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# The Medical Cost of Abusive Head Trauma in the United States

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## Abstract

**OBJECTIVES—**Health consequences of shaken baby syndrome, or pediatric abusive head trauma (AHT), can be severe and long-lasting. We aimed to estimate the multiyear medical cost attributable to AHT.

**METHODS—**Using Truven Health MarketScan data, 2003–2011, we identified children 0 to 4 years old with commercial or Medicaid insurance and AHT diagnoses. We used exact case–control matching based on demographic and insurance characteristics such as age and health plan type to compare medical care between patients with and without AHT diagnoses. Using regression models, we assessed service use (ie, average annual number of inpatient visits per patient) and inpatient, outpatient (including emergency department), drug, and total medical costs attributable to an AHT diagnosis during the 4-year period after AHT diagnosis.

**RESULTS—**We assessed 1209 patients with AHT and 5895 matched controls. Approximately 48% of patients with AHT received inpatient care within 2 days of initial diagnosis, and 25% were treated in emergency departments. AHT diagnosis was associated with significantly greater medical service use and higher inpatient, outpatient, drug, and total costs for multiple years after



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the diagnosis. The estimated total medical cost attributable to AHT in the 4 years after diagnosis was $47 952 (95% confidence interval [CI], $40 219–$55 685) per patient with AHT (2012 US dollars) and differed for commercially insured ($38 231 [95% CI, $29 898–$46 564]) and Medicaid ($56 691 [95% CI, $44290–$69 092]) patients.

**CONCLUSIONS—**Children continue to have substantial excess medical costs for years after AHT. These estimates exclude related nonmedical costs such as special education and disability that also are attributable to AHT.

## Keywords

child abuse; shaken baby syndrome; economic analysis

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The health consequences of shaken-baby syndrome, or pediatric abusive head trauma (AHT), can be severe and long-lasting. Survivors of AHT, which refers to conditions resulting from assaults on infants and young children that include violent shaking and blunt impact, can experience physical, neurologic, and behavioral impairments; an estimated two-thirds have significant disability.[1–5] From 2003–2007, an estimated 780 (0.76 per 100 000 person-years) US children age 0 to 4 years old died of AHT, and there were 1759 (8.6 per 100 000 population) nonfatal AHT hospitalizations annually.[5,6] These national estimates were derived by using a new administrative code–based definition of AHT from the Centers for Disease Control and Prevention.[7] Even these figures probably underestimate the extent of AHT. In a detailed single-institution study, 30% of patients with AHT were at first inaccurately diagnosed, and 28% of them were subsequently reinjured.[8]

A recent systematic review assessed available estimates of the medical cost of child maltreatment.[9] Authors examined 12 studies, including 2 that estimated medical costs for pediatric head trauma and brain injury due to abuse,[9,10] and reported notable limitations. Previous studies assessed medical costs based on charges that medical providers submitted to payers, although payments received by providers are a more relevant measure of medical costs. Previous studies did not use recommended statistical techniques to estimate the medical cost attributable to specific health conditions. All studies identified maltreated children primarily through inpatient treatment, and most assessed the cost of a single inpatient admission. Such an approach does not account for victims not treated as inpatients, nor the longer-term associated medical costs.

The comprehensive medical cost of AHT should be quantified, both to estimate a component of the financial impact of AHT and to facilitate comparisons of AHT medical costs with costs for interventions that might reduce AHT occurrence.[11,12] This study aimed to estimate medical costs specific to AHT and to address limitations of previous related medical cost studies. In this study, we estimated the multiyear medical cost attributable to AHT.

# METHODS

## Data and Costs

To isolate the medical cost of AHT from other, unrelated medical costs among patients diagnosed with AHT, we compared a sample of patients with AHT diagnoses with a simulated control cohort of patients without AHT diagnoses who resembled patients with AHT in observable ways. The medical cost attributable to AHT is the cost difference between a child experiencing AHT and a child not experiencing AHT, and not, for example, the cost difference between AHT and nonabusive head trauma. A statistical model that compares the difference in medical cost between children with AHT and those without yields a direct estimate of the cost that could be saved by preventing AHT.

