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Sepsis Among Medicare Beneficiaries: 1. The Burdens of Sepsis, 2012–2018*

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Objectives: To provide contemporary estimates of the burdens (costs and mortality) associated with acute inpatient Medicare beneficiary admissions for sepsis.

Design: Analysis of paid Medicare claims via the Centers for Medicare & Medicaid Services DataLink Project.

Setting: All U.S. acute care hospitals, excluding federally operated hospitals (Veterans Administration and Defense Health Agency).

Patients: All Medicare beneficiaries, 2012–2018, with an inpatient admission including one or more explicit sepsis codes.

Interventions: None.

Measurements and Main Results: Total inpatient hospital and skilled nursing facility admission counts, costs, and mortality over time. From calendar year (CY)2012–CY2018, the total number of Medicare Part A/B (fee-for-service) beneficiaries with an inpatient hospital admission associated with an explicit sepsis code rose from 811,644 to 1,136,889. The total cost of inpatient hospital admission including an explicit sepsis code for those beneficiaries in those calendar years rose from \$17,792,657,303 to \$22,439,794,212. The total cost of skilled nursing facility care in the 90 days subsequent to an inpatient hospital discharge that included an explicit sepsis code for Medicare Part A/B rose from \$3,931,616,160 to \$5,623,862,486 over that same interval. Precise costs are not available for Medicare Part C (Medicare Advantage) patients. Using available federal data sources, we estimated the aggregate cost of inpatient admissions and skilled nursing facility admissions for Medicare Advantage patients to have risen from \$6.0 to \$13.4 billion over the CY2012–CY2018 interval. Combining data for fee-for-service beneficiaries and estimates for Medicare Advantage beneficiaries, we estimate the total inpatient admission sepsis cost and any subsequent skilled nursing facility admission for all (fee-for-service and Medicare Advantage)

Medicare patients to have risen from \$27.7 to \$41.5 billion. Contemporary 6-month mortality rates for Medicare fee-for-service beneficiaries with a sepsis inpatient admission remain high: for septic shock, approximately 60%; for severe sepsis, approximately 36%; for sepsis attributed to a specific organism, approximately 31%; and for unspecified sepsis, approximately 27%.

Conclusion: Sepsis remains common, costly to treat, and presages significant mortality for Medicare beneficiaries. (*Crit Care Med* 2020; 48:276–288)

Key Words: cost; Medicare; mortality; sepsis

Sepsis is a syndromic illness most generally recognized as one or more adverse host responses to infection. Anyone can develop sepsis. Children younger than 1 year, adults 65 years old and older, persons with weakened immune systems, and persons with chronic medical conditions are at increased risk (1–3). According to recent (2016) Centers for Disease Control and Prevention estimates, 1.7 million adult Americans become septic each year; of those, nearly 270,000 Americans die, and one in three patients who die in a hospital have sepsis (4). Septicemia, which is the detection of a pathogen in the bloodstream in the context of adverse host responses, was recently recognized to be the most costly hospital inpatient condition and accounted for \$23.663 billion in costs in 2013 (5). Early survivors are often too ill to return to their homes and require ongoing progressive healthcare in venues such as long-term acute care hospitals (LTCHs) and skilled nursing facilities (SNFs).

Medicare is the U.S. federal health insurance program authorized under the Title XVIII of the Social Security Act for persons who are 65 years old or older, for certain younger persons with disabilities, and for persons with permanent end-stage renal disease requiring long-term dialysis. Medicare Program spending grew to \$706 billion in 2017: those costs reflect 20% of the national health expenditure (6). The number of beneficiaries is growing as Americans are aging into Medicare and they are living longer. Summaries of the Medicare program and its beneficiaries are publicly available (7, 8).

With rising numbers of beneficiaries come rising numbers of sepsis diagnoses. At the same time, clinical scientists have created and deployed new diagnostics and treatments. The aggregate effects of these demographic, diagnostic, and treatment changes are poorly understood. We therefore sought to clarify the contemporary burdens of sepsis among Medicare beneficiaries, focusing on those who elect fee-for-service (FFS) under Medicare parts A and B, and comparing wherever possible those who have elected Medicare Advantage (MA) under Medicare part C (9–11).

We sought to assess the recent and current burdens of sepsis borne by Medicare beneficiaries, their families, and the nation. Specifically, we wished to 1) count the numbers and calculate the percentages of inpatient admissions linked to sepsis; 2) report the payments for inpatient admissions and subsequent SNF admissions for those patients; and 3) describe the sepsis-associated

admission mortality during the inpatient admission and 3 years subsequent to discharge from the inpatient hospital.

METHODS

We used claims from the Centers for Medicare & Medicaid Services (CMS) DataLink Project. Under the DataLink contract, Acumen, LLC (<https://www.acumenllc.com/>, Burlingame, CA) produces reports with funding from the CMS and the Assistant Secretary of Preparedness and Response. These reports are compiled using data matching strategies across multiple databases containing claims, payments, and outcomes data. This DataLink project relies initially on pre-adjudicated administrative claims data to conduct near real-time monitoring and research and quality improvement analyses (12–14).

We include a glossary of terms (Table 1).

For all three reports in this set, we restricted analysis to include only those claims having their final action as paid and to omit claims either denied or awaiting final action. For this study, the study interval included all claims for services rendered January 1, 2012, to December 31, 2018 (21, 22).

We identified: 1) all FFS Medicare beneficiaries with an inpatient hospital admission claim associated with one or more explicit sepsis codes (vide infra); 2) the subset of that cohort with a SNF admission claim within 90 days immediately subsequent to the inpatient hospital claim; and 3) encounter data submitted by MA program insurance plans on behalf of enrollees who required inpatient hospital admission associated with one or more sepsis codes. In cost analysis estimates, we assign costs through encounter data claims made on behalf of MA beneficiaries equivalent to claims paid on behalf of FFS beneficiaries using prevailing FFS rates.

Each inpatient admission is defined by paid (FFS) and encounter data (MA) claims that provide beneficiary, admission date, and provider-level information. The discharge date, diagnoses, and procedure information for the admission were taken from the most recent claim, whereas the admission date information was taken from the earliest claim associated with the particular inpatient admission. Sepsis admissions were identified by the presence of any sepsis diagnosis code listed on the last claim in the inpatient admission. Thus sepsis admissions include both sepsis present on admission (POA) and sepsis not POA (NPOA) meaning that the condition was acquired during the inpatient hospital admission.

