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Centers for Disease Control and Prevention, Atlanta, GA

Corresponding author: Eric Tai, MD, Division of Cancer Prevention and Control, Centers for Disease Control and Prevention, 4770 Buford Highway, MS F76, Atlanta, GA 30341; e-mail: [etai@cdc.gov](mailto:etai@cdc.gov).

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## Cost of Cancer-Related Neutropenia or Fever Hospitalizations, United States, 2012

*Eric Tai, Gery P. Guy Jr, Angela Dunbar, and Lisa C. Richardson*

**QUESTION ASKED:** What is the cost of cancer-related neutropenia hospitalizations in the United States?

**SUMMARY ANSWER:** In 2012, there were 108,419 cancer-related neutropenia hospitalizations in the United States at a total cost of \$2.7 billion.

**WHAT WE DID:** We examined data from the 2012 National Inpatient Sample and Kids' Inpatient Database. Hospitalizations for cancer-related neutropenia were defined as those with a primary or secondary diagnosis of cancer and a diagnosis of neutropenia or a fever of unknown origin. We examined characteristics of cancer-related neutropenia hospitalizations among children (age < 18 years) and adults (age ≥ 18 years). Adjusted predicted margins were used to estimate length of stay and cost per stay.

**WHAT WE FOUND:** There were 91,560 and 16,859 cancer-related neutropenia hospitalizations among adults and children, respectively. Total cost of cancer-related neutropenia hospitalizations was \$2.3 billion for adults and \$439 million for children. Cancer-related neutropenia hospitalizations accounted for 5.2% of all cancer-related

hospitalizations and 8.3% of all cancer-related hospitalization costs. For adults, the mean length of stay for cancer-related neutropenia hospitalizations was 9.6 days, with a mean hospital cost of \$24,770 per stay. For children, the mean length of stay for cancer-related neutropenia hospitalizations was 8.5 days, with a mean hospital cost of \$26,000 per stay.

### **BIAS, CONFOUNDING FACTOR(S), REAL-LIFE IMPLICATIONS:**

Efforts from patients with cancer, their caregivers, and health care providers to prevent and minimize neutropenia-related complications may decrease hospitalizations and associated costs. Our study has several limitations. First, the diagnosis of cancer, neutropenia, and fever of unknown origin is clinical and may be subject to error and different diagnostic standards across hospitals. Second, we only estimated the cost of hospitalization for cancer-related neutropenia among patients with cancer. Our costs only include hospital costs and do not include the costs of physician services. We did not calculate costs from a societal perspective, such as patient and caregiver time and transportation costs and aspects of productivity loss. Third, neutropenia may not have been caused by chemotherapy. **JOP**

# Cost of Cancer-Related Neutropenia or Fever Hospitalizations, United States, 2012

Eric Tai, Gery P. Guy Jr, Angela Dunbar, and Lisa C. Richardson

Centers for Disease Control and Prevention, Atlanta, GA

## Abstract

### Purpose

Neutropenia and subsequent infections are life-threatening treatment-related toxicities of chemotherapy. Among patients with cancer, hospitalizations related to neutropenic complications result in substantial medical costs, morbidity, and mortality. Previous estimates for the cost of cancer-related neutropenia hospitalizations are based on older and limited data. This study provides nationally representative estimates of the cost of cancer-related neutropenia hospitalizations.

### Methods

We examined data from the 2012 National Inpatient Sample and Kids' Inpatient Database. Hospitalizations for cancer-related neutropenia were defined as those with a primary or secondary diagnosis of cancer and a diagnosis of neutropenia or a fever of unknown origin. We examined characteristics of cancer-related neutropenia hospitalizations among children (age < 18 years) and adults (age ≥ 18 years). Adjusted predicted margins were used to estimate length of stay and cost per stay.

### Results

There were 91,560 and 16,859 cancer-related neutropenia hospitalizations among adults and children, respectively. Total cost of cancer-related neutropenia hospitalizations was \$2.3 billion for adults and \$439 million for children. Cancer-related neutropenia hospitalizations accounted for 5.2% of all cancer-related hospitalizations and 8.3% of all cancer-related hospitalization costs. For adults, the mean length of stay for cancer-related neutropenia hospitalizations was 9.6 days, with a mean hospital cost of \$24,770 per stay. For children, the mean length of stay for cancer-related neutropenia hospitalizations was 8.5 days, with a mean hospital cost of \$26,000 per stay.


