Characteristics of Patients Presenting to the Emergency Department and Urgent Care for Treatment of Sunburn

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Trends in Nationwide Herpes Zoster Emergency Department Utilization From 2006 to 2013

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[Supplemental content](#)

IMPORTANCE The effect of vaccination on emergency department (ED) utilization for herpes zoster (HZ) has not been examined to date.

OBJECTIVE To determine trends in US ED utilization and costs associated with HZ.

DESIGN, SETTING, AND PARTICIPANTS The Nationwide Emergency Department Sample data set was examined for temporal trends in the number of visits and costs for treatment of HZ in EDs in the United States from January 1, 2006, through December 31, 2013. Cases of HZ were identified using validated *International Classification of Diseases, Ninth Revision–Clinical Modification* diagnosis codes. Patients were stratified by age: less than 20 years (varicella vaccine recommended), 20 to 59 years (no vaccine recommended), and 60 years or older (HZ vaccine recommended). Population-based rates were estimated using sampling weights.

MAIN OUTCOMES AND MEASURES Population-based incidence rates of HZ-related ED visits, charge for ED services, and total charges.

RESULTS A total of 1 350 957 ED visits for HZ were identified between 2006 and 2013, representing 0.13% of all US ED visits. Of these patients, 563 200 (51.7%) were male; mean (SE) age was 54.0 (0.1) years. Between 2006 and 2013, the percentage of HZ-related ED visits increased from 0.13% to 0.14% (8.3%). This growth was driven by patients aged 20 to 59 years (increase of 22.8% [from 0.12% to 0.14% of ED visits]) while the proportion of ED HZ visits decreased for patients aged less than 20 years and 60 years or older, from 0.03% to 0.02% (−39.6%) and from 0.28% to 0.25% (−10.9%), respectively. For all age groups, there was an increase from 2006 to 2013 in overall adjusted total (from \$92.83 to \$202.47 million) and mean charges (from \$763 to \$1262) for HZ-related ED visits.

CONCLUSIONS AND RELEVANCE The number of ED visits and total cost associated with HZ increased between 2006 and 2013. Greater use was driven by an increased number of visits by patients aged 20 to 59 years, but populations recommended for vaccination (<20 and ≥60 years) demonstrated decreased ED utilization. Per-visit and total costs increased across all age groups. Vaccination may be associated with a reduction of ED utilization. Further research is required to confirm these results and examine the drivers of increased ED costs.

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Herpes zoster (HZ), or shingles, is caused by reactivation of the HZ virus, the same virus that causes varicella.¹ One-third of individuals in the United States will develop HZ in their lifetime, with the risk increasing sharply after age 50 years.² Any individual who has had varicella or received the varicella vaccine can develop HZ, although the risk is lower in those who are vaccinated.³

The rate of HZ has been increasing gradually over many years in the United States and other countries. The reason for this trend is currently unknown.⁴⁻⁶ According to a hypothesis proposed by Hope-Simpson, exposure to primary varicella or subclinical latent varicella zoster virus can boost varicella zoster virus-specific immunity and reduce the risk of HZ.⁷ A live-attenuated vaccine for varicella was introduced into the US vaccination schedule in 1995 for children aged 12 months or older, with subsequent significant declines in the incidence of varicella. Although vaccination rates were slow at first, they reached 89% in 2006 in children aged 19 to 35 months.⁸ Observational studies suggest that individuals vaccinated for varicella are at a decreased risk of developing HZ.³ However, studies examining the effect on the overall population rates in the United States with observation periods ranging from 1992 through 2010 have been inconclusive.^{3-6,9}

A live-attenuated vaccine for HZ has been available in the United States since 2006. The vaccine reduces the likelihood of developing HZ by 51.3% in individuals aged 60 years or older, and vaccinated individuals who develop HZ usually have less severe disease. In 2008, the Advisory Committee on Immunization Practices (ACIP) recommended zoster vaccine live for the prevention of HZ and its complications among adults aged 60 years or older.² Vaccination rates in this population increased from 6.7% in 2008 to 24.2% in 2013.^{10,11}

To our knowledge, there are no data on nationwide emergency department (ED) utilization, hospitalization, and costs related to HZ and limited data on trends of disease since routine varicella vaccination was implemented in 1995 for children, as well as both before and after the ACIP recommendation of HZ vaccination in 2008. We hypothesized that, despite the increased incidence of HZ, the introduction of the HZ vaccine in 2008 led to attenuation of severe disease and reduction of ED utilization for patients aged 60 years or older with HZ. We additionally hypothesized that routine varicella vaccination decreased ED utilization for HZ in patients aged less than 20 years.

