HHS Public Access
Author manuscript
Crit Care Med. Author manuscript; available in PMC 2017 July 01.

Published in final edited form as:
Crit Care Med. 2016 July ; 44(7): 1353–1360. doi:10.1097/CCM.0000000000001664.

Longitudinal changes in intensive care unit admissions among elderly patients in the United States

Michael W. Sjoding, MD[1,7], **Hallie C. Prescott, MD, MSc**[1,4], **Hannah Wunsch, MD, MSc**[2,3], **Theodore J. Iwashyna, MD, PhD**[1,4,5,6], and **Colin R. Cooke, MD, MSc, MS**[1,7]

[1]The Division of Pulmonary & Critical Care Medicine, Department of Internal Medicine, University of Michigan, Ann Arbor, MI

[2]Department of Critical Care medicine, Sunnybrook Health Sciences Centre, Toronto, ON

[3]Department of Anesthesia and Interdisciplinary Division of Critical Care Medicine, University of Toronto, Toronto, ON

[4]VA Center for Clinical Management Research, Ann Arbor, MI

[5]Institute for Social Research, Ann Arbor, MI

[6]Australian and New Zealand Intensive Care Research Centre, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC, Australia

[7]Center for Healthcare Outcomes & Policy, Institute for Healthcare Policy & Innovation, University of Michigan, Ann Arbor, MI

Abstract

Objective—Changes in population demographics and comorbid illness prevalence, improvements in medical care, and shifts in care delivery may be driving changes in the composition of patients admitted to the ICU. We sought to describe the changing demographics, diagnoses, and outcomes of patients admitted to critical care units in US hospitals.

Design—Retrospective cohort study

Setting—U. S. Hospitals

Corresponding Author: Michael Sjoding, MD, University of Michigan, 3916 Taubman Center, 1500 E. Medical Center Dr., SPC 5360, Ann Arbor, MI 48109-5360. Phone: 734-763-9077. Fax: 734-936-5048. msjoding@med.umich.edu.

Author Contributions: Dr. Sjoding had full access to all the data in the study and takes full responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Sjoding, Cooke
Acquisition of data: Cooke
Analysis and interpretation of data: Sjoding, Prescott, Wunsch, Iwashyna, Cooke
Drafting of the manuscript: Sjoding
Critical revision of the manuscript for important intellectual content and approval of the final manuscript: Sjoding, Prescott, Wunsch, Iwashyna, Cooke
Statistical analysis: Sjoding
Obtained funding: Cooke, Sjoding

Conflict of interest disclosures: No disclosures were reported

Disclaimer: This manuscript dose not necessarily represent the view of the U.S. Government or the Department of Veterans Affairs.

Patients—27.8 million elderly (age>64) fee-for-service Medicare beneficiaries hospitalized with an intensive care or coronary care room and board charge from 1996 to 2010.

Interventions—None

Measurements and Main Results—We aggregated primary ICD-9-CM discharge diagnosis codes into diagnoses and disease categories. We examined trends in demographics, primary diagnosis, and outcomes among patients with critical care stays. Between 1996 and 2010, we found significant declines in patients with a primary diagnosis of cardiovascular disease, including coronary artery disease (26.6% to 12.6% of admissions), and congestive heart failure (8.5% to 5.4% of admissions). Patients with infectious diseases increased from 8.8% to 17.2% of admissions, and explicitly labeled sepsis moved from the eleventh ranked diagnosis in 1996 to the top ranked primary discharge diagnosis in 2010. Crude in-hospital mortality rose (11.3% to 12.0%), while discharge destinations among survivors shifted, with an increase in discharges to hospice and post-acute care facilities.

Conclusions—Primary diagnoses of patients admitted to critical care units have substantially changed over 15 years. Funding agencies, physician accreditation groups, and quality improvement initiatives should ensure their efforts account for the shifting epidemiology of critical illness.

