They also postulated a gender-related susceptibility, given the fact that all the cases in their literature review were females [3]. The association of RCVS and Bickerstaff's brain stem encephalitis was reported in a 75 year old woman who presented with headache, new-onset hypertension, and the association of left eyelid ptosis and limitation of extraocular movements in the left eye [4]. Computed tomography angiography ruled out cerebral aneurysm. MRI showed stigmata consistent with RCVS. She subsequently developed right side ptosis and bilateral oculomotor and trochlear nerve palsy, followed by clinical and laboratory stigmata of peripheral demyelinating neuropathy. A subsequent complication was the development of impaired consciousness and euvolemic hyponatremia, the latter attributable to the syndrome of inappropriate antidiuretic hormone secretion. Her conscious level and ophthalmoplegia improved after plasmapheresis. The hyponatremia was also gradually corrected. Two months later she had completely recovered [4]. Conversely, however, reversible cerebral vasoconstriction syndrome can develop as a complication of the use of intravenous immunoglobulin for treatment of Bickerstaff brain stem encephalitis [5]. The latter complication occurred in a 25 year old woman who had been admitted with typical neurological stigmata of brain stem encephalitis, followed by clinical and laboratory stigmata of demyelinating peripheral neuropathy, in association with a cerebrospinal fluid protein content of 80.2 mg/dL. The MRI study performed on admission was normal. Due to rapid progression of her disease she was treated with intravenous immunoglobulin. Forty eight hours after initiation of that treatment she experienced further neurological deterioration, and also subsequently became comatose. A second MRI study showed stigmata of RCVS in the cerebral hemispheres, vertebral artery vasospasm, and brainstem edema. At no stage of her hospital stay did she experience hypertension. She improved markedly after plasmapheresis, and the MRI showed a decrease in the RCVS-associated bihemispheric lesions, with only a small parieto-occipital infarction. By contrast brainstem edema persisted. After 3 months intense rehabilitation she was completely orientated and she could walk, although binocular ptosis, ocular palsy, and dysphagia persisted [5].

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Patient factors associated with nationwide emergency department utilization for cellulitis

1. Introduction

Although studies have estimated costs associated with inpatient admissions for cellulitis, data on emergency department (ED) utilization for cellulitis-related visits are limited [1, 2]. Importantly, the existing literature lacks an analysis of epidemiological factors that may be associated with ED utilization for cellulitis-related visits. In this study, we employ a nationally representative emergency department database to 1) characterize the utilization of ED services for cellulitis-related visits and 2) describe epidemiolocal factors associated with greater likelihood of ED visits for cellulitis.

2. Methods

We conducted a cross-sectional study using the 2013 Healthcare and Cost Utilization Project National Emergency Department Sample (HCUP-NEDS), a national US dataset containing approximately 135 million hospital-based emergency department visits [3]. Patients with a primary International Classification of Diseases, Ninth Revision (ICD-9) code corresponding to cellulitis were included. The validity of these measures for accurately classifying cellulitis has previously been established [4]. Patients with atypical distributions including laryngeal, pharyngeal, or orbital cellulitis were excluded. In addition, patients with a procedure code for incision and drainage of skin and subcutaneous tissue (86.04) were excluded to eliminate cellulitis complicated by abscess. Demographics and clinical characteristics were calculated overall and for visits with a primary diagnosis of cellulitis. Multivariable logistic regression analysis of visit characteristics associated with a primary diagnosis of cellulitis was performed. Survey procedures in SAS 9.4 (SAS Institute) were used to account for the HCUP-NEDS sampling design. This study was deemed exempt by the Partners Healthcare Institutional Review Board.

3. Results

Of 134.9 million ED visits in 2013, 2.9 million (2.1%) were related to cellulitis, resulting in total ED and inpatient service charges of $4.2 billion and $9.5 billion, respectively. Patients evaluated for cellulitis had a mean (SE) age of 39.2 (0.25) and 48.3% were female (Table 1). The lower extremities were most commonly affected anatomic region among patients seen for cellulitis (46.1%). The most common insurances for these patients were Medicaid (27.2%), self-pay (25.3%), and private (23.2%). ED patients seen for cellulitis had lower ED-related healthcare spending ($1696 vs $2699) and a shorter mean length of inpatient hospitalization (4.1 days vs 4.8 days) compared to all other ED patients whose visits were unrelated to cellulitis. Most patients evaluated for cellulitis (84.6%) were discharged home.

