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Original Investigation

Mortality, Hospitalizations, and Expenditures for the Medicare Population Aged 65 Years or Older, 1999-2013

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IMPORTANCE In a period of dynamic change in health care technology, delivery, and behaviors, tracking trends in health and health care can provide a perspective on what is being achieved.

OBJECTIVE To comprehensively describe national trends in mortality, hospitalizations, and expenditures in the Medicare fee-for-service population between 1999 and 2013.

DESIGN, SETTING, AND PARTICIPANTS Serial cross-sectional analysis of Medicare beneficiaries aged 65 years or older between 1999 and 2013 using Medicare denominator and inpatient files.

MAIN OUTCOMES AND MEASURES For all Medicare beneficiaries, trends in all-cause mortality; for fee-for-service beneficiaries, trends in all-cause hospitalization and hospitalization-associated outcomes and expenditures. Geographic variation, stratified by key demographic groups, and changes in the intensity of care for fee-for-service beneficiaries in the last 1, 3, and 6 months of life were also assessed.

RESULTS The sample consisted of 68 374 904 unique Medicare beneficiaries (fee-for-service and Medicare Advantage). All-cause mortality for all Medicare beneficiaries declined from 5.30% in 1999 to 4.45% in 2013 (difference, 0.85 percentage points; 95% CI, 0.83-0.87). Among fee-for-service beneficiaries (n = 60 056 069), the total number of hospitalizations per 100 000 person-years decreased from 35 274 to 26 930 (difference, 8344; 95% CI, 8315-8374). Mean inflation-adjusted inpatient expenditures per Medicare fee-for-service beneficiary declined from \$3290 to \$2801 (difference, \$489; 95% CI, \$487-\$490). Among fee-for-service beneficiaries in the last 6 months of life, the number of hospitalizations decreased from 131.1 to 102.9 per 100 deaths (difference, 28.2; 95% CI, 27.9-28.4). The percentage of beneficiaries with 1 or more hospitalizations decreased from 70.5 to 56.8 per 100 deaths (difference, 13.7; 95% CI, 13.5-13.8), while the inflation-adjusted inpatient expenditure per death increased from \$15 312 in 1999 to \$17 423 in 2009 and then decreased to \$13 388 in 2013. Findings were consistent across geographic and demographic groups.

CONCLUSIONS AND RELEVANCE Among Medicare fee-for-service beneficiaries aged 65 years or older, all-cause mortality rates, hospitalization rates, and expenditures per beneficiary decreased from 1999 to 2013. In the last 6 months of life, total hospitalizations and inpatient expenditures decreased in recent years.

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In recent decades, the United States has experienced a period of dynamic change in health care technology, health care delivery, and health behaviors. Given these changes, which could provide benefit or cause unintended harm, there is a need to assess the results that are being achieved. The Medicare fee-for-service program of the Centers for Medicare & Medicaid Services (CMS), the nation's social insurance program, is ideally positioned to provide information on trends in mortality, hospitalizations, and hospitalization outcomes during this period in health care. A comprehensive analysis of national hospital trends in the Medicare fee-for-service population can reveal what has been achieved and the trajectories of change. Such an analysis can provide an assessment of past performance and targets for future interventions.

Accordingly, for the period 1999 through 2013 we assessed trends in overall mortality for all beneficiaries (fee-for-service and Medicare Advantage, the managed care component of Medicare). In addition, in the fee-for-service program, which contains information about health care utilization, we determined hospitalization rates and hospitalization-associated outcomes and expenditures. We also evaluated trends in hospitalization rates, costs, and disposition at the end of life in the fee-for-service program.

Methods

Study Population

The Medicare denominator files, which are produced by CMS, describe the demographic characteristics, monthly enrollment status, and mortality information for all beneficiaries. We used the denominator files to identify the overall Medicare population by limiting the analyses to beneficiaries aged 65 years or older enrolled in the Medicare program for at least 1 month from January 1999 through December 2013. For each year, the number of beneficiaries according to their choice of plan (ie, fee-for-service or Medicare Advantage) were counted; to reflect the focus on the fee-for-service plan, any beneficiary enrolled in this plan for at least 1 month of the year was counted in the fee-for-service analysis for the duration of the period in which they were enrolled (which could be as little as 1 month). Beneficiaries who were never enrolled in the fee-for-service plan in a given year were classified as only Medicare Advantage. Person-years of enrollment, based on an aggregate of the month, were used to reflect new enrollment, disenrollment, and deaths occurring during the benefit year among the fee-for-service beneficiaries. This was used as the denominator in our analyses of hospitalizations, their related outcomes, and expenditures.

The Yale University Human Investigation Committee approved the study and waived the requirement for informed consent.

All-Cause Mortality

To measure all-cause mortality, we identified beneficiaries who died during the study period, regardless of cause, and determined the timing of their death. We calculated the all-cause mortality rate for the entire Medicare population. We also cal-

culated the all-cause mortality rate for the groups separately by dividing the total number of deaths in each year by the corresponding number of Medicare beneficiaries (fee-for-service and Medicare Advantage). For this analysis, individuals were considered in fee-for-service if they were participating in that plan for any part of the year. For beneficiaries enrolled in the fee-for-service plan, the all-cause mortality rates for those who were also eligible for Medicaid ("dual-eligibles") for at least 1 month were also calculated.