We identified patients with AHT and matched control patients in the Truven Health MarketScan database, 2003–2011.[13] MarketScan reports paid insurance claims and encounters from a selection of large employers, health plans, and government and public organizations.[13] MarketScan reports payments to providers for patients' medical care; charges submitted by providers are not reported. The database is not a population-based surveillance system, and the duration of patient records in MarketScan varies based on patients' insurance coverage. Mortality was not examined in this analysis because MarketScan does not systematically capture mortality data. All costs reported here represent payments to medical providers adjusted to 2012 US dollars, based on the gross domestic product deflator.[14,15]

## Outcome Measures

The primary outcome measures were per-patient average number of medical services by type (ie, numberof inpatient admissions, outpatient visits including emergency department [ED], and drug prescriptions) and per-patient average cost of services by type attributable to AHT at selected endpoints after initial abuse diagnosis. Secondary outcome measures included descriptive characteristics among patients with AHT, such as age at first AHT diagnosis, gender and racial or ethnic distributions, and location of medical services (ie, inpatient or outpatient) where patients were treated immediately after their initial abuse diagnosis. We also estimated 2 episodic costs: the per-patient average costs of an inpatient admission and the ED visit during which AHT was initially diagnosed.

## Patient Samples

We scanned all inpatient and outpatient MarketScan records for patients with commercial or Medicaid insurance to identify payment records with definite or probable AHT diagnoses among children 0 to 4 years old. AHT was defined by a combination of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes and External Cause of Injury codes, based on a recent Centers for Disease Control and Prevention definition (Table 1).[7] Because we were interested in multiyear costs, we limited our analysis to patients with AHT who had ≥6 months of insurance claim data after their initial AHT diagnosis.

We identified approximately 5 control patients without AHT diagnoses for each patient with AHT based on selected characteristics. Among commercially insured patients, we exactly matched control patients to patients with AHT based on age, gender, residential location (ie, metropolitan statistical area), and health plan type (eg, health management organization, plus an indicator for mental health and substance abuse treatment coverage). Among Medicaid patients, we exactly matched control patients to patients with AHT based on year of birth, gender, race or ethnicity, health plan type (in the same manner as commercially insured patients, plus indicators for drug coverage and Medicare dual eligibility), and basis for Medicaid eligibility (ie, foster care). For matching purposes, we defined patients' residential location, health plan type, and Medicaid eligibility as the first such entry for each patient. Age and residential location were not reported for Medicaid patients, and race or ethnicity was not reported for commercially insured patients. Selected control patients had insurance coverage during exactly the same period as patients with AHT, although control patients could have start and end dates for coverage up to 2 years before and after AHT patients' coverage to improve the rate at which we were able to exactly match patients with AHT to those without AHT based on selected sociodemographic criteria. To improve the likelihood that we captured all medical costs for patients in our sample, we examined MarketScan enrollment data files to exclude all patients with >10% missing insurance coverage days between the patient's first and last dates of insurance coverage. We also excluded all patients enrolled in capitated payment plans; payments to providers under such plans are probably not a valid reflection of medical costs.

## Analysis

Data analysis was conducted primarily withSAS9.2 (SAS Institute, Inc, Cary, NC), including exact matching with a greedy algorithm to select control patients with a 5:1 ratio with patients with AHT.[16,17] Stata 13 (Stata Corp, College Station, TX) was used for regression modeling. We first reported descriptive statistics for patients with AHT and control patients, separately for commercially insured and Medicaid patients, including statistical tests (paired *t* tests) for group differences of key characteristics to confirm the validity of the case–control matching. We also reported the locations (ie, inpatient hospital) where patients with AHT received separately billed medical care on the day of and day after their initial AHT diagnosis (referred to hereafter as within 2 days of initial AHT diagnosis). For example, a patient might have received an initial AHT diagnosis in a nonhospital setting, such as a doctor's office or ambulance, followed by hospital-based care later that day. We included the day after AHT diagnosis because admission and visit times were not reported; therefore, an early-morning inpatient admission after a late-night ED visit would not be captured if we assessed care only on the day AHT was diagnosed. We also reported the average costs of an inpatient admission and of an ED visit during which AHT was initially diagnosed among patients with AHT treated in those settings.

