non-ID hospital charge during the study period (\$21,342 vs \$22,787,  $P < .001$ ). The average annual rate for ID hospitalizations was 503 per 10,000 older adults, which remained stable during the study period.

**CONCLUSION:** The total charges for ID hospitalizations and for all hospitalizations in older adults in the United States increased 45% and nearly 40%, respectively, during the 7-year study period, whereas the population of older adults grew by only 5%. Sustained increases of such magnitude will have major implications for the U.S. healthcare system as it prepares for the more than doubling of the older

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**Key words:** infectious disease; older adults; lower respiratory tract infection; hospitalizations

Since 1980, infectious disease (ID) hospitalization rates have increased in adults aged 65 and older in the United States.<sup>1,2</sup> These increasing rates are troubling, because the population of older adults is expected to increase dramatically in the coming decades. Between 2000 and 2030, the population of older adults is expected to double from 35 million to 72 million, and older adults will account for nearly 20% of the U.S. population in 2030, compared with 12% in 2000.<sup>3</sup> It is estimated that nearly 25% of all older adults will be aged 85 and older by 2050.<sup>3</sup> In conjunction with the increasing ID hospitalization rates during the past 2 decades in older adults, increases in healthcare costs continue to exceed the rate of inflation in the United States.<sup>4</sup> Total Medicare costs were \$309 billion in 2004 and accounted for 2.6% of the U.S. gross domestic product (GDP). By 2035, Medicare spending is projected to amount to 7.5% of the GDP. Total healthcare expenditures in the United States amounted to nearly \$1.9 trillion and accounted for 16% of the U.S. GDP in 2004. During the same year, hospitalizations accounted for 30% of healthcare expenditures, and the increase in hospital spending accounted for one-third of the overall increase in healthcare expenditures.<sup>4</sup>

Given the increasing ID hospitalization rates of older adults and the substantial influence of older adults on the U.S. healthcare system, it is important to better understand the economic burden associated with ID hospitalizations in older adults in the United States. The objectives of the study were to estimate the total and average hospital charges associated with ID hospitalizations, as well as for specific ID categories, and to estimate the number and rate of hospi-

From the <sup>\*</sup>National Center for Zoonotic, Vector-Borne, and Enteric Diseases and <sup>†</sup>National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia; and <sup>‡</sup>Center for Delivery, Organization and Markets, Agency for Healthcare Research and Quality, Rockville, Maryland.

Address correspondence to Aaron T. Curns, MPH, Centers for Disease Control and Prevention, 1600 Clifton Rd, NE, MS-A47, Atlanta, GA 30333. E-mail: agc8@cdc.gov

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**Table 1. Classifications of Infectious Disease Categories**

Infectious Disease Category	<i>International Classification of Diseases, Ninth Revision, Clinical Modification Code(s)</i>
Septicemia	038
Hepatobiliary disease	070, 095.3, 573.1, 573.2, 576.1
Mycoses	110–118
Infections of the heart	093, 391, 392.0, 393, 394.1, 395.0–395.2, 397.1, 397.9, 398, 421, 422.0, 424.9
Upper respiratory tract infections	032.0–032.3, 034.0, 098.6, 101, 460–465, 473.0–474.0, 475
Lower respiratory tract infections	022.1, 031.0, 033, 095.1, 466, 480–487, 510, 511.1, 513, 517.1
Abdominal and rectal infections	095.2, 098.7, 540–542, 566, 567.0–567.2, 569.5
Kidney, urinary tract, and bladder infections	095.4, 099.4, 590, 595.0, 597, 598.0, 599.0
Cellulitis	680–686
Enteric infections	001–009, 022.2
Infection and inflammatory reaction to prosthetic devices	996.6
Postoperative infection	998.5
Osteomyelitis	730
Other infectious diagnoses	Codes available upon request.

talizations associated with ID in older adults in the United States during 1998 to 2004.

## METHODS

Hospitalization estimates for older adults were obtained from the Nationwide Inpatient Sample (NIS), the largest all-payer inpatient care database in the United States.<sup>5</sup> The NIS is developed as part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality in partnership with participating states. The NIS is designed to approximate a 20% sample of U.S. community hospitals.<sup>6</sup> The 1998 NIS included 6.8 million discharges from 984 hospitals located in 22 states, and the 2004 NIS included approximately 8 million discharges from 1,004 hospitals located in 37 states.<sup>7</sup> By using HCUP weighting methodology, nationally representative estimates of hospitalization characteristics, including hospital charges, for the United States can be calculated.

