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Impact of Policies on the Rise in Sepsis Incidence, 2000–2010

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(See the Editorial Commentary by Cluzet and Lautenbach on pages 704–6.)

Background. Sepsis hospitalizations have increased dramatically in the last decade. It is unclear whether this represents an actual rise in sepsis illness or improved capture by coding. We evaluated the impact of Centers of Medicare and Medicaid Services (CMS) guidance after newly introduced sepsis codes and medical severity diagnosis-related group (MS-DRG) systems on sepsis trends.

Methods. In this retrospective cohort study of California hospitalizations from January 2000 to December 2010, sepsis was identified by *International Classification of Diseases, Ninth Revision* (ICD-9) coding (Dombrovskiy method). Sepsis-associated mortality rates were calculated. Logistic regression models evaluated variables associated with sepsis and mortality. Segmented regression time series analysis assessed changes in sepsis frequency for (1) baseline (January 2000 to September 2003); (2) post-CMS guidelines on sepsis coding (October 2003 to September 2007); and (3) after the introduction of MS-DRG (October 2007 to December 2010).

Results. Annual hospitalizations with sepsis diagnoses tripled within a decade, from 21.1 to 59.9 cases per 1000 admissions, with a 2.8- and 2.0-fold increase in severe and nonsevere sepsis, respectively, whereas annual admissions remained unchanged and sepsis-associated mortality decreased. Greatest increases were seen for severe sepsis present on admission (3.8-fold increase). Increases in sepsis were temporally correlated with CMS coding guidance and MS-DRG introduction after adjustment for comorbidity and other factors.

Conclusions. Sepsis rate increases were associated with introduction of CMS-issued guidance for new sepsis ICD-9 coding and MS-DRGs. Coding artifact ("up-capture" of less severely ill septic patients) may be contributing to the apparent rise in sepsis incidence and decline in mortality. Epidemiologic trends based on administrative data should account for policy-related effects.

Keywords. sepsis; healthcare policy; sepsis epidemiology; sepsis mortality.

Sepsis, a dangerous inflammatory response to infection, is a major cause of morbidity and mortality worldwide [1, 2]. Hospitalizations for sepsis have increased steadily during the last 2 decades in the United States. Sepsis accounted for 1.7 million hospitalizations in 2009 and now ranks as the most expensive condition associated with hospitalization, at $15.4 billion in costs annually [2–4].

The alarming rise in sepsis rates has sparked national and global efforts to improve awareness, early recognition, diagnosis, and management [1, 2]. Meanwhile, significant changes in sepsis coding criteria, definitions, and reimbursements have occurred. After the introduction of new *International Classification of Diseases, Ninth Revision* (ICD-9) codes in the 995.9x series (October 2002) allowing specific sepsis diagnosis within a single code, the Centers for Medicare and Medicaid Services (CMS) issued guidance on appropriate sepsis coding in October 2003 [5–7]. In October 2007, CMS overhauled the previous diagnosis-related group (DRG) reimbursement system into the current medical severity DRG (MS-DRG) system in an effort to tie reimbursements to medical severity [8]. Together, these changes have the potential to affect coding practices via increased ease of coding for sepsis and financial incentives to capture sepsis cases.

It is unclear if sepsis rate increases as measured by large-scale administrative data sets can be fully accounted for by an actual rise in septic illness or whether these trends may, in part, represent an "up-capture" of sepsis due to surveillance bias, whereby individuals not previously categorized as having sepsis might be more likely to be categorized as such [2, 3, 9, 10]. Policy effects on coding practices can have important impact on the epidemiology of other parameters, such as sepsis-associated mortality. Understanding limitations of administrative data to track trends in sepsis burden over time has important public health and policy implications, particularly in the context of government mandates for protocolled sepsis care and public reporting of sepsis-related outcomes [11].

We sought to evaluate the potential impact of these national policy changes on sepsis frequency and sepsis-associated

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mortality between 2000 and 2010. We hypothesized that sepsis rates increased in response to policy changes that directed physician coding and hospital reimbursement. We examined these policy effects accounting for sepsis severity, present on admission (POA) status, comorbidity, and demographic factors.

METHODS

Study Population and Data Source

We conducted a retrospective cohort study of hospitalizations in California from 1 January 2000 to 31 December 2010. We used comprehensive statewide data from the California Mandatory Hospital Discharge Dataset, which includes demographics, insurance type, admission and discharge location, in-hospital deaths, and up to 25 administrative codes for medical and procedural diagnoses [12]. We excluded patients aged <18 years and those admitted to psychiatric, chemical dependency, and long-term acute care facilities.