Keywords

Critical Care; Sepsis; Respiratory Insufficiency; Coronary artery disease; longitudinal studies; Utilization

INTRODUCTION

Spending on critical care services in the US has grown substantially over the past two decades.[1] Estimates suggest that critical care accounted for over $82 billion in annual spending in 2005 and nearly 1% of the US gross domestic product.[2] This expansion has likely resulted from increasing demand for critical care services due to an aging population, growing comorbidity burden among hospitalized patients, and perhaps due to increases in the supply of critical care beds.[3] The location where critical care is delivered has also changed, with an increasing number of patients receiving intermediate care instead of intensive care.[4] It is not known, however, how these changes have affected the composition of patients cared for in intensive care units (ICUs). Several longitudinal studies suggest that the incidence of certain critical illnesses, including sepsis[5,6] and acute and chronic respiratory failure,[7,8] have increased, and other studies described how mortality rates for certain conditions have declined.[9,10] Understanding the overall shifts in the population of patients receiving ICU care should inform resource allocation for multiple stakeholder groups, including funding agencies and policy makers seeking to improve the quality of critical care at the national level. In addition, accrediting bodies can use such information to ensure that the future critical care workforce is adequately trained to care for this evolving population.

To address this knowledge gap, we sought to describe changes in the composition of patients with ICU stays during the course of their hospitalization. As Medicare beneficiaries make up a substantial proportion of patients admitted to the ICU,[11,12] we examined shifts among elderly Medicare beneficiaries who received ICU care from 1996 to 2010. We examined changes in patient demographics, diagnoses, comorbid illness, and outcomes. In a post-hoc analysis, we also tested the generalizability of the results to other patient populations using discharge data from New York State.

METHODS

We performed a retrospective cohort study of all acute care hospitalizations among elderly (age > 64) fee-for-service Medicare beneficiaries between 1996 and 2010. All patients with fee-for-service eligibility at the time of admission were included. We identified patients admitted to a critical care unit during their hospitalization as those with an ICU room and board charge, including intensive care unit or coronary care codes, but excluding psychiatric ICUs and intermediate care units. We obtained age, sex, and race from MedPAR files. We categorized race as white, black, or other, as other racial categories are less reliable in Medicare data.[13,14] We abstracted information on length of stay, principal and secondary ICD-9-CM diagnosis codes, procedure codes, DRG codes, discharge status (alive or dead), and discharge destination. We excluded 50 records with missing data sex, race or primary diagnoses data. Because discharge destination codes for hospice care were added to MedPAR files in October 1996, we analyzed these codes starting in 1998 to allow hospitals a full calendar year for adoption.[15] All other comparisons were made between 1996 and 2010

We used the clinical classification software (CCS) developed by the Agency for Healthcare Research and Quality (AHRQ) to aggregate the approximately 16,000 ICD-9-CM diagnosis codes present in the Medicare files into 271 unique diagnoses.[16] We grouped these 271 diagnoses into disease categories, including cardiac, respiratory, gastrointestinal, infectious, musculoskeletal/injuries, hematologic and oncologic disease. Details of assignments of individual diagnoses can be found in the eAppendix.

We determined comorbidities among patients using secondary diagnosis codes from their index hospitalization according to Elixhauser, et al.[17] To estimate a patient's severity of illness, we used ICD-9-CM-based organ failure codes developed by Angus et al.[18,19] We used ICD-9-CM procedure codes to identify invasive mechanical ventilation (96.7X), non-invasive mechanical ventilation (93.90), blood transfusion (99.0X) and hemodialysis (39.95). We used DRG codes to characterize whether the hospitalization was a primary surgical or medical admission. Medicare payment amounts for hospitalizations were adjusted for inflation using the consumer price index and are reporting in 2010 US dollars.

Statistical Analysis

We calculated the percentage of total patients with an ICU stay in each disease category for each year. The denominator for these calculations was the total number of patients admitted to critical care beds each year. We choose this denominator because ICU case-mix is most relevant to clinicians, credentialing bodies, and agencies that fund health care delivery in the ICU. We also performed this analysis in the subgroup of patients who died during their hospitalization. We plotted the results using stacked bar graphs, with the total height of each bar representing 100% of admissions. Patient demographic, hospitalization characteristics, and outcomes in 1996 and 2010 are presented as means or percentages of total admissions. We describe changes in the rankings of primary diagnoses across years, presenting the results as a slope graph and online interactive data visualization. Further details regarding the creation of the interactive data visualization is available in the online supplement. We calculated the percentage of total hospitalizations with each CCS primary diagnosis for each year and assessed their relative change between years. Given the large size of the dataset, we did not perform inferential statistics, as all comparisons were likely to be statistically different regardless of clinical significance.

Sensitivity Analysis

We performed a number of sensitivity analyses to test the robustness of the results. First, we excluded patients with coronary care billing charges unless they were also billed for intensive care. We excluded these admissions to ensure the primary findings were consistent when isolated to patients receiving only ICU care, as CCU admissions may not be representative of patients in the ICU. In addition, the number of coronary care units declined over the study period.[2] Reduction in CCU bed capacity could have impacted ICU case-mix by decreasing the number of patients admitted to critical care units with cardiac disease overall, while potentially increasing in the number admitted to general ICUs.