ID hospitalizations were identified and categorized into major ID categories using the *International Classification of Diseases, Ninth Edition, Clinical Modification* (ICD-9-CM, Table 1).<sup>1,2,8</sup> Up to 15 discharge diagnoses could be recorded for a hospitalization, but only a hospitalization with a primary ID discharge diagnosis was considered an ID hospitalization for this study because the ID could then reasonably be assumed to be the cause of the hospitalization.

Appropriate software for calculating statistics and standard errors (SEs) from the NIS is required because of its survey design.<sup>9</sup> SUDAAN 9.0 was used to generate hospitalization estimates and the SEs of the estimates from the NIS to account for its sample design (Research Triangle Institute, Research Triangle Park, NC). All statistical tests incorporated the survey design information to ensure that the variances of estimates resulting from the survey within calendar years and across calendar years were properly inflated before assessing statistical significance.<sup>9,10</sup> Before calculating total and average hospitalization charges, all annual hospital charge data were expressed in terms of 2004 dollars using the Consumer Price Index for Medical

Care, Hospital, and Related Services.<sup>11</sup> Hospital charges were then evaluated according to year, age group (65–74, 75–84, and ≥85), sex, U.S. Census region (Northeast, Midwest, South, and West), and ID category. In addition, the average charges for ID hospitalizations were compared with those for non-ID hospitalizations. Comparisons of average charges according to various characteristics (e.g., age group) were made using *t*-tests. Tests for trends in hospital charges over time were made using weighted least squares linear regression.

The number and rate of hospitalizations in older adults were also evaluated according to year, age group, sex, and region. For hospitalization rate calculations, the National Center for Health Statistics' Bridged Race population estimates was used to obtain the population of U.S. older adults for 1998 through 2004.<sup>12,13</sup>

## RESULTS

### Charges and Cost Estimates

From 1998 through 2004, there were approximately 12.4 million ID hospitalizations of older adults, and these hospitalizations accounted for approximately 14% of all hospitalizations of older adults (Table 2). Total charges for ID hospitalizations during the study period were more than \$261 billion and accounted for 13% of hospital charges for all hospitalizations of older adults (Table 2). The average charge for an ID hospitalization was slightly lower than that for a non-ID hospitalization during the study period (\$21,342 vs \$22,787,  $P < .001$ ). The annual total charges for ID hospitalizations increased from approximately \$31.4 billion in 1998 to \$45.7 billion in 2004 (Figure 1, test for trend,  $P < .001$ ). Expressed in terms of 2004 dollars per person aged 65 and older, ID hospitalization charges for older adults in 1998 amounted to approximately \$865 for each person aged 65 and older in the United States; by 2004, this had increased to approximately \$1,160. During the same period, the average charge for an ID hospitalization increased 36%, from \$18,396 in 1998 to \$25,034 in 2004 (Figure 1, test for trend,  $P < .001$ ). The average charge for a

**Table 2. Total Hospital Charges, Mean Hospital Charges, and Number and Rate of Hospitalizations per 10,000 Older Adults According to Infectious Disease Categories and All-Cause Hospitalizations—United States, 1998–2004**

