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Herpes Zoster-Attributable Resource Utilization and Cost Burden in Patients With Solid Organ Transplant

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Objectives. To evaluate health-care utilization and costs attributable to herpes zoster (HZ) within a population of patients with solid organ transplant (SOT).

Methods. Using administrative claims data, a commercially/Medicare-insured population of patients with SOT between January 1, 1999, and January 1, 2007, and a Medicaid population between January 1, 1999, and January 1, 2006, were identified. Each patient group was screened to select patients with claims of SOT with an incident diagnosis of HZ and continuous enrollment for the 6 months prior and 3 months subsequent to the incident HZ. Controls were selected from group of SOT patients without claims of HZ using a propensity score matching process. Descriptive analyses were performed to quantify health-care utilization and costs attributable to HZ. Multivariate analyses were used to estimate HZ-attributable costs adjusted by demographic and clinical variables.

Results. A total of 205 commercially/Medicare-insured matched pairs and 136 Medicaid matched pairs were selected. Mean age in the commercial/Medicare SOT-HZ population was 56.9 years, and that in the Medicaid population was 42.5 years. The majority of HZ patients were diagnosed within 2 years of evidence of SOT. The unadjusted differences in total HZ-attributable health-care costs were $4762 and $6705 for commercial/Medicare-insured and Medicaid patients, respectively (P=0.176 and P=0.003, respectively) and were largely driven by hospitalization costs. Adjusted incremental costs in the SOT-HZ commercial/Medicare-insured patients were $5335 ($P$<0.001), and that in noncapitated Medicaid patients were $3711 ($P$<0.001).

Conclusion. The occurrence of HZ in patients immunocompromised by SOT significantly increased health-care utilization and costs.

Key Words: Cost analysis, Resource use, Herpes zoster, Immunocompromise, Solid organ transplant.

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Herpes zoster (HZ) is common in the U.S. population—with approximately one in three persons in the general population developing HZ in their lifetime (*1*). The annual incidence rate is estimated at one million cases per year (*2*). Older adults and persons who are immunocompromised are more likely to experience severe HZ pain, which impacts activities of daily living, overall quality of life, and health-care resource utilization (HRU) (*3*).

The risk of HZ is particularly high in immunocompromised persons including those with a history of solid organ transplant (SOT) (*4–6*). Gourishankar et al. (*4*) found that approximately 9% of solid organ transplant recipients developed HZ; the majority developed HZ within 1 to 2 years following the procedure. Although research indicates that costs are almost twice as high among patients with both HZ and an immunocompromising condition relative to patients with only HZ infection (*7, 8*), few studies have examined the incremental impact of HZ within an immunocompromised population. Studies that have evaluated costs of HZ in immunocompromised patients have evaluated the population as a whole and have not focused on subpopulations of interest.

Because transplant patients have high rates of hospitalizations and their condition increases the complexity of care and the risk of serious disease (*9*), the assumption may be that the incremental costs of HZ are relatively minor. However, studies have shown that the severity and cost of HZ disease are greater in the broad immunocompromised population compared with the general population (*10*). We hypothesized that HZ-related HRU and costs in the SOT population would be clinically and statistically higher

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because of the high degree of immunosuppression in this patient population. The objective of the current study was to measure HRU and costs attributable to HZ within a population of patients after a SOT and to evaluate these costs relative to a group of matched SOT patients without evidence of HZ.

MATERIALS AND METHODS

Study Design

A retrospective study of patients with SOT was conducted using administrative claims from the Truven Health MarketScan Databases. Patients were selected into mutually exclusive groups and matched using propensity score analysis; the exposed cohort group includes patients with HZ (SOT-HZ) and the unexposed cohort includes patients without evidence of HZ (SOT-only). HZ-related utilization and costs were analyzed descriptively for the period of the HZ episode (among SOT-HZ patients) and for a corresponding time period in the SOT-only cohort. Multivariate analyses were used to evaluate the relationship between HZ and incremental costs. Analyses were performed separately for patients with commercial and Medicaid coverage.