A multivariable analysis adjusting for age, gender, payer, day/month of visit, hospital region, location, and median household income suggests that ED patients evaluated for cellulitis were more likely to be of lower socioeconomic status (SES) relative to those with other diagnoses. Medicare, Medicaid, and self-pay patients were more likely to have a cellulitis-related visit compared to patients with private insurance (Table 2). Patients belonging to the lowest quartile by median household income were more likely to have an ED visit for cellulitis compared to patients in the highest quartile (OR 1.15; 95% CI, 1.10–1.21). There was also an inverse association between median household income category and likelihood of cellulitis-related ED visits.

4. Discussion

This study highlights nationally representative healthcare utilization patterns associated with cellulitis-related ED visits, which accounted for

Table 1
Characteristics of visits with primary diagnosis of cellulitis in 2013 (NEDS).

	All visits 134,869,015	Visits for cellulitis[a] 2,867,705 (2.13%)	Visits for other diagnoses 132,001,310
Age, mean (SD)	39.5 (0.37)	39.2 (0.25)	39.5 (0.38)
Age, n (%)			
≤18	28,411,573 (21.1)	401,855 (14.0)	28,009,718 (21.2)
19–30	26,352,153 (19.5)	698,041 (24.3)	25,654,112 (19.4)
31–50	34,909,104 (25.9)	942,553 (32.9)	33,966,550 (25.7)
51–65	21,999,712 (16.3)	478,574 (16.7)	21,521,138 (16.3)
> 65	23,190,371 (17.2)	346,631 (12.1)	22,843,740 (17.3)
Gender, n (%)			
Male	60,049,843 (44.5)	1,483,026 (51.7)	58,566,817 (44.4)
Female	74,814,441 (55.5)	1,384,615 (48.3)	73,429,826 (55.6)
Payer, n (%)			
Medicare	30,392,185 (22.6)	537,849 (18.8)	29,854,336 (22.7)
Medicaid	38,115,577 (28.3)	778,141 (27.2)	37,337,435 (28.3)
Private	36,744,425 (27.3)	663,040 (23.2)	36,081,385 (27.4)
Self-pay	21,693,865 (16.1)	725,080 (25.3)	20,968,786 (15.9)
No charge	1,270,619 (0.9)	42,467 (1.5)	1,228,151 (0.9)
Other	6,417,307 (4.8)	116,087 (4.1)	6,301,220 (4.8)
Day of visit, n (%)			
Weekday	96,839,993 (71.8)	2,028,792 (70.7)	94,811,201 (71.8)
Weekend	38,028,647 (28.2)	838,899 (29.3)	37,189,747 (28.2)
Month of visit, n (%)			
December – February	28,578,737 (24.9)	484,913 (20.1)	28,093,825 (25.0)
March – May	29,067,088 (25.3)	562,212 (23.4)	28,504,877 (25.3)
June – August	29,143,382 (25.4)	742,839 (30.9)	28,400,543 (25.2)
September – November	28,150,445 (24.5)	616,766 (25.6)	27,533,679 (24.5)
Patient location, n (%)			
Central metro areas ≥ 1MM population	37,831,644 (28.2)	726,219 (25.5)	37,105,426 (28.3)
Fringe metro areas ≥ 1MM population	28,426,526 (21.2)	590,975 (20.8)	27,835,550 (21.2)
Metro areas of 250,000–999,999 population	29,601,006 (22.1)	659,953 (23.2)	28,941,053 (22.1)
Metro areas of 50,000–249,999 population	12,292,170 (9.2)	268,507 (9.4)	12,023,663 (9.2)
Micropolitan areas	15,931,532 (11.9)	379,202 (13.3)	15,552,330 (11.9)
Not metro/micropolitan areas	9,899,228 (7.4)	222,785 (7.8)	9,676,444 (7.4)
Hospital region, n (%)			
Northeast	25,758,251 (19.1)	508,401 (17.7)	25,249,850 (19.1)
Midwest	30,767,113 (22.8)	597,745 (20.8)	30,169,368 (22.9)
South	53,817,056 (39.9)	1,240,620 (43.3)	52,576,436 (39.8)
West	24,526,595 (18.2)	520,940 (18.2)	24,005,655 (18.2)
Median HH income for ZIP code, n (%)			
Q1	45,478,192 (34.5)	1,048,689 (37.5)	44,429,504 (34.4)
Q2	36,453,173 (27.6)	790,150 (28.2)	35,663,023 (27.6)
Q3	29,128,389 (22.1)	580,128 (20.7)	28,548,261 (22.1)
Q4	20,852,356 (15.8)	379,065 (13.5)	20,473,291 (15.9)
Length of stay (days), mean (SE)	4.81 (0.033)	4.14 (0.034)	4.82 (0.033)
Discharge disposition, n (%)			
Routine	109,513,656 (81.2)	2,426,368 (84.6)	107,087,288 (81.1)
Other	5,900,210 (4.4)	70,148 (2.4)	5,830,062 (4.4)
Admitted as inpatient	19,255,862 (14.3)	371,076 (12.9)	18,884,786 (14.3)
Died in ED	199,286 (0.1)	113 (0.0)	199,173 (0.2)
Charges, mean $ (SE)			
ED	2678 (59)	1696 (34)	2699 (60)
IP	41,684 (860)	25,932 (613)	41,995 (868)