Infectious Disease Category	Total Charges (\$ Billions)	Mean Charges \$ (95% CI)	Discharges, n (Standard Error)	Rate (95% CI)
All hospitalizations	2,018.6	22,588 (22,194–22,983)	90,673,329 (721,645)	3,661.4 (3,604.3–3,718.5)
Total infectious diseases	261.5	21,342 (20,925–21,759)	12,447,087 (91,587)	502.6 (495.4–509.9)
Lower respiratory tract infections	107.5	19,496 (19,140–19,852)	5,601,816 (40,801)	226.2 (223.0–229.4)
Septicemia	49.2	30,053 (29,231–30,874)	1,657,302 (18,962)	66.9 (65.4–68.4)
Kidney, urinary tract, and bladder infections	24.1	13,815 (13,518–14,112)	1,778,695 (14,894)	71.8 (70.6–73.0)
Infection and inflammatory reaction to prosthetic devices	15.5	36,312 (35,416–37,208)	434,650 (5,400)	17.6 (17.1–18.0)
Cellulitis	13.7	14,401 (14,076–14,726)	966,672 (8,410)	39.0 (38.4–39.7)
Other infectious diagnoses	13.7	23,584 (22,972–24,195)	590,927 (5,470)	23.9 (23.4–24.3)
Postoperative infections	8.9	30,221 (29,444–30,998)	298,139 (3,905)	12.0 (11.7–12.3)
Infections of the heart	7.9	34,671 (33,344–35,999)	229,210 (4,922)	9.3 (8.9–9.6)
Enteric infections	5.9	17,114 (16,620–17,607)	347,799 (4,128)	14.0 (13.7–14.4)
Abdominal and rectal infections	5.6	30,918 (30,254–31,583)	186,677 (1,959)	7.5 (7.4–7.7)
Osteomyelitis	4.6	31,413 (30,415–32,410)	149,712 (2,034)	6.0 (5.9–6.2)
Mycoses	2.7	35,422 (34,199–36,644)	77,217 (1,077)	3.1 (3.0–3.2)
Hepatobiliary disease	1.3	26,723 (25,429–28,018)	50,929 (877)	2.1 (2.0–2.1)
Upper respiratory tract infections	0.9	11,283 (10,954–11,613)	77,342 (989)	3.1 (3.0–3.2)

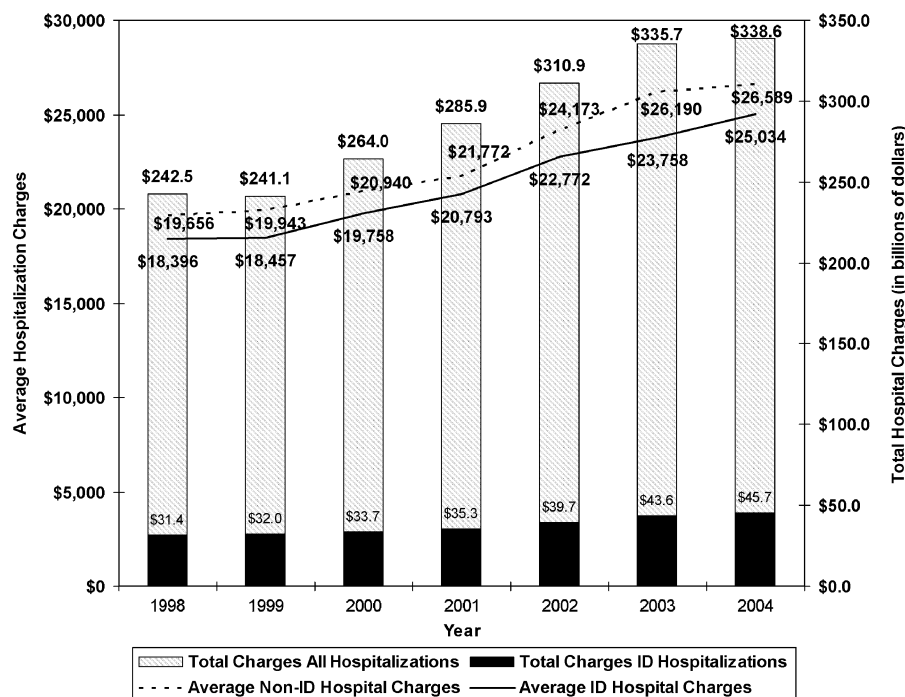
Note: Hospital charges were adjusted using the medical care consumer price index and are expressed in 2004 dollars.<sup>11</sup> CI = confidence interval.

non-ID hospitalization increased 35% during the study period, from \$19,656 to \$26,589 (test for trend, *P* < .001).