### Conclusion

We found the costs of cancer-related neutropenia hospitalizations to be substantially high. Efforts to prevent and minimize neutropenia-related complications among patients with cancer may decrease hospitalizations and associated costs.

## INTRODUCTION

In 2012, > 1.5 million persons received a diagnosis of cancer in the United States.<sup>1</sup> In the next two decades, the number of people with cancer is expected to substantially increase, in part as a result of aging of the US population.<sup>2,3</sup> Currently, > 650,000

patients with cancer receive chemotherapy annually in the United States.<sup>4</sup> Treatment of cancer with chemotherapy may lead to bone marrow suppression, which can mask the early signs and symptoms of an infection as well as diminish the patient's capacity to fight infections.<sup>5</sup> Neutropenia

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and subsequent infectious complications are some of the most serious treatment-related toxicities of chemotherapy for cancer and result in preventable morbidity and mortality.<sup>5-7</sup> Previous estimates indicate that > 60,000 persons with cancer are hospitalized with neutropenia and > 4,000 persons die of febrile neutropenia each year in the United States.<sup>5,7,8</sup> With a mortality rate ranging between 2% and 21% among patients hospitalized for febrile neutropenia complications, cancer-related neutropenia is a substantial cause of preventable mortality among patients with cancer.<sup>5,7,9,10</sup> As the number of patients with cancer in the United States continues to increase, the number of patients with cancer who are treated with chemotherapy and diagnosed with neutropenia is also expected to increase.<sup>11</sup> Treatment of cancer-related neutropenia often requires inpatient hospitalization, which can be costly. Quantifying the economic impact of neutropenia among patients with cancer is needed to fully address this issue. Although previous studies have examined the cost of hospitalization for neutropenia among patients with cancer, these studies do not provide nationally representative estimates.<sup>6,12-15</sup> This study aims to provide nationally representative estimates of the cost of neutropenia hospitalizations among patients with cancer using the largest all-payer inpatient database in the United States.

## METHODS

We examined data from the 2012 National Inpatient Sample (NIS) and Kids' Inpatient Database (KID) of the Healthcare Costs and Utilization Project (HCUP) from the Agency for Healthcare Research and Quality.<sup>16</sup> We used 2012 data because it was the latest year with both NIS and KID data. The NIS is the largest publicly available all-payer inpatient health care database in the United States, yielding national estimates of hospital inpatient stays with > 7 million hospital stays each year.<sup>16</sup> The NIS uses systematic random sampling of discharges stratified by hospital characteristics drawn from all HCUP-participating hospitals.<sup>16</sup> The KID, which includes hospital use, outcome, and charge data, is a systematic random sample of pediatric discharge information from all community, nonrehabilitation hospitals participating in HCUP.<sup>17</sup> We examined hospitalizations among children age 0 to 17 years using the KID and adults age  $\geq$  18 years using the NIS. To identify cancer-related neutropenia hospitalizations, we used diagnostic codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).<sup>18</sup> We selected inpatient stays with a primary or secondary

diagnosis of cancer (ICD-9-CM code 140-208) and a diagnosis of neutropenia (ICD-9-CM code 288) or a fever of unknown origin (FUO; ICD-9-CM code 780.6) during the hospital stay. We used these codes based on previous literature examining neutropenia hospitalizations.<sup>13,15</sup> Hospitalizations with a primary or secondary diagnosis of cancer without an indication of neutropenia or FUO constituted our control group. We compared patient, payer, and hospital characteristics between cancer-related neutropenia hospital stays and all other cancer-related stays to highlight any potential differences among these groups. Sample weights were applied to provide nationally representative estimates.

Total hospital charges were converted to costs using HCUP cost-to-charge ratios based on hospital accounting reports from the Centers for Medicare and Medicaid Services.<sup>19</sup> All costs are in 2012 US dollars. On the basis of the findings of our specification tests, we determined that generalized linear models with a gamma distribution and a log link were the most appropriate to estimate length of stay and cost per stay among cancer-related neutropenia hospitalizations and all other cancer-related hospitalizations. Adjusted estimates are presented as predictive margins, which are standardized to the covariate distribution of the overall population.<sup>20</sup> All regression models controlled for age, sex, race/ethnicity, insurance status, cancer type, the presence of other chronic conditions, and admission through the emergency department. We estimated the mean length of stay, mean cost per stay, mean cost per day, and total costs for all cancer-related neutropenia stays and for individual cancer sites.