In this study, we used the Nationwide Emergency Department Sample (NEDS) to evaluate trends in ED utilization and costs to assess the potential impact of routine varicella vaccination and HZ vaccination.

Methods

Data Source

We conducted a US population-based, descriptive epidemiologic study of HZ-related ED visits from 2006 through 2013 using the NEDS, a nationally representative all-payer database that includes a 20% stratified sample of US community hospitals and contains data on approximately 130 million ED

Key Points

Question What is the effect of vaccination on emergency department utilization for herpes zoster?

Findings In this population-based, descriptive epidemiologic study of more than 1.3 million herpes zoster-related emergency department visits from 2006 through 2013, the overall rate of visits rose by 8.3%, driven by an increased number of visits by patients aged 20 to 59 years; populations recommended for vaccination (aged <20 and ≥60 years) demonstrated a decrease in utilization. Herpes zoster annual incidence rates fell after the recommended use of the herpes zoster vaccine in 2008 in patients 60 years or older.

Meaning Vaccination may be associated with a reduction of emergency department utilization for herpes zoster.

visits per year when weighted.¹² Cases of HZ were identified by a primary *International Classification of Diseases, Ninth Revision—Clinical Modification (ICD-9-CM)* code of 053.x, which has been shown to detect HZ with 98% sensitivity and a positive predictive value between 85% and 100%.¹³⁻¹⁵ The Partners Healthcare Institutional Review Board approved the study and granted an exemption for use of deidentified data from the NEDS database.

Statistical Analysis

We estimated the number of population-based total and HZ-related ED visits using sampling weights, clusters, and strata provided in the NEDS databases for each year. We stratified patients into the following age groups: less than 20 years, 20 to 59 years, and 60 years or older. Population-based incidence rates were calculated using US Census Bureau American FactFinder.¹⁶ Emergency department charges were adjusted to 2016 dollars using the Consumer Price Index adjustments for medical care.¹⁷ Separate logistic regression models for each age group were used to estimate the change in the log odds of a HZ visit per 1-year increase in the survey, and significant coefficients were interpreted as a trend in the probability of an HZ visit over the survey time period. We used the Rao-Scott χ^2 test to compare the proportion of visits for HZ from 2006-2007 with those from 2008-2013 among patients 60 years or older. *P* values <.05 were considered statistically significant. All tests were 2-tailed except for the Rao-Scott χ^2 test, which is 1-tailed. All group comparisons were unpaired. Analyses were performed with survey procedures in SAS, version 9.4 (SAS Institute Inc).

Results

From 2006 to 2013, there were 1 350 957 visits to the ED for HZ, which represented 0.13% of all ED visits in the United States (Table 1). When stratified by age groups, visits by patients 60 years or older represented 42.3% of all ED visits for HZ compared with representing 21.3% of ED visits without a primary diagnosis of HZ. Most patients were women (58.3%) and there was a slightly higher number of visits for HZ in the summer