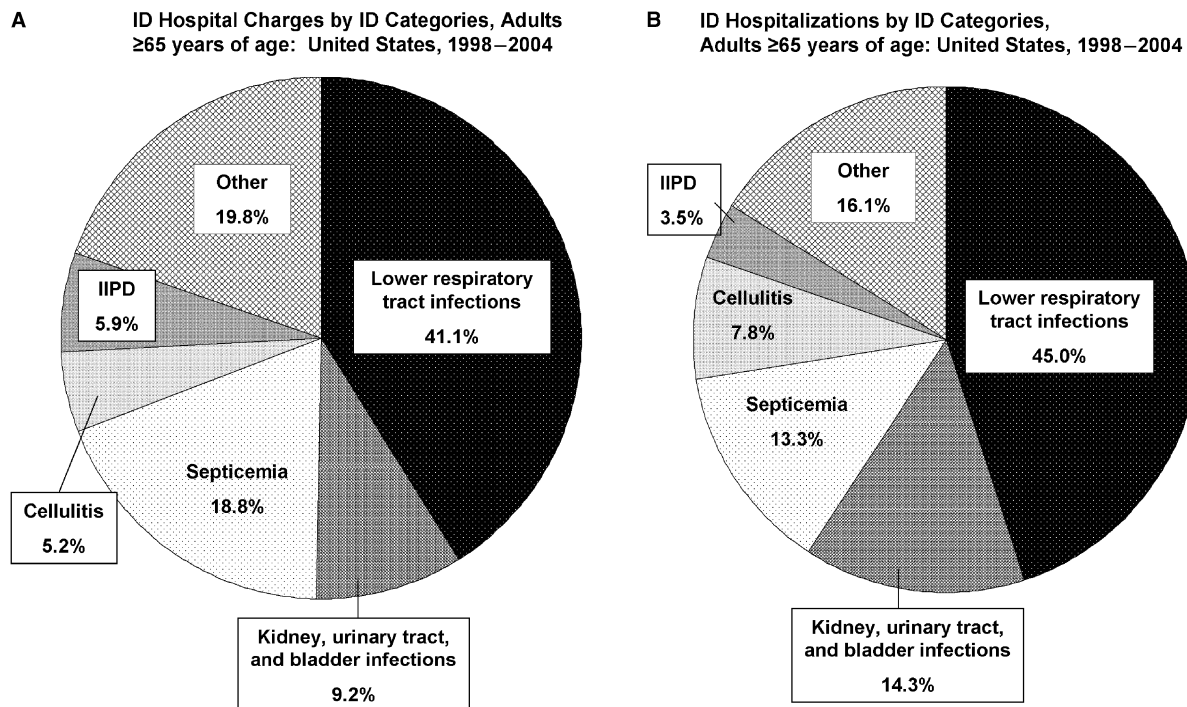
Lower respiratory tract infections (LRTIs) accounted for 5.6 million hospital discharges and \$107.5 billion in hospital charges during the study period (Table 2). Approximately 41% of ID hospitalization charges were for LRTI, and they accounted for 45% of ID hospital discharges (Figure 2A, B). Septicemia accounted for 19% of ID

hospital charges and 13% of hospital discharges, and kidney, urinary tract, and bladder (KUB) infections accounted for 9% of ID hospital charges and 14% of ID hospital discharges.

The three ID categories of infection and inflammatory reaction to prosthetic devices, mycoses, and infections of the heart had the highest average charges of the ID categories, averaging more than \$34,000 per hospitalization



**Figure 1.** Total hospital charges for all-cause and infectious disease (ID) hospitalizations and average hospital charges for non-ID and ID hospitalizations of adults aged 65 and older, United States, 1998 to 2004.



**Figure 2.** Proportions of infectious disease (ID) hospital charges (A) and ID hospitalizations (B) according to ID category of adults aged 65 and older, United States, 1998 to 2004. IIPD, infection and inflammatory reaction to prosthetic devices.

(Table 2). The osteomyelitis, septicemia, and the abdominal and rectal infection ID categories had the next highest average charges of more than \$30,000 per hospitalization. LRTI hospitalizations had an average charge of approximately \$19,500. Hospitalizations for upper respiratory tract infections had the lowest average charge (approximately \$11,300 per hospitalization) of the ID categories.