Data Sources

Data for the Commercial Claims Database and the Medicare Supplemental Database (Commercial/Medicare) contains the healthcare experience of several million individuals annually, and the Medicaid Database contains the pooled health-care experience of more than 10 million enrollees in geographically dispersed states of varying population size. Coverage is provided under a variety of fee-for-service and managed care health plans covering inpatient services, outpatient services, and prescription drug claims.

Patient Selection

Patients with a claim for a SOT between January 1, 1999, and September 30, 2007, (Commercial/Medicare) and between January 1, 1999, and September 30, 2006, (Medicaid) were selected for study inclusion. Evidence of SOT was based on the presence of a procedure of interest (*International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* codes: 33.5x, 33.6, 37.51, 46.97, 50.5x, 52.80, 52.82, 52.83, 55.6x; Healthcare Common Procedure Coding System (HCPCS) codes: S2053, S2054, S2060, S2065; or Current Procedural Terminology (CPT) codes: 32851-32854, 33935, 33945, 44135, 44136, 47135, 47136, 48554, 50360, 50365, 50380). Patients (0.5% of commercial/Medicare patients; 2.0% of Medicaid patients) were excluded from the analysis if there was evidence in the claims history indicating administration of the herpes zoster vaccine, the varicella virus vaccine, or the measles, mumps, rubella, and varicella virus vaccine. Because of prescription drug coverage changes associated with Medicare Part D, patients whose study period extended into 2006 and were dually eligible for Medicaid and Medicare were also excluded from the analysis.

Identification of SOT-HZ and SOT-Only Cohorts

Claim histories for SOT patients were evaluated for a diagnosis for HZ (ICD-9-CM codes 053.xx). Patients with evidence of HZ were assigned to the SOT-HZ cohort and claim date for the first HZ occurrence was selected as "index date." Patients were included in the analysis if they had continuous health-care insurance and prescription drug coverage for 6 months prior and 3 months following index date. Index date was required to occur subsequent to SOT procedure. Patients without evidence of HZ were assigned to the control group (SOT-only). SOT-only patients were required to have a minimum of 3 months of continuous health-care insurance and prescription drug coverage after the SOT procedure. Direct matching was used to match on year of SOT procedure. Propensity score matching was then used to match patients (1:1) in the two cohorts based on sex, age group, plan type, race (Medicaid only), basis of eligibility (Medicaid only), state of residence (Medicaid only), and months of continuous eligibility after initial SOT procedure. Months of continuous eligibility after initial procedure were used to ensure comparability of recent transplant patients and long-term recipients. After matching, an index date was randomly assigned to patients in the SOT-only cohort, and continuous eligibility and timing of SOT relative to index date was reassessed. If a control did not meet these criteria, the case-control pair was excluded from the study.

Variable Definitions

Demographic variables were assessed at index date and included sex, mean age, age group, index date year, and time from initial SOT procedure to index date. Commercial/Medicare patients were also described by U.S. Census groupings and urban/rural, whereas Medicaid patients were described by race, insurance plan type, and basis of eligibility.

The presence of opportunistic infections and medications associated with immunosuppression was evaluated for both cohorts for the study period. The administration of intravenous therapy (IV) acyclovir (presence of claim for IV acyclovir within 7 days of patient's index date) was assessed for both cohorts during the 3-month period after the index date. Variables were assessed solely for the SOT-HZ cohort during the 3 months after the index date included the presence of HZ-related hospitalizations (principal diagnosis of 0.53xx), disseminated HZ including rash and viremia (diagnosis of viremia 790.8 and HZ 0.53xx on same claim), ophthalmic HZ (claim with diagnosis code 0.53.2x), and HZ neurologic impairment (claim with diagnosis code 0.53.1x).

Using a methodology adapted from Insinga et al., HZ-attributable utilization and costs were measured for the HZ episode (or corresponding time period in controls). The episode was defined to be consistent with measurement of outcomes for acute/subacute HZ, which has been previously defined as the 21-day period before incident HZ diagnosis and the 90-day period after index date (*8*). Use of this period allows inclusion of care for prodromal symptoms of HZ, and the 90-day period subsequent to the diagnosis limits inclusion of care for longer term complications of HZ. The 90-day period examined in the current analysis reflects the prodromal and acute/subacute phase. This period was selected because it provides cost information without introducing "noise" related to medical resource utilization for non–HZ-related care during the longer follow-up period. Previous research has shown that the majority of HZ-related costs are incurred during this earlier time period (*7, 11*). The current study adapted the medication list used in the Insinga et al. to include new classes of drugs and new entries within existing drug classes that may be used in the management of HZ (*8*).