Using each patient's initial AHT diagnosis date as the index date (Day 0), we calculated each AHT and control patient's subsequent number of and cost for inpatient admissions, outpatient visits, and drug prescriptions between the index date and selected endpoints: 0 to 6 months, 6 months to 1 year, 1 to 2 years, 3 to 4 years, and the cost for the entire period, 0 to 4 years. With increasing time since AHT diagnosis, the number of patients for analysis

declined. We lacked information to analyze the reasons for this sample attrition, although it is reasonable to assume that changes to patients' or their families' health insurance, related employment changes, and patient mortality were contributing factors. Beyond 4 years after AHT diagnosis, the number of patients with AHT was too small ($n < 50$ commercially insured patients) for analysis. MarketScan data include multiple billing transaction records per visit or admission, per patient; for example, each billable service during an outpatient visit could appear as a separate record. We combined inpatient payment records for admissions beginning on the same date for the same patient and attributed the sum of those payments to a single admission. We combined outpatient payment records for visits to the same type of provider (ie, general practitioner), on the same date, for the same patient. We combined prescription drug payment records for the same drug (based on National Drug Codes[18]) on the same date for the same patient.

We used multivariable regression models to estimate the number of medical services and costs attributable to AHT diagnosis by service type and time since AHT diagnosis. Estimates of attributable medical services were based on negative binomial count models with robust standard errors. Estimates of attributable medical costs were based on generalized linear models (GLMs) with gamma, inverse Gaussian, or Poisson variance based on data distribution, the log link function, and robust standard errors.[19] We used primarily 2-part GLMs, except where <5% of patients had zero costs in a particular service category. All models included as independent variables indicators of patients' AHT diagnosis status and the amount of time each patient's medical service use and costs were observed for this analysis (ie, the number of days between AHT diagnosis and either 4 years after AHT diagnosis or the end of the patient's insurance record in MarketScan, whichever was earlier). Each reported estimate of service use or cost attributable to AHT diagnosis represents the average marginal effect of an AHT diagnosis in the regression models, with all other variables at their observed values. We examined separate models for commercially insured and Medicaid patients as well as models that included all patients plus a Medicaid indicator variable.

## RESULTS

### Patient Characteristics

We assessed medical service use and costs for 1209 patients with AHT and 5895 control patients (Fig 1). No significant group differences existed between AHT and control patients in terms of gender, race or ethnicity (Medicaid only), health plan type, or basis of Medicaid eligibility (Medicaid only; Table 1). Among patients with AHT with commercial insurance ($n = 668$) and Medicaid ($n = 541$), approximately the same proportions (69% and 67%, respectively) were <2 years old at the time their first AHT diagnosis was recorded (Table 2). Approximately 60% of patients with AHT were male (Table 2). A majority (66%) of Medicaid patients with AHT were White (Table 2). Within 2 days of initial AHT diagnosis, 48% of all patients with AHT received inpatient hospital care, 34% received outpatient hospital care, and 25% received ED care (data shown separately for patients with commercial and Medicaid insurance in Table 2). These measures were not mutually exclusive (ie, a patient could have been separately billed as both an outpatient and an

inpatient), and in total 83% (*n* = 1006/1209) of patients with AHT were treated in an inpatient, outpatient, or ED setting within 2 days of initial diagnosis (data not shown). Among patients not treated in any hospital setting (*n* = 203/1209), >76% (*n* = 155) had the ICD-9-CM diagnosis code 995.55, indicating "shaken-baby syndrome" (data not shown).

### Estimated Episodic Costs of an Initial AHT ED Visit and Inpatient Admission

Among patients with AHT treated in an ED within 2 days of initial AHT diagnosis (*n* = 310), the average cost of that ED visit was $685 (95% confidence interval [CI], $567–$802) (or $299 [95% CI, $192–$405] for *n* = 105 Medicaid patients and $882 [95% CI, $718–$1045] for *n* = 205 commercially insured patients) (data not shown). Among patients with AHT treated as inpatients within 2 days of initial AHT diagnosis (*n* = 546), the average cost of that hospitalization was $29 791 (95% CI, $25 612–$33 971) (or $22 279 [95% CI, $17 933–$26 626] for *n* = 256 Medicaid patients and $36 423 [95% CI, $29 618–$43 227] for *n* = 290 commercially insured patients) (data not shown). A small number of patients with AHT with a record indicating inpatient services within 2 days of initial diagnosis lacked procedure and payment records for inpatient admissions (*n* = 17 Medicaid patients and *n* = 34 commercially insured patients) and were not included in these estimates.