During this study interval, Medicare and other payers transitioned their coding bases from *International Classification of Disease* (ICD), 9th Edition (ICD-9) to 10th Edition (ICD-10) (23). We used the common standard of general equivalence mappings (“GEMs”) to crosswalk the explicit sepsis diagnosis codes (DGNs) of ICD-9 into ICD-10 (24). In addition to these explicit codes, we also evaluated claims reflecting ICD-10 codes used to denominate the sepsis CMS quality metric (SEP-1) (25). Thus, three specific code sets were initially identified:

- “ICD-9”—Explicit sepsis using ICD-9 codes 038, 995.91, 995.92, and 785.52.
- “ICD-10 crosswalk”—Explicit sepsis using ICD-10 codes

TABLE 1. Glossary and Description of Terminology Used in Medicare Claims

Term	Description
(Sepsis inpatient) admission	An inpatient admission includes one or more sepsis diagnostic (<i>International Classification of Disease</i>) codes. If at least one of those codes is flagged as “Present on admission,” then the entire inpatient admission is designated as sepsis present on admission.
(Medicare) claim	A claim is a report (“filing”) of a healthcare service rendered to a beneficiary. A claim on behalf of a fee-for-service beneficiary under Medicare parts A and B is also a request for reimbursement. A claim on behalf of a hospitalized Medicare Advantage beneficiary merely reports the service and diagnostic code(s). The latter are sometimes referred to as “no-pay,” “information only,” or “shadow billing” but are more accurately described as encounter data that enable counting care services and describing outcomes of that care.
Acute care hospital	A hospital that provides inpatient medical care and other related services for surgery, acute medical conditions, or injuries (usually for a short-term illness or condition). The vast majority of sepsis inpatient admissions occur in this hospital type (15).
Long-term care hospital	LTCHs are certified as acute care hospitals, but LTCHs focus on patients who, on average, stay > 25 d. Many of the patients in LTCHs are transferred there from an intensive or critical care unit. LTCHs specialize in treating patients who may have > 1 serious condition, but who may improve with time and care, and return home (16).
Rehabilitation hospital	Inpatient rehabilitation facilities are free-standing rehabilitation hospitals and rehabilitation units in acute care hospitals. They provide an intensive rehabilitation program and patients who are admitted must be able to tolerate 3 hr of intense rehabilitation services per day (17).
Psychiatric hospital	Psychiatric hospital means an institution which is engaged primarily in providing, by or under the supervision of a Doctor of Medicine or Osteopathy, psychiatric services for the diagnosis and treatment of mentally ill persons (18).
SNF	A SNF provides nursing and therapy care that only can be performed safely and effectively by, or under the supervision of, professionals or technical personnel (19).
Nursing home, assisted living	Nursing homes and assisted living facilities are residences. Such residential care is considered custodial care and is not covered by Medicare (20).

LTCH = long-term care hospital, SNF = skilled nursing facility.

obtained using the GEMs for the ICD-9 codes above: A409, A412, A4101, A4102, A411, A403, A414, A4150, A413, A4151, A4152, A4153, A4159, A4189, A419, A419, R6520, R6521.

- “ICD-10 SEP-1 metric”—Sepsis defined using ICD-10 codes for the SEP-1 metric: A021, A227, A267, A327, A400, A401, A403, A408, A409, A4101, A4102, A411, A412, A413, A414, A4150, A4151, A4152, A4153, A4159, A4181, A4189, A419, A427, A5486, B377, R6520, R6521.

Note that the ICD-10 crosswalk and ICD-10 SEP-1 metric code sets are similar but not identical: the SEP-1 code set is a superset (contains more codes) compared with the ICD-10 set obtained from the GEMs-enabled crosswalk. In order to capture the maximum number of sepsis-associated inpatient admissions, we generally used the SEP-1 denominator code set to identify, administratively, sepsis following the transition from ICD-9 to ICD-10 that occurred in October 2015. For details of the code sets, see **Supplement 1** (Supplemental Digital Content 1, <http://links.lww.com/CCM/F243>).

Conventionally, sepsis is classified according to level of severity, and that severity reflects (1) the extent of the physiologic derangement (2), the individual patient’s ability to respond to that derangement, and (3) the intensity of the corrective treatments. We stratified the severities into tiers based on ICD-9→10 codes as follows:

1. Septic Shock is specified by ICD-9 code 785.52 or ICD-10 code R6521.
2. Severe Sepsis without Shock is specified by ICD-9 code

995.92 or ICD-10 code R6520, and excepting septic shock codes.

3. Non-Severe Sepsis, Organism-Specific is specified by organism-specific sepsis codes (ICD-9: 0380, 03810, 03811, 03812, 03819, 0382, 03840, 03841, 03842, 03843, 03844, 03849, 0388 and ICD-10: A409, A412, A4101, A4102, A411, A403, A414, A4150, A413, A4151, A4152, A4153, A4159, A4189, A021, A227, A267, A327, A400, A401, A408, A4181, A427, A5486, B377) and excepting severe sepsis or septic shock codes.
4. Non-Severe Sepsis, Unspecified, specified by ICD-9 codes 0389 or 995.91 or ICD-10 code A419, and excepting severe sepsis, septic shock, or organism-specific sepsis codes.

We classified sepsis as being POA when at least one sepsis diagnostic code on the last claim in the admission reported a POA indicator on that claim as Y (yes). Conversely, we classified sepsis as NPOA when all sepsis diagnostic codes on the last claim in the admission had POA indicators as equals to N (no). Some admissions were therefore indeterminate (designated as unknown presence on admission) because there was no sepsis diagnostic code on the last claim in the admission having POA indicator equals to Y and yet not all sepsis codes “during” the admission have POA indicator equals to N. This situation meant that at least one sepsis code had unknown status on admission. (The fraction of sepsis admissions classified as unknown is reported below and was always < 0.4%. These indeterminate admissions were omitted from analyses aimed to compare outcomes of POA and NPOA

admissions but were otherwise included, e.g., in aggregate cost reporting.)

Total payment was computed by adding the inpatient stay payment and when applicable, the payment from the most recent Emergency Department outpatient claim with a through date 3 days/72 hours prior to the beneficiary's inpatient sepsis admission.

Regarding MA inpatient admissions, they are considered MA inpatient admissions if they are a) not FFS inpatient admissions and b) if their associated claims contain a related condition code equal to "04" (signifying an "information only" claim and used by all MA systems) (26). We counted both paid and encounter data inpatient claims for MA beneficiaries that capture services rendered to MA beneficiaries.

MA costs for inpatient sepsis admissions were assigned hierarchically as follows:

1. Based on the CMS diagnosis-related group (DRG), admission month, and 1-week mortality status (either death within 1 wk of discharge or survival) for the MA inpatient sepsis admission, we assigned a payment equal to the average FFS payment for that DRG, admission month, and 1-week mortality group.
2. If data for the method in the prior paragraph were not available, we assigned a payment equal to the average FFS payment for the same DRG and 1-week mortality group.
3. If data for the two prior paragraphs were not available, we assigned a payment equal to the average FFS payment for the same 1-week mortality group.

MA payments for subsequent SNF stays were assigned by assuming that the proportion of SNF stays is the same as that for the FFS group and also that the average payment for MA SNF stays are the same as the FFS SNF stays.

The analysis included dual-eligible beneficiaries. Dual-eligible beneficiaries (Medicare dual eligible ["duals"]) are patients who qualify for and are enrolled in the federal Medicare program and state-operated Medicaid programs. They are considered an at-risk population due to their qualifying disability, chronic illness, and/or socioeconomic status and commonly have higher occurrence of hospitalizations due to their poorer health status and making proportionately greater claims (27).

Medicaid-only beneficiaries were not analyzed or reported in this study.

The interval to death is reported in reference to the date of discharge from the inpatient hospital reported in the index hospital claim. More precisely, mortality percentages are reported referencing an admission associated with the death of the beneficiary at intervals following each admission and reported herein stratified by the inferred severity. Mortality percentages are computed for 6-month, 1-year, and 3-year "look-forward" periods starting from the beneficiaries' inpatient hospital discharge dates. (This introduces a slight bias in the data, in that admissions represented earlier in the cohort have completed a 3-yr look-forward, whereas more recent admissions are over-represented in the shorter look-forward intervals.)

The analyses for this report were generated using SAS software (Version 9.4, SAS System for Windows; SAS Institute,

Cary, NC). Herein, we report only descriptive (counts, rates, and costs) statistics.