HZ-attributable utilization included inpatient admissions, emergency room (ER) visits, outpatient visits, and outpatient prescriptions. HZ-attributable costs were calculated for each of these service categories as well as for overall costs. Costs were determined based on payments from insurer and patient (deductibles, coinsurance, and copayments) and were adjusted to 2007 dollars using the consumer price index.

Analyses

Frequency and percentage are reported for categorical variables, and statistical differences between the SOT-HZ and SOT-only cohorts were tested using chi-square tests. Mean and standard deviation are reported for continuous variables, and differences were assessed using *t* tests.

A second-stage regression was estimated to control for any remaining differences between case and control cohorts. HZ-attributable costs were evaluated using a two-part model. The first part of the model (logistic regression) was used to estimate whether patients have HZ-attributable costs, whereas the second part of the model (negative binomial generalized estimating equation) was used to predict costs.

In addition to the cohort variable, the following independent variables were included in the models: dual eligibility for Medicare, region of residence (Commercial/Medicare only), urban/rural residence, presence of opportunistic conditions during preperiod, and presence of medications associated with immunosuppression.

RESULTS

Characteristics of Cases and Controls

Demographic characteristics for Commercial/Medicare and Medicaid populations included in the analysis are presented in Table 1. A total of 205 commercial/Medicare and 136 Medicaid matched pairs met the study selection criteria

TABLE 1. Demographic characteristics of study sample

	Commercial and Medicare population					Medicaid population				
	HZ group		Control group			HZ group		Control group		
	N=205		N=205			N=136		N=136		
	N	%	N	%	*P*	N	%	N	%	*P*
Sex										
Male	118	57.6%	126	61.5%	0.421	60	44.1%	72	52.9%	0.145
Female	87	42.4%	79	38.5%	0.421	76	55.9%	64	47.1%	0.145
Age group										
≤17	1	0.5%	3	1.5%	0.315	20	14.7%	16	11.8%	0.474
18–34	5	2.4%	6	2.9%	0.76	25	18.4%	29	21.3%	0.543
35–44	16	7.8%	19	9.3%	0.596	19	14.0%	13	9.6%	0.259
45–54	45	22.0%	49	23.9%	0.638	27	19.9%	30	22.1%	0.655
55–64	95	46.3%	89	43.4%	0.551	37	27.2%	39	28.7%	0.787
65+	43	21.0%	39	19.0%	0.621	8	5.9%	9	6.6%	0.802
Mean (SD) age	56.9	10.3	55.9	11.6	0.914	42.5	17.5	43.1	18.4	0.933
Year of index										
1999	2	1.0%	2	1.0%	NA					
2000	1	0.5%	1	0.5%	NA	3	2.2%	3	2.2%	NA
2001	9	4.4%	9	4.4%	NA	16	11.8%	16	11.8%	NA
2002	20	9.8%	20	9.8%	NA	27	19.9%	27	19.9%	NA
2003	36	17.6%	36	17.6%	NA	28	20.6%	28	20.6%	NA
2004	26	12.7%	26	12.7%	NA	33	24.3%	33	24.3%	NA
2005	56	27.3%	56	27.3%	NA	29	21.3%	29	21.3%	NA
2006	55	26.8%	55	26.8%	NA					
Time to HZ										
Within Year 1	63	30.7%	61	29.8%	0.83	61	44.9%	60	44.1%	0.903
Within Year 2	68	33.2%	71	34.6%	0.754	43	31.6%	42	30.9%	0.896
Within Year 3	40	19.5%	38	18.5%	0.801	19	14.0%	22	16.2%	0.611
Within Year 4	22	10.7%	21	10.2%	0.872	10	7.4%	6	4.4%	0.303
Year 5 or more	12	5.9%	14	6.8%	0.685	3	2.2%	6	4.4%	0.309
Geographic region										
Northeast	20	9.8%	21	10.2%	0.869					
North Central	74	36.1%	76	37.1%	0.838					
South	77	37.6%	75	36.6%	0.838					
West	33	16.1%	32	15.6%	0.892					
Unknown	1	0.5%	1	0.5%	NA					
Urban rural residence	162	79.0%	175	85.4%	0.093					
Urban	42	20.5%	30	14.6%	0.119					
Rural	1	0.5%	0	0.0%	0.317					
Unknown	162	79.0%	175	85.4%	0.093					
Insurance plan type										
Noncapitated						113	83.1%	107	78.7%	0.355
Capitated						23	16.9%	29	21.3%	0.355
Race										
White						61	44.9%	58	42.6%	0.714
Black						19	14.0%	23	16.9%	0.502
Hispanic						23	16.9%	30	22.1%	0.284
Other						24	17.6%	16	11.8%	0.171
Unknown						9	6.6%	9	6.6%	NA
Basis of eligibility										
Aged/poverty related						3	2.2%	5	3.7%	0.473
Blind/disabled individual						104	76.5%	111	81.6%	0.297
Other						29	21.3%	20	14.7%	0.156