Second, to assess whether changes in Medicare enrollment could explain shifts in diagnosis, we compared the results among fee-for-service Medicare beneficiaries with those among all patients ≥ 65 (including both traditional fee-for-service Medicare and Medicare Advantage patients) hospitalized in New York State. This analysis was performed because the proportion of elderly patients enrolled in fee-for-service Medicare declined while the number enrolled in Medicare managed care plans rose.[20] Finally, to evaluate the generalizability of the results to the non-elderly, we repeated the analysis among all adult patients (18 ≥ years old) hospitalized in New York State.

To evaluate whether secondary coding of comorbid illnesses and acute organ dysfunction may have been affected by Medicare's adoption of the Medicare Severity-Diagnosis Related Group (MS-DRG) based reimbursement system beginning October 1st, 2007, we compared comorbid illness and organ failure rates in the periods before and after 2008. To allow for comparisons of rates and trends before and after the rule change, we graphed rates of comorbidity and organ dysfunction yearly.

All data management and analysis was conducted using SAS 9.2 (SAS Institute, Cary, NC) and Stata 13 (StataCorp, College Station, Tx). The institutional review board of the University of Michigan approved this study.

RESULTS

There were 27.8 million hospitalizations with a critical care unit stay among elderly fee-for-service Medicare beneficiaries from 1996 to 2010. The total number of hospitalizations with ICU stays among this group declined yearly, from 2.16 million in 1996 to 1.53 million in 2010 (Table 1). A cardiovascular primary diagnosis was the leading disease category in 1996, present in 50.8% of critical care unit stays (Figure 1A). Although cardiovascular diseases remained the most common primary diagnosis over the study period, it declined yearly to 33.3% of critical care unit admissions in 2010. Concurrently, patients with infectious diagnoses increased substantially, from 8.8% to 17.2% of critical care unit stays. Other disease categories with increases included musculoskeletal diseases and injuries (4.4% to 7.4%) and respiratory diseases (7.0% to 9.2%). Among decedents, these primary diagnoses shifts were even more pronounced. Cardiovascular diseases declined from 37.0% to 20.8%, while infectious diagnoses increased from 16.3% to 31.9% (Figure 1B).

Among primary diagnoses, the top two diagnoses in 1996 were coronary atherosclerosis and acute myocardial infarction, making up 14.6 % and 11.8% of admissions respectively, followed by congestive heart failure, arrhythmias, and cerebrovascular diseases (Figure 2). However, in 2010, sepsis was the most frequent diagnosis at 10.2% of admissions, while acute myocardial infarction and coronary atherosclerosis dropped to numbers two and three, at 7.4% and 5.3% respectively. Other primary admission diagnoses with large relative increases included intracranial injuries (3.1 fold increase), renal failure (3.1 fold increase), respiratory failure (1.8 fold increase), complications of medical care (1.7 fold increase), and heart value disorders (1.6 fold increase).

We created an online interactive data visualization to allow for comparisons of diagnosis rankings between study years, either among the entire cohort or within a specific age or sex subgroup. These supplements can be accessed at: https://s3-us-west-2.amazonaws.com/colinrcooke/visualization/slopegraph.html https://s3-us-west-2.amazonaws.com/colinrcooke/visualization/heatmap_sjoding.html

Demographics and comorbid illnesses of Medicare beneficiaries with critical care unit stays changed over the study period (Table 1 and eTable 1). Average age increased from 76 to 77, while the proportion of patient's age 85 to 94, and the proportion age 95 years or older increased from 14.1% to 20.1% and 1.0% to 1.7% respectively. There was also an increase in secondary diagnosis codes for comorbid illnesses, including congestive heart failure (13.1% to 25.6%) and chronic renal disease (3.4% to 15.2%).

Over the study period, severity of illness among Medicare beneficiaries in the ICU appeared to increase while discharge destination among survivors shifted. The percentage of patients with secondary diagnosis codes for acute organ dysfunction increased (21.1% to 44.5%), including cardiovascular, respiratory and renal dysfunction (Table 2). The percentage undergoing invasive procedures increased, including invasive mechanical ventilation (11.4% to 16.7%) and hemodialysis (2.2% to 4.6%). Although hospital length of stay remained the same, crude in-hospital mortality rose slightly from 11.3% to 12.0%. Patients discharged to home decreased from 68.1% to 56.3% and patients discharged to other acute care hospitals decreased from 13.4% to 4.6%. Patients discharged to post-acute care facilities increased from 18.2% to 33.8% and patients discharges to hospice care increased from 0.1% to 4.6%.