## RESULTS

For 2012, we identified 91,560 cancer-related neutropenia hospitalizations among adults and 16,859 cancer-related neutropenia hospitalizations among children in the NIS and KID data (Tables 1 and 2). Cancer-related neutropenia hospitalizations accounted for 5.2% and 22.7% of all cancer-related hospitalizations among adults and children, respectively.

Adults hospitalized for cancer-related neutropenia were younger, had a higher number of chronic conditions, and were more likely to be admitted from the emergency department than adults hospitalized for other cancer-related conditions (Table 1). Although Medicare was the most common primary payer for both groups, private insurance was more common among cancer-related neutropenia hospitalizations compared with other cancer-related hospitalizations (40% *v* 33%, respectively; *P* < .001). Cancer-related neutropenia stays were

**Table 1. Characteristics of Cancer-Related Neutropenia Hospitalizations Compared With Other Cancer-Related Hospitalizations Among Adults, 2012 NIS**

Characteristic	Hospital Stays Related to Cancer Neutropenia (n = 18,312)		All Other Cancer-Related Hospital Stays (n = 337,185)		P
	%	95% CI	%	95% CI	
<b>Patient characteristics</b>					
Age, years					< .001
18-44	16.5	15.5 to 17.4	9.0	8.7 to 9.3	
45-64	43.5	42.7 to 44.4	39.1	38.7 to 39.6	
≥ 65	40.0	38.8 to 41.3	51.9	51.1 to 52.6	
Sex					.433
Male	49.8	48.9 to 50.6	49.4	49.1 to 49.8	
Female	50.2	49.4 to 51.1	50.5	50.2 to 50.9	
Race/ethnicity					< .001
Non-Hispanic white	67.6	65.5 to 69.7	69.9	68.0 to 71.1	
Non-Hispanic black	11.6	10.3 to 13.2	11.7	10.9 to 12.7	
Asian or Pacific Islander	2.9	2.5 to 3.3	2.6	2.3 to 2.9	
Hispanic	8.8	7.9 to 9.8	7.3	6.7 to 8.0	
Other*	3.8	3.0 to 4.7	3.6	3.0 to 4.3	
Household income					< .001
Lowest quartile	24.5	23.2 to 25.9	26.2	25.3 to 27.2	
All other quartiles	73.3	71.9 to 74.6	71.6	70.7 to 72.6	
No. of chronic conditions					< .001
0-1	6.7	6.3 to 7.1	16.2	15.8 to 16.5	
2-3	24.4	23.7 to 25.2	26.2	25.8 to 26.5	
4-5	29.5	28.8 to 30.3	25.4	25.2 to 25.6	
≥ 6	39.3	38.3 to 40.4	32.2	31.6 to 32.8	
Received emergency department services					< .001
Yes	49.7	47.5 to 51.9	39.8	38.7 to 40.9	
Patient disposition					< .001
Routine	67.4	66.2 to 68.6	61.7	61.0 to 62.4	
Transfer	10.0	9.4 to 10.7	14.9	14.5 to 15.4	
Home health care	18.0	17.1 to 19.0	18.8	18.3 to 19.3	
Died in hospital	4.1	3.8 to 4.4	4.0	3.9 to 4.2	
Other	0.4	0.4 to 0.6	0.5	0.5 to 0.6	
<b>Payer information</b>					
Expected primary payer					< .001
Medicare	41.3	40.2 to 42.5	51.5	50.8 to 52.2	
Medicaid	12.7	11.9 to 13.6	9.5	9.1 to 10.0	
Private	39.7	38.3 to 41.1	32.6	31.6 to 33.6	
Self-pay	2.9	2.6 to 3.3	3.0	2.8 to 3.2	
Other	3.2	2.7 to 3.8	3.2	2.9 to 3.4	
<b>Hospital characteristics</b>					
Region					.057
Northeast	19.6	17.2 to 22.3	21.6	19.7 to 23.7	
Midwest	24.7	21.9 to 27.8	23.9	22.3 to 25.6	
South	37.7	34.2 to 41.4	36.5	34.5 to 38.6	
West	18.0	15.9 to 20.2	18.0	16.8 to 19.2	
Location/teaching status					< .001
Rural	7.6	6.8 to 8.6	8.1	7.5 to 8.7	
Urban nonteaching	26.3	24.3 to 28.4	30.9	29.5 to 32.3	
Urban teaching	66.1	63.6 to 68.6	61.0	59.3 to 62.7	
No. of visits (weighted)	91,560		1,777,485		

Abbreviation: NIS, National Inpatient Sample.