Characteristics of Medicare Beneficiaries

We determined the age, sex, and race (white, black, other) of beneficiaries and counted the number eligible for Medicaid for at least 1 month (dual eligible) for the Medicare population, the number enrolled in the fee-for-service plan, and the number enrolled in Medicare Advantage. For fee-for-service beneficiaries who were hospitalized, we ascertained comorbidities from secondary diagnosis codes as well as principal and secondary diagnosis codes from all hospitalizations for 12 months before the index hospitalization; data from 1998 were used for hospitalizations in 1999. These comorbidities were classified using the Hierarchical Condition Categories method.^{1,2}

Hospitalizations and Outcomes

The Medicare inpatient files aggregate claims data submitted to CMS by hospitals on behalf of fee-for-service beneficiaries. Using the 1999 through 2013 inpatient files, the all-cause hospitalization rate among fee-for-service beneficiaries was estimated by dividing the total number of hospitalizations for each year by the corresponding number of person-years of fee-for-service enrollment, based on the total months that people were in fee-for-service. All fee-for-service hospitalizations were counted. Using a similar approach, the rates of beneficiaries with at least 1 hospitalization and rates of in-hospital major surgical procedures based on the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes listed in the Surgical Care Improvement Project were calculated.³ Deaths during the hospitalization, within 30 days of admission, and within 1 year of admission were also analyzed. We used the 2014 denominator file to obtain 1-year mortality information for patients discharged in 2013. All mortality rates were calculated at the patient level. Trends in hospital length of stay and major discharge dispositions (discharge to home, home care, intermediate care or skilled nursing facility, hospice, and transfer to another acute care hospital) were also assessed.

To measure Medicare inpatient expenditures for fee-for-service beneficiaries, we determined the annual Medicare inpatient reimbursements, adjusting for inflation using the Consumer Price Index (CPI) with 2013 as the index year.⁴ The average inpatient expenditure per Medicare beneficiary each year was calculated by dividing the CPI-adjusted Medicare inpatient expenditure by the corresponding number of person-years of fee-for-service enrollment.

To assess trends in the utilization of inpatient care at the end of life, we calculated the all-cause hospitalization rate per 100 deaths in the last 1, 3, and 6 months of deceased

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fee-for-service beneficiaries' lives, using all-cause deaths in each calendar year as the denominator. Similarly, we computed CPI-adjusted Medicare inpatient expenditure per death, and length of stay in the last 1, 3, and 6 months of deceased fee-for-service beneficiaries' lives.

Statistical Analysis

To assess trends in rates of mortality and hospitalization among beneficiaries enrolled in the fee-for-service plan, a mixed-effects model with a Poisson link function and state-specific random intercepts was fitted, adjusting for age, sex, and race. Time was modeled as a continuous variable corresponding to years 1999 (time = 0) to 2013 (time = 14). The adjusted annual decline for each reported outcome is based on the incidence rate ratio of the time variable, which represents the age-, sex-, and race-adjusted annual trends in these outcomes. We repeated each model for the various subgroups.

To assess geographic trends and variation in outcomes,⁵ the CMS model used for profiling hospital performance on outcomes^{1,2,6} was extended with a Poisson link function and county-specific random intercepts to model the number of deaths as a function of patients' age, sex, and race and geographic differences between counties. Geographic differences were accounted for because several factors that are related to health outcomes, such as lifestyle, access to care, and local environments, vary across counties and may affect outcomes. Using this model, we calculated the rates of risk-standardized all-cause mortality for each county or county equivalent for years 1999 and 2013. The county-specific risk-standardized rates were then mapped, coloring counties according to their risk-standardized rates in 1999 with a gradient from green to red (the lowest rates to the highest rates). To assess the changes in death rates between 1999 and 2013, we applied the 1999 map's color classification to the 2013 map. The model was repeated to calculate the risk-standardized hospitalization rate for years 1999 and 2013.

The analyses were conducted with SAS version 9.3.

Results**Trends and Characteristics in Fee-for-Service Medicare and Medicare Advantage Beneficiaries**

There were 68 374 904 unique beneficiaries aged 65 years or older enrolled in the Medicare program for at least 1 month from 1999 to 2013. The number increased from 33 540 416 in 1999 to 42 474 269 in 2013 (Table 1). Of these, 60 056 069 were enrolled in the fee-for-service plan for at least 1 month, representing 416 667 038 person-years of enrollment over the 15-year period. The proportion of beneficiaries enrolled in the fee-for-service plan decreased from 82.1% in 1999 to 71.0% in 2013. Over the study period, 2.1% to 3.0% of beneficiaries changed their enrollment between fee-for-service and Medicare Advantage plans.

Between 1999 and 2013, the average age of beneficiaries enrolled in the fee-for-service plan decreased slightly (75.3 years [SD, 7.5] vs 74.8 years [SD, 8.0]), the proportion of female Medicare beneficiaries declined from 59.4% to 55.7%,

white beneficiaries decreased from 86.7% to 84.6%, and black beneficiaries increased from 7.8% to 8.1%. Additionally, there were significant changes in the comorbidities of fee-for-service beneficiaries: heart failure, myocardial infarction, stroke, and cancer decreased, while asthma and diabetes increased (Table 1 and eTable 1 and eTable 2 in the Supplement).

In the Medicare Advantage program, between 1999 and 2013, the average age of beneficiaries was unchanged (74.3 years [SD, 6.8] vs 74.6 years [SD, 7.4]), the proportion of female beneficiaries was unchanged (57.7% vs 57.2%), white beneficiaries decreased from 85.5% to 82.1%, and black beneficiaries increased from 7.8% to 9.6%.

Beneficiaries enrolled in fee-for-service were 1 year older than beneficiaries enrolled in Medicare Advantage, a difference that has declined in recent years (Table 1). Between 1999 and 2013, beneficiaries dually enrolled in Medicare and Medicaid increased from 13.0% to 13.2% for those enrolled in fee-for-service, and from 4.6% to 11.9% for beneficiaries enrolled in Medicare Advantage (Table 1).

The annual all-cause mortality rate across the Medicare population declined from 5.30% in 1999 to 4.45% in 2013 (difference, 0.85 percentage points; 95% CI, 0.83-0.87). There were declines for both fee-for-service and Medicare Advantage (Figure 1). The difference between the fee-for-service and Medicare Advantage populations did not substantially change from 2003 through 2013 (difference, 0.72% in 2003; 0.76% in 2005; 0.68% in 2007; 0.78% in 2009; 0.89% in 2011; and 0.80% in 2013).

Trends in All-Cause Fee-for-Service Mortality

Among fee-for-service beneficiaries, there was a decrease in mortality, which was consistent across age, sex, and race subgroups, after accounting for beneficiaries' age, sex, race, and geographic location (adjusted relative annual decline, 1.32%; 95% CI, 1.29-1.36; eFigure 1, eTable 3, and eTable 4 in the Supplement). At the county level, there were declines in risk-standardized rates between 1999 and 2013, but considerable geographic variation persisted. Figure 2 (top panels) shows the county-level changes in risk-standardized rates between 1999 and 2013 in US maps and eFigure 2 in the Supplement shows histograms of these changes. There was improvement throughout the United States.