When we excluded Medicare beneficiaries billed for coronary care in a sensitivity analysis, we found that cardiovascular diseases declined from 45.7% of ICU admissions in 1996 to 28.6% of admissions in 2010, while infectious diagnosis rose from 9.5% to 18.5% of admissions (Figure 3). Shifts in demographics, primary diagnoses, procedure use and outcomes were also similar in this subgroup (eTable 2, eTable 3, and eTable 4). When we repeated the analysis using New York State data, which included fee-for-service Medicare beneficiaries and those on Medicare Advantage plans, the shifts in diagnoses were the same (eFigure 1). When all adult patients (age ≥ 18 years) hospitalized with a critical care admission in New York State were analyzed, we again found similar shifts in primary diagnoses, procedure use, and outcomes (eFigure 2 and eTable 5).

The percentage of patients billed for comorbid illnesses and acute organ failures increased steadily between 1996 and 2010 (eFigure 3 and eFigure 4). These increases began well before the adoption the MS-DRG based reimbursement system in 2008.

DISCUSSION

In the current study, we found dramatic shifts in hospital discharge diagnosis for patients receiving care in critical care beds between 1996 and 2010, with a substantial decrease in cardiac diagnoses, largely replaced by infection diagnoses. Although sepsis was the eleventh ranked primary diagnosis in 1996, its prevalence rose dramatically and was the most common diagnosis by 2008. We also found increases in age, comorbidity, and acute organ dysfunction. Finally, although crude hospital mortality did not change substantially, the discharge rate to home and other acute care facilities decreased, while discharges to post-acute care facilities and hospice care increased among survivors.

There are likely many factors driving the shifts in diagnoses among Medicare beneficiaries receiving critical care, including true changes in underlying disease burden, as well as external factors such as shifts in critical care bed supply[1,2,21] and the location where care is delivered.[4] For example, the decline in ICU admissions for cardiac disease likely reflects broad advances in medical care for this condition that allow for care outside of the ICU,[22] as well as changes in cardiovascular population health. In particular, the prevalence of coronary artery disease among Medicare beneficiaries, [23] as well the yearly total number of hospitalizations for this condition also declined over the study period.[6,24]

As critical care admissions with cardiac disease declined, our study showed that three other disease categories filled their place. The proportion of admissions with a diagnosis of respiratory diseases increased, likely reflecting the rising incidence of respiratory failure in adults.[7,25,26] Musculoskeletal diseases and injuries also increased, echoing findings demonstrating trends of increasing fall-related injuries in the elderly,[27,28] including severe head injuries.[29-31] Finally, we found a significant rise in the proportions of admissions for infectious diseases, and in particular, a primary diagnosis of sepsis. Sepsis is now the most common diagnosis among Medicare beneficiaries hospitalized in the ICU. Together with recent data suggesting sepsis is the most expensive hospital condition[32] and a common reason for death among hospitalized adults[33], our study further demonstrates how sepsis is increasingly recognized as a major public health problem.

Our results have implications for funding agencies supporting research and advocacy for critically ill patients, particularly those that fund research on healthcare delivery in the ICU. Although diagnoses synonymous with critical illness, including sepsis and respiratory failure are increasing, the proportion of National Institute of Health (NIH) research dollars spent on critical illnesses, relative to other diseases, is quite small.[34] A unique challenge to developing a research agenda for critical care at the NIH is its multi-disciplinary nature, with critical care research potentially supported by many different institutes. Efforts to create a coordinating center for research in critical care within the NIH, such has one introduced in legislation in November of 2014 might help to better address the disproportionately poor funding for research on critical illness.[35] These findings could help such a coordinating center identify the most common critical illness conditions in need of coordinated calls for research.