Defining Sepsis, Outcomes, and Variables

Sepsis was defined according to the Dombrovskiy approach, a definition with high specificity that is closely aligned with clinical determination of sepsis on chart review [13–15]. Briefly, sepsis was identified by ICD-9 codes specifying presence of septicemia (038x), sepsis (995.91), severe sepsis (995.92), or septic shock (785.52) and subcategorized as severe if accompanied by codes for organ failure. Admissions with >1 sepsis code per hospitalization were categorized by the most severe code. The following outcomes were evaluated separately: (1) all sepsis (severe and nonsevere), (2) severe sepsis, and (3) nonsevere sepsis. Sepsis was further stratified by POA status. Sepsis-associated mortality was identified by sepsis hospitalizations resulting in death during hospitalization.

Patient-level descriptors were collected, including demographic and comorbidity information. Romano comorbidity score was calculated for each patient and required retrospective data for comorbid conditions for up to 1 year and therefore could not be calculated for hospitalizations between 1 January and 31 December 2000 [16, 17]. We defined 3 time periods based on policies that may have impacted sepsis coding: (1) the baseline period, 1 January 2000 to 30 September 2003; (2) issuance of CMS guidance on proper sepsis coding in October 2003 after introduction of specific sepsis ICD-9 codes (995.xx series); and (3) introduction of MS-DRG, beginning 1 October 2007.

Analysis

Sepsis rates were calculated per 1000 hospitalizations. Sepsis-associated mortality was calculated using in-hospital mortality data (number of hospitalizations with severe or nonsevere sepsis diagnoses resulting in death at discharge divided by the total number of severe or nonsevere sepsis hospitalizations, respectively). We also assessed primary versus secondary diagnosis of sepsis, severe sepsis, pneumonia, bacteremia, and urinary tract infection.

We applied segmented regression analysis on time series data, assessing change in sepsis and mortality level (immediate change) and trends (change in slope) following the 2 distinct policies [18]. Separate models were run for each sepsis subgroup, all adjusted for age, sex, and winter seasonal effects. Multivariate logistic regression modeling was used to evaluate adjusted sepsis rates and mortality outcomes. Models evaluating mortality were adjusted for sepsis severity and POA status.

RESULTS

Sepsis Epidemiology and Descriptive Characteristics

Among 31 431 372 patients hospitalized in California between 1 January 2000 and 31 December 2010, a total of 1 107 541 (3.5%) had a diagnosis of sepsis, of whom 635 780 (57.4%) met criteria for severe sepsis. The annual sepsis hospitalization rate tripled from 2000 to 2010, from 21.1 to 59.9 cases per 1000 admissions, with a 2.8- and 2.0-fold increase in severe and nonsevere sepsis, respectively (Figure 1*A*). The increase was most pronounced among severe sepsis POA, with a 3.8-fold increase during the study period (Figure 1*B*, Supplementary Table 1). Sepsis rate increases in the baseline period were modest, occurring after October 2002, after ICD-9 sepsis-specific codes were published, with distinct rate increases seen after CMS sepsis coding guidance release in 2003 and MS-DRG introduction in 2007 (Supplementary Table 1). Change in the use of individual sepsis codes over time are shown in Supplementary Figure *A*. Total statewide admission rates (per 100 000 persons, using US census bureau annual data) remained unchanged over the study period (7940 and 7912 per 100 000 persons in years 2000 and 2010, respectively, with nonsignificant time series *t* test; $P = .49$).

Mean Romano comorbidity scores were highest among severe sepsis hospitalizations and increased steadily between 2003 and 2007 for all subgroups, after which they remained stable (Figure 1*C*), whereas mortality rates decreased (Figure1*D*, Supplementary Table 1). Sepsis was associated with 31.3% of in-hospital deaths, of which 87% were categorized as severe. The percentage of hospitalizations with a primary diagnosis of pneumonia declined (3.7% to 2.7%) and the percentage of urinary tract infections rose (from 6.7% to 10.6%), while coding for sepsis in the primary position increased from 1.1% to 4.0%.

Descriptive characteristics of hospitalizations due to sepsis by severity and POA status are shown in Table 1. For both severe and nonsevere sepsis, POA was more common in Medicare-insured, elderly patients, and those admitted from a skilled nursing facility (SNF). Romano scores were generally higher for sepsis not POA. Severe sepsis rates increased most dramatically among elderly patients (aged >85 years), from 62.8 to 118.3 cases per 1000 admissions (1.9-fold increase) across the study period. Sepsis rates among nonwhite patients increased 1.7-fold (from 118.3 to 203.6 cases per 1000 admissions)