Fee-for-service beneficiaries who were dual-eligible had higher mortality compared with those who were not dual-eligible (10.22% vs 4.84%) in 1999, a difference that persisted in 2013 (8.34% vs 4.13%). The age-, sex-, race-adjusted odds of dying were 2.11 (95% CI, 2.11-2.12) in 1999 and 2.19 (95% CI, 2.18-2.20) in 2013 for beneficiaries who were dual-eligible compared with those who were not dual-eligible.

Trends in All-Cause Hospitalizations Among Fee-for-Service Beneficiaries

Between 1999 and 2013, the total number of hospitalizations per 100 000 person-years of enrollment in the fee-for-service plan decreased from 35 274 in 1999 to 26 930 in 2013 (difference, 8344; 95% CI, 8315-8374; Table 1, Figure 3A). Correspondingly, the number of beneficiaries admitted to the hospital at

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Table 1. Medicare Population 1999-2013: Demographic Features, Comorbidities, and Hospitalizations

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Medicare Population, Age ≥65 y															
Total No. of Medicare beneficiaries, in millions	33.5	33.8	33.9	34.2	34.4	34.8	35.2	35.6	36.2	37.0	37.9	38.8	39.6	40.8	42.5
Age, mean (SD), y	75.1 (7.4)	75.2 (7.4)	75.2 (7.4)	75.3 (7.5)	75.3 (7.5)	75.3 (7.5)	75.3 (7.6)	75.3 (7.6)	75.3 (7.7)	75.2 (7.7)	75.1 (7.8)	75.1 (7.8)	75.1 (7.8)	74.9 (7.8)	74.7 (7.8)
Female sex, %	59.1	58.9	58.7	58.6	58.4	58.1	58.0	57.7	57.5	57.3	57.0	56.8	56.6	56.3	56.1
Race, %															
White	86.5	87.0	86.8	86.5	86.4	86.2	85.9	85.7	85.5	85.3	85.2	84.9	84.6	84.3	83.9
Black	7.8	7.9	8.0	8.0	8.1	8.1	8.2	8.2	8.3	8.3	8.4	8.4	8.5	8.5	8.5
Other	5.7	5.1	5.2	5.4	5.6	5.7	5.9	6.1	6.2	6.4	6.5	6.7	6.9	7.2	7.6
Dual eligible, %	11.5	11.7	11.8	12.3	12.5	12.6	12.9	13.1	13.0	12.9	12.7	12.9	13.1	13.0	12.8
All-cause annual death, %	5.3	5.3	5.2	5.2	5.2	5.0	5.0	4.9	4.8	4.8	4.6	4.6	4.6	4.5	4.5
Medicare Fee-for-Service Population															
Enrolled in fee-for-service for ≥1 mo, No. in millions	27.5	27.7	28.6	29.3	29.7	30.0	30.2	29.8	29.0	28.7	28.7	29.0	29.2	29.5	30.1
Proportion of total Medicare population, %	82.1	82.1	84.1	85.7	86.2	86.3	85.8	83.6	80.1	77.6	75.6	74.7	73.6	72.3	71.0
Person-years of fee-for-service enrollment, in millions	26.2	26.4	27.2	28.0	28.4	28.7	28.7	28.0	27.5	27.3	27.3	27.7	27.9	28.3	28.8
Age, mean (SD), y	75.3 (7.5)	75.3 (7.5)	75.3 (7.5)	75.3 (7.5)	75.3 (7.6)	75.3 (7.6)	75.3 (7.6)	75.3 (7.7)	75.3 (7.8)	75.3 (7.8)	75.2 (7.9)	75.2 (7.9)	75.1 (7.9)	75 (8)	74.8 (8)
Female sex, %	59.4	59.1	58.8	58.5	58.3	58.0	57.9	57.6	57.4	57.1	56.8	56.6	56.3	56.0	55.7
Race, %															
White	86.7	87.1	87.0	86.8	86.6	86.4	86.2	86.2	86.1	86.0	85.8	85.5	85.2	84.9	84.6
Black	7.8	8.0	8.0	8.0	8.1	8.1	8.1	8.1	8.0	7.9	7.9	8.1	8.1	8.1	8.1
Other	5.4	4.9	5.0	5.2	5.3	5.4	5.7	5.7	5.9	6.1	6.3	6.5	6.7	7.0	7.3
Dual eligible, %	13.0	13.1	13.1	13.3	13.4	13.5	13.7	13.5	13.6	13.5	13.4	13.6	13.7	13.6	13.2
At least 1 mo enrollment in Medicare Advantage, %	2.5	2.2	2.4	1.9	1.5	1.8	3.0	4.4	3.3	3.3	2.7	2.5	2.0	2.1	2.5
All-cause annual death, %	5.5	5.5	5.4	5.4	5.3	5.1	5.1	5.0	5.0	5.0	4.8	4.8	4.8	4.7	4.7
Comorbidities (per 100 000 person-years)															
Hypertension	10 543	11 106	11 681	12 060	12 356	12 666	12 786	12 504	13 054	13 177	12 864	12 726	12 849	12 505	11 623
Chronic atherosclerosis	6694	6826	6972	7027	7042	7053	7003	6790	6618	6504	6195	5958	5937	5635	5140
Diabetes	4733	4879	5032	5142	5242	5336	5445	5362	5356	5334	5278	5249	5337	5207	4972
Chronic obstructive pulmonary disease	4466	4452	4503	4578	4627	4662	4746	4641	4515	3995	3777	3703	3744	3580	3414
Heart failure	2552	2592	2596	2582	2602	2642	2638	2556	2503	2357	2274	2239	2237	2141	2048
Cancer	2502	2482	2492	2478	2434	2397	2364	2312	2289	2263	2185	2117	2099	2018	1927
Pneumonia	1937	1985	1942	2028	2048	2113	2176	2155	2192	2425	2369	2346	2373	2277	2277