Our findings also highlight how policy makers and health system leaders could affect the greatest improvements in the quality of critical care. In particular, sepsis and respiratory failure should increasingly be targeted by efforts to improve the quality of critical care services. As sepsis becomes the dominant condition among hospitalized patients, and is increasing among patients receiving care in critical care units, it has been identified as a prime target for improving hospital quality.[36] Not only does the care of sepsis vary dramatically across hospitals, efforts to improve the quality of sepsis care can improve outcomes.[37,38] Beginning in October, 2015, the Centers for Medicare & Medicaid Services required hospitals to collect data on their adherence to the National Quality Forum severe sepsis and septic shock bundle,[39] although it is uncertain whether such efforts will result in meaningful improvement.[36]

Major shifts in the epidemiology of patients receiving care in critical care units may also be of interest to certification, accreditation, and credentialing bodies responsible for ensuring intensive care practitioners are adequately trained to meet the needs of current critically ill adults. For example, evidence showing how non-cardiovascular critical illness was rising in a single University hospital's cardiac critical care unit between 1989 and 2006[40] motivated the American Heart Association to reexamine current staffing and training in cardiovascular critical care. Due to the increase in non-cardiac critical illness seen in cardiac ICUs, a redesign of the cardiovascular training program is under consideration.[41] As providers from many specialties interact with critically ill adults, specialty organizations and credentialing bodies must ensure their workforce is competent to care for the diversity of diagnoses present in critical care units.

Our study should be interpreted in the context of several limitations. First, our study relies on Medicare claims, which are designed for billing purposes. However, the clinical classification software we employed accounted for changes made to ICD-9-CM codes over the study period, and is designed to allow for comparisons among individual diagnosis over time.[16] Nevertheless, observed changes in the disease patterns could reflect both shifts in coding practice and changes in true disease burden. For example, some authors have raised concern that the increase in sepsis incidence may be spurious and due to financial incentives to receive higher reimbursement rates,[42] though others provide empiric arguments against this assertion.[43] However, because analysis in the current manuscript relied on administrative data, we cannot say with certainty that the shifts in diagnoses codes we observed represent true changes in disease burden among patients in the ICU.

Our primary analysis was among patients 65 years and older enrolled in fee-for-service Medicare. However, patients 65 years and older represent approximately 56% of all ICU admissions,[11] so national Medicare data should provide a reasonable picture of trends in critical care utilization. Moreover, our analysis of New York State data found similar diagnoses shifts among patients 18 and older and also suggested these trends were not related to shifts in enrollment from fee-for-service to Medicare managed care, further supporting that our findings are generalizable.

CONCLUSION

We found major shifts in diagnosis, comorbid illness, and illness severity among Medicare beneficiaries hospitalized in critical care units from 1996 to 2010. This work should guide funding agencies supporting critical care research, healthcare administrators involved in monitoring the quality of critical care delivered across hospitals, and educators involved in training the future critical care workforce.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Funding/Support: This work was supported by grants to Dr. Sjoding and Dr. Prescott from the NHLBI T32HL007749, Dr. Wunch from the NIA K08AG038477, Dr. Iwashyna from the Department of Veterans Affairs Health Services Research & Development Services - IIR 11-109, and NIH R21AG044752, Dr. Cooke from the AHRQ K08HS020672.

Role of the sponsors: The funding organizations had no role in the design and conduct of the study; in the collection, analysis, and interpretation of the data; or in the preparation, review, or approval of the manuscript.

Copyright form disclosures: Dr. Sjoding received support for article research from the National Institutes of Health (NIH). Dr. Prescott received support for article research from the NIH. Her institution received grant support from the NIH. Dr. Wunsch received funding from the NIH/NIA and the CIHR. Dr. Iwashyna disclosed government work. Dr. Cooke received support for article research from the Agency For Healthcare Research and Quality (AHRQ). His institution received funding from the AHRQ.