This analysis and publication is exempt from institutional review board oversight. It was performed as a health-care quality improvement analysis. CMS is a covered entity. Deidentification methods were implemented in accordance with CMS policy, Privacy Act of 1974 (5 U.S.C. § 552a) and HIPAA (45 Code of Federal Regulations Part 160 and Subparts A and E of Part 164) requirements.

Supplement 2 (Supplemental Digital Content 2, <http://links.lww.com/CCM/F244>) and **Supplement 3** (Supplemental Digital Content 3, <http://links.lww.com/CCM/F245>) include the source data used to create figures and also unabridged tables.

RESULTS

Dynamic interactive visualizations accompany some of the results reported below and can be viewed at https://lippincott.shinyapps.io/BARDA_sepsis_study/.

Medicare FFS sepsis claims and costs steadily increased during the study interval. There is seasonal variation in claims and costs, with increases during those winter months generally associated with excess respiratory infections including but not limited to seasonal influenza (28). Despite the transition from ICD-9 to ICD-10 codes, there was not visible discontinuity in the growth of costs or of inpatient admission rates owing to the GEMs crossover (**Fig. 1**, *dashed line vs dotted line*, respectively). Inpatient hospital admissions that included SEP-1 explicit sepsis codes tracked and slightly exceeded the ICD-10 explicit sepsis codes (**Fig. 1**, *dotted line vs solid line*). (The slight excess is a result of the SEP-1 code set being a superset of the sepsis code set obtained from cross-walking ICD-9 to ICD-10 as mentioned in Methods and shown in detail in Supplement 1 [Supplemental Digital Content 1, <http://links.lww.com/CCM/F243>].)

The number and proportion of inpatient admissions that included a sepsis diagnostic code increased steadily during the interval at all levels of severity (**Fig. 2, A and B**). A sepsis diagnostic code was included among an average of about 17.8 diagnostic codes in 2012, rising to about 19.5 diagnostic codes in 2018. Although the largest increases occurred in the least severe sepsis tier group admissions, year-over-year increases in both admission counts and proportion of total admissions within the beneficiary community rose steadily (albeit with seasonal variation) through the 7-year period at all severity tiers. The proportions of admissions coded as septic shock, severe sepsis, and sepsis of lower severity varied little (averaging about 2.3% between code types) over the 7-year study interval; however, identification of a specific causative organism declined among admissions with lower severity sepsis (**Fig. 2C**).

The mortality of sepsis diagnoses was different across the severity tiers with greatest 1-week, 6-month, 1-year, and 3-year mortality among patients initially diagnosed with septic shock. Although the least severe cases had less initial mortality, that sepsis tier continued to be associated with increased risk for death 3 years following the index inpatient admission (**Fig. 3**). Under the Sepsis-3 rubric, these less severe cases are not

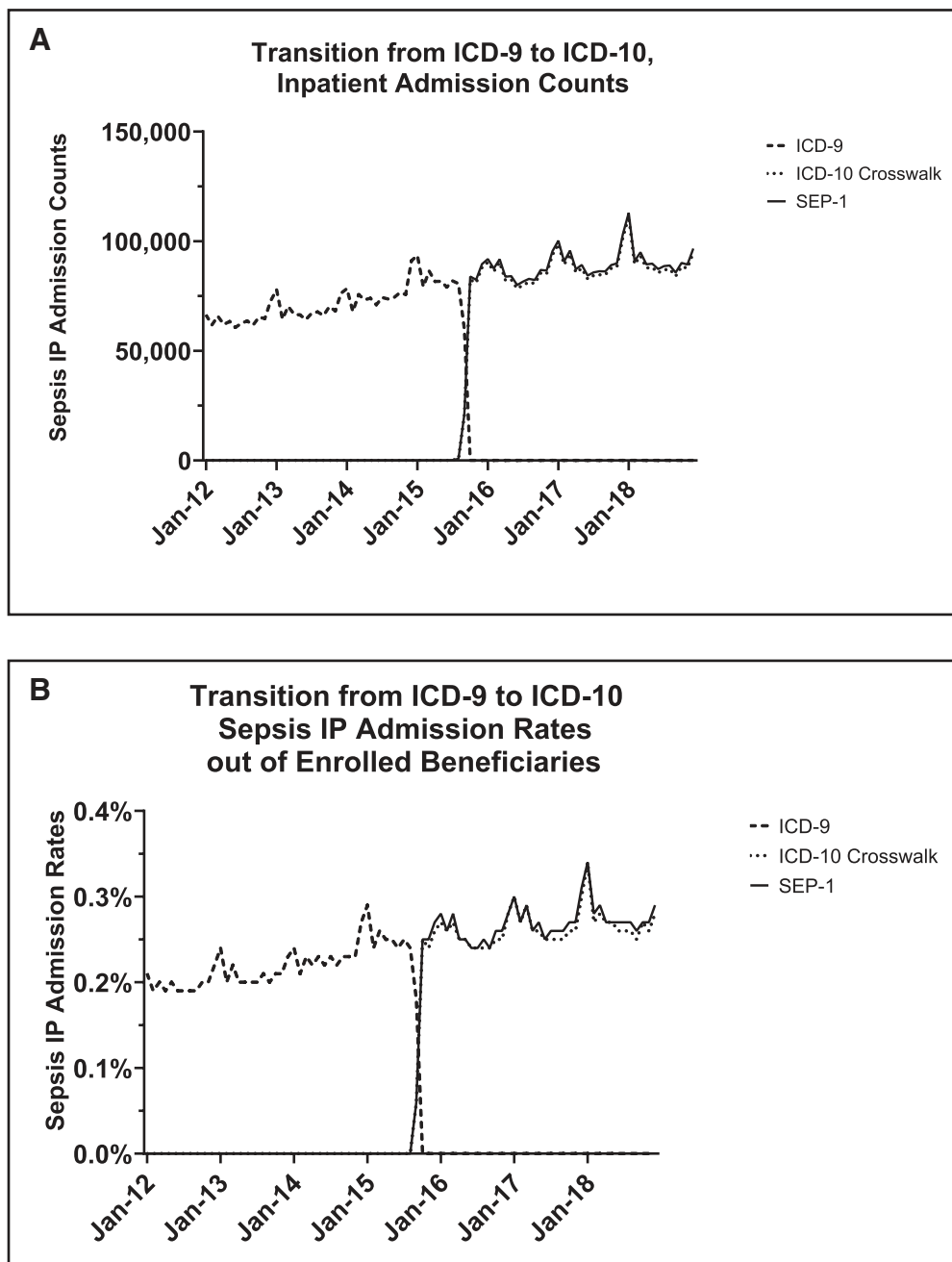


Figure 1. Analysis of the transition between editions of the coding system ($n = 6,731,828$ inpatient [IP] admissions to acute care hospitals of Medicare Part A/B beneficiaries). **A**, Transition from *International Classification of Diseases*, 9th Edition (ICD-9) to *International Classification of Diseases*, 10th Edition (ICD-10), IP admission counts. Counts of Medicare fee-for-service-only IP admissions with a sepsis code, by month. **B**, Transition from ICD-9 to ICD-10 sepsis IP admission rates out of enrolled beneficiaries. Sepsis IP admission rates as a fraction of enrolled beneficiaries, by month. *Dashed line*, ICD-9; *dotted line*, ICD-10 crosswalk; *solid line*, ICD-10 Centers for Medicare & Medicaid Services core measure (SEP-1) metric denominator code set. Note that the SEP-1 metric denominator is a superset of the ICD-10 crosswalk from ICD-9 (the *filled squares* are slightly higher valued than the *open squares*).

classified as sepsis, yet despite the absence of organ failure or shock during the index inpatient admission, all-cause mortality among those initial survivors continues to accumulate to total 60% for 3 yr following that stay. For comparison, nonsepsis inpatient admissions, all-cause mortality at 3 years

due to their qualifying medical condition. Their trajectories are discussed in greater detail in the second report of this set (21). Those costs for a SNF admission following a sepsis inpatient admission appear to be approaching the costs of that prior inpatient admission owing to the decline in the latter (**Fig. 8**).

is approximately 40%. See Supplement 2 (Supplemental Digital Content 2, <http://links.lww.com/CCM/F244>) for data. There was a steady reduction in the mortality rate over the study period at all levels of sepsis severity.