and remained after the propensity score matching process. The majority of patients in the commercial/Medicare cohort had a kidney transplant (63.6%) followed by liver (19.8%) and heart transplants (10.2%). The distributions were similar among those in the Medicaid group (kidney [58.4%], liver [23.2%], and heart [14.0%]). Patients in the commercial/Medicare population were mostly male, whereas male and female subjects were equally represented in the Medicaid population. Patients in the SOT-HZ and SOT-only commercial/Medicare cohort were generally older than patients in the respective Medicaid cohorts. More than 60% of patients in both the commercial/Medicare and Medicaid populations were diagnosed with HZ within 2 years of their SOT procedure. Patients with Medicaid coverage were predominantly white, and the primary reason for Medicaid eligibility in the SOT-HZ and SOT-only populations was blindness/disability status. Postmatching, there were no significant differences in demographic characteristics between the SOT-HZ and SOT-only groups in either the commercial/Medicare or Medicaid populations.

During the preperiod, the majority of patients in the commercial/Medicare and Medicaid populations had evidence of at least 1 medication associated with immunosuppression; the percentage of patients with these medications continued to be high during the postperiod. Few patients had evidence of an opportunistic infection during the preperiod (Table 2). The rate of opportunistic infections was much higher in the postperiod than in the preperiod across all cohorts.

Risk of HZ-specific sequela was relatively low with no evidence of disseminated HZ, rash or viremia and few patients with a diagnosis of ophthalmic or neurologic impairment because of HZ. HZ-related hospitalizations were also relatively rare—10.2% of commercial/Medicare SOT-HZ and 20.6% of Medicaid SOT-HZ patients.

Utilization and Costs

Regardless of service type, patients in the SOT-HZ cohorts (in both Commercial/Medicare and Medicaid groups) had statistically more visits than in the SOT-only cohorts. The mean number of prescription medications was also significantly greater in the commercial/Medicare and Medicaid SOT-HZ groups than in the SOT-only comparators. Total health-care costs were higher for the SOT-HZ groups in both