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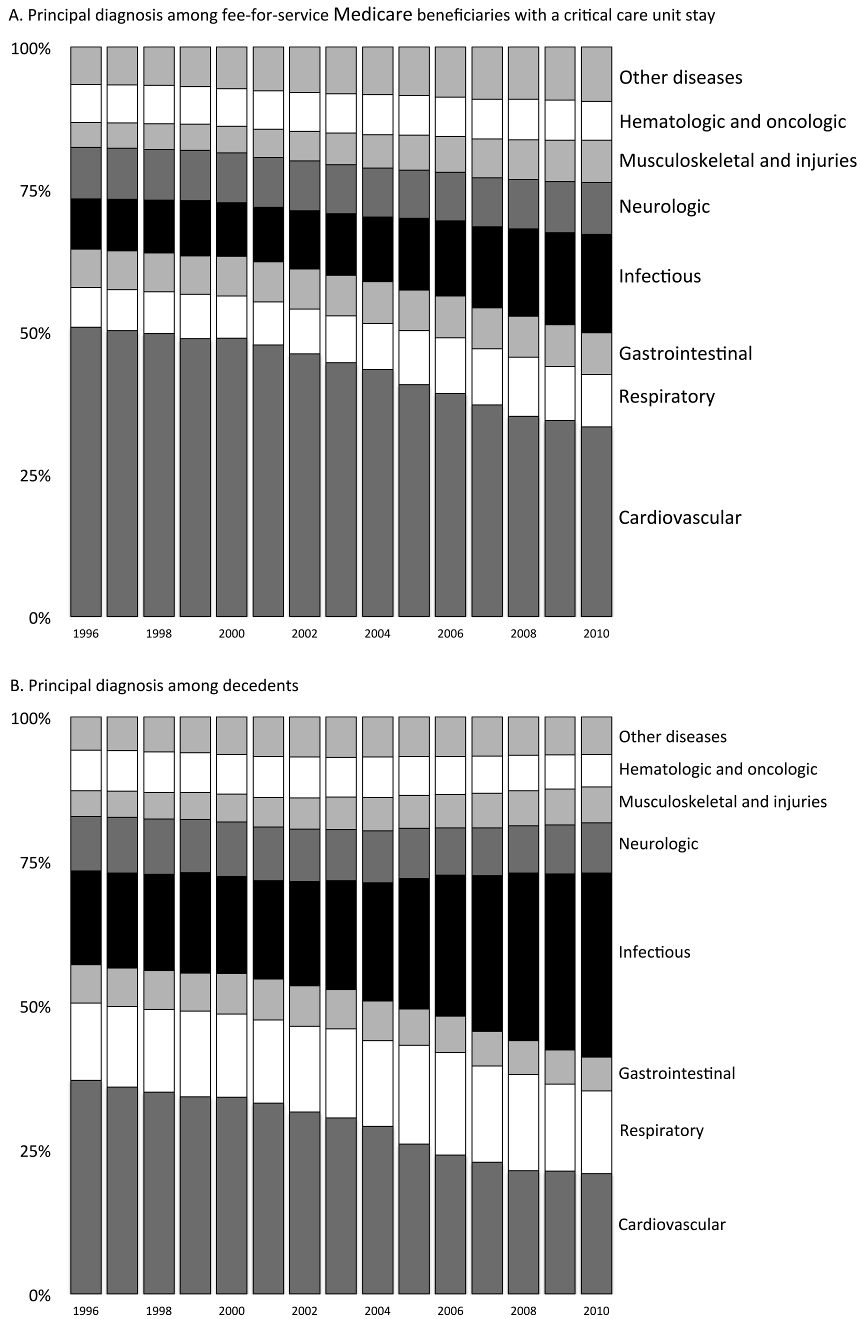

Figure 1.

A. Principal diagnoses among fee-for-service Medicare beneficiaries with a critical care unit stay during the hospitalization. Critical care units stays were defined as the presence of an intensive care or coronary care revenue center code in the hospitalization billing record, excluding intermediate care. B. Principal diagnoses among fee-for-service Medicare beneficiaries with a critical care stay who died during their hospitalization.

1996

Rank	Diagnosis	% Admits
1	Coronary atherosclerosis	14.6%
2	Acute myocardial infarction	11.8%
3	Congestive heart failure	7.9%
4	Cardiac arrhythmias	4.5%
5	Acute cerebrovascular disease	4.1%
6	Pneumonia	3.8%
7	Pre-cerebral artery disease	3.1%
8	**Respiratory failure**	**2.7%**
9	Gastrointestinal hemorrhage	2.1%
10	Complication of device	2.0%
11	**Sepsis**	**1.9%**
12	Chronic obstructive pulmonary disease	1.8%
13	Aortic; peripheral artery aneurysms	1.8%
14	Nonspecific chest pain	1.7%
15	Hypertension with complications	1.5%
16	Peripheral and visceral atherosclerosis	1.4%
17	**Heart valve disorders**	**1.3%**
18	Hip fracture	1.2%
19	Lung Cancer	1.1%
20	Biliary tract disease	1.1%
23	Aspiration pneumonitis	0.9%
25	**Complications of care**	**0.8%**
33	**Intracranial injury**	**0.6%**
34	**Acute and unspecified renal failure**	**0.6%**