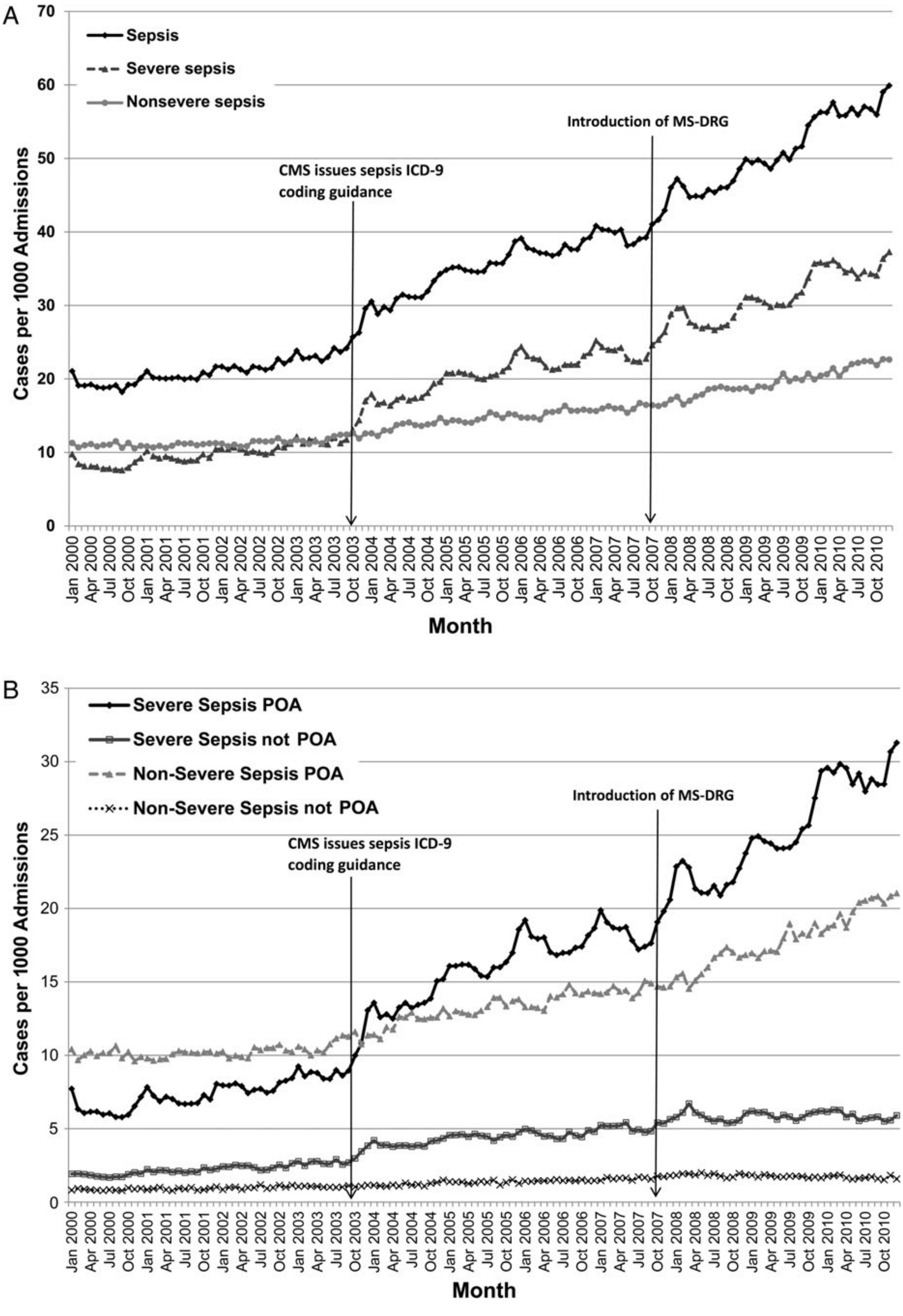

Figure 1. Sepsis rates in California between 2000 and 2010. *A*, Sepsis rates across the study period, 2000–2010. *B*, Sepsis by severity and present on admission (POA) status.

compared with a 1.3-fold increase among white patients (from 310.7 to 415.2 cases per 1000 admissions). Severe and nonsevere sepsis rates by Hispanic ethnicity, insurance type, and teaching hospital status were stable over the study period.

Time Series Analysis: Changes in Sepsis Rates After Policy Changes

Segmented regression analysis results are shown in Table 2, comparing baseline sepsis rates with those after CMS sepsis coding guidance, and comparing the latter to rates after