(continued)

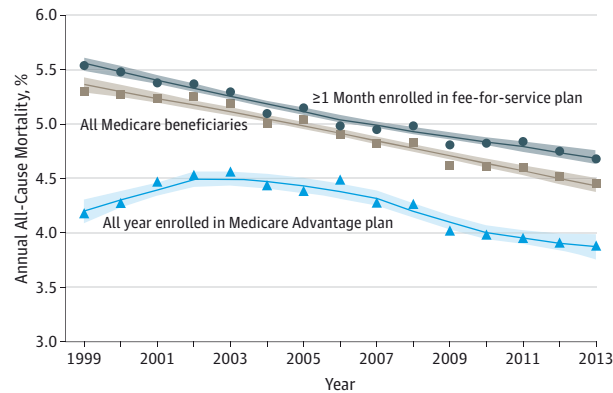
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Table 1. Medicare Population 1999-2013: Demographic Features, Comorbidities, and Hospitalizations (continued)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Trauma, past year	1727	1767	1864	1951	1995	2020	2036	2009	1916	1918	1658	1621	1708	1533	1410
Myocardial infarction	489	504	524	519	520	504	480	459	447	449	433	417	411	393	378
Asthma	477	512	539	570	597	625	666	667	643	648	636	622	644	637	615
Stroke	453	445	435	421	402	384	373	363	350	345	334	330	326	311	298
Chronic liver disease	230	233	236	244	249	253	252	250	252	239	240	250	266	273	279
Hospitalization (per 100 000 person-years)															
No. of hospitalizations	35 274	35 412	35 682	35 328	35 060	34 655	34 368	33 538	33 050	32 603	31 169	30 677	29 941	29 460	26 930
≥1 Hospitalization	21 782	21 760	21 829	21 660	21 464	21 272	21 167	20 703	20 387	20 087	19 495	19 227	18 811	18 248	17 344
Hospitalizations for major surgical care	3784	3751	3780	3746	3711	3749	3699	3614	3572	3515	3420	3363	3229	3102	3105
Mortality (per 100 fee-for-service beneficiaries) among those hospitalized, %															
In-hospital	1.30	1.26	1.22	1.20	1.13	1.06	1.02	0.95	0.91	0.91	0.84	0.80	0.78	0.72	0.71
30-Day all-cause	2.16	2.11	2.08	2.07	2.02	1.93	1.92	1.83	1.81	1.83	1.76	1.74	1.73	1.67	1.65
1-Year all-cause	4.49	4.41	4.41	4.33	4.25	4.10	4.05	3.92	3.93	3.90	3.76	3.73	3.68	3.65	3.48
Medicare Advantage Population															
Enrolled in Medicare Advantage for all 12 mo, No. in millions	5.9	6.0	5.4	4.9	4.7	4.8	5.0	5.8	7.2	8.3	9.3	9.8	10.4	11.3	12.3
Proportion of total Medicare population, %	17.9	17.9	15.9	14.3	13.8	13.7	14.2	16.4	19.9	22.4	24.4	25.3	26.4	27.7	29.0
Age, mean (SD), y	74.3 (6.8)	74.4 (6.8)	74.7 (6.9)	75 (6.9)	75.3 (7)	75.4 (7)	75.5 (7)	75.4 (7.1)	75.2 (7.2)	75.1 (7.3)	74.9 (7.3)	74.8 (7.3)	74.8 (7.3)	74.7 (7.3)	74.6 (7.4)
Female sex, %	57.7	57.9	58.3	58.6	58.7	58.7	58.6	58.4	58.1	58.0	57.7	57.5	57.4	57.2	57.2
Race, %															
White	85.5	86.1	85.8	85.3	84.9	84.6	84.1	83.1	83.0	83.1	83.2	83.3	82.9	82.6	82.1
Black	7.8	7.8	7.8	7.9	8.0	8.1	8.5	9.0	9.4	9.6	9.6	9.4	9.5	9.6	9.6
Other	6.7	6.1	6.4	6.8	7.1	7.2	7.4	7.9	7.6	7.3	7.2	7.3	7.6	7.8	8.2
Dual eligible, %	4.6	4.9	5.2	6.2	6.9	7.5	8.3	10.8	10.8	10.9	10.8	10.8	11.2	11.5	11.9
All-cause annual death, %	4.2	4.3	4.5	4.5	4.6	4.4	4.4	4.5	4.3	4.3	4.0	4.0	4.0	3.9	3.9

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Figure 1. Trends in Observed All-Cause Mortality Rates in the Medicare Population, 1999-2013



The symbols around each trend line represent the observed mortality rates for each year. All Medicare beneficiaries aged ≥ 65 years, Medicare beneficiaries aged ≥ 65 years who were enrolled in the fee-for-service plan for ≥ 1 month, and Medicare beneficiaries aged ≥ 65 years who were enrolled in a Medicare Advantage program for the full duration for the year are shown. The shaded areas around each line represent 95% CIs. Lines were smoothed using the loess method (local regression). The numbers of Medicare beneficiaries aged 65 years or older in each year and plan are shown in Table 1.

least once, per 100 000 person-years, decreased from 21 782 to 17 344 (difference, 4438; 95% CI, 4415-4462). The number of hospitalizations that involved major surgical procedures per 100 000 person-years of beneficiaries also decreased from 3784 to 3105 (difference, 679; 95% CI, 652-712). These findings did not change substantially after accounting for beneficiaries' demographic characteristics and geographical differences: the adjusted relative annual declines were 1.57% (95% CI, 1.54%-1.71%) and 1.36% (95% CI, 1.33%-1.39%) for the number of beneficiaries who had at least 1 hospitalization and the total number of hospitalizations, respectively (eFigure 3 in the Supplement). Although declines were consistent across age, sex, and race subgroups, there was considerable variation (eTable 3 and eTable 4 in the Supplement). At the county level, there was substantial decline in rates of risk-standardized hospitalization. Figure 2 (bottom panels) shows the county-level changes in risk-standardized rates between 1999 and 2013 in the United States, and eFigure 4 in the Supplement shows histograms of these changes. Variation in risk-standardized hospitalizations noted in 2013 still exist.