2010

Rank	Diagnosis	% Admits	Relative change in % admits
1	**Sepsis**	**10.2%**	**5.52**
2	Acute myocardial infarction	7.4%	0.62
3	Coronary atherosclerosis	5.3%	0.36
4	Congestive heart failure	5.1%	0.64
5	**Respiratory failure**	**4.9%**	**1.78**
6	Acute cerebrovascular disease	4.8%	1.17
7	Cardiac arrhythmias	4.7%	1.05
8	Pneumonia	3.2%	0.84
9	Gastrointestinal hemorrhage	2.5%	1.19
10	Complication of device	2.4%	1.18
11	Pre-cerebral artery disease	2.2%	0.72
12	**Heart valve disorders**	**2.0%**	**1.56**
13	**Intracranial injury**	**2.0%**	**3.13**
14	**Acute renal failure**	**1.8%**	**3.11**
15	Chronic obstructive pulmonary disease	1.7%	0.96
16	Aortic; peripheral artery aneurysms	1.5%	0.84
17	Peripheral and visceral atherosclerosis	1.4%	0.99
18	**Complications of care**	**1.4%**	**1.68**
19	Hip fracture	1.3%	1.14
20	Aspiration pneumonitis	1.2%	1.37
22	Lung Cancer	1.1%	1.02
25	Hypertension with complication	1.0%	0.65
28	Nonspecific chest pain	0.9%	1.07
30	Biliary tract disease	0.8%	0.77

Figure 2.

Rankings of principal diagnosis among fee-for-service Medicare beneficiaries with a critical care unit stay during hospitalizations in 1996 and 2010. Diagnoses highlighted in black are those with a 50% relative increase between 1996 and 2010.