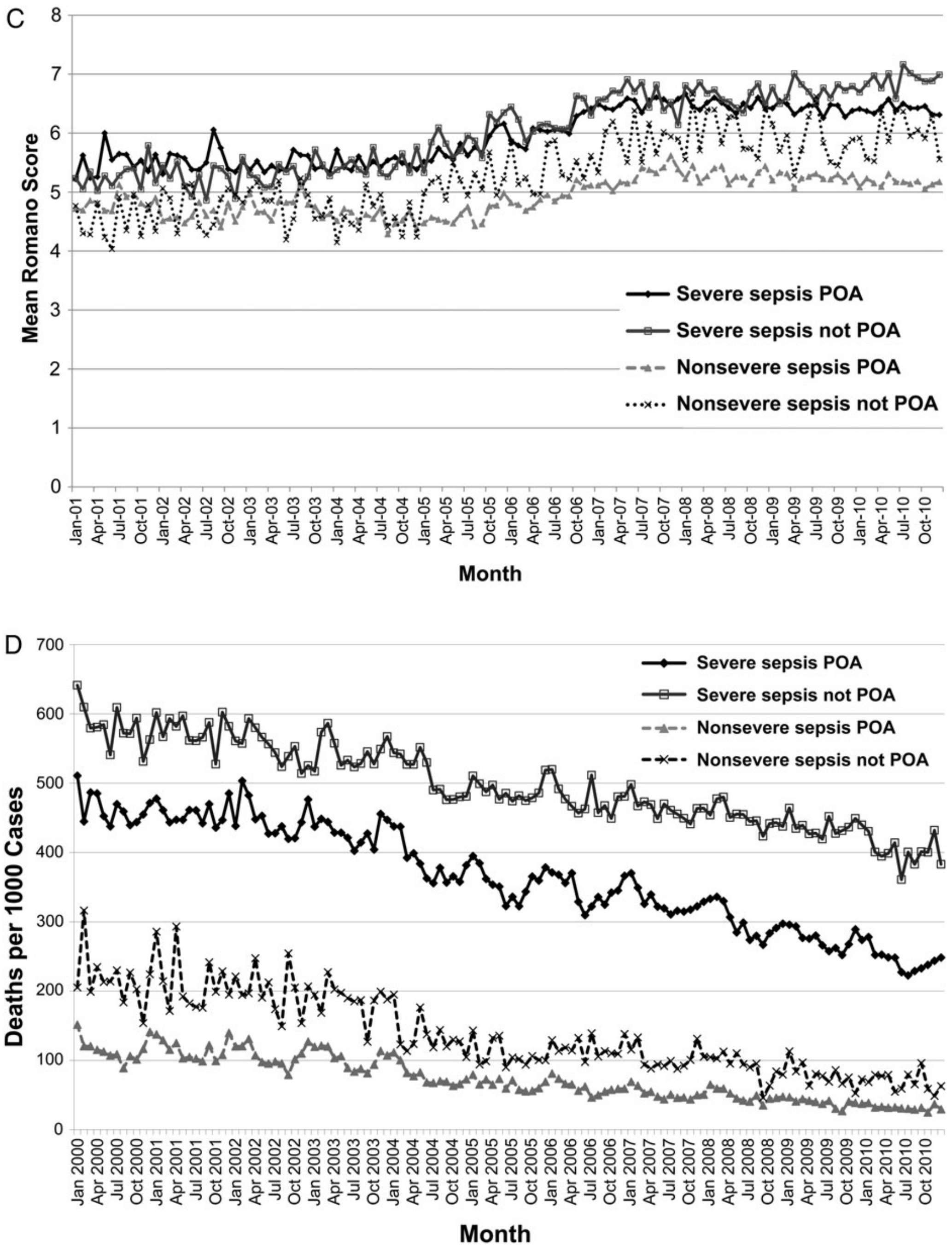

Figure 1 continued. C, mean Romano Score, 2001–2010. *D*, sepsis-associated mortality by severity and POA status. Abbreviations: CMS, Centers of Medicare and Medicaid Services; MS-DRG, medical severity diagnosis-related group.

MS-DRG introduction. CMS sepsis coding guidance was associated with significant increases in both immediate level and trend changes in sepsis rates (Table 2). Increases were greater for POA cases compared with in-hospital sepsis. Winter seasonal effects were consistently observed (Figure 1) and adjusted for within these analyses, along with age and sex. If baseline trends had continued, the projected severe sepsis rate in September 2007 would have been 30.6 cases per 1000 admissions. Instead, 4 years after CMS coding guidance, the rate was 39.2 severe sepsis cases per 1000 admissions.

The introduction of MS-DRG resulted in additional increases in severe and nonsevere sepsis POA trends, beyond that seen after CMS coding guidance. Decreases in sepsis-associated mortality paralleled increases in sepsis rates. If post-CMS coding guidance trends had continued unchanged after MS-DRG introduction, the projected severe sepsis rate on December 2010

Table 1. Descriptive Characteristics of Sepsis Hospitalizations, Stratified by Severity and Present on Admission Status[a]

Characteristic	All Sepsis, %	Severe Sepsis, %		Nonsevere Sepsis, %	
		POA	Not POA	POA	Not POA
Male sex	49.1	50.1	54.2	46.2	49.0
Age, y					
18–34	4.7	3.6	4.6	5.8	7.6
35–44	5.9	5.3	5.9	6.4	7.3
45–54	11.4	11.5	12.4	10.8	12.5
55–64	15.4	16.0	17.6	14.0	16.1
65–74	19.6	19.9	22.0	18.5	19.8
75–84	25.1	25.2	25.0	25.2	22.8
≥85	17.9	18.4	12.5	19.3	13.9
Insurance					
Medicaid, indigent	15.5	16.1	17.1	14.2	16.5
Medicare	64.7	65.2	60.3	65.8	59.7
Other, including self-pay	3.4	3.5	3.6	3.2	3.6
Private	16.5	15.2	19.0	16.8	20.3
Race					
White	69.1	68.7	68.4	69.9	67.0
Black	10.5	10.6	10.2	10.4	12
Asian	9.5	9.7	9.9	9.0	9.7
Native American	0.3	0.3	0.4	0.4	0.3
Other	10.6	10.7	11.1	10.4	11.1
Romano score					
0	14.3	11.0	10.04	19.2	18.2
1–2	19.9	18.0	16.84	23.1	20.2
3–4	20.7	21.0	21.06	20.3	18.1
5–6	18.5	19.5	20.5	16.6	18.0
7–8	12.1	13.5	14.26	9.8	11.6
9–10	6.7	7.9	8.14	5.0	6.4
>10	7.9	9.2	9.17	6.0	7.6
Admitted from SNF	13.4	16.4	7	12.3	8.1