Table 1. Nationwide ED Visit Characteristics for HZ From 2006 to 2013

Characteristic	No. (%) ^a	
	Visits With Primary Diagnosis of HZ	Visits Without Primary Diagnosis of HZ
Total visits	1 350 957 (0.13)	1 024 131 999 (99.87)
Age, mean (SE), y	54.0 (0.1)	38.5 (0.2)
Age group, y		
<20	66 078 (4.9)	247 892 699 (24.2)
20-59	713 753 (52.8)	557 985 576 (54.5)
≥60	571 115 (42.3)	218 246 765 (21.3)
Sex		
Male	563 200 (41.7)	459 670 847 (44.9)
Female	787 495 (58.3)	564 190 324 (55.1)
Hospital region		
Northeast	279 676 (20.7)	197 994 358 (19.3)
Midwest	296 883 (22.0)	238 684 851 (23.3)
South	524 783 (38.8)	403 661 728 (39.4)
West	249 616 (18.5)	183 791 061 (17.9)
Primary payer		
Medicare	479 771 (35.6)	214 329 554 (21.0)
Medicaid	179 478 (13.3)	256 676 982 (25.1)
Private insurance	393 090 (29.2)	322 453 842 (31.6)
Self-pay	239 811 (17.8)	169 336 307 (16.6)
No charge	12 255 (0.9)	7 878 378 (0.8)
Other	42 411 (3.1)	49 999 330 (4.9)
Month of visit by quarter		
December-February	259 796 (23.0)	214 160 934 (24.5)
March-May	278 900 (24.7)	221 966 293 (25.4)
June-August	304 703 (27.0)	222 131 582 (25.4)
September-November	284 003 (25.2)	216 418 879 (24.7)
Range in days of visit		
Monday-Friday	861 779 (63.9)	729 065 973 (71.2)
Saturday-Sunday	486 917 (36.1)	294 554 910 (28.8)
Charge for ED services, mean (SE), \$ ^b	1035 (14)	2321 (29)
ED disposition		
Routine	1 229 972 (91.0)	816 794 125 (79.8)
Transfer to short-term hospital	3626 (0.3)	14 230 986 (1.4)
Other transfers ^c	5341 (0.4)	11 848 345 (1.2)
Home health care	1952 (0.1)	1 978 365 (0.2)
Against medical advice	2712 (0.2)	14 012 246 (1.4)
Admitted as inpatient	97 618 (7.2)	154 155 613 (15.1)
Died in ED	33 (0)	1 544 204 (0.2)
Not admitted; destination unknown	13 (0)	19 441 (0)
Inpatient characteristics		
Length of stay, mean (SE), d	4.72 (0.04)	4.87 (0.02)
Charge for ED and inpatient services, mean (SE), \$	30 056 (561)	40 400 (521)

Abbreviations: ED, emergency department; HZ, herpes zoster.

^a Subcategories of counts may not sum to totals owing to missing values for some variables. Percentages were calculated using the total counts for each subcategory.

^b All charges adjusted to 2016 dollars.

^c Skilled nursing facility, intermediate care, and other.

Figure 1. Percentage of Total Emergency Department (ED) Visits With Primary Diagnosis of Herpes Zoster (HZ) From 2006 to 2013

Percentages were calculated as weighted number of ED visits with primary diagnosis of HZ over the total number of ED visits, multiplied by 100.

months (June through August). Overall, 7.2% of patients who presented to the ED with a primary diagnosis of HZ were admitted, with a mean (SE) length of stay of 4.72 (0.04) days (Table 1). The percentage of patients admitted declined from 2006 to 2013 for all age groups. We found that the overall percentage of HZ-related ED visits (Figure 1), population-based incidence rates (eTable in the Supplement), percentage admitted, and mean ED and inpatient charges, rose with increasing age (Table 2).

From 2006 to 2013, the overall population-based rate for HZ-related ED visits increased from 51.57 to 59.44 per 100 000 persons per year (15.2%). The overall percentage of HZ-related ED visits also increased from 0.13% to 0.14% (8.3%). After stratifying the sample into age groups (<20, 20-59, and ≥60 years), the percentage of ED HZ visits from 2006 to 2013 increased for patients 20 to 59 years from 0.12% to 0.14% (22.8%) (Figure 1). The percentage of ED HZ visits decreased for the <20 years and 60 years or older groups, from 0.03% to 0.02% (−39.6%) and from 0.28% to 0.25% (−10.9%), respectively ($P < .001$ for the change in odds of an HZ visit by year for all age groups).

For all age groups, there was an increase from 2006 to 2013 in overall adjusted total (from \$92.83 to \$202.47 million) and mean charges (from \$763 to \$1262) for HZ-related ED visits (Figure 2 and Figure 3). For patients 60 years or older, although incidence rates declined, total charges increased by 110%. This rise was due to an increase in that population, as well as a greater mean charge per visit. Adjusted mean charges per HZ-related ED visit increased the most for patients 60 years or older (75.5%) from 2006 to 2013 compared with those 20 to 59 years (57.3%) and less than 20 years (58.6%) (Figure 3). The increases in adjusted mean charges per ED visit for HZ outpaced those seen for all ED visits for any indication for patients 60 years or older and those less than 20 years, which increased by 72.8% and 45.9%, respectively, but were similar for the 20- to 59-year age group (59.5%).