TABLE 2. Clinical characteristics of study sample

	Commercial and Medicare population					Medicaid population				
	HZ group N=205		Control group N=205			HZ group N=136		Control group N=136		
	N	%	N	%	*P*	N	%	N	%	*P*
Preperiod										
Presence of medications associated with immunocompromise:										
Low	33	16.1%	34	16.6%	0.894	34	25.0%	33	24.3%	0.888
Moderate	20	9.8%	11	5.4%	0.093	12	8.8%	10	7.4%	0.656
High	1	0.5%	0	0.0%	0.317	1	0.7%	0	0.0%	0.316
Very High	94	45.9%	87	42.4%	0.486	81	59.6%	62	45.6%	0.021
Comorbidities/complications										
Presence of opportunistic infections[a]	20	9.8%	11	5.4%	0.093	15	11.0%	8	5.9%	0.127
Postperiod										
Presence of medications associated with immunocompromise:										
Low	96	46.8%	83	40.5%	0.195	94	69.1%	77	56.6%	0.033
Moderate	36	17.6%	29	14.1%	0.344	15	11.0%	20	14.7%	0.365
High	5	2.4%	1	0.5%	0.1	1	0.7%	0	0.0%	0.316
Very High	166	81.0%	159	77.6%	0.394	123	90.4%	107	78.7%	0.007
Comorbidities/complications										
Presence of opportunistic infections[a]	45	22.0%	35	17.1%	0.213	28	20.6%	26	19.1%	0.761
Hospitalization due to HZ	21	10.2%	0	0.0%	<0.001	28	20.6%	0	0.0%	<0.001
Administration of IV acyclovir[b]	2	1.0%	0	0.0%	0.156	1	0.7%	0	0.0%	0.316
Disseminated HZ including rash and viremia	0	0.0%	0	0.0%	n/a	0	0.0%	0	0.0%	n/a
Ophthalmic HZ	25	12.2%	0	0.0%	<0.001	14	10.3%	0	0.0%	<0.001
Neurological impairment due to HZ	27	13.2%	0	0.0%	<0.001	15	11.0%	0	0.0%	<0.001

[a] Tuberculosis (TB), disseminated mycobacterium avium-intracellulare complex (DMAC), Mycobacterium avium-intracellulare complex (MAC) bacteremia, hepatitis (A, B or C), cytomegaloviral disease (CMV), candidiasis of the mouth, toxoplasmosis, pneumocystosis, Kaposi's sarcoma, anemia, and other bacterial pneumonia.

[b] Having a claim with the HCPCS code or NDC for IV acyclovir within 7 days of the patient's index date; for HZ cases, that was the date of incident HZ diagnosis; for controls, the index date was randomly assigned.

TABLE 3. Health-care utilization and costs 21 days before index date to 90 days postindex date

	Commercial and Medicare population						Medicaid population					
	HZ group N=205		Control group N=205				HZ group N=136		Control group N=136			
	Mean	SD	Mean	SD	Difference	*P*	Mean	SD	Mean	SD	Difference	*P*
Total health-care costs	$8086	$35,150	$3324	$36,014	$4762	0.176	$8682	$24,694	$1977	$8884	$6705	0.003
Inpatient admissions												
Mean no. admissions	0.30	0.67	0.05	0.23	0.25	<0.001	0.45	0.69	0.07	0.28	0.38	<0.001
Mean length of stay	1.60	3.88	0.63	5.51	0.97	0.04	2.81	8.31	0.62	3.53	2.19	0.005
Mean costs	$6524	$34,784	$2883	$36,020	$3640	0.299	$7427	$24,641	$1398	$8449	$6028	0.007
No. ER visits												
Mean no. Visits	0.32	0.57	0.06	0.26	0.26	<0.001	0.49	0.86	0.10	0.35	0.39	<0.001
Mean costs	$82	$226	$39	$225	$42	0.059	$71	$233	$69	$475	$2	0.97
No. outpatient office visits												
Mean no. Visits	1.53	1.46	0.18	0.58	1.35	<0.001	1.06	1.34	0.16	0.49	0.90	<0.001
Mean costs	$103	$111	$13	$47	$90	<0.001	$30	$61	$3	$15	$27	<0.001
No. other outpatient services												
Mean no. Visits	2.92	4.47	1.01	2.26	1.91	<0.001	3.92	6.85	1.24	3.07	2.68	<0.001
Mean costs	$854	$3065	$225	$816	$630	0.005	$617	$1809	$298	$2092	$319	0.179
No. outpatient prescriptions												
Mean no. prescriptions	8.66	5.44	4.02	3.97	4.64	<0.001	9.96	8.30	6.37	4.98	3.60	<0.001
Mean costs	$523	$488	$163	$267	$360	<0.001	$537	$810	$208	$383	$329	<0.001

the commercial/Medicare and Medicaid populations. Commercial/Medicare SOT-HZ patients had unadjusted incremental costs that were $4762 greater than their SOT-only counterparts, and Medicaid SOT-HZ patients had costs that were $6705 higher than SOT-only patients. Inpatient admission costs accounted for the largest share of these overall health-care costs (Table 3).