Abbreviations: POA, present on admission; SNF, skilled nursing facility.

[a] Data represent percentages calculated among each substratum.

would have been 53.5 cases per 1000 admissions, compared with the observed 59.9 cases per 1000 admissions; if baseline trends had continued without the effect of either policy, the expected severe sepsis rate would have been 26.7 cases per 1000 admissions.

Association of Clinical and Sociodemographic Factors and Policies With Sepsis and Mortality

In adjusted models, the proportion of coded sepsis cases was significantly higher after each policy change compared with baseline. There was a significant association between increased risk for sepsis (all subsets) and age, race, comorbidity, insurance status, and nursing home residence. CMS coding guidance and MS-DRG policies remained independent predictors of sepsis risk (Table 3). In adjusted models assessing sepsis-related mortality, associated variables were similar (Table 4).

DISCUSSION

Marked rises in sepsis incidence have generated substantial concern and national campaigns to address sepsis [19, 20]. We show that a significant portion of this increase is temporally related to CMS policy changes that affected sepsis coding and reimbursement [2–4, 15]. Time phases after policy changes were independently associated with sepsis after adjustment for multiple variables, including comorbid conditions and sociodemographic factors. Specifically, these policy changes seem to have led to the up-capture of sepsis, whereby patients qualifying for multiple diagnostic codes are preferentially coded as septic. Sepsis as the primary diagnosis increased 3.6-fold during the study period, while primary pneumonia diagnosis decreased 1.4-fold, despite stable total annual admissions and decreasing sepsis-associated mortality, suggesting preferential exchange of other infection diagnoses for sepsis diagnoses. Other studies have shown changes in coding of primary infectious illnesses, in which sepsis coding increases occurred concurrently with a decline in coding of other infectious illnesses [4, 9, 10, 14, 15, 21].

The possibility of up-capture may be further supported by the notable decreases in sepsis mortality reported here and elsewhere [9, 22]. We now show that decreases in these rates are associated with the change in sepsis coding guidance in October 2003. Policy changes may have increased physician and medical coder awareness of sepsis identification or dual description of patients meeting both a disease-specific diagnosis (eg, pneumonia) and clinical sepsis [23]. If patients representing previously uncaptured sepsis were less severely ill than the population of patients captured before policy impacts, then this surveillance bias may explain both the rise in sepsis codes and the reduction in case fatality rate [24]. The capture of comorbid conditions seemed to be similarly enhanced in advance of the 2007 policy that increased payment based on medical severity. This could be an additional marker of improved physician and coder education resulting in global up-capture of both sepsis and comorbid conditions.

MS-DRG introduction in October 2007 represented a seminal restructuring of hospital reimbursement strategies in the context of value-based purchasing, explicitly tying reimbursement to severity of illness [8, 25]. Under MS-DRG, sepsis was listed as first among the top 10 DRGs with increasing payments [25]. We show that this policy was associated with additional increases in sepsis coding trends beyond that seen with CMS sepsis coding guidance in 2003. MS-DRGs adjusted severity of illness and mortality risk by the interaction of multiple comorbid conditions to account for difficult-to-treat patients with poorer expected outcomes. This policy led to national efforts to educate physicians on accurate documentation on the complexity and severity of the patients they treat [25].

The rise in sepsis POA was seen in both severe and nonsevere sepsis. POA status has been used as an indicator of healthcare quality and its designation can have serious impacts on financial reimbursements. The Deficit Reduction Act of 2005 required collection of POA status by CMS inpatient claims, and beginning October 2008, Medicare identified a series of hospital-acquired conditions for which payment was reduced if the

Table 2. Time Series Analysis Showing Level and Trend Changes for Baseline, Post-Centers for Medicare and Medicaid Services Sepsis Coding Guidance, and Post–Medical Severity Diagnosis-related Group Introduction