### Estimated Medical Services and Costs Attributable to AHT

AHT was significantly associated with excess medical services and costs for multiple years after initial AHT diagnosis among commercially insured and Medicaid patients (Table 3). In the 6 months after AHT diagnosis, AHT was significantly associated with 0.6 (95% CI, 0.6–0.7) more inpatient admissions, 14.7 (95% CI, 13.4–16.0) more outpatient visits, and 2.7 (95% CI, 2.2–3.1) more drug prescriptions per patient, with patients' insurance type (ie, commercial or Medicaid) controlled for (Table 3, last column). AHT diagnosis among Medicaid patients was significantly associated with excess inpatient admissions, outpatient visits, and prescriptions throughout the 4 years after the abuse diagnosis, with the exception of inpatient admissions from 2 to 3 years after AHT diagnosis (Table 3). AHT diagnosis among commercially insured patients was significantly associated with excess outpatient visits throughout the 4 years after initial diagnosis and inpatient admissions and drug prescriptions up to 2 years after initial diagnosis (Table 3).

AHT was associated with an estimated excess medical cost of $47 952 (95% CI, $40 219–$55 685) per patient during the 4 years after that diagnosis (Table 3). Much of that excess cost was for inpatient care in the 6 months after AHT diagnosis. However, among commercially insured and Medicaid patients, AHT diagnosis continued to be associated with hundreds or thousands of dollars of excess inpatient, outpatient, and drug costs per patient for multiple years after AHT diagnosis (Table 3).

## DISCUSSION

Results suggest patients with AHT had significantly greater medical service use and substantially higher inpatient, outpatient, and drug costs for multiple years after their abuse diagnosis, amounting to tens of thousands of dollars in avoidable medical care per child with AHT.

This study was limited in several ways. We may have failed to identify children affected by AHT because of physician underreporting or misdiagnosis.[7,8] We relied on a code-based definition of AHT that uses External Cause of Injury codes, which are known to be incompletely recorded.[7] We attempted to select control patients who resembled patients with AHT in relevant ways; however, based on available data we were not able to match patients based on socioeconomic details, family configurations, or parental characteristics, and we were limited in our ability to match precisely based on patients' age and residential location among Medicaid patients and race or ethnicity among commercially insured patients. Research has indicated that gender, age, race or ethnicity, having a young mother, and low socioeconomic status are among the risk factors for AHT.[20] We did not match patients based on non-AHT health conditions, including comorbidities; for any factor not included in the matching algorithm we implicitly assumed an even distribution of that factor among AHT and non-AHT patients, which is a limitation. Our objective was to determine how much medical care for a child with AHT costs above and beyond medical care for a typical child. Because some children, including some with AHT, have chronic conditions, a randomly selected control group without AHT appropriately includes some children with chronic conditions and some without any.

Despite careful implementation of case–control matching, such techniques cannot account for unobserved characteristics. Based on the large number of patients in the MarketScan database, we were able to match 5 control patients to nearly all patients with AHT. Matching >1 control patient per case patient is intended to improve the precision of comparative estimates in observational studies, although evidence from propensity score matching studies suggests that matching >1 control per case can increase bias.[17] Although it would have been ideal to compare pre–index date service use and costs for patients with AHT and controls as an additional check of our case–control matching approach, such a comparison was not realistic primarily because AHT diagnosis peaks at 2 months of age.[5,6] Within such a narrow time period, a meaningful comparison of medical services and costs between patients with AHT and controls was not feasible.

We were not able to account for patient mortality during the observation period. Our sample criteria would have excluded patients with AHT who died soon after AHT diagnosis because we limited our sample to children who had insurance claim data for at least 6 months after AHT diagnosis. An assessment of nationally representative hospital discharge data estimated that 7% of inpatient admissions for AHT among patients 0 to 4 years old ended in death during 2000–2009.[20] The data used for this study did not permit investigation of AHT victims' relationships to perpetrators, which might have been associated with patients' insurance coverage after AHT diagnosis. This study examined only the direct medical cost of AHT and did not examine other, probably substantial long-term costs attributable to AHT, such as developmental services, special education, and lifelong medical care and support, such as assistive eating devices, that some AHT victims need. Our medical service use and cost estimates were based on a sample of patients with AHT that diminished in size as time passed since AHT diagnosis. Using regression models, we attempted to control for this sample attrition. However, this data arrangement and modeling approach meant the adjusted mean estimates of medical costs by service type and time since diagnosis did not

sum precisely to the total estimated cost attributable to AHT in the 4 years after initial AHT diagnosis.