The most frequent principal diagnosis of these hospitalizations changed between 1999 and 2013; pneumonia was the leading diagnosis in 1999, but it declined to fifth by 2013, surpassed by osteoarthritis and other allied disorders, septicemia, heart failure, and cardiac dysrhythmias (eFigure 5 in the Supplement).

Trends in Hospitalization-Related Deaths, Expenditures, and Patterns of Care Among Fee-for-Service Beneficiaries

Among hospitalized fee-for-service beneficiaries, in-hospital mortality declined from 1.30% to 0.71% (difference, 0.59 percentage points; 95% CI, 0.59-0.60), 30-day mortality declined from 2.16% to 1.65% (difference, 0.51 percentage points; 95%

CI, 0.50-0.51), and 1-year mortality declined from 4.49% to 3.48% (difference, 1.01 percentage points; 95% CI, 0.99-1.01) (Table 1, Figure 3B). These findings did not change substantially after accounting for beneficiary age, sex, and race and geographic location: the adjusted annual declines, consistent across age-sex-race subgroups, were 4.49% (95% CI, 4.45%-4.55%) for in-hospital mortality, 2.02% (95% CI, 1.98%-2.06%) for 30-day mortality, and 1.80% (95% CI, 1.76%-1.83%) for 1-year mortality (eFigure 1, eTable 3, and eTable 4 in the Supplement).

From 1999 through 2013, the annual CPI-adjusted mean Medicare inpatient expenditure per beneficiary declined from \$3290 to \$2801 (difference, \$489; 95% CI, \$487-\$490). The median (IQR) hospital length of stay for beneficiaries who had at least 1 hospitalization declined from 5.0 (5.0) to 4.0 (4.0) days. Between 1999 and 2013, beneficiaries were increasingly likely to be discharged to an intermediate care or skilled nursing facility (20.04% to 23.92%), home with care (10.65% to 17.56%), hospice (0.12% to 3.28%), and long-term care (0.37% in 2002 to 1.18%), and less likely to be discharged to home (55.29% to 42.94%) or transferred to another acute care facility (3.21% to 1.81%) (Table 2).

Trends in Hospitalizations and Expenditures in the Last Months of Life Among Fee-for-Service Beneficiaries

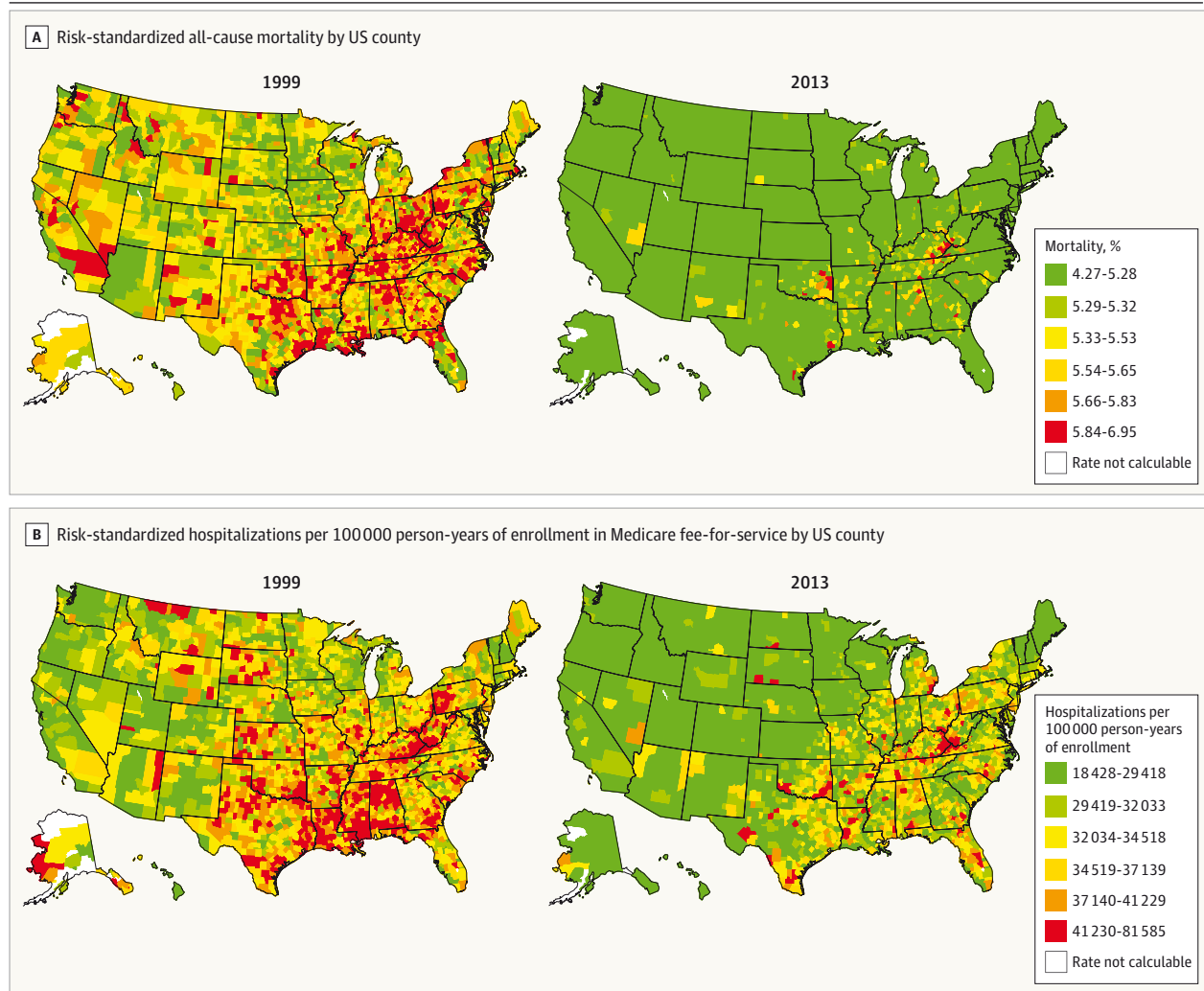
Among Medicare fee-for-service beneficiaries who died during the study period, the utilization of inpatient care during their last 6 months of life decreased: the total number of hospitalizations declined from 131.1 to 102.9 per 100 deaths (difference, 28.2; 95% CI, 27.9-28.4), the percentage of beneficiaries with 1 or more hospitalizations decreased from 70.5 to 56.8 per 100 deaths (difference, 13.7; 95% CI, 13.5-13.8), and the average number of days spent as an inpatient declined from 17 to 14 (Table 3). However, there was a mixed pattern of expenditures in the last 6 months of life, which increased from \$15 312 per deceased beneficiary in 1999 to \$17 423 in 2009, then decreased to \$13 388 in 2013. Similar patterns were observed in the last 3 months and 1 month of life (Table 3). Overall, approximately 60% of spending in the last 6 months of beneficiaries' lives occurred during their final month.