Outcome	Baseline Monthly Trend (1 January 2000 to 30 September 2003)	*P* Value	Change Immediately After CMS Sepsis Coding Guidance (1 October 2003)	*P* Value	Trend After CMS Sepsis Coding Guidance (1 October 2003 to 30 September 2007)	*P* Value	Change Immediately After MS-DRG Introduction (1 October 2007)	*P* Value	Trend After MS-DRG Introduction (1 October 2007 to 30 December 2010)	*P* Value
Sepsis rate[a]										
Severe sepsis	0.09	<.001	4.04	<.001	0.09	<.001	−0.02	.95	0.11	<.001
POA	0.07	<.001	3.18	<.001	0.09	<.001	−0.56	.04	0.14	<.001
Not POA	0.03	<.001	0.85	<.001	0.01	.005	0.51	<.001	−0.03	<.001
Nonsevere sepsis	0.02	<.001	1.00	<.001	0.06	<.001	−0.11	.43	0.08	<.001
POA	0.01	.001	1.00	<.001	0.05	<.001	−0.36	.008	0.09	<.001
Not POA	0.01	<.001	−0.01	.82	0.01	<.001	0.22	<.001	−0.02	<.001
Sepsis mortality[b]										
Severe sepsis	−0.80	<.001	−23.22	<.001	−0.94	<.001	5.03	.40	−0.50	.05
POA	−0.75	<.001	−25.70	<.001	−1.01	<.001	1.21	.85	−0.36	.20
Not POA	−1.09	<.001	−7.07	.35	−0.32	.26	9.03	.26	−0.01	.98
Nonsevere sepsis	−0.36	<.001	−14.66	<.001	−0.46	<.001	3.99	.27	0.24	.12
POA	−0.36	<.001	−12.07	<.001	−0.46	<.001	3.30	.35	0.31	.04
Not POA	−0.85	.005	−31.43	.003	−0.28	.46	9.81	.37	0.35	.45

Abbreviations, CMS, Centers for Medicare and Medicaid Services; MS-DRG, medical severity diagnosis-related group; POA, present on admission.

[a] Sepsis rates calculated as cases per 1000 admissions.

[b] Mortality calculated as deaths per 1000 septic patients. All models were adjusted for age, sex, and seasonal effects.

Table 3. Logistic Regression Model of Variables Associated With Sepsis, Severe Sepsis, and Sepsis Present on Admission[a]