\*All other races including multiracial.

**Table 2. Characteristics of Cancer-Related Neutropenia Hospitalizations Compared With Other Cancer-Related Hospitalizations Among Children, 2012 KID**

Characteristic	Hospital Stays Related to Cancer Neutropenia (n = 11,801)		All Other Cancer-Related Hospital Stays (n = 40,143)		P
	%	95% CI	%	95% CI	
<b>Patient characteristics</b>					
Age, years					< .001
0-9	67.5	66.2 to 68.8	54.6	53.3 to 55.9	
10-17	32.5	31.2 to 33.8	45.4	44.1 to 46.7	
Sex					.939
Male	55.2	53.8 to 56.5	55.2	54.0 to 56.4	
Female	44.8	43.5 to 46.2	44.8	43.6 to 46.0	
Race/ethnicity					< .001
Non-Hispanic white	55.1	50.7 to 59.5	51.3	46.5 to 56.1	
Non-Hispanic black	7.5	6.3 to 8.9	10.3	9.0 to 11.8	
Asian or Pacific Islander	3.5	2.8 to 4.4	3.2	2.5 to 4.0	
Hispanic	19.5	16.4 to 23.2	19.3	15.9 to 23.2	
Other*	5.4	4.3 to 6.7	5.3	4.2 to 6.6	
Household income					.984
Lowest quartile	25.5	22.7 to 28.7	25.6	23.2 to 28.2	
All other quartiles	71.8	68.3 to 75.1	71.9	69.2 to 74.5	
No. of chronic conditions					< .001
0-1	34.2	31.8 to 36.7	52.2	49.9 to 54.4	
2-3	45.6	44.2 to 47.1	35.8	34.5 to 37.2	
4-5	15.2	14.0 to 16.5	9.2	8.3 to 10.1	
≥ 6	4.9	4.2 to 5.7	2.8	2.5 to 3.2	
Received emergency department services					< .001
Yes	36.7	31.8 to 42.0	14.6	13.2 to 16.2	
Patient disposition					< .001
Routine	87.1	83.4 to 90.1	88.3	85.4 to 90.7	
Transfer	1.6	1.3 to 2.0	2.0	1.7 to 2.4	
Home health care	10.6	7.6 to 14.5	8.6	6.3 to 11.7	
Died in hospital	0.6	0.5 to 0.8	1.0	0.9 to 1.1	
Other	0.1	0.0 to 0.1	0.1	0.0 to 0.1	
<b>Payer information</b>					
Expected primary payer					.123
Medicare	0.1	0.0 to 0.5	0.2	0.1 to 0.6	
Medicaid	40.7	38.1 to 43.3	40.1	37.4 to 42.8	
Private	51.4	48.6 to 54.2	51.3	48.6 to 54.0	
Self-pay	2.3	1.3 to 3.9	2.2	1.4 to 3.4	
Other	5.3	3.9 to 7.2	6.0	4.4 to 8.3	
<b>Hospital characteristics</b>					
Region					.395
Northeast	16.2	10.6 to 24.0	16.2	10.4 to 24.2	
Midwest	23.9	17.3 to 32.0	23.6	17.0 to 31.7	
South	41.4	32.2 to 51.3	40.0	31.2 to 49.6	
West	18.5	12.4 to 26.7	20.2	14.0 to 28.4	
Location/teaching status					< .001
Rural	1.0	0.4 to 2.5	0.6	0.2 to 1.9	
Urban nonteaching	3.4	2.0 to 5.5	4.5	2.7 to 7.4	
Urban teaching	95.7	93.3 to 97.2	94.9	91.9 to 96.8	
No. of visits (weighted)	16,859		74,312		

Abbreviation: KID, Kids' Inpatient Database.

\*All other races including multiracial.

more likely to occur in urban teaching hospitals compared with other cancer-related hospitalizations (66% v 61%, respectively;  $P < .001$ ).