The average hospital charges for IDs were highest in those aged 65 to 74 (\$23,625), followed by 75 to 84 (\$21,521); those aged 85 and older had lower hospital charges (\$18,382) than for the two other age groups ( $P < .001$ , all comparisons, Table 3). Hospital charges were higher for men than women, and the differences according to sex remained when stratified according to age group ( $P < .001$ , all comparisons). The West had the highest average ID hospitalization charge (\$28,732) of the four regions, followed by the Northeast (\$25,515,  $P = .001$ , West vs Northeast). The Midwest had the lowest average ID hospitalization charge (\$17,024), which was slightly lower than the average charge for the South (\$18,835,  $P < .001$ , Midwest vs South). The differences in hospital charges according to sex, age group, and region were found for non-ID hospitalizations as well.

More than 60% of ID hospitalizations in older adults did not list a procedure. An average of 0.9 (0–1, 25th–75th percentile) procedures were reported for ID hospitalizations in older adults, and this increased slightly from 0.9 to 1.0 procedures during the study period (test for trend,  $P < .001$ ). The average number of procedures decreased with increasing age group (1.2, 0.9, and 0.7 procedures for subjects aged 65–74, 75–84, and  $\geq 85$ , respectively,  $P < .001$  for all comparisons between age groups). The top five principal procedures were venous catheterization, not elsewhere classified (3.0% of ID hospitalizations);

transfusion of packed cells (2.3%); excisional debridement of wound, infection, or burn (1.8%); injection of antibiotic (1.4%); and hemodialysis (1.3%).

The average length of stay was 6.7 days for ID hospitalizations during the study period and 5.7 days for non-ID hospitalizations in older adults ( $P < .001$ ). The average length of stay for ID hospitalizations decreased slightly ( $-4.4\%$ ) during the study period, from 6.9 days in 1998 to 6.6 days in 2004 ( $P = 0 < .001$ ). The average length of stay also decreased ( $-6.7\%$ ) for non-ID hospitalizations, from 6.0 days in 1998 to 5.6 days in 2004 ( $P < .001$ ). During 2004, the average charge for ID hospitalizations with a length of stay of 1 day was \$6,951; this increased to \$16,542 for 5 days and \$36,527 for 10 days. There were 12,291,447 days of hospitalization associated with IDs, accounting for 16.5% of all hospitalization days in older adults during 2004. ID hospitalizations ending with the patient's death averaged a higher number of procedures (1.9 vs 0.9 procedures,  $P < .001$ ), a longer length of stay (8.3 vs 6.6 days,  $P < .001$ ), and a higher average hospitalization charge (\$38,330 vs \$19,966,  $P < .001$ ) than ID hospitalizations with the patient discharged alive.

### ID Hospitalization Rates

The number of ID hospitalizations ranged from 1,713,106 (SE = 33,715) in 2000 to 1,870,363 (SE = 36,149) in 2003, and ID hospitalization rates ranged from 485 per 10,000 during 2001 to 520 per 10,000 during 2003. (Table 3) The average annual rate was 503 per 10,000 older adults during the study period. The ID hospitalization rate for adults aged 85 and older was almost double that for those aged 75 to 84 (1,082 and 583 per 10,000 older adults within each age group, respectively,  $P < .001$ ) and three times higher than

**Table 3. Total Hospital Charges, Mean Hospital Charges, and the Number and Rate per 10,000 Older Adults for Infectious Disease Hospitalizations of Older Adults in the United States from 1998 through 2004**