Dual beneficiaries were found to have a higher proportion of their inpatient admissions attributable to or at least accompanied by sepsis (**Fig. 4**).

Sepsis POA admissions have been rising generally, whereas sepsis acquired during the hospitalization (NPOA) have modestly declined, albeit with minor seasonal variation (**Fig. 5**).

Medicare FFS inpatient sepsis payments totaled \$ ≈ 22.4 billion for CY2018 (**Fig. 6**). Although many beneficiaries' cost responsibility is reduced or eliminated through supplemental insurance plan coverage (30% employer-sponsored insurance, 29% Medigap insurance, 22% Medicaid Program), nearly one in five Medicare beneficiaries in FFS Medicare did not have a supplemental coverage in 2016, placing them at financial risk (29). On average, Medicare covered around 95% of the total care payment for the average FFS inpatient admission that included a sepsis code (**Table 2**).

The cost of inpatient sepsis care declined on a per-admission basis at all levels of sepsis severity (**Fig. 7**).

A substantial proportion of FFS beneficiaries who survived their inpatient hospital admission was transferred to SNFs

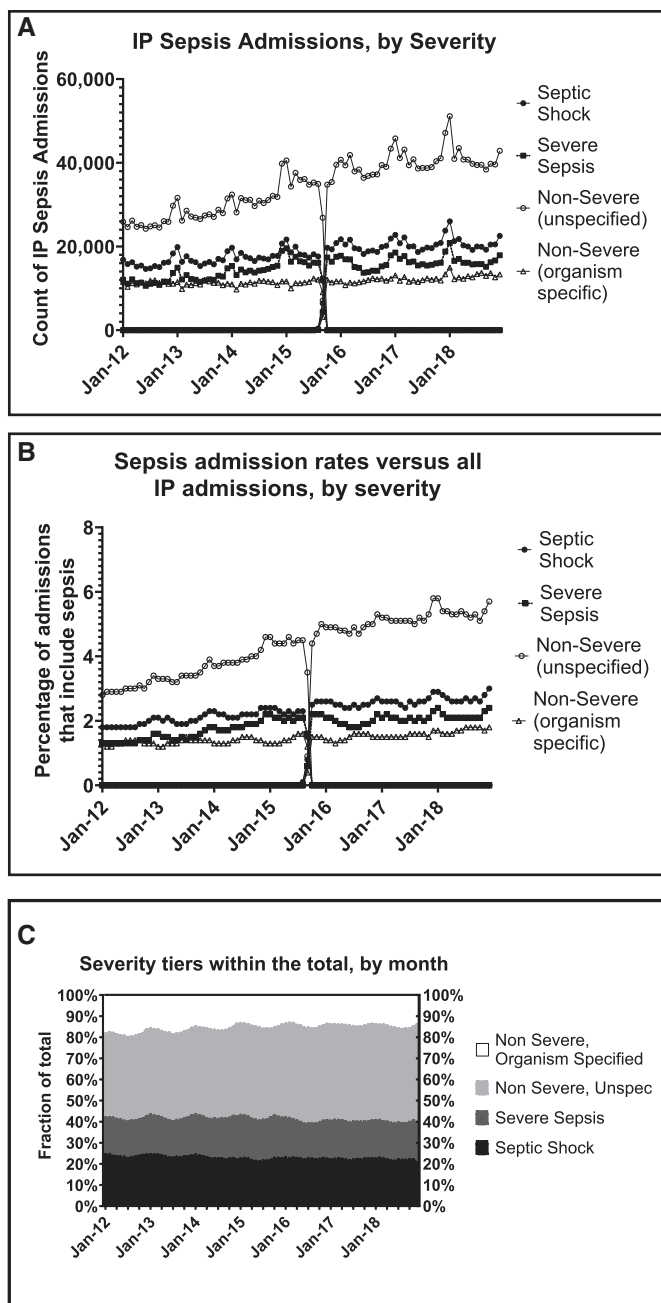


Figure 2. Analysis of sepsis admissions stratified by severity by counts, rates, and proportions ($n = 6,731,828$ inpatient [IP] admissions to acute care hospitals of Medicare Part A/B beneficiaries). **A**, IP sepsis admissions, by severity. Sepsis by IP hospital admission counts. *Filled circles*: septic shock; *filled squares*: severe sepsis; *open circles*, nonsevere sepsis (organism unspecified); *open triangles*, nonsevere sepsis (organism-specified). **B**, Sepsis admission rates versus all IP admissions, by severity. Percentage of IP admissions featuring a sepsis code (rate). Even for severe sepsis and septic shock, both the count and the rate of sepsis admissions are rising. The impact of seasonal infections on sepsis rates during the winter months is apparent. Note to reviewers, “count” plots have abnormal right “tails” because claims through December 2018 are not yet complete. These tails will disappear when the data and plots are updated in January 2020 prior to publication. **C**, Fractional severity tiers, by month. Despite the increase in counts and in the fraction of total admissions requiring a sepsis code, the fraction of admissions coded as septic shock and as severe sepsis has remained stable. The fraction of less severe sepsis has also remained stable; however, the identification of specific organisms has declined among the less severe sepsis IP admissions.

DISCUSSION

To our knowledge, this is the largest set of Medicare sepsis data ever reported. We observe that the large number of beneficiaries and claims analyzed for this report (100% of the Medicare population over a 7-yr interval) can suggest statistical differences even when the actual differences between the groups being compared are trivial. Therefore, we have relied on illustrations, counts, percentages, and mortality to make key points.

Despite improvements in survival and reductions in costs per case, Medicare and its beneficiaries face significant challenges around their long-term survival and quality of life. Furthermore, the rapid expansion of the Medicare population owing to the post-war “baby boom” reaching the age of eligibility has increased case volume in excess of cost-per-case efficiencies: at the beginning of this cohort (i.e., end 2011), Medicare person-years totaled 48,892,758, whereas at the end of the reporting period (end 2018), Medicare person-years totaled 59,950,214, an increase of 22.6%. During that same interval, the overall U.S. population (including these beneficiaries) grew from 312.8 million to 328.1 million, only 4.9%. In other words, the beneficiary population is growing more than 4.5 times faster than the nation as a whole (30). Improvements in care of other chronic (e.g., cancer) and acute conditions (e.g., myocardial infarction) have enabled Medicare beneficiaries to live longer and more productive lives, paradoxically increasing the lifetime probability that they may experience an inpatient admission caused by or complicated by sepsis. Summing the known costs of inpatient and SNF care for FFS beneficiaries with the inferred costs based on encounter data from MA inpatient admissions and (based on the Long-Term Care Minimum Data Set assessment that nursing facilities must report to CMS) a similar rate of transfer of MA sepsis survivors to SNFs, the annual costs of sepsis inpatient admissions and subsequent SNF care to Medicare exceed \$41.5 billion (Table 3).