Discussion

In this comprehensive analysis of the hospital trends in the Medicare fee-for-service population aged 65 years or older, there were marked reductions in all-cause mortality rates, all-cause hospitalization rates, and inpatient expenditures, as well as improvements in outcomes during and after hospitalization. Although the geographic variations were marked, many of the worst-performing regions in 2013 performed at a higher level than the best-performing regions in 1999. Moreover, hospitalizations for beneficiaries in the last 6 months of life declined. Even though it is difficult to disentangle the specific reasons for improvement, it is clear that over the past 15 years there have been marked reductions in mortality, hospitalization, and adverse hospital outcomes among the Medicare population aged 65 years or older.

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Figure 2. Maps Showing Trends in Risk-Standardized All-Cause Mortality and Hospitalizations Among Fee-for-Service Beneficiaries for Individual US Counties, 1999-2013



United States counties are shaded according to the risk-standardized all-cause mortality rates (reported as percentages) (top 2 panels) and the number of risk-standardized hospitalizations (bottom 2 panels) per 100 000 person-years of enrollment in the Medicare fee-for-service program. Counties are shaded white if there were missing data that precluded the calculation of death or hospitalization rates. Both all-cause mortality and hospitalizations were for all beneficiaries enrolled for 1 or more months in Medicare fee-for-service. For 1999 and 2013, respectively, there were 27 552 139 and 30 148 234 unique

Medicare fee-for-service beneficiaries aged 65 years or older, representing 26 147 690 and 28 834 706 person-years of enrollment. Data from Puerto Rico were included to estimate the national rates but were not included in the maps. For Puerto Rico, the risk-standardized mortality rate decreased from 4.97% (95% CI, 4.91%-5.04%) in 1999 to 3.64% (95% CI, 3.55%-3.73%) in 2013. The risk-standardized hospitalization rate per 100 000 person-years decreased from 29 038 (95% CI, 27 891-30 184) in 1999 to 17 432 (95% CI, 16 775-18 089) in 2013.

There are many possible explanations for our findings of reduced hospitalizations and improved mortality. First, the improvements may, at least in part, be associated with national efforts to improve the care of all patients across the study period. The US Health Care Financing Administration (now CMS) introduced the Health Care Quality Improvement Initiative in 1992.⁷ In the ensuing years, many other efforts driven by CMS and other organizations were launched, which may have favorably affected outcomes.⁸⁻¹³ There is evidence for improvements in process measures for many conditions that affect large numbers of beneficiaries¹⁴ as well as outcomes for specific conditions.^{5,15-18}

Second, these changes may have been, in part, a reflection of healthier behaviors. Although the prevalence of obe-

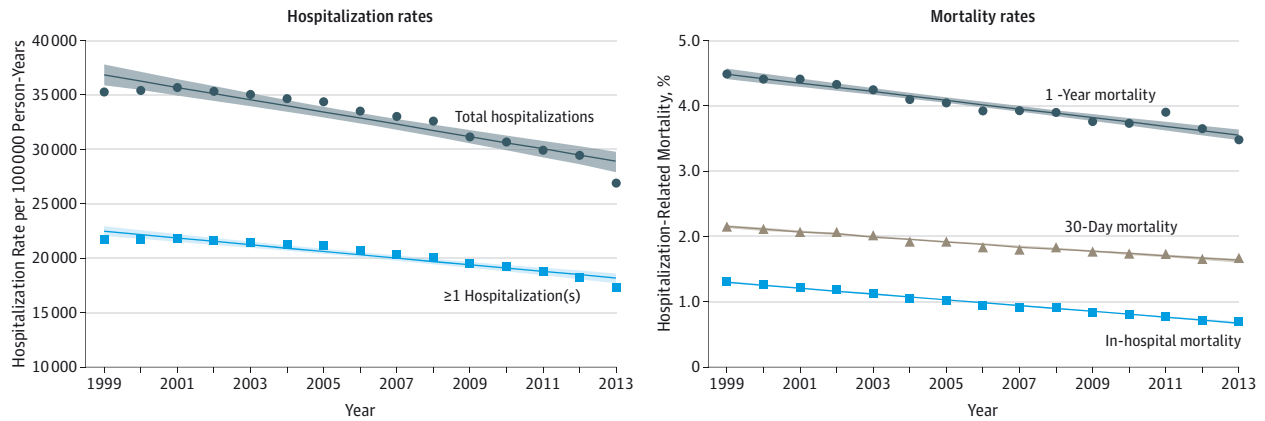
sity was increasing, this period was marked by increases in rates of exercise and decreases in rates of smoking.¹⁹ Risk factor management has also improved.¹⁹

Third, shifting lifetime exposures could also have accounted for some of the change. For example, people born in later years are healthier because of improvements in public health and different exposures during their lifetime. However, the period is rather short for dramatic changes in effects based on the years when people were born.