After adjustment, the incremental costs for SOT-HZ patients were significantly greater than the control group patients in both the commercial/Medicare and Medicaid populations. Among commercial/Medicare patients, those with HZ infection had incremental total health-care costs $5335 higher than patients without HZ infection (Fig. 1). In the Medicaid population, adjusted incremental costs for HZ-attributable services in the SOT-HZ population were $3711 greater than in the SOT-only population (Fig. 2).

DISCUSSION

This study reports incremental HRU and costs associated with HZ infection in a population of SOT patients. Study findings indicate that SOT-HZ patients had significantly more HRU across all service types. With the exception of inpatient costs in the commercial/Medicare population, incremental costs were greater in SOT-HZ patients across all service types. The adjusted incremental costs of HZ during the acute/subacute period were $5335 for commercial/Medicare and $3711 for the Medicaid patients.

To our knowledge, this is the first study to evaluate HZ costs among patients with SOT. In an evaluation using medical records, Yawn and colleagues (*11*) found that during the acute/subacute period, the mean number of hospitalizations, ER visits, outpatient visits, and prescribed medications was 0.07, 0.20, 2.39, and 4.35 respectively; incremental HZ attributable cost during the acute/subacute phase was $1112. Similarly, a study by Insinga et al. (*8*) using administrative claims found HZ was associated with an additional 0.05 ER visits, 0.03 hospital admissions, 1.7 additional outpatient visits, and 2.1 additional prescriptions filled, with incremental costs of $431. Differences in utilization and costs among patients in the current study were similar for some services but much higher for others. Both the Insinga et al. (*8*) and Yawn et al. (*11*) analyses focused on a general population with HZ. Differences in incremental service use in the current

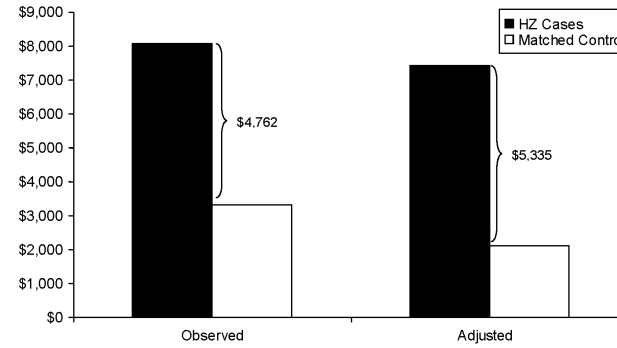

FIGURE 1. Adjusted incremental cost of HZ-attributable services in commercial and Medicare population.

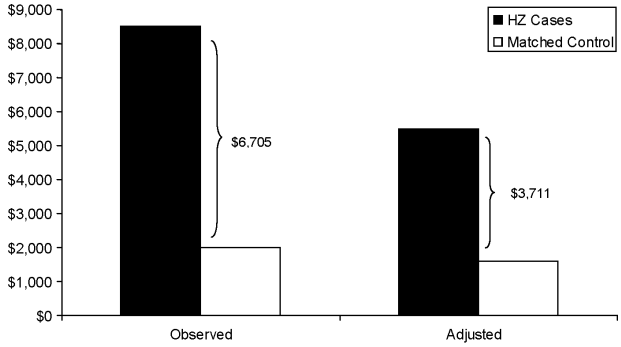

FIGURE 2. Adjusted incremental cost of HZ-attributable services in Medicaid population.

analysis may be the result of the underlying health of the study population, which we attempted to control for by adjusting for presence of medications associated with immunosuppression.

When considering health-care costs among immunocompromised patients, White et al.(*7*) estimated incremental cost differences at 1 year between HZ cases and controls of $1745 in immunocompromised patients. Estimates by Insinga et al. (*8*) were lower, with 90-day incremental costs of $674 for immunocompromised patients. Finally, Yawn et al. (*11*) reported mean per-patient costs of $3633 in the immunocompromised for the 3 week prediagnosis through 1-year postdiagnosis period. Adjusted incremental costs (commercial/Medicare: $5,335; Medicaid: $3,711) in the current study were higher during the acute/subacute period and provides insight into the impact of HZ on SOT cost burden.