The method for identification of sepsis cases often is debated and sometimes disputed (1, 31). There are no fewer than six current definitions of sepsis, and analysis of each is likely to yield a unique cost (and mortality) estimate (Table 4) (42). We aimed to describe the current costs to Medicare, and therefore adopted the current CMS definitions for this report.

The CMS definition relies on the expertise of professional coders trained to evaluate medical records and assign codes using specific guidance (43). This report further focuses on a code set containing only four ICD-9 codes that collectively are widely accepted as explicit sepsis diagnostic codes beginning in 2002 (34).

We were concerned initially that the change in coding bases over the study interval could affect findings independent of patient condition and care rendered. We observed continuity of costs and of mortality during the ICD-9→ICD-10 transition at all tiers of sepsis severity. We also observed that the SEP-1 denominator is a superset of the ICD-10 codes identified by the GEMs crosswalk. An advantage of choosing the explicit code approach is that it is fully described and therefore can be readily migrated to diverse datasets using a detailed

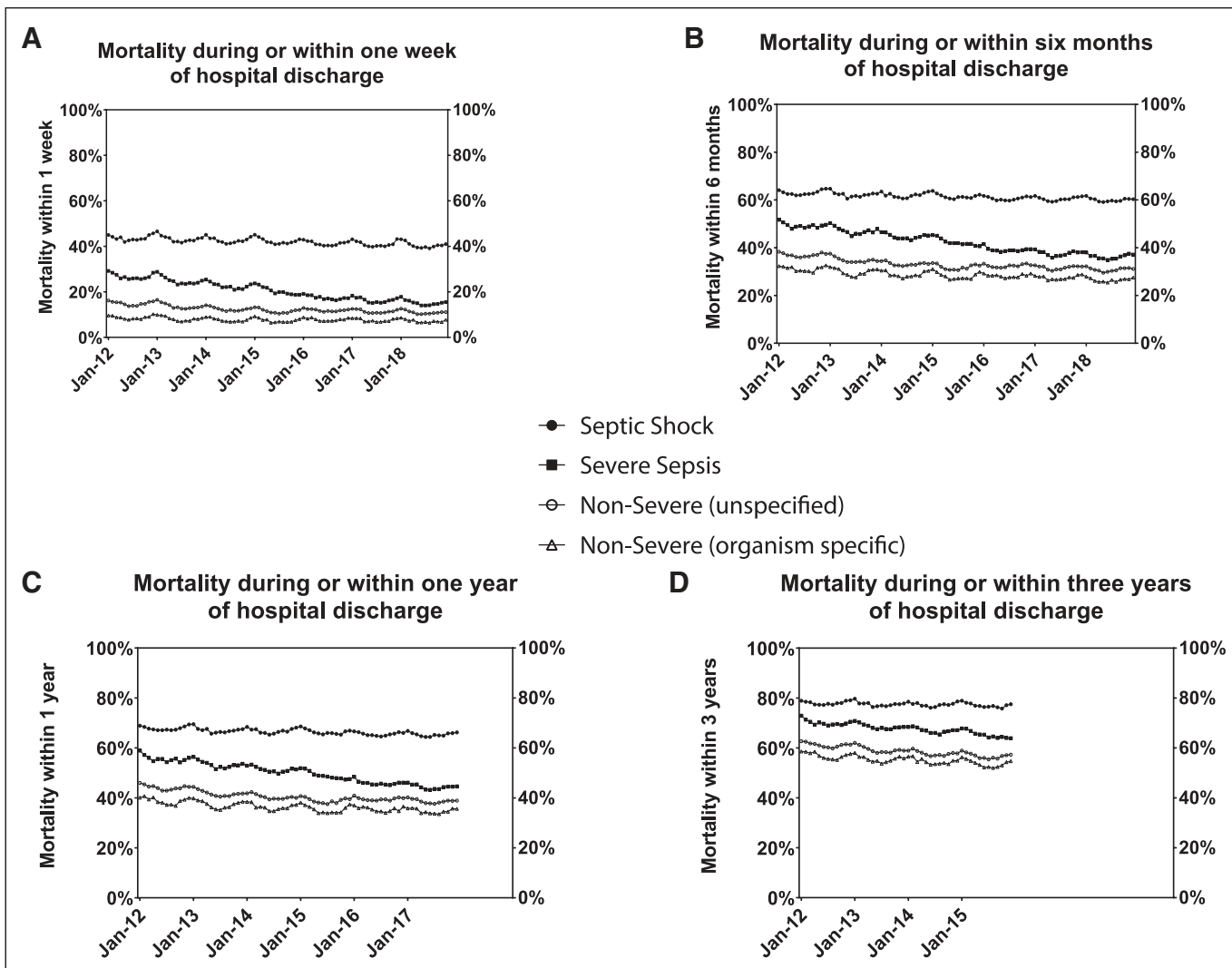


Figure 3. Medicare fee-for-service mortality stratified by sepsis severity within 1 wk (A), 6 mo (B), 1 yr (C), and 3 yr (D) of hospital discharge. Even the least severe sepsis admissions serve to mark substantial risk of late mortality. *Filled circles*, septic shock; *filled squares*, severe sepsis; *open circles*, nonsevere sepsis (organism unspecified); *open triangles*, nonsevere sepsis (organism-specified).

method in a way that simplifies comparisons across patient populations (22).

Although the rise in the use of explicit diagnosis codes might reflect increasing patient and provider awareness of sepsis and possibly financial incentives to use those codes, the observed steady rise in the severest sepsis diagnoses with objective findings (such as septic shock) suggests that sepsis in fact may be becoming more common as opposed to more commonly coded. The fact that the proportions of patients with septic shock, severe sepsis, and less severe sepsis were little changed (varying only about 2.3%) over the 7-year study interval, even while the rate of sepsis admissions increased approximately 50% suggests that changes in coding behavior are not contributing substantially to the increased number of admissions. Rather, there are more beneficiaries and a rising incidence of POA sepsis. We observed that the number of sepsis-related claims and their aggregate dollar cost is rising, even while the cost per inpatient admission and mortality by severity are declining.

Plausible alternatives may also contribute to the rise in counts and percentages of sepsis inpatient admissions. Those alternatives note that a) although the shock aspect of septic shock is arguably objective, the sepsis part of septic shock is certainly not given that up to half of septic shock is culture negative; b) the estimated sensitivity of coding for septic shock relative to clinical markers of shock (i.e., vasopressors) has been reported by others to be only 66% and therefore codes are an imperfect proxy for true disease incidence; c) other investigators have reported substantial differences in the trajectories of septic shock incidence and mortality when using claims data compared with data in the electronic health record; and d) more sensitive and complete coding could be occurring at all levels of sepsis severity (1, 44–46). We further note that the accuracy of POA coding has been reported as only moderate; however, this assessment is based on data now a decade and half old (47).