A number of patients with AHT ($n$ = 203/1209, or 17%) included in our sample were not treated in hospitals during what might be interpreted as the diagnostic and acute treatment period (ie, within 2 days of initial AHT diagnosis). A lack of hospital care might be surprising to clinicians and other professionals involved with AHT victims. Based on available data, we were not able to further examine the circumstances surrounding these children. The patients in question had significantly lower total medical costs compared with the other patients with AHT in our sample. Excluding such patients from the model of total medical costs had a modest effect on overall estimates (an increase of 5% for the mean estimate, from $47 952 to $50 291, still within the 95% CI of the original estimate).

Despite limitations, this analysis benefitted from a large sample of patients with AHT, many followed up to 4 years after AHT diagnosis. We took steps to improve the likelihood that this analysis captured all reimbursed medical services for patients in the sample. We used matching techniques to create a control cohort for comparison; this approach facilitated an estimate of medical costs directly attributable to AHT, as opposed to a description of medical costs for all services received by patients diagnosed with AHT. We separately estimated inpatient, outpatient, and prescription drug use and costs attributable to AHT at several endpoints relative to AHT diagnosis. Through this analysis we have produced what might reasonably be regarded as an estimate of the excess and preventable medical cost of AHT. These estimates could be compared with the cost of AHT preventive programs to assess such programs' cost-effectiveness.

## CONCLUSIONS

Based on a simulated case–control analysis of patients with AHT from a large health insurance claim database over several years, our results suggest that the excess medical cost of AHT is substantial and that excess costs continue for years after this type of physical abuse is diagnosed. These results may confirm the assumptions of medical and social service professionals who work with AHT victims, although our analysis appears to be the first to quantify the multiyear medical cost of AHT. These estimates represent only the medical cost of AHT and therefore represent a minimum identifiable cost attributable to AHT for affected children, families, and society. Given the high average per-patient medical cost of AHT estimated in this analysis, a range of evidence-based prevention efforts could conceivably be deemed cost-effective. Cost estimates presented here could be weighted against future estimates of the cost of AHT intervention programs. Additional information on AHT prevention program costs and effectiveness is desirable.

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## ABBREVIATIONS

| | |
|---|---|
| **AHT** | abusive head trauma |
| **CI** | 95% confidence interval |
| **ED** | emergency department |
| **GLM** | generalized linear model |
| **ICD-9-CM** | International Classification of Diseases Ninth Revision Clinical Modification |

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**WHAT'S KNOWN ON THIS SUBJECT**

Children with shaken-baby syndrome, or abusive head trauma (AHT), have lasting health and development problems. The long-term medical cost of AHT is unknown.

**WHAT THIS STUDY ADDS**

Patients with AHT had higher inpatient, outpatient, and drug costs compared with other children for 4 years after their abuse diagnosis, amounting to tens of thousands of dollars in excess and preventable medical care per patient with AHT.