	All Sepsis		Severe Sepsis				Nonsevere Sepsis			
			POA		Not POA		POA		Not POA	
Variable	OR (CI)	*P* Value	OR (CI)	*P* Value	OR (CI)	*P* Value	OR (CI)	*P* Value	OR (CI)	*P* Value
Male sex	1.21 (1.2–1.21)	<.001	1.22 (1.21–1.22)	<.001	1.38 (1.36–1.39)	<.001	1.16 (1.16–1.17)	<.001	1.33 (1.32–1.34)	<.001
Age, y										
35–44	2.31 (2.29–2.34)	<.001	2.78 (2.72–2.83)	<.001	2.28 (2.21–2.36)	<.001	2.34 (2.31–2.37)	<.001	2.08 (2.02–2.14)	<.001
45–54	3.3 (3.26–3.33)	<.001	4.31 (4.23–4.38)	<.001	3.26 (3.16–3.36)	<.001	3.33 (3.29–3.37)	<.001	2.89 (2.81–2.96)	<.001
55–64	3.6 (3.56–3.64)	<.001	4.69 (4.61–4.78)	<.001	3.62 (3.51–3.74)	<.001	3.64 (3.6–3.68)	<.001	3.17 (3.09–3.25)	<.001
65–74	3.31 (3.28–3.35)	<.001	4.34 (4.26–4.42)	<.001	3.7 (3.58–3.82)	<.001	3.34 (3.29–3.38)	<.001	3.16 (3.07–3.24)	<.001
75–84	3.57 (3.53–3.61)	<.001	4.54 (4.46–4.62)	<.001	3.62 (3.5–3.74)	<.001	3.68 (3.63–3.72)	<.001	3.1 (3.02–3.19)	<.001
≥85	4.15 (4.1–4.2)	<.001	5.21 (5.12–5.31)	<.001	3.07 (2.97–3.18)	<.001	4.48 (4.42–4.54)	<.001	2.77 (2.7–2.86)	<.001
Insurance										
Medicaid, indigent	1.3 (1.29–1.3)	<.001	1.37 (1.35–1.38)	<.001	1.18 (1.16–1.2)	<.001	1.31 (1.3–1.32)	<.001	1.16 (1.14–1.18)	<.001
Medicare	1.52 (1.51–1.53)	<.001	1.46 (1.45–1.48)	<.001	1.16 (1.14–1.18)	<.001	1.58 (1.57–1.59)	<.001	1.21 (1.19–1.23)	<.001
Other	1.02 (1.01–1.03)	<.001	1.1 (1.08–1.12)	<.001	0.89 (.86–.92)	<.001	1.04 (1.03–1.06)	<.001	0.89 (0.86–0.91)	<.001
Race										
Asian	1.26 (1.26–1.27)	<.001	1.25 (1.24–1.26)	<.001	1.3 (1.27–1.32)	<.001	1.26 (1.25–1.27)	<.001	1.32 (1.3–1.34)	<.001
Black	1.16 (1.15–1.17)	<.001	1.12 (1.11–1.13)	<.001	1.06 (1.04–1.08)	.07	1.17 (1.16–1.17)	.08	1.14 (1.12–1.16)	<.001
Native American	1.12 (1.08–1.15)	.974	1.11 (1.06–1.16)	.631	1.04 (.95–1.14)	.312	1.13 (1.09–1.17)	.48	0.99 (0.91–1.08)	.004
Other	1.05 (1.05–1.06)	<.001	1.02 (1.01–1.03)	<.001	1.04 (1.02–1.06)	<.001	1.06 (1.05–1.07)	<.001	1.07 (1.05–1.09)	.009
Romano score										
1–2	1.66 (1.65–1.67)	<.001	1.87 (1.85–1.89)	<.001	2.11 (2.06–2.15)	<.001	1.6 (1.59–1.61)	<.001	1.87 (1.83–1.9)	<.001
3–4	2.51 (2.49–2.53)	<.001	3.12 (3.08–3.15)	<.001	4.09 (4–4.18)	<.001	2.31 (2.3–2.33)	<.001	3.31 (3.25–3.37)	<.001
5–6	3.12 (3.1–3.15)	<.001	3.94 (3.89–3.98)	<.001	5.52 (5.4–5.65)	<.001	2.8 (2.78–2.82)	<.001	4.48 (4.4–4.56)	<.001
7–8	3.77 (3.74–3.8)	<.001	4.86 (4.8–4.92)	<.001	7.16 (6.99–7.33)	<.001	3.27 (3.24–3.3)	<.001	5.72 (5.61–5.84)	<.001
9–10	4.38 (4.34–4.43)	<.001	5.79 (5.71–5.87)	<.001	8.5 (8.27–8.73)	<.001	3.74 (3.7–3.78)	<.001	6.75 (6.6–6.91)	<.001
>10	2.62 (2.6–2.64)	<.001	3.78 (3.74–3.83)	<.001	4.45 (4.34–4.57)	<.001	2.37 (2.35–2.4)	<.001	3.53 (3.45–3.61)	<.001
Time phase										
CMS sepsis coding guidance	1.6 (1.6–1.61)	<.001	2.01 (2–2.03)	<.001	1.82 (1.79–1.85)	<.001	1.5 (1.49–1.51)	<.001	1.6 (1.58–1.62)	<.001
MS-DRG introduction	2.15 (2.14–2.16)	<.001	2.86 (2.84–2.89)	<.001	2.14 (2.1–2.17)	<.001	2.08 (2.07–2.09)	<.001	1.94 (1.91–1.96)	<.001
Admitted from SNF	3.57 (3.55–3.60)	<.001	4.04 (4.01–4.08)	<.001	1.46 (1.43–1.49)	<.001	3.81 (3.78–3.83)	<.001	1.59 (1.56–1.62)	<.001

Abbreviations: CI, confidence interval; CMS, Centers for Medicare and Medicaid Services; MS-DRG, medical severity diagnosis-related group; OR, odds ratio; POA, present on admission; SNF, skilled nursing facility.

[a] For each outcome, the base population used was all hospitalized patients. Referent groups for non-binary categories defined as follows: Romano score, 0; age, 18–34; insurance, commercial/private; race, white; time phase, phase 1 (1 January 2000 to 30 September 2002).

condition was not POA and thereby deemed "hospital-acquired" [26]. Although sepsis was not specified as one of these hospital-acquired conditions, sepsis associated with these conditions, such as central vascular device infections and surgical site infections, would be at risk for Medicare reimbursement reductions if not documented as POA. Thus, linkage of POA status to hospital reimbursement may have resulted in efforts to train hospital staff on proper designation and assignment of POA status for all diagnoses [27, 28].

Our work is the first to assess the impact of policy on sepsis epidemiology and provides direct evidence of the impact of coding practices on sepsis rates, supporting findings suggested by Lindenauer et al and others [9, 10, 29] that increases in sepsis rates accompanied by paradoxical decreases in mortality, pneumonia, and other infections may indicate shifts in coding. In our view, these findings do not necessarily represent intentional attempts to improve financial reimbursement, but rather improvements in capture of sepsis in the context of physician training on coding structure and advancing electronic medical records systems. Our approach in evaluating the impact of policy on clinical disease as measured by large-scale administrative data is novel; studies using ICD-9 coding data do not methodologically account for policy impacts or changes in coding practices. This work suggests that policy and other systemic changes that seriously affect coding should be accounted and adjusted for in epidemiologic studies. Certainly, national priorities and responses (such as hospital benchmarking on sepsis outcomes) to epidemiologic trends should be assessed after adjusting for coding artifact and national policy effects.