Fourth, these improvements in outcomes observed may have been related, at least in part, to technological advances. During the study period, several targeted cancer therapies that appear to extend life became available to patients, and the use

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Figure 3. Trends in Observed Hospitalization Rates and Hospitalization-Related Outcomes in the Medicare Fee-for-Service Population, 1999-2013



Rates for ≥1 hospitalization and total hospitalizations are shown on the left and in Table 1; hospitalizations for major surgical care are shown in Table 1. They all declined over time. The symbols around each trend line represent the observed hospitalization rates for each year. The shaded areas around each line represent

95% CIs. On the right are rates for in-hospital mortality, 30-day mortality, and 1-year mortality among hospitalized fee-for-service beneficiaries. The symbols around each trend line represent the observed mortality rates for each year. The shaded areas around the top line represent 95% CIs.

Table 2. Major Discharge Disposition, 1999-2013

Discharge Disposition	Rate, % (95% CI)							
	1999	2000	2001	2002	2003	2004	2005	2006
Home	55.29 (55.25-55.32)	55.81 (55.78-55.84)	55.82 (55.79-55.85)	54.47 (54.44-54.50)	52.79 (52.76-52.82)	50.49 (50.46-50.52)	50.06 (50.03-50.09)	49.31 (49.28-49.34)
Home with care service	10.65 (10.63-10.67)	10.26 (10.24-10.28)	10.00 (9.98-10.02)	10.48 (10.46-10.50)	11.65 (11.63-11.67)	13.68 (13.66-13.70)	13.92 (13.90-13.95)	14.53 (14.51-14.56)
Transferred out	3.21 (3.20-3.22)	3.20 (3.19-3.21)	3.09 (3.08-3.10)	3.07 (3.06-3.08)	2.71 (2.70-2.72)	2.47 (2.47-2.48)	2.28 (2.27-2.29)	2.11 (2.11-2.12)
Rehabilitation ^a				2.80 (2.79-2.81)	4.00 (3.99-4.01)	4.21 (4.20-4.22)	3.90 (3.89-3.91)	3.77 (3.75-3.78)
Long-term care ^a				0.37 (0.37-0.37)	0.70 (0.70-0.71)	0.82 (0.82-0.83)	0.90 (0.89-0.90)	0.95 (0.94-0.95)
Intermediate care or skilled nursing facility	20.04 (20.02-20.07)	19.76 (19.73-19.78)	19.75 (19.72-19.77)	19.48 (19.45-19.50)	19.82 (19.80-19.85)	20.43 (20.40-20.45)	21.05 (21.03-21.08)	21.54 (21.51-21.57)
Hospice	0.12 (0.12-0.13)	0.19 (0.19-0.20)	0.35 (0.35-0.36)	0.66 (0.66-0.67)	0.99 (0.98-0.99)	1.39 (1.38-1.40)	1.68 (1.67-1.69)	1.94 (1.93-1.95)
Expired	5.98 (5.96-6.00)	5.80 (5.78-5.82)	5.59 (5.57-5.61)	5.53 (5.51-5.55)	5.28 (5.26-5.30)	4.97 (4.95-4.99)	4.84 (4.82-4.86)	4.60 (4.58-4.61)
Others	5.38 (5.36-5.39)	5.64 (5.63-5.66)	5.99 (5.98-6.01)	3.76 (3.75-3.78)	2.61 (2.60-2.62)	2.07 (2.06-2.08)	1.86 (1.85-1.86)	1.70 (1.69-1.71)
	Rate, % (95% CI)							
Discharge Disposition	2007	2008	2009	2010	2011	2012	2013	
Home	48.34 (48.31-48.37)	47.21 (47.18-47.25)	46.51 (46.47-46.54)	45.40 (45.36-45.43)	44.74 (44.70-44.77)	43.93 (43.90-43.96)	42.94 (42.91-42.98)	
Home with care service	14.99 (14.96-15.01)	15.43 (15.41-15.46)	16.00 (15.97-16.02)	16.63 (16.61-16.66)	16.62 (16.59-16.64)	17.38 (17.36-17.41)	17.56 (17.53-17.58)	
Transferred out	2.03 (2.02-2.04)	1.96 (1.95-1.97)	1.85 (1.84-1.86)	1.79 (1.78-1.80)	1.75 (1.74-1.75)	2.06 (2.05-2.07)	1.81 (1.80-1.82)	
Rehabilitation	3.63 (3.62-3.64)	3.63 (3.62-3.65)	3.74 (3.72-3.75)	3.74 (3.73-3.75)	3.89 (3.88-3.91)	3.84 (3.83-3.86)	4.10 (4.08-4.11)	
Long-term care	0.99 (0.98-1.00)	1.03 (1.02-1.04)	1.07 (1.06-1.08)	1.11 (1.10-1.11)	1.15 (1.15-1.16)	1.14 (1.13-1.15)	1.18 (1.18-1.19)	
Intermediate care or skilled nursing facility	22.16 (22.13-22.19)	22.72 (22.69-22.75)	22.90 (22.87-22.93)	23.35 (23.33-23.38)	23.74 (23.71-23.77)	23.63 (23.60-23.66)	23.92 (23.89-23.95)	
Hospice	2.17 (2.16-2.18)	2.37 (2.36-2.38)	2.57 (2.56-2.58)	2.76 (2.75-2.77)	2.98 (2.96-2.99)	3.03 (3.02-3.04)	3.28 (3.27-3.30)	

^a Blank cells mean information was not available or considered unreliable.

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Table 3. Trends in Hospitalizations and Expenditures in the Last 1, 3, and 6 Months of Life Among Fee-for-Service Beneficiaries, 1999-2013