Children hospitalized for cancer-related neutropenia were younger, had more chronic conditions, and were more likely to be admitted through the emergency department than children hospitalized for other cancer-related conditions (Table 2). Hospital deaths were slightly lower among children hospitalized for cancer-related neutropenia compared with children hospitalized for other cancer-related conditions (0.6% v 1.0%, respectively;  $P < .001$ ).

The mean length of stay for adult hospitalizations for cancer-related neutropenia was 2.7 days longer than adult hospitalizations for non-neutropenia conditions. The mean length of stay for pediatric hospitalizations for cancer-related neutropenia was 0.7 days longer than pediatric hospitalizations for non-neutropenia conditions. For adults, the mean cost per stay for cancer-related neutropenia hospitalizations was \$5,685 higher than hospitalizations for non-neutropenia conditions (\$20,778 for neutropenia-related admissions and \$15,093 for non-neutropenia-related admissions). For children, the mean cost per stay for cancer-related neutropenia hospitalizations was \$1,748 lower than hospitalizations for non-neutropenia conditions (\$20,366 for neutropenia-related admissions and \$22,114 for non-neutropenia-related admissions).

The total cost of cancer-related neutropenia hospitalizations (Table 3) was \$2.3 billion for adults and \$439 million for children. The total cost of all cancer-related hospitalizations was \$27.5 billion for adults and \$1.6 billion for children. Leukemia was the most common cancer type among both adults and children hospitalized for cancer-related neutropenia. There were significant differences in mean length of stay and cost between all cancer types. Patients with leukemia hospitalized for cancer-related neutropenia had the longest mean length of stay and the highest mean hospital cost per stay for both adults (16.0 days, \$45,148 per stay) and children (9.9 days, \$30,410 per stay) compared with other cancer types. Among adults, cancer-related neutropenia hospitalizations accounted for 5.2% of all cancer-related hospitalizations (91,560 of 1,777,485 hospitalizations) and for 8.3% of all cancer-related hospitalization costs (\$2.3 billion of \$27.5 billion). Among children, cancer-related neutropenia hospitalizations accounted for 22.7% of all cancer-related hospitalizations (16,859 of 74,312 hospitalizations) and for 27.2% of all cancer-related hospitalization costs (\$439 million of \$1.6 billion).

## DISCUSSION

In this report, we provide nationally representative estimates of the cost of cancer-related neutropenia hospitalizations using the largest all-payer inpatient database in the United States. Expenditures related to cancer-related neutropenia hospitalizations are substantial for both adults and children. In 2012, there were 108,419 cancer-related neutropenia hospitalizations in the United States at a total cost of \$2.7 billion. Although these cancer-related neutropenia hospitalizations composed 5.2% of all cancer-related hospitalizations, they accounted for 8.3% of all cancer-related hospitalization costs.

Our cost estimates among adults, although based on different methodology and populations, are consistent with previous estimates of mean cancer-related neutropenia hospitalization costs in the United States, which ranged from \$12,689 to \$27,587.<sup>6,12-15,21</sup> However, our cost estimates were higher compared with neutropenia-related hospitalization costs in studies from other countries, including Spain, Bosnia, and Singapore.<sup>22-24</sup> We found the length of stay for cancer-related neutropenia hospitalizations to be significantly higher compared with non-neutropenia-related hospitalizations for both adults and children. This aligns with previous literature and reflects the life-threatening nature of neutropenia and subsequent infectious complications among patients with cancer.<sup>14,25</sup> Comparable to previous literature, hematologic cancers were the most common cancer type and had the longest length of stay and highest hospital cost per stay for both adults and children.<sup>14,15,26</sup> These results are expected because leukemia originates in the bone marrow and lymph nodes requiring myeloablative chemotherapy to eradicate the cancer.<sup>27-29</sup>

Adults hospitalized for cancer-related neutropenia were younger than adults admitted for other cancer-related conditions. Despite the younger age of patients hospitalized for cancer-related neutropenia, there was a significantly higher proportion of chronic conditions among this group. This is similar to previous literature reporting associations between higher numbers of comorbidities and increasing risk of febrile neutropenia.<sup>30,31</sup> Admissions through the emergency department were also more common among patients hospitalized for cancer-related neutropenia. This is understandable given the need for immediate treatment of infections among patients with cancer receiving chemotherapy. This may also reflect the higher number of chronic conditions among this group.<sup>30,31</sup>