In 2016, Torio and Moore (5) reported that septicemia was the most costly inpatient diagnosis in the United States,

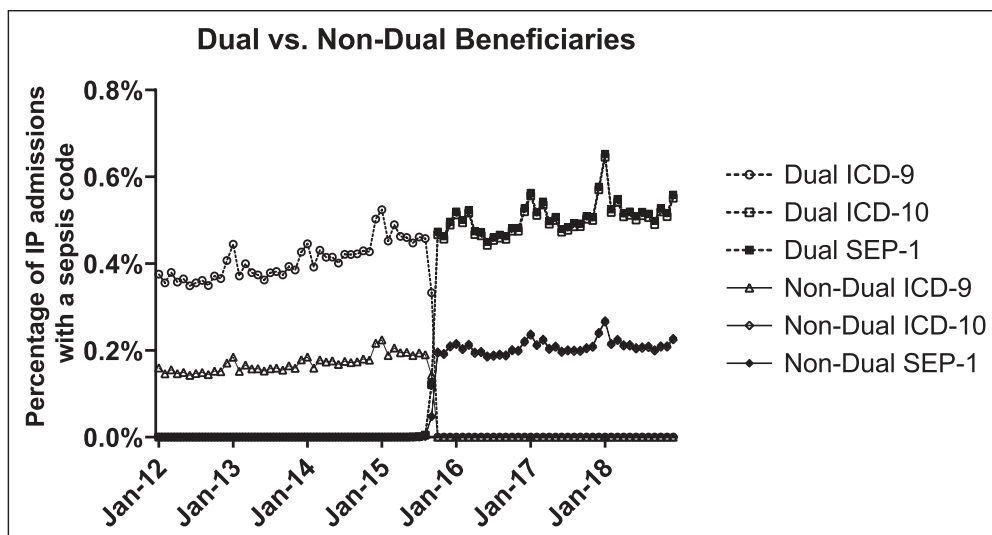


Figure 4. Percentage of Medicare fee-for-service inpatient (IP) admissions associated with a sepsis code. Dual beneficiaries have a sepsis code assigned to an IP admission more than twice as frequently as non-dual beneficiaries. Furthermore, the likelihood of a sepsis code assignment is rising faster in the dual beneficiary population. Dual beneficiaries: *open circles*, *International Classification of Diseases*, 9th Edition (ICD-9); *open squares*, *International Classification of Diseases*, 10th Edition (ICD-10); *filled squares*, Centers for Medicare & Medicaid Services core measure (SEP-1). Non-dual beneficiaries: *open triangles*, ICD-9; *open diamonds*, ICD-10; *filled diamonds*, SEP-1.

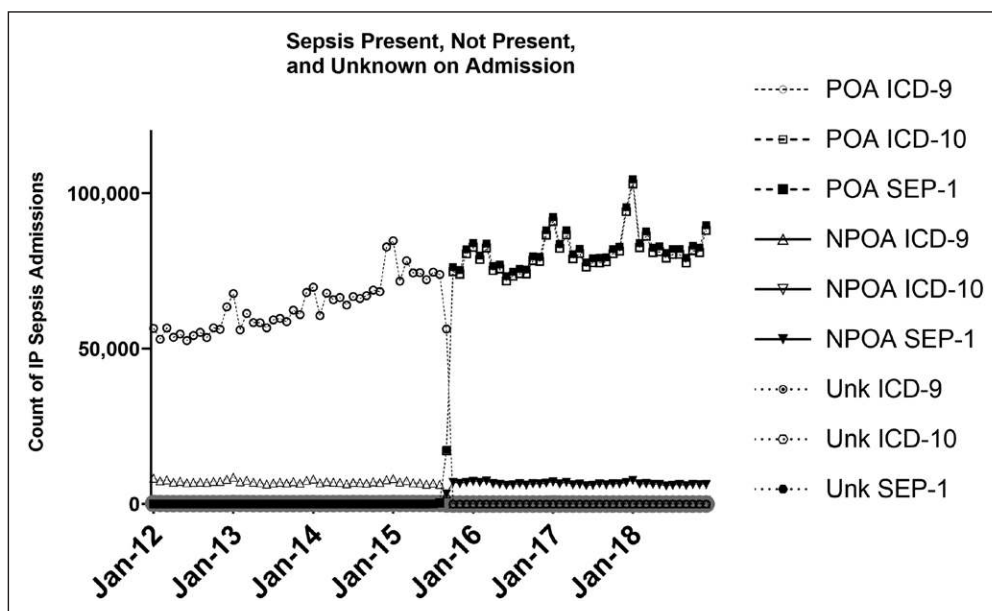


Figure 5. Counts of Medicare fee-for-service sepsis present on admission (POA), not POA (NPOA), and unknown. During the 7-yr study period, the counts of sepsis POA have risen steadily, whereas the counts of sepsis NPOA (i.e., acquired during the inpatient [IP] stay) have declined slightly. The fraction of admissions where the sepsis status at admission could not be determined was typically 0.2–0.3% of the total. POA: *open circles*, *International Classification of Diseases*, 9th Edition (ICD-9); *open squares*, *International Classification of Diseases*, 10th Edition (ICD-10); *filled squares*, SEP-1. NPOA: *open triangles*, ICD-9; *open wedge*, ICD-10; *filled wedge*, Centers for Medicare & Medicaid Services core measure (SEP-1). Unknown: *circle-dot*, ICD-9; *open hexagon*, ICD-10; *filled hexagon*, SEP-1.

totaling \$23.7 billion in 2013. Their analysis leveraged the Health Care Utilization Project, which itself was based on the national inpatient sample covering all U.S. acute care hospitals with the exception of federal hospitals operated by the Department of Veterans Affairs and the Defense Health Agency (48). The cost estimated by Torio and Moore (5) is contrasted

to the costs reported herein as follows. Our study population was restricted to Medicare beneficiaries, who accounted for 61.5% of the total cost in the Torio and Moore (5) study, or about \$15 billion in 2013 dollars. Different from Torio and Moore (5), a) we did not restrict the analysis to a single ICD-9 code (038) but rather used an expanded and widely accepted set of codes (including ICD-9 code 038) and b) we further assessed the costs of SNF inpatient admissions subsequent to a sepsis inpatient hospital admission claim.

Similar to Torio and Moore (5), no attempt was made to attribute any portion of the cost directly to sepsis diagnosis and treatment. No attempt was made to estimate the secondary costs of sepsis including (but not limited to) costs related to prehospital care, transport to the hospital, loss of productivity or employment of the beneficiary, loss of employment by family workers as they assume caregiver roles, costs associated with temporary relocation in order to accompany the beneficiary to inpatient hospital and SNF settings, or costs of outpatient care such as home health, provider visits, and other supplier supports such as home oxygen. The costs reported herein represent only payments for facility care rendered in inpatient and SNF settings. As such the summed costs reported herein inform only a lower bound for the actual costs for Medicare beneficiaries only and must not be

interpreted as an estimate of national costs. (Such an estimate is considered in the third report of this series [22].) We observe that, for Medicare FFS beneficiaries who are discharged to SNF care, the average costs of their inpatient care and the average costs of subsequent SNF care are converging. Fortunately, the percentage of sepsis patients requiring

SNF care declined steadily over CY2012–CY2018 from 37% to 30%.

The data illuminate differences in costs and mortality associated with sepsis POA to the inpatient hospital compared with costs and mortality associated with sepsis that is NPOA and is acquired as a complication during an inpatient hospital

admission. Although NPOA (i.e., hospital-acquired) sepsis constitutes a declining minority of cases (approximately 13% at the beginning of the study interval, declining to about 7.5% at the end of the study interval), such hospital-acquired sepsis continues to portend disproportionate mortality ($\approx 60\%$ for NPOA vs $\approx 40\%$ for POA sepsis at 6 mo) and costs (generally,

more than double the costs of sepsis POA) (49, 50). Similarly, dual beneficiaries are at risk for later mortality and accumulated expense (22). Such analyses draw attention to uniquely vulnerable populations that might otherwise be lost by use of a single estimate of cost or mortality risk.