Measure	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Last 1 Month of Life															
CPI-adjusted Medicare inpatient expenditure per death, \$ ^a	9038	8771	9102	9189	8852	8652	8683	8759	8893	9242	9836	9438	9115	8793	8410
Total length of stay, mean, d	15	15	15	15	15	15	15	15	15	14	14	14	13	13	13
Hospitalization (per 100 deaths)^a															
≥1	41.5	41.3	41.3	41.4	41.0	40.7	39.9	38.9	39.0	39.0	38.8	38.2	38.0	37.3	36.4
Total	65.9	65.9	66.7	66.5	66.3	65.8	64.8	63.3	63.6	63.7	62.9	61.8	61.1	60.3	57.1
Last 3 Months of Life															
CPI-adjusted Medicare inpatient expenditure per death, \$ ^a	12 406	12 104	12 616	12 710	12 412	12 273	12 316	12 445	12 660	13 093	13 984	13 475	12 985	12 703	11 446
Ratio of expenditure (last 1 mo to last 3 mo)	0.729	0.725	0.725	0.721	0.723	0.713	0.705	0.704	0.704	0.702	0.706	0.703	0.700	0.702	0.692
Total length of stay, mean, d	16	16	16	16	16	16	16	16	16	16	16	15	15	14	14
Hospitalization (per 100 deaths)^a															
≥1	57.2	57.0	57.4	57.3	57.0	57.0	55.8	54.9	55.2	55.0	54.9	54.4	53.9	53.3	49.1
Total	100.0	100.4	102.2	101.5	102.1	102.0	100.3	98.8	99.7	99.5	98.6	97.3	96.1	95.5	84.4
Last 6 Months of Life															
CPI-adjusted Medicare inpatient expenditure per death, \$ ^a	15 312	15 014	15 684	15 727	15 455	15 370	15 371	15 565	15 838	16 292	17 423	16 865	16 231	16 012	13 388
Ratio of expenditure (last 1 mo to last 6 mo)	0.590	0.584	0.584	0.580	0.584	0.573	0.563	0.565	0.563	0.561	0.567	0.565	0.560	0.562	0.549
Total length of stay, mean, d	17	17	17	17	17	17	16	16	16	16	16	15	15	15	14
Hospitalization (per 100 deaths)^a															
≥1	70.5	70.7	71.2	70.6	70.6	70.7	69.0	68.2	68.7	68.1	68.4	67.9	67.2	66.9	56.8
Total	131.1	132.6	134.9	133.4	134.6	134.9	132.0	130.7	132.2	131.3	130.8	129.4	127.4	127.4	102.9

Abbreviation: CPI, Consumer Price Index.

^a Any deaths that occurred within 1 y regardless of hospitalizations.

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of statins for prevention and coronary revascularization for treatment markedly expanded, likely easing the morbidity and mortality associated with cardiovascular disease.²⁰ In addition to drug and device innovation, the proliferation of other technologies may be contributory; for example, advances in telecommunications have helped many patients, especially those in rural areas, to receive medical attention more rapidly.

Fifth, changes in the percentage of people enrolled in fee-for-service Medicare may be related to less-well individuals moving from fee-for-service to Medicare Advantage, leaving a healthier population in fee-for-service and an appearance of improvement over time. However, with respect to mortality, our empirical analyses and those of others indicate that the Medicare Advantage beneficiaries have a lower risk of death than fee-for-service beneficiaries.²¹ Moreover, since 2003 both groups have experienced similar declines in overall mortality, lending support to the conclusion that the observed changes among the fee-for-service population are not the result of changes in the risks of the groups relative to each other and do represent true improvement. Other studies have found that healthier people are likely to shift enrollment from fee-for-service to Medicare Advantage, which may have led to an underestimation of the improvement over time,^{22,23} because we observed increasing enrollment in Medicare Advantage over time.

Other factors merit consideration. Lack of access to care is an unlikely explanation for the declining hospitalization rates because the Medicare population is insured and few physicians have opted out of Medicare.²⁴ Hospitalizations have been avoided as a result of trends toward performing elective procedures on an outpatient basis. However, prior studies showing reductions in selected acute events, such as acute myocardial infarction and heart failure,⁵ suggest that the reduction in hospitalization rates is not entirely a result of movement of procedures to the outpatient setting. Additionally, improvements in air quality may have affected hospitalization and mortality rates.^{25,26}

The study also revealed that the improvements were consistent across several patient groups, defined by age, sex, and race. Declines in annual mortality and hospitalization rates, although most pronounced in the youngest age groups, were even observed among patients who were 85 years or older. Black and white patients had similar magnitudes of improvement, yet racial disparities persisted.

The study has other important findings. Patients were increasingly discharged to rehabilitation and nursing facilities or with home health care, whereas the proportion of patients discharged to home without care decreased steadily. The cause of this shift may be the declining lengths of hospital stay or the increased focus on providing high-quality postacute care.^{27,28} It may also be that hospitalizations are being reserved for pa-

tients who have higher clinical severity of disease, although if that is true we may have even underestimated the amount of improvement during this period.

In addition, analyses of data on care during the last 6 months of life revealed decreases in utilization in the recent years compared with the beginning of the study period. The decreased hospitalization rates may reflect an increasing recognition of the importance of person-centered care at the end of life and a focus on decreasing the burden of multiple care transitions and hospitalizations on patients and their families.²⁹⁻³³ The increasing role of hospice may also be a contributory factor. Other studies, which are important but less contemporary and with a more limited range of years, have also noted lower hospitalization rates at the end of life and increasing expenditures.³⁴ Our study adds a perspective since 1999 and evidence that the trend has continued through 2013. We also show that more than half of the inpatient expenditures in the last 6 months of life occur in the last month.

The study has several limitations. First, we necessarily focused on the Medicare fee-for-service population to describe hospitalizations and their associated outcomes and expenditures because those enrolled in the Medicare Advantage program are not described in the Medicare inpatient files. Nevertheless, our findings and those of others suggest that changes in the fee-for-service population as a result of movement into Medicare Advantage do not account for the improvement. Second, the study was not capable of establishing the causes of the observed changes in mortality, hospitalization rates, and expenditures. It is likely that improvements in health and the health care of the population, as well as changes in health care delivery, have produced tangible benefits that are reflected in mortality and hospital resource utilization. There is a need for further study of all expenditures to determine how reductions in inpatient expenditures are related to those in other areas, particularly with respect to postacute care. Finally, we used administrative claims data, which lack the clinical detail afforded by medical records; however, clinical data do not offer a significant advantage over administrative claims data in analyses of overall mortality, hospitalization, and expenditures.

Conclusions

Among Medicare fee-for-service beneficiaries aged 65 years or older, all-cause mortality rates, hospitalization rates, and expenditures per beneficiary decreased from 1999 to 2013. In the last 6 months of life, total hospitalizations and inpatient expenditures decreased in recent years. Health outcomes related to hospitalizations appear to have improved substantially in the last 2 decades.

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