Table 2. Nationwide ED Visit Characteristics for All Indications and HZ Stratified by Age Group From 2006 to 2013

Characteristic	Year								
	2006	2007	2008	2009	2010	2011	2012	2013	
Age <20 y									
Population, No.	82 510 125	82 783 310	83 018 887	83 634 477	83 397 926	83 021 612	82 719 360	82 498 316	
ED visit characteristics for all indications									
Total ED visits, No.	30 425 292	31 060 816	30 650 811	32 762 889	29 741 232	31 059 334	31 844 647	30 413 756	
Charge for ED services, mean (SE), \$ ^a	1148 (23)	1239 (26)	1326 (30)	1386 (25)	1497 (31)	1515 (31)	1577 (35)	1675 (51)	
Total charges for ED services, \$	27 604 962 894	31 016 967 070	33 567 535 354	37 817 436 806	37 929 885 649	40 307 149 676	42 373 213 149	43 142 472 175	
HZ visit characteristics									
ED visits for HZ, No. (%)	9628 (0.03)	9907 (0.03)	9427 (0.03)	8534 (0.03)	7969 (0.03)	7981 (0.03)	6818 (0.02)	5814 (0.02)	
Incidence rate of ED visits for HZ per 100 000 ^b	11.67	11.97	11.36	11.36	10.20	9.56	9.61	8.24	7.05
Charge for ED services, mean (SE), \$	506 (24)	555 (21)	627 (31)	633 (24)	701 (24)	744 (27)	756 (27)	802 (39)	
Total charges for ED services, \$	3 838 645	4 366 860	4 822 975	4 482 483	4 870 170	5 106 371	4 302 108	3 923 266	
Admitted as inpatient, No. (%)	448 (4.65)	408 (4.12)	348 (3.69)	210 (2.45)	256 (3.21)	249 (3.13)	263 (3.85)	214 (3.68)	
Inpatient characteristics									
Length of stay, mean (SE), d	4.41 (0.49)	4.37 (0.39)	4.13 (0.38)	5.08 (0.73)	4.57 (0.34)	3.78 (0.47)	4.09 (0.43)	3.72 (0.41)	
Charge for ED plus inpatient services, mean (SE), \$	28 561 (5940)	24 024 (3576)	21 239 (2507)	29 088 (5390)	27 690 (3202)	21 886 (3288)	27 499 (4402)	24 244 (4926)	
Age 20-59 y									
Population, No.	166 128 280	166 382 782	166 953 613	167 846 047	168 438 960	169 294 391	170 089 273	170 737 933	
ED visit characteristics for all indications									
Total ED visits, No.	64 972 939	66 075 155	67 978 994	69 279 077	71 647 180	71 405 870	73 497 562	73 842 551	
Charge for ED services, mean (SE), \$	1867 (37)	2002 (41)	2207 (46)	2356 (44)	2549 (55)	2629 (59)	2799 (68)	2977 (66)	
Total charges for ED services, \$	94 203 165 826	109 477 696 851	125 491 584 720	138 226 816 785	157 062 583 739	161 294 145 239	176 989 085 885	189 814 844 037	
HZ visit characteristics									
ED visits for HZ, No. (%)	75 514 (0.12)	78 999 (0.12)	82 187 (0.12)	84 794 (0.12)	91 765 (0.13)	93 395 (0.13)	101 677 (0.14)	105 421 (0.14)	
Incidence rate of ED visits for HZ per 100 000	45.46	47.48	49.23	50.52	54.48	55.17	59.78	61.74	

(continued)

Table 2. Nationwide ED Visit Characteristics for All Indications and HZ Stratified by Age Group From 2006 to 2013 (continued)