**Table 3. Estimated Characteristics of Hospital Stays for Cancer-Related Neutropenia, 2012**

Cancer Site	No. of Discharges	Mean Length of Stay (days)*	Mean Hospital Cost (\$)		Total Cost (\$)
			Per Stay	Per Day	
All cancer-related neutropenia stays among adults	91,560	9.6	24,770	2,588	2,267,928,382
Leukemia	21,780	16.0	45,148	2,819	983,333,241
Secondary malignancies	16,030	6.4	14,250	2,230	228,430,225
Non-Hodgkin lymphoma	14,065	9.3	25,676	2,755	361,136,456
Lung and bronchus	7,790	6.0	12,532	2,075	97,623,501
Multiple myeloma	6,135	11.1	30,042	2,705	184,306,688
Other and unspecified primary tumor	3,775	7.4	18,013	2,436	68,000,321
Breast	2,875	4.0	8,033	2,005	23,096,169
Colon	2,840	7.0	15,431	2,212	43,823,926
Pancreas	2,245	5.4	10,714	1,994	24,052,324
Hodgkin disease	2,070	10.3	28,715	2,798	59,439,450
Rectum and anus	1,935	7.2	14,278	1,990	27,627,001
Ovary	1,800	6.2	12,579	2,044	22,642,488
Bone and connective tissue	1,620	6.4	15,316	2,396	24,812,519
Stomach	1,215	8.9	18,195	2,037	22,107,229
Head and neck	1,055	10.9	24,799	2,277	26,163,240
Esophagus	1,045	6.6	13,623	2,062	14,236,035
Liver and intrahepatic bile duct	980	5.6	12,922	2,292	12,663,697
Other GI organs; peritoneum	805	7.0	17,700	2,526	14,248,548
Kidney and renal pelvis	750	5.8	15,238	2,633	11,428,208
Brain and nervous system	750	8.3	21,924	2,639	16,443,240
All cancer-related neutropenia stays among children	16,859	8.5	26,022	3,051	438,697,480
Leukemia	8,895	9.9	30,410	3,082	270,495,260
Bone and connective tissue	2,085	5.8	16,211	2,779	33,800,936
Other and unspecified primary tumor	1,527	8.6	27,826	3,232	42,489,615
Brain and nervous system	1,262	7.6	23,840	3,125	30,086,093
Non-Hodgkin lymphoma	1,052	7.2	20,320	2,824	21,376,577
Secondary malignancies	732	6.4	19,561	3,045	14,318,359
Kidney and renal pelvis	502	5.9	16,798	2,850	8,432,546
Liver and intrahepatic bile duct	404	9.3	27,809	2,990	11,234,848
Hodgkin disease	400	5.3	15,823	2,986	6,329,280

NOTE. For individuals with a primary and secondary cancer diagnoses, site-specific estimates only include the primary cancer diagnosis. Children are defined as age 0 to 17 years. Adults are defined as age  $\geq$  18 years.

\*Unadjusted estimates are presented.

Children hospitalized with cancer-related neutropenia were significantly younger than children hospitalized for non-neutropenia-related conditions. This is reflective of the large number of children with leukemias, which are typically diagnosed among young children.<sup>1</sup> Similar to adults, there was a significantly higher proportion of chronic conditions among children hospitalized for cancer-related neutropenia.<sup>30,31</sup> Admissions through the emergency department were also more common among pediatric patients with cancer hospitalized for cancer-related neutropenia compared with pediatric patients with cancer hospitalized for non-neutropenia-related conditions. Our results align

with literature reporting that febrile neutropenia is the most common reason for emergency department visits among children with cancer and is strongly associated with subsequent inpatient hospitalization.<sup>32</sup>

Patients with cancer receiving chemotherapy may become neutropenic and are susceptible to infections, leading to morbidity, mortality, and substantial financial costs.<sup>33</sup> Our results suggest that renewed efforts are needed to prevent infections among this vulnerable population. Patients with cancer are in frequent contact with the health care system and are at risk for nosocomial infections while undergoing treatment. In addition, these patients often require

indwelling intravascular access devices or surgical procedures that increase the risk of infectious complications.<sup>33-35</sup> Because the vast majority of oncology care is provided in outpatient settings, efforts to improve infection control in these settings is important to protect the health of patients with cancer.<sup>4,36</sup> Compared with inpatient acute care settings, ambulatory care settings have traditionally lacked infrastructure and resources to support infection prevention and surveillance activities.<sup>33,37-39</sup> This is reflected in outbreaks associated with outpatient oncology settings such as hepatitis C and bacterial bloodstream infections resulting from breaches in basic infection prevention practices.<sup>40-42</sup> To help address this issue, the Centers for Disease Control and Prevention (CDC) created a Basic Infection Control and Prevention Plan for use by outpatient oncology settings.<sup>33,43</sup> This plan contains policies and procedures tailored to outpatient oncology settings to meet minimal expectations of patient protections.<sup>33</sup>