Incremental HZ-attributable costs were generally lower in the Medicaid population than in the commercial/Medicare population. The reason for this is not immediately clear but could be the result of differences in health-care reimbursement. Similar results were observed by Dworkin et al. (*12*) who found that HZ-associated costs were greater among commercially/Medicare-insured patients than in Medicaid patients. That said, although lower in the Medicaid cohort than in the commercial/Medicare population, incremental costs are similar for the two populations and are confirmatory of each other.

A number of approaches have been documented to identify HZ-attributable costs using claims data. White et al. (*7*) attributed costs to HZ using regression analyses based on all services received by patients, with the incremental cost estimate reflecting the difference between HZ and control patients. Dworkin et al. (*12*) used a similar methodology. Insinga et al. (*6*) attributed costs to HZ using regression analyses based on select services identified as likely to represent HZ care. In that study, only 49% of HZ costs resulted from claims with a HZ diagnosis code, whereas 32% and 19% resulted from prescriptions and symptom-based diagnosis codes, respectively. Although a substantial proportion of costs in these studies came from services without an HZ diagnosis code, estimates were similar to and, in some cases, lower than estimated in the chart review study by Yawn et al. (*11*) underscoring the importance of using a broader definition of services for attribution to HZ to avoid underestimation of costs.

The cost estimates reported for this analysis are largely driven by hospitalization costs. Differences in the unadjusted hospitalization costs for HZ cases and controls in the commercial/Medicare group were not statistically significant; however, the large variance in hospitalization costs require either very large differences or sample sizes to have the necessary statistical power to detect significant differences. Because impact of hospitalization costs on overall HZ costs was not a primary objective of this analysis, they were not evaluated using multivariate modeling techniques; however, variances would likely be smaller had this been completed. Hospitalization cost variances in the Medicaid group were much lower, and the unadjusted incremental hospital costs were highly significant. Ten to 20% of HZ cases had evidence of hospitalization, and mean number of hospitalizations among HZ cases was significantly higher.

This study has several potential limitations. First, administrative coding was used for selection of SOT patients and HZ-status differentiation. Thus, the accuracy of provider diagnosis and coding determined who potentially would be included in this analysis. Because SOT is a condition/procedure of consequence and is not a subjective diagnosis or procedure, we would expect miscoding to be low. There is also the potential for misclassification associated with the diagnosis of HZ; however, previous research indicates clinician diagnosis of HZ is greater than 90% reliable (*13, 14*). HZ identification is also dependent on the recording of this diagnosis in a health-care record. Individuals who do not seek medical care will not be identified; although the frequency with which this occurs is unknown, we expect that patients with serious medical conditions like SOT would be more likely to seek medical care. Despite using a broader definition of services to estimate HZ-attributable costs, as defined by Insinga et al. (*8*), it is still possible that costs were underestimated. Patients experiencing HZ have varied symptoms and require a wide range of care, which may not be completely captured by the study definition. Furthermore, this study only examined HZ-attributable costs for the 21 days prior and 90 days subsequent to the index date. Costs attributable to chronic HZ were not included, thus it is not possible to estimate impact on the cost burden of SOT patients. Specific to the MarketScan databases, the commercial/Medicare data are based on the health-care experiences of individuals with employer-based or commercially purchased health insurance and may not reflect the experience of individuals with other types of insurance coverage. Although the Medicaid database is pooled from several small and large geographically diverse States, it may not accurately represent Medicaid recipients from all States.

CONCLUSION

Based on results of the present study, HZ is associated with significant incremental costs in both a commercial/Medicare and Medicaid insured population with evidence of SOT. Incremental costs were $5335 in commercial/Medicare population and $3711 in Medicaid population. Although previous studies have estimated HZ-attributable health-care utilization and costs in the general population

and broadly defined immunocompromised populations, current study results support this finding in a population of patients with SOT-related immunosuppression and demonstrate that the cost per HZ case could be higher in SOT patients compared to a more broadly defined immunocompromised population.

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