Characteristic	Year							
	2006	2007	2008	2009	2010	2011	2012	2013
Charge for ED services, mean (SE), \$	688 (18)	723 (18)	791 (22)	848 (22)	934 (24)	992 (27)	1019 (28)	1083 (30)
Total charges for ED services, \$	41 267 503	47 083 261	53 759 336	60 892 935	73 997 148	79 204 880	88 536 491	98 522 963
Admitted as inpatient, No. (%)	3313 (4.39)	3320 (4.20)	3402 (4.14)	3641 (4.29)	3566 (3.89)	3934 (4.21)	3829 (3.77)	3629 (3.44)
Inpatient characteristics								
Length of stay, mean (SE), d	4.24 (0.14)	4.20 (0.13)	4.43 (0.15)	4.23 (0.17)	4.19 (0.17)	4.30 (0.14)	4.21 (0.15)	4.45 (0.44)
Charge for ED plus inpatient services, mean (SE), \$	26 103 (1515)	25 989 (1394)	28 752 (1410)	26 747 (1817)	28 619 (1484)	30 673 (1922)	30 066 (1556)	32 201 (3865)
Age ≥60 y								
Population, No.	50 760 080	52 455 067	54 087 228	55 526 032	57 512 803	59 275 916	61 105 407	62 892 590
ED visit characteristics for all indications								
Total ED visits, No.	24 634 675	25 194 096	26 314 582	26 842 098	27 581 197	28 582 165	29 056 674	30 612 393
Charge for ED services, mean (SE), \$	2215 (41)	2345 (46)	2659 (54)	2952 (58)	3064 (65)	3244 (75)	3498 (81)	3827 (84)
Total charges for ED services, \$	38 990 919 074	44 982 575 497	54 030 777 472	62 871 053 040	68 580 817 883	76 249 469 658	83 774 908 653	96 079 414 196
HZ visit characteristics								
ED visits for HZ, No. (%)	69 268 (0.28)	70 151 (0.28)	67 924 (0.26)	68 642 (0.26)	69 929 (0.25)	73 259 (0.26)	75 279 (0.26)	76 662 (0.25)
Incidence rate of ED visits for HZ per 100 000	136.46	133.74	125.58	123.62	121.59	123.59	123.20	121.89
Charge for ED services, mean (SE), \$	883 (22)	969 (24)	1130 (36)	1226 (34)	1321 (35)	1363 (37)	1447 (38)	1549 (57)
Total charges for ED services, \$	47 722 442	54 856 363	62 283 913	68 589 539	77 211 199	84 757 783	92 423 503	100 020 113
Admitted as inpatient	8470 (12.2)	8704 (12.4)	8350 (12.3)	8789 (12.8)	8258 (11.8)	8779 (12.0)	8015 (10.6)	7226 (9.4)
Inpatient characteristics								
Length of stay, mean (SE), d	4.79 (0.11)	4.88 (0.11)	4.99 (0.12)	5.02 (0.11)	5.09 (0.13)	5.01 (0.12)	4.75 (0.11)	4.85 (0.14)
Charge for ED plus inpatient services, mean (SE), \$	27 343 (1200)	26 754 (1179)	30 431 (1315)	31 137 (1097)	31 926 (1322)	32 529 (1410)	33 525 (1323)	33 416 (1176)

Abbreviations: ED, emergency department; HZ, herpes zoster.

^a All charges adjusted to 2016 dollars.^b Population-based cumulative incidence rates were calculated using US Census Bureau American FactFinder.¹⁶

Figure 2. Percentage of Total Emergency Department (ED) Visits With Primary Diagnosis of Herpes Zoster (HZ) and Associated Annual Charge for ED Services From 2006 to 2013

Proportion of ED visits for HZ and charge for HZ-related ED services from 2006 to 2013 overall (A), in patients aged less than 20 years (B), 20 to 59 years (C), and 60 years or older (D). All charges were adjusted to 2016 dollars using the Consumer Price Index adjustments for medical care.

Figure 3. Mean Charge per Emergency Department (ED) Visit for Herpes Zoster in 2006 and 2013

All charges were adjusted to 2016 dollars using the Consumer Price Index adjustments for medical care.

Discussion

We identified increasing utilization and costs associated with treatment of HZ in US EDs. Although the overall proportion of ED visits for HZ is increasing marginally (0.13% to 0.14% from 2006 to 2013), stratification by age revealed that this growth is driven by patients between ages 20 and 59 years, while younger and older patients have had fewer ED visits for HZ over time. We found that a higher percentage of women presented

to the ED with HZ (58.3%), which is consistent with the results of almost all studies identifying a greater disease burden among women.² However, women were also higher utilizers of the ED for any indication (Table 1).

The trends in ED utilization may reflect a combination of influences. Patients seen in the ED for HZ must (1) develop HZ and (2) choose the ED as their venue of care. The trends that we observed thus could be attributable to trends in the incidence of HZ and/or ED utilization among different age groups. We found that, although the overall incidence rate of ED visits for all indications for patients 60 years or older and those less than 20 years remained stable from 2006 to 2013, there was a decrease in the rate of ED visits for HZ for these age groups. This finding suggests that the observed decrease may be due to a reduced disease incidence among individuals vaccinated for varicella (<20 years) and those who qualify for HZ vaccination (≥60 years), potentially providing further insight into the population-level impact of vaccination.