[a] Excludes those with procedure code 86.04; weighted counts and percentages reported.

Table 2
Adjusted odds ratios for demographic and clinical characteristics associated with visits for cellulitis.

	Odds ratio (95% CI)	p-Value
Age		
≤18	1 (reference)	
19–30	1.83 (1.79–1.87)	<0.001
31–50	1.88 (1.84–1.93)	<0.001
51–65	1.59 (1.54–1.64)	<0.001
>65	1.14 (1.10–1.18)	<0.001
Gender		
Female	1 (reference)	
Male	1.35 (1.34–1.37)	<0.001
Payer		
Private	1 (reference)	
Medicare	1.14 (1.12–1.16)	<0.001
Medicaid	1.24 (1.21–1.26)	<0.001
Self-pay	1.61 (1.57–1.64)	<0.001
No charge	1.61 (1.41–1.84)	<0.001
Other	0.91 (0.85–0.97)	0.002
Day of visit		
Weekday	1 (reference)	
Weekend	1.06 (1.06–1.07)	<0.001
Month of visit		
December – February	1 (reference)	
March – May	1.29 (1.27–1.30)	<0.001
June – August	1.14 (1.13–1.15)	<0.001
September – November	1.49 (1.47–1.51)	<0.001
Hospital region		
Northeast	1 (reference)	
Midwest	0.94 (0.89–0.99)	0.049
South	1.02 (0.96–1.08)	0.58
West	1.12 (1.05–1.18)	<0.001
Patient location		
Central metro areas ≥ 1MM population	1 (reference)	
Fringe metro areas ≥ 1MM population	1.20 (1.13–1.27)	<0.001
Metro areas of 250,000–999,999 population	1.18 (1.12–1.25)	<0.001
Metro areas of 50,000–249,999 population	1.17 (1.10–1.25)	<0.001
Micropolitan areas	1.29 (1.21–1.36)	<0.001
Not metro/micropolitan areas	1.20 (1.14–1.28)	<0.001
Median HH income for ZIP code		
Q1	1.15 (1.10–1.21)	<0.001
Q2	1.10 (1.05–1.14)	<0.001
Q3	1.05 (1.01–1.09)	0.014
Q4	1 (reference)	

This nationwide burden of cellulitis must be considered in the context of known misdiagnosis rates, which is reported to exceed 30% in prospective studies [1]. Implementation of point-of-care diagnostics and specialist consultations may be especially beneficial to avoid inappropriate treatment associated with misdiagnosis of cellulitis [1, 6].

Although patient characteristics were similar between ED visits related to cellulitis and visits for other reasons, our data suggest that patients who visit the ED for cellulitis are more likely to be of lower SES. Further research is required to understand the relative contribution of clinical risk factors and systems-based issues to this epidemiologic trend. In the interim, improved access to primary care and after-hours urgent care targeted at lower SES patients may be beneficial in decreasing ED utilization. This study is limited by cross-sectional design and potentially unmeasured covariates. Future studies should examine trends in healthcare utilization of cellulitis-related ED visits over time.