Policy changes cannot account entirely for the rise in sepsis diagnoses or reduction in mortality. Sepsis epidemiology was likely also affected by the marked increase in campaigns for

Table 4. Logistic Regression Model of Variables Associated With In-Hospital Mortality Among Patients With Sepsis[a]

Variable	Odds Ratio	P Value
Male sex	1.01 (1–1.02)	.25
Age, y		
35–44	1.42 (1.36–1.47)	<.001
45–54	1.68 (1.62–1.73)	<.001
55–64	1.87 (1.81–1.93)	<.001
65–74	2.2 (2.13–2.28)	<.001
75–84	2.76 (2.67–2.85)	<.001
≥85	3.77 (3.65–3.9)	<.001
Insurance		
Medicaid, indigent	1.09 (1.07–1.11)	.01
Medicare	0.96 (0.95–0.98)	<.001
Other	1.25 (1.21–1.29)	<.001
Race		
Asian	0.91 (0.9–0.93)	<.001
Black	0.93 (0.92–0.95)	<.001
Native American	1.02 (0.94–1.1)	.16
Other	0.99 (0.97–1)	.07
Romano score		
1–2	1.17 (1.15–1.2)	<.001
3–4	1.44 (1.41–1.47)	<.001
5–6	1.67 (1.64–1.7)	<.001
7–8	1.89 (1.86–1.93)	<.001
9–10	2.05 (2.01–2.1)	<.001
>10	2.1 (2.05–2.15)	<.001
Time phase		
CMS sepsis coding guidance	0.62 (0.61–0.63)	<.001
MS-DRG introduction	0.41 (0.4–0.41)	<.001
Admitted from SNF	1.02 (1.01–1.04)	.002
Severe sepsis	7.36 (7.27–7.46)	<.001
Sepsis present on admission	0.52 (0.51–0.52)	<.001

Abbreviations: CMS, Centers for Medicare and Medicaid Services; MS-DRG, medical severity diagnosis-related group; SNF, skilled nursing facility.

[a] Referent groups for nonbinary categories are defined as follows: Romano score, 0; age, 18–34 years; insurance, commercial/private; race, white; time phase, phase 1 (1 January 2000 to 30 September 2002).

early recognition and improved diagnosis and treatment, as may be suggested by our findings that sepsis POA accounted for the majority of increase in overall sepsis [30–32]. The Surviving Sepsis Campaign released its first guidelines in spring 2004, and several studies have demonstrated gains in mitigating sepsis-related morbidity and mortality [30, 33]. Also worth noting is the rise in electronic medical records and hospital coding systems across the United States, which improved capture of illness [34]. Nevertheless, while clinical and technological advances may account for some of the rise in sepsis and POA coding, the strong temporal association with coding policies suggests that these policies were instrumental in producing a substantial portion of the increases seen.

Given the multitude of factors affecting sepsis epidemiology, adjustment for and interpretation of sepsis rates in light of policy impacts may allow attention to other areas of sepsis care warranting consideration. For example, concerns over alarming and potentially inflated increases in sepsis might be refocused toward prevention strategies for sepsis arising in SNFs. Clinical presentation of infection among elderly or disabled nursing home residents is often more subtle than those currently defined in most sepsis criteria, bundles, or protocols [35]. We found that SNF residence was one of the strongest independent risk factors associated with sepsis and mortality and highest for severe sepsis POA (adjusted odds ratio, 4.0). Further study is needed to understand the specific mechanisms underlying this increased risk for sepsis among SNF residents.

Our study has several important limitations. First, although the administrative data set provided a large volume of data, sepsis outcomes were based purely on ICD-9 discharge diagnostic coding, without clinical assessment of sepsis. Second, we studied only adults; our findings are not pertinent to pediatric populations. Third, our data are limited to a single state and may not be generalizable to other cohorts; however, California is sociodemographically diverse and represents the most populous state in the nation. Fourth, only within-hospital mortality was assessed without verification of actual cause of death or capture of postdischarge death. Fifth, our work cannot account for risk factors not available in the administrative data set, such as access to care, clinical presentation, or medical management.

In conclusion, the acute rise in sepsis reported in California may represent, in part, a substantial up-capture of administrative coding of sepsis cases in response to 2 CMS policies. To the extent that rapid rises in sepsis have been noted nationally and that such trends are alarming and direct national resource allocations and prevention efforts, it is imperative that reported sepsis rates based on administrative data account for policy-related effects. The increase in sepsis coding may also lead to false measurements of important parameters, such as underestimation of sepsis-associated mortality. Our findings suggest that interpretation of recent epidemiologic trends in sepsis based on administrative data should be approached with caution.

Supplementary Data

Supplementary materials are available at http://cid.oxfordjournals.org. Consisting of data provided by the author to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the author, so questions or comments should be addressed to the author.

Notes

Disclaimer. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH) or the Centers for Disease Control and Prevention.

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Potential conflicts of interest. S. S. H. is conducting clinical studies for which participating hospitals and nursing homes are receiving contributed product from Sage Products, Molnycke, 3M, and Clorox. All other authors report no potential conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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