Characteristic	Total Charges \$ Billions	Mean Charges \$ (95% CI)	Discharges, n (Standard Error)	Rate (95% CI)
Total	261.5	21,342 (20,925–21,759)	12,447,087 (91,587)	502.6 (495.4–509.9)
Year				
1998	31.4	18,396 (17,659–19,132)	1,737,929 (33,275)	502.0 (483.2–520.9)
1999	32.0	18,457 (17,771–19,143)	1,773,613 (35,053)	509.7 (489.9–529.4)
2000	33.7	19,758 (18,498–21,019)	1,713,106 (33,715)	488.4 (469.5–507.2)
2001	35.3	20,793 (19,859–21,727)	1,714,543 (31,153)	485.3 (468.0–502.6)
2002	39.7	22,772 (21,303–24,241)	1,778,916 (36,415)	499.9 (479.8–520.0)
2003	43.6	23,758 (22,609–24,907)	1,870,363 (36,149)	520.4 (500.7–540.1)
2004	45.7	25,034 (23,847–26,220)	1,858,617 (36,224)	512.1 (492.5–531.7)
Age				
65–74	92.1	23,625 (23,189–24,061)	3,968,139 (28,463)	308.2 (303.8–312.5)
75–84	108.6	21,521 (21,093–21,949)	5,122,409 (39,476)	583.0 (574.2–591.8)
≥85	60.9	18,382 (17,943–18,820)	3,356,539 (27,711)	1,082.3 (1,064.7–1,099.8)
Age group according to sex				
Men	116.7	22,632 (22,188–23,076)	5,245,854 (39,338)	512.2 (504.7–519.7)
65–74	45.7	24,464 (23,992–24,937)	1,903,114 (14,018)	326.4 (321.6–331.1)
75–84	49.6	22,594 (22,137–23,051)	2,232,004 (17,989)	639.6 (629.5–649.7)
≥85	21.4	19,575 (19,098–20,051)	1,110,736 (9,550)	1,206.1 (1,185.8–1,226.4)
Women	144.8	20,406 (20,001–20,811)	7,199,513 (53,874)	495.7 (488.5–503.0)
65–74	46.4	22,853 (22,430–23,276)	2,064,573 (15,149)	293.0 (288.8–297.3)
75–84	59.0	20,695 (20,276–21,114)	2,889,494 (22,425)	545.5 (537.2–553.8)
≥85	39.5	17,794 (17,362–18,226)	2,245,447 (18,998)	1,029.8 (1,012.7–1,046.9)
Region				
Northeast	65.9	25,515 (24,064–26,966)	2,584,597 (48,227)	500.3 (482.0–518.6)
Midwest	50.7	17,024 (16,621–17,427)	3,004,286 (45,695)	517.4 (502.0–532.8)
South	90.2	18,835 (18,434–19,235)	4,788,639 (51,993)	541.8 (530.2–553.3)
West	54.7	28,732 (27,461–30,004)	2,069,565 (35,652)	417.9 (403.7–432.0)

Hospital charges were adjusted by the medical care consumer price index and are expressed in 2004 dollars.<sup>11</sup>  
CI = confidence interval.

the rate for those aged 65 to 74 (308 per 10,000 older adults aged 65–74,  $P < .001$ ). Older men had a higher ID hospitalization rate than older women in general and also according to age group ( $P < .001$ , all comparisons). The South had the highest ID hospitalization rate, and the West had the lowest (542 and 418 per 10,000, respectively). The ID hospitalization rates were similar between the Northeast and Midwest regions (500 and 517 per 10,000, respectively). The LRTI hospitalization rate (226 per 10,000) was highest of the rates for the major ID categories, followed by hospitalization rates for KUB infections and septicemia (72 and 67 per 10,000, respectively, Table 2). Cellulitis and hospitalizations with other ID diagnoses rounded out the top five hospitalization rates of the ID categories (39 and 24 per 10,000 respectively).

## DISCUSSION

ID hospitalizations were associated with \$204.2 billion in hospital charges from 1998 to 2004 and accounted for approximately 13% of all hospital charges for older adults in the United States. The average hospital charges for ID and non-ID hospitalizations were increasing between 5% and 6% per year after adjusting for inflation. The total charges for all hospitalizations of older adults in the United States

increased nearly 40% during the 7-year study period, whereas the population of older adults grew only 5%.<sup>12,13</sup> In 1998, ID hospitalization charges for older adults amounted to approximately \$865 for every man and woman aged 65 and older in the United States; by 2004, this amount had increased to approximately \$1,160.

It is likely that there are many factors associated with the large increases in average hospitalization charges for all older adults and those hospitalized for IDs. The prevalence of comorbid conditions that increase the risk for and complicate the management of IDs, such as diabetes mellitus and chronic obstructive pulmonary disease, is increasing in older adults.<sup>3,14–17</sup> Future studies comparing hospital charges for older adults with comorbid conditions with charges for those without will help determine the extent to which the increasing prevalence of comorbid conditions is contributing to the large increases in hospitalization charges. Another potential factor for the large increases in hospital charges was that hospitalizations for specific ID categories with high average hospital charges are among the ID categories with increasing hospitalization rates. For example, three ID categories that experienced dramatic increases in hospitalization rates during 1990 to 2002,<sup>2</sup> infections of the heart, infections and inflammatory reactions to prosthetic devices, and postoperative infection ID cate-