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IRB approval status

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total ED-related charges of $4.2 billion in 2013. For reference, the ED charge for chronic obstructive pulmonary disease was $3.1 billion in 2012 [5].

Conflicts of interest

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Heart rate variability in the risk stratification of emergency department patients with chest pain

Chest pain is the second most common presenting complaint in the emergency department (ED), accounting for 8–10 million ED visits per year and between $10–13 billion dollars per year in ED costs [1, 2]. Several scoring systems developed recently have attempted to stratify patients based on their risk for major adverse cardiac events. The HEART score is a prospectively studied scoring system designed to identify patients who are at highest risk of a major adverse cardiac event (MACE) in the next 6 weeks [3-5], and this score is used as a part of chest pain management protocols in many hospitals.

Heart rate variability (HRV) is a physiologic parameter that is altered in many conditions including heart disease, hypertension, hyperlipidemia, obesity, smoking and diabetes and is associated with increased mortality in patients following myocardial infarction [6-15]. Based on these findings, HRV presents a promising strategy to differentiate chest pain patients who will be diagnosed with ACS. We conducted a prospective observational study of patients presenting to a 65,000-visit academic Midwestern ED with a chief complaint of chest pain. The objective of our study was to measure the diagnostic utility of HRV in diagnosing ACS among ED patients with chest pain. Using a 10-min heart tracing performed in the ED, we assessed the correlation between HRV with 30-day MACE, HEART score, and cardiovascular risk factors. Inclusion criteria included age > 30, no obvious traumatic or non-cardiac cause of chest pain, and sinus rhythm. Those with ST-elevation myocardial infarction (STEMI) were excluded from the study.

Our hypothesis was that lower HRV in the ED is associated with ACS measured by 30-day MACE, higher HEART score, and more cardiovascular (CV) risk factors. Our primary endpoint was MACE diagnosed during index hospitalization or within 30 days of ED visit. Secondary endpoints included associations between HRV and HEART score and CV risk factors. HRV is measured and analyzed in many ways, we used frequency domain measures including low frequency (LF), high frequency (HF), LF/HF ratio, and total power (TP).

Sixty patients were included in the final analysis. Our sample population was 58% percent women with mean age of 55 (Table 1). 92% of participants had at least one cardiovascular risk factor. Admission rate was 65%. Six participants experienced the primary endpoint of MACE: three patients were diagnosed with non-ST-elevation myocardial infarction and one patient underwent PCI for unstable angina during the index hospitalization. Two additional patients experienced MACE in the subsequent 30 days. One patient died due to unknown causes, and 1 additional patient underwent PCI for a critical coronary stenosis found on coronary angiogram. There were no significant associations found between HRV and the primary outcome MACE (all $p > 0.05$), Table 2.

Table 3 shows the results of univariate regression analysis of the association between HEART score and HRV. Table 4 shows the results of univariate regression analysis between the five HEART score parameters and HRV. Notably, significant associations were found between HEART score and heart rate variability. Lower HRV was associated with higher heart score. Within the Risk Factors category (Table 5), diabetes and hypertension appeared to drive the association between increased risk factors and less heart rate viability.

In this observational prospective study measuring HRV in patients presenting to the ED with chest pain, we found a significant

Table 1
Patient characteristics.

Parameter	N (%)
Women	35 (58)
Prior MACE	23 (38)
HTN	36 (60)
HLD	34 (57)
DM	17 (28)
Smoking	23 (38)
Obesity	27 (45)
Family history	33 (55)
Age, mean (range)	55 (30–87)

Patient characteristics with respect to cardiovascular risk factors.

Table 2
Association between primary outcome, MACE[a], and heart rate variability

HRV parameter	MACE Odds ratio, 95% confidence interval	P-value
TP	1.00 (0.99–1.00)	0.20
LF/HF	1.22 (0.82–1.81)	0.33
LF	1.00 (0.99–1.00)	0.09
HF	0.99 (0.99–1.00)	0.94

Results of univariate logistic regression to evaluate associations between four HRV parameters and MACE.
[a] Includes combined MACE during index hospitalization and within 30 days of presentation.