Despite advances in oncology care, infections remain a major cause of morbidity and mortality among patients with cancer.<sup>44-46</sup> Because treatment of neutropenia-related infections among patients with cancer is costly and often results in poor outcomes, efforts to prevent infection during treatment can result in significant decreases in morbidity and mortality. Educational programs directed toward this population may reduce the risk of preventable infections and decrease morbidity and mortality.<sup>10</sup> As part of the CDC's Preventing Infections in Cancer Patients public health campaign, the CDC developed and launched an interactive, evidence-based Web site designed for patients with cancer undergoing chemotherapy.<sup>10,34,43</sup> On the Web site, patients may complete a risk assessment for developing neutropenia and receive information designed to empower them with the knowledge and skills to lower the risk for infection. This information also empowers patients to take actions to seek care for this life-threatening condition.<sup>10</sup>

Findings from this study can inform evidence-based clinical decision making.<sup>13,15</sup> Because cancer-related neutropenia hospitalizations are costly, understanding the financial impact of preventing such hospitalizations is important. Medical options can be considered in the context of hospitalization costs for neutropenia as well as clinical factors.<sup>13,15</sup> Although this may not be reflected in all clinical guidelines, increasing health care costs in the United States may provide an impetus to at least consider

the cost-benefit ratio of interventions in the overall context of clinical options for neutropenia.<sup>47</sup> This can be seen in the 2015 ASCO clinical practice guidelines on the use of colony-stimulating factors.<sup>48</sup> Although the ASCO guidelines state that use of colony-stimulating factors should be driven by clinical considerations and not by cost, the authors also state that questions remain about the cost-effectiveness of colony-stimulating factors in certain settings.<sup>48</sup>

Our study has several limitations. First, the diagnosis of cancer, neutropenia, and FUO is clinical and may be subject to error and different diagnostic standards across hospitals. Second, we only estimated the cost of hospitalization for cancer-related neutropenia among patients with cancer. Our costs only include hospital costs and do not include the costs of physician services. We did not calculate costs from a societal perspective, such as patient and caregiver time and transportation costs and aspects of productivity loss. Third, neutropenia may not have been caused by chemotherapy.

In conclusion, we found the costs of cancer-related neutropenia hospitalizations to be substantially high in the United States. Few resources exist that offer specific information on infection control among patients with cancer receiving chemotherapy. Efforts from patients with cancer, their caregivers, and health care providers to prevent and minimize neutropenia-related complications may decrease hospitalizations and associated costs. The goal may be met by developing new educational materials for patients, caregivers, and providers on ways to lower the risk of contracting an infection while their WBC count is low. In addition, continued dissemination and implementation of programs to prevent and minimize neutropenia-related infections are needed to help educate and empower patients to take action against infection.<sup>10</sup> **JOP**

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#### Authors' Disclosures of Potential Conflicts of Interest

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#### Author Contributions

**Conception and design:** Eric Tai, Gery P. Guy Jr, Lisa C. Richardson  
**Collection and assembly of data:** Eric Tai, Gery P. Guy Jr, Lisa C. Richardson  
**Data analysis and interpretation:** All authors  
**Manuscript writing:** All authors



**Final approval of manuscript:** All authors

**Accountable for all aspects of the work:** All authors

Corresponding author: Eric Tai, MD, Division of Cancer Prevention and Control, Centers for Disease Control and Prevention, 4770 Buford Highway, MS F76, Atlanta, GA 30341; e-mail: [etai@cdc.gov](mailto:etai@cdc.gov).

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**AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST**

**Cost of Cancer-Related Neutropenia Hospitalizations, United States, 2012**

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**Eric Tai**

No relationship to disclose

**Gery P. Guy Jr**

No relationship to disclose

**Angela Dunbar**

No relationship to disclose

**Lisa C. Richardson**

No relationship to disclose