Although we found a significant difference in the proportion of ED visits related to HZ before and after the recommended use of the HZ vaccine in 2008 ($P < .001$) in the 60 years or older age group, we were unable to perform a similar analysis examining the effect of the varicella vaccination (which was introduced into the vaccination schedule in 1995) on HZ incidence in the younger than 20-year age group since the NEDS database started in 2006. Thus, the decline seen in this population could have been associated with other factors. However, the decrease in HZ incidence in patients aged less than

20 years is consistent with prior studies in the outpatient setting that found a stabilization or decrease in age-specific incidence of HZ in the varicella-vaccinated population before and after 1996.^{4,5} Among patients aged 20 to 59 years, there was an increase in the rate of HZ-related ED visits from 2006 to 2013, which may have been partially due to an elevated rate of ED visits for all indications in this age group. However, HZ-related ED visits represented an increasing percentage of all ED visits over this time period, which suggests a rising disease incidence in this age group.

Other studies have found an increasing incidence of HZ in the United States and other countries, consistent with our findings.^{2,18-21} The cause for this elevation in disease burden is unclear and is likely multifactorial. The age-specific increased rate of HZ-related ED visits in patients aged 20 to 59 years may be explained in part by the Hope-Simpson hypothesis that increased varicella zoster virus vaccination has led to a rise in overall HZ incidence.⁷ However, other studies have found that the rate of HZ was rising before introduction of routine varicella zoster virus vaccination and that this increased rate did not accelerate after routine vaccination was started.¹⁹ Unfortunately, the NEDS data collection began in 2006 and we could not examine prior trends.

The substantial increase in costs is also likely to be multifactorial. The NEDS database does not provide insight into the treatments administered at each visit, and it is unclear whether changes in practice (additional testing or imaging) or increased costs for similar therapeutics are the culprit.

These findings suggest that, although vaccination rates may be correlated with a broader effect on HZ incidence and downstream utilization of ED services, reduction in disease incidence or ED presentation may be insufficient to reduce overall health care expense. Further research is needed to identify drivers of increased costs and implement interventions to streamline treatment and evaluation of patients with HZ. Currently, there is a subunit vaccine containing varicella zoster virus glycoprotein E and the AS01B adjuvant system (called HZ/su) being evaluated for the prevention of HZ. Because it is not a live vaccine, the HZ subunit vaccine is considered safe for individuals who are immunocompromised and has been found to have an efficacy rate of 97.2% in adults 50 years or older in

a phase 3 trial. This vaccine may provide a means by which we can reverse the disease burden and associated costs of HZ in this population.²²

Limitations

These results must be interpreted in the context of our study design. Although we present these changes in ED utilization over a period marked by the introduction of vaccines, this study does not allow us to directly link change in utilization to vaccination. This limitation is especially true in the context of the substantial change in the American health care system that occurred during the study period—the real driver of changes in ED presentation and cost may be larger systems issues. Aside from primary payer type, there are no indicators of changing access to care or health care coverage, and we were not able to adjust for this in our analysis.

Although the NEDS database provides nationally representative estimates for ED utilization, there are limitations to these data. Because this is a publicly available, deidentified data set, validation by medical records review of HZ cases identified by ICD-9-CM codes was not possible. However, prior studies have found that the algorithm used in the present study detected HZ with a positive predictive value of 85% or more.¹³⁻¹⁵ In addition, because our study was limited to ED visits, the results may not be generalizable to the outpatient setting.

Our findings should be corroborated in other data sets, especially those including outpatient visits for HZ, that allow for evaluation of the impact of patient characteristics and validation of our findings in other settings outside of the ED.

Conclusions

Our study found an increase in total ED visits associated with HZ between 2006 and 2013 due to an increased number of visits by patients aged 20 to 59 years. Despite decreased utilization in patients aged less than 20 years and 60 years or older, we found increased total adjusted charges in these populations. Our findings suggest that vaccination may be associated with a reduction of ED utilization. Further research is necessary to identify the drivers of increased costs.

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Author Contributions: Drs Joyce and Mostaghimi had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Dommasch, Mostaghimi.
Acquisition, analysis, or interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: All authors.

Administrative, technical, or material support: Mostaghimi.

Supervision: Dommasch, Mostaghimi.

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