gories were among the top five mostly costly ID conditions. The hospitalization rate increases in these ID categories with higher average hospitalization charges suggests that advances in surgical procedures and other therapies are contributing to the increased hospitalization charges for older adults.<sup>18–20</sup> In addition, treatments or procedures that were previously confined to the youngest of the older adults may be increasingly offered to older, frailer individuals because these techniques have been improved and refined. However, the dramatic increases in hospital charges occurred despite relatively slight changes in the average length of stay, the number of procedures, and a stable hospital fatality rate during the study period.

The ID hospitalization rates from 1998 through 2004 were relatively stable, and the average annual rate of 503 ID hospitalizations per 10,000 older adults was similar to the estimate (508 per 10,000 older adults) obtained for 2000 to 2002 in a previous study describing ID hospitalization rates for older adults.<sup>2</sup> Nevertheless, unless the stable ID hospitalization rates in older adults begin to decline, it is likely that the forecasted large increase in the number of older adults in the not-too-distant future will lead to greater numbers of older adult ID hospitalizations and concomitant large increases in total ID hospital costs.

LRTIs accounted for more than 40% of ID hospital charges and 45% of ID hospitalizations, highlighting this ID category as a potentially good target for intervention. Others have discussed strategies for preventing LRTIs in detail; these include vaccinations, improved pharmacotherapy, and the reduction or improved management of comorbid conditions such as diabetes mellitus and chronic heart disease.<sup>15,21–24</sup> The reduction of septicemia in older adults could also have a substantial effect on reducing hospital charges given its relatively high average hospital charge and hospitalization rate among the ID categories.

To describe the economic burden associated with ID hospitalizations in older adults, this study relied on the hospital charges provided on the hospital discharge record, which likely overestimated the true direct costs for the hospitalizations. In general, the reimbursement level paid by the payer and the actual cost of the hospitalization to the hospital is lower than reflected by the hospital charge,<sup>25</sup> although possibly offsetting this effect is that the hospital charges in the NIS do not include doctor charges associated with the hospitalizations. In addition, this study did not attempt to estimate indirect costs associated with ID hospitalizations. Future studies enumerating doctor charges and indirect costs associated with ID hospitalizations could be helpful for describing the total economic and societal burden of ID-associated hospitalizations of older adults.

This study relied only on the primary diagnosis from the discharge record to identify ID hospitalizations. By relying on the primary diagnosis, it is likely that the analyses in this study identified hospitalizations for which the ID was the main cause of hospitalization. Up to 15 discharge diagnoses could be recorded for a hospitalization, and approximately 44% of all older adult hospitalizations listing an ID discharge diagnosis had the ID as the primary diagnosis. The relative importance of an ID listed as a secondary diagnosis and how it contributed to the patient's admission to the hospital or whether the ID was acquired during the hospitalization could not be reliably ascertained. Conse-

quently, this study was conservative by relying on the primary diagnosis of an ID for the estimated economic burden associated with ID hospitalizations.

## CONCLUSION

In older adults, IDs accounted for approximately 13% of hospitalization charges and 14% of total hospitalizations, illustrating that IDs did not account for a disproportionate share of hospital charges in older adults during the study period. Older adults are the fastest-growing age group in the United States, and as this population continues to grow and age, the demands that they place on the U.S. healthcare system will be substantial.<sup>4,26</sup> Continued monitoring of hospitalization costs for hospitalizations in general, as well as for specific subsets of hospitalizations such as those for ID, can be useful for evaluating preventive strategies through cost-benefit analysis and for developing healthcare policy and strategies to contain healthcare costs. Because many IDs are effectively treatable and frequently preventable, they may represent an area in which preventive measures could help offset some of the substantial healthcare costs associated with hospitalizations.<sup>27,28</sup> During a brief 7-year study period, estimated hospital charges for IDs and for all hospitalizations increased 45% and almost 40%, respectively, in older adults in the United States. Sustained increases of such magnitude will have major implications for the U.S. healthcare system as it prepares for the more than doubling of the older U.S. adult population during the first 30 years of this century.

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