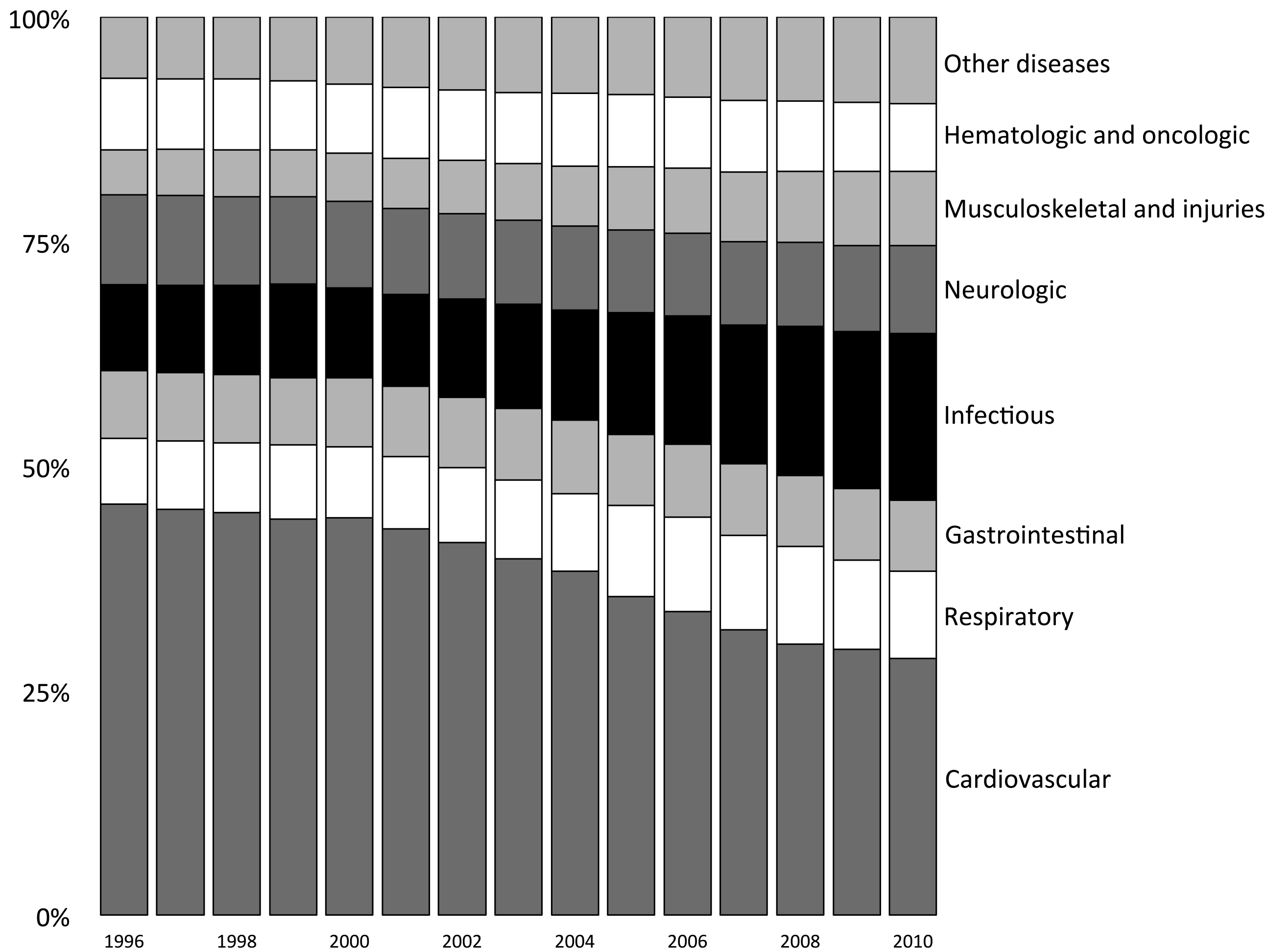

Figure 3.

Principal hospital diagnoses among fee-for-service Medicare beneficiaries with a critical care unit stay, excluding coronary care from the definition of a critical care unit.

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Table 1

Characteristics of fee-for-service Medicare Beneficiaries with critical care unit stays during hospitalizations in 1996 and 2010

	1996	2010
No. Patients	n=2,161,341	n=1,531,303
Age, mean (SD)	76.4 (7.3)	77.0 (8.2)
65-74 (%)	44.2	40.7
75-84	40.7	37.5
85-94	14.1	20.1
95+	1.0	1.7
Sex		
Male	48.9	49.3
Female	51.1	50.7
Race		
White	88.3	84.8
Black	8.2	9.9
Other	3.5	5.3
Select comorbid illnesses [a]		
Hypertension	38.7	49.6
Fluid and electrolyte disorders	16.3	29.3
Congestive heart failure	13.1	25.6
Chronic pulmonary disease	22.1	20.2
Diabetes	18.3	17.9
Chronic kidney disease	3.4	15.2
Deficiency anemia	7.4	9.7
Weight loss	3.1	8.2
Hypothyroidism	5.5	7.8
Peripheral vascular disease	8.3	7.2
Valvular heart disease	4.4	6.7
Coagulopathy	2.8	5.5
Neurological disorders	1.6	5.3

Critical care unit stays were defined as the presence of an intensive care or coronary care revenue center code in the hospital billing record. All data are percentages unless otherwise stated.

[a] Select comorbid illnesses are those Elixhauser comorbidities with rates above 5% in 2010.

Table 2

Characteristics of hospitalizations and outcomes among fee-for-service Medicare Beneficiaries with a critical care unit stay in 1996 and 2010

	1996	2010
Critical care unit type [a]		
Medical and/or Surgical	66.4	73.3
Coronary care	27.2	22.2
Other	6.4	4.5
Medical or Surgical Admission		
Medical	59.1	59.8
Surgical	40.9	40.2
Organ failure		
Yes	21.1	44.5
Organ failure type [b]		
Cardiovascular	6.3	16.7
Respiratory	11.4	16.7
Renal	4.4	24.7
Hepatic	0.2	1.3
Hematologic	2.5	5.2
Neurologic	1.7	2.7
Procedure use		
Invasive Mechanical Ventilation	11.4	16.7
Noninvasive Ventilation	0.3	4.6
Hemodialysis	2.2	4.6
Transfusion	6.4	18.0
Median Hospital length of stay	6.0	6.0
Average Medicare payment[c]	15,292	17,418
In-hospital Mortality	11.3	12.0
Discharge destination among hospital survivors [d]	n=1,913,956	n=1,347,031
Home	68.1	56.3
Acute Care Hospital	13.4	4.6
Post Acute Care Facility	18.2	33.8
Hospice Care	0.1	4.6
Other	0.3	0.6

All data are percentages unless otherwise stated.

[a]Medical and/or surgical includes general, medical, and surgical intensive care revenue center codes; other includes burn, trauma and other intensive care codes.

[b]Patients with secondary ICD-9-CM codes for acute organ dysfunction.

[C]Payments are inflation adjusted and inflated to 2010 US dollars using consumer price index.

[d]Discharge destination comparisons were made between 1998 and 2010 since hospice codes were not available until October 1996. Post-acute care includes long-term care hospitals, nursing and rehab facilities, hospice includes inpatient and outpatient services.