Although the data are comprehensive (100% of Medicare beneficiaries for the interval 2012–2018), the analysis strategy creates its own limitations. First, there is an accounting anomaly. We studied all admissions with a sepsis diagnostic code and reported both costs and mortality relative to each admission and not relative to each beneficiary. Such admission-based

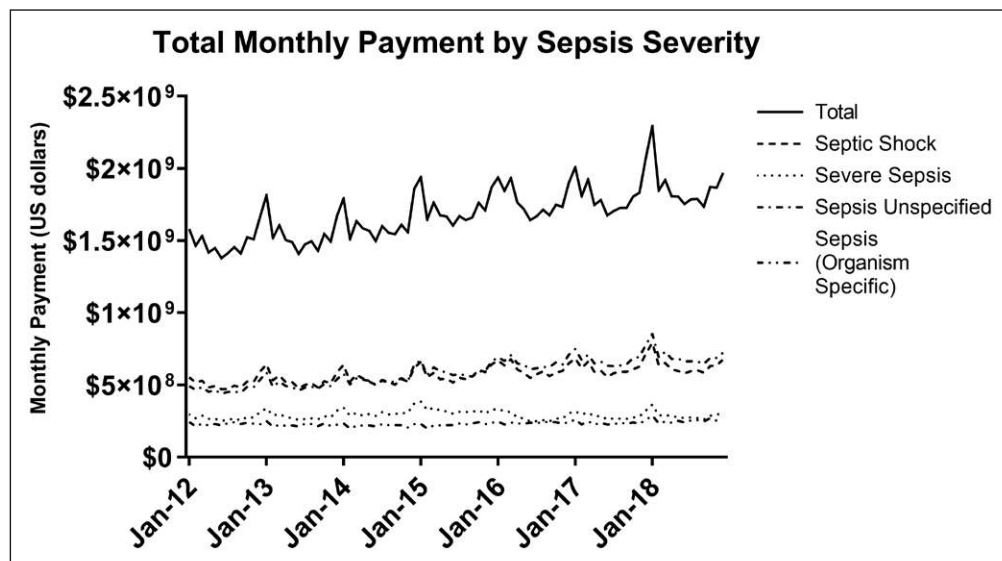


Figure 6. Total monthly payments for all inpatient sepsis admission by severity, Medicare fee-for-service only ($n = 6,998,888$ inpatient admissions [acute care hospitals, psychiatric hospitals, rehabilitation hospitals, and long-term care hospitals]). *Solid line*, total payment; *dashed line*, septic shock; *dash and single dot*, sepsis with organism unspecified; *dotted line*, severe sepsis; *dash and double dot*, sepsis with organism specified.

TABLE 2. Total Payments and Beneficiary Responsibilities, Inpatient, and Part B, Fee-for-Service, Acute Care Hospitals, Psychiatric Hospitals, Rehabilitation Hospitals, and Long-Term Care Hospitals

CY	Total Sepsis IP Admissions	Total Payment	Average Payment	Total Beneficiary Payment	Average Beneficiary Payment
CY 2012 IP	811,644	\$17,792,657,303	\$21,922	\$843,421,224	\$1,039
CY 2012 part B		\$1,866,452,571	\$2,300	\$380,343,855	\$469
CY 2013 IP	865,833	\$18,447,810,017	\$21,306	\$897,230,413	\$1,036
CY 2013 part B		\$1,963,243,194	\$2,267	\$405,509,702	\$468
CY 2014 IP	945,990	\$19,309,784,643	\$20,412	\$985,241,739	\$1,041
CY 2014 part B		\$2,179,417,082	\$2,304	\$451,901,043	\$478
CY 2015 IP	1,042,169	\$20,603,580,531	\$19,770	\$1,107,703,456	\$1,063
CY 2015 part B		\$2,388,173,606	\$2,292	\$495,937,208	\$476
CY 2016 IP	1,073,373	\$21,274,126,382	\$19,820	\$1,150,887,806	\$1,072
CY 2016 part B		\$2,462,196,357	\$2,294	\$513,233,153	\$478
CY 2017 IP	1,122,990	\$21,808,992,873	\$19,420	\$1,206,122,121	\$1,074
CY 2017 part B		\$2,599,470,853	\$2,315	\$543,444,697	\$484
CY 2018 IP	1,136,889	\$22,439,794,212	\$19,738	\$1,229,512,337	\$1,081
CY 2018 part B		\$2,633,144,269	\$2,316	\$548,143,265	\$482

CY = calendar year, IP = inpatient.

The total admissions ($n = 6,998,888$) include 6,731,828 admissions to acute hospitals, 206,316 admissions to long-term hospitals, 53,558 admissions to rehabilitation hospitals, 3,267 admissions to psychiatric hospitals, and 3,919 admissions to other IP hospitals.

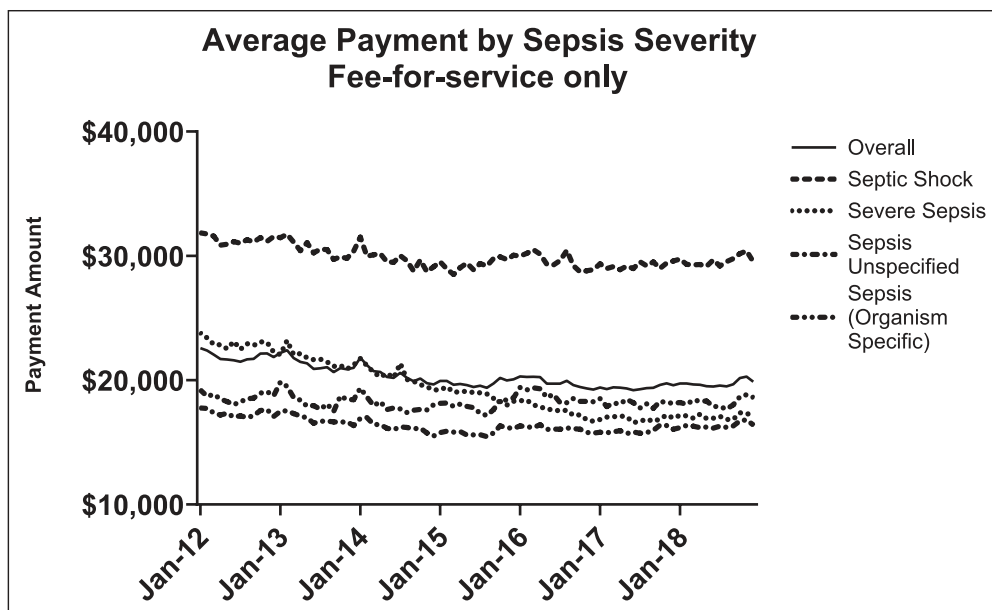


Figure 7. Average payment for inpatient hospital admission by sepsis severity, Medicare fee-for-service only. Data are given in current dollars, not constant dollars. *Solid line*, overall average payment; *dashed line*, septic shock; *dash and single dot*, sepsis with organism unspecified; *dotted line*, severe sepsis; *dash and double dot*, sepsis with organism specified. There has been a reduction in payment across all sepsis severities and in the average payment. The payment for organism-specific treatment is now less than that caused by an unspecified organism.