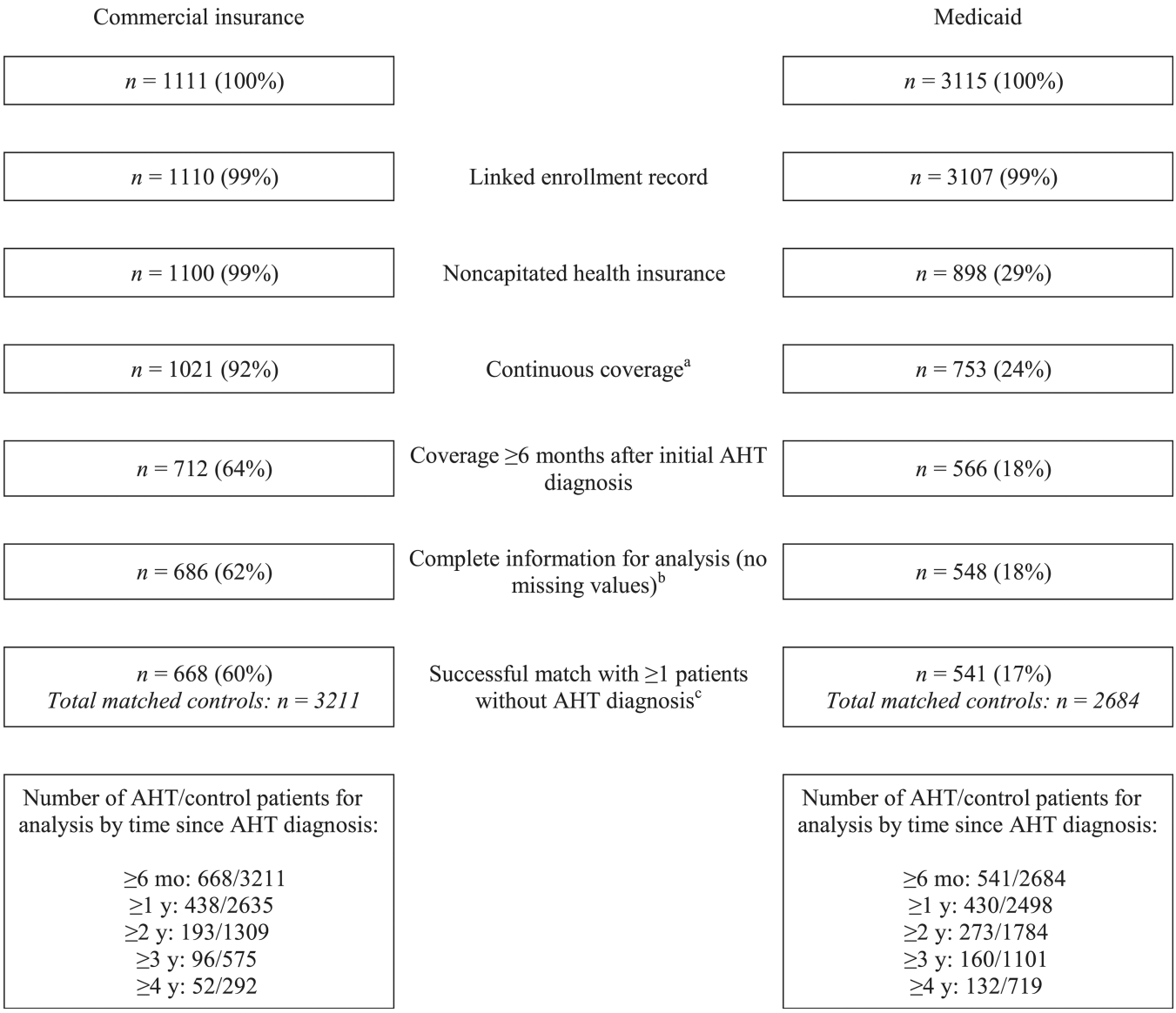


**FIGURE 1.**

Sample selection of patients 0–4 years old with pediatric AHT in MarketScan, 2003–2011. [a]Continuous coverage defined as ≤10% missing enrollment days between the patient's first and last enrollment day in the database. [b]Patients with commercial insurance excluded based only on missing residential location ($n = 5$) and health plan type (ie, preferred provider organization) information ($n = 21$). Patients with Medicaid insurance excluded based only on missing health plan type information ($n = 18$). [c]Exact match based on age (commercial) or year of birth (Medicaid), gender, race (Medicaid only), residential location (based on metropolitan statistical area, commercial only), health plan type (including mental health and substance abuse coverage [both] and drug coverage [Medicaid only]), basis of Medicaid eligibility (Medicaid only), and Medicare dual eligibility (Medicaid only).

## TABLE 1

Definition of AHT

| | Clinical Diagnosis Code (ICD-9-CM) | External Cause-of-Injury or Abuse Code |
|---|---|---|
| Definite or presumptive abusive head trauma | 781.0–781.4, 781.8, 800, 801, 803, 804.1–804.4, 804.6–804.9, 850, 851, 852.0–852.5, 853.0, 853.1, 854.0, 854.1, 925.1, 950.0–950.3, 959.01, 995.55[a] | E960.0, E967, E968.1, E968.2, E968.8, E968.9, 995.50,[b] 995.54, 995.59[b] |
| Probable abusive head trauma | All of those above (except 995.55) | E987, E988.8, E988.9 |

Partially reproduced from Parks et al (2012).[6]

[a] Does not require an external cause or abusive code.

[b] Excludes cases in the presence of a fall or unintentional injury code: E800–E807, E810–E838, E840–E848, E880–E888, and E890–E928.

## TABLE 2

Description of Patients Age 0–4 y With Pediatric AHT and Matched Controls

| Characteristic | Commercial Insurance | | | Medicaid | | |
|---|---|---|---|---|---|---|
| | AHT (*n* = 668), *n* (%) | Control (*n* = 3211), *n* (%) | *P* | AHT (*n* = 