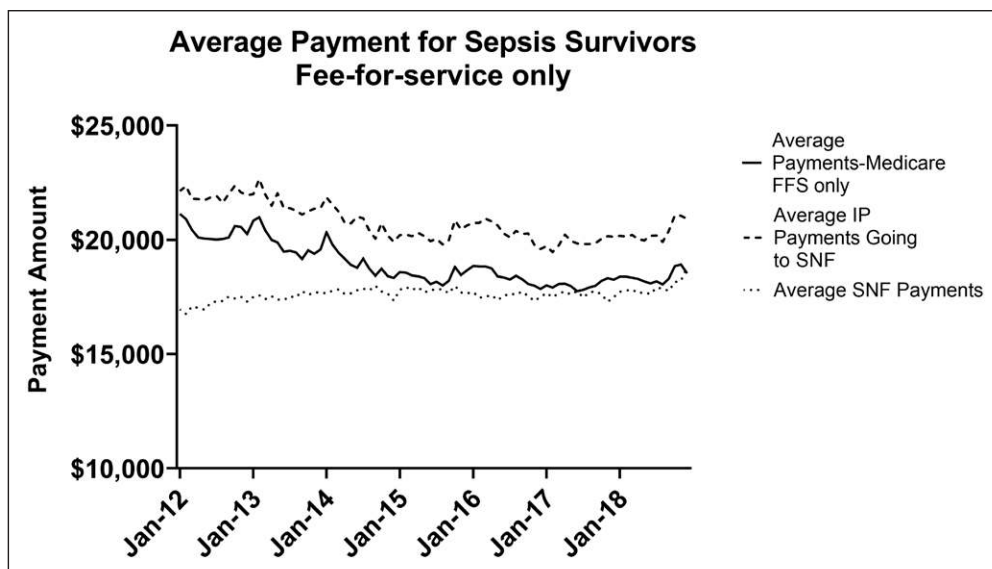


Figure 8. Average payments for sepsis survivors, Medicare fee-for-service (FFS) only. *Dashed line*, average inpatient (IP) payment for beneficiaries who survive and will go on to a skilled nursing facility (SNF) stay; *solid line*, average IP payment for all beneficiaries who survive the IP admission; *dotted line*, average 90 d payment to SNF for beneficiaries who survive sepsis and require SNF care. Although average payments for IP care are declining, payments for SNF care are steady. As a consequence, the average payments for IP care and for subsequent SNF care appear to be converging.

data may provide additional perspective for discussing outcomes with patients and families based on the most recent inpatient admission and reflecting the beneficiary's most current response to infection. (For a companion, beneficiary-focused exploration of the impact of serial admissions, we studied beneficiaries who have not experienced any inpatient admission for a year prior to an index admission [21].) Second, there is a labeling uncertainty.

Although sepsis is defined as organ dysfunction consequent to infection, it is widely understood that approximately half of patients "thought to be septic" never yield a positive culture (51). Specifics aside, every sepsis definition generally depends on a clinical impression that infection is sufficiently likely that cultures are obtained and antibiotics are initiated. We do not assert that the administrative codes that identify the patients we term "septic" reliably collects all patients with adverse systemic responses attributable to microbial pathogens. We only assert that there is a consistent method attempting to identify such patients, and the clinical care of patients so identified (diagnostic, treatment, rehabilitation, progressive care) is associated with claims. There are no generally accepted criteria for reliably classifying patients as infected or uninfected, reliably distinguishing physiologic from pathologic responses to infection, or reliably attributing a cost to sepsis or some other illness.

CONCLUSIONS

This report offers insight into mortality associated with sepsis administrative codes and costs associated with sepsis administrative codes. Sepsis may accompany other conditions that are also lethal and costly.

The human and economic burdens of sepsis experienced by Medicare beneficiaries continue to grow. Although there are improvements in mortality and in cost-per-case throughout a pragmatic hierarchy of sepsis severity, the year-over-year growth of the beneficiary population, the year-over-year increase in the total number of sepsis deaths, and the year-over-year increase in the total cost of sepsis care highlight the need to understand how beneficiaries become septic, their clinical courses once septic, and how sepsis survivors fare following discharge from the acute care hospital. Such

TABLE 3. Total Payments for Sepsis Inpatient and Subsequent Skilled Nursing Facility Care

Total Payments for Sepsis IP and SNF Admissions (Within 90 Days of Discharge From the Index IP Admission)			
	FFS (Medicare Part A/B)	MA (Medicare Part C)	Combined
CY	Total Cost (IP and SNF)	Estimated Total Cost (Based on Encounter Data and Proportional SNF Utilization)	Estimated Total Cost (Sum of FFS and MA)
CY 2012	\$21,724,273,464	\$5,956,474,977	\$27,680,748,441
CY 2013	\$22,750,849,546	\$7,018,204,984	\$29,769,054,530
CY 2014	\$24,045,224,974	\$8,232,207,834	\$32,277,432,808
CY 2015	\$25,847,062,649	\$9,524,805,866	\$35,371,868,515
CY 2016	\$26,566,780,492	\$10,341,325,153	\$36,908,105,645
CY 2017	\$27,298,599,761	\$11,812,168,753	\$39,110,768,514
CY 2018	\$28,063,656,698	\$13,444,779,958	\$41,508,436,656

CY = calendar year, FFS = fee-for-service, IP = inpatient, MA = Medicare Advantage, SNF = skilled nursing facility.
Data from total IP admissions (n = 9,587,636), representing 6,998,888 FFS IP admissions and 2,588,748 MA IP admissions.

TABLE 4. Contemporary Definitions of Sepsis

Definition Name	Basis	How Sepsis Is Defined Therein	Specific Organ Failure Thresholds	Notes
ICD-9 (32–34)	Sepsis-1	Inflammation with suspicion of infection with some sensitivity for severity (“septicemia,” septic shock, ...)	No	Explicit sepsis codes were first added to the ICD (ICD-9, Clinical Modification) lexicon in 2002.
Centers for Medicare & Medicaid Services (35)	Sepsis-1	Some, but not all ICD-10 sepsis codes	No	Under ICD-10 but retaining the general concept of “infection plus generalized inflammation,” typically a combination of an A code and an R code.
Centers for Medicare & Medicaid Services SEP-1 core measure (25)	Sepsis-1	Some, but not all ICD-10 sepsis codes	No	Denominates a core measure. Facilities that maintain higher percentages of compliance with the core measures receive higher reimbursement from Medicare and other payers.
“Sepsis” (operational bedside jargon) (34, 36, 37)	Sepsis-2	Sepsis-1 (infection and inflammation) plus enumeration of possible organ failures	No	As a practical matter, what is widely taught; basis for Surviving Sepsis Campaign; spans all stages of sepsis.
Sepsis-3 (38–40)	Sepsis-3	“Life threatening organ dysregulation attributable to infection”	Yes	Later stage or decompensating sepsis; revised definition intended to identify patients at higher risk of mortality and in greater need of immediate intervention
Adult Sepsis Event (41)	Sepsis-3	As above, but requires no subjective assessment of mental status: substitutes lactate level for Glasgow Coma Scale	Yes	Engineered for automatic sensing in electronic medical records

ICD-9 = *International Classification of Diseases*, 9th Edition, ICD-10 = *International Classification of Diseases*, 10th Edition.

insights are necessary to prevent and to more rapidly detect sepsis earlier, to mitigate the effects of sepsis, and to improve the lives of surviving beneficiaries and their families after they leave the hospital. Analysis of these trajectories of sepsis is the focus of the second report in this series (21).

Finally, these recent data might be used to create models of the sepsis population to predict future circumstances including the number of cases and associated costs. Methodology, models, and forecasts are reported in the third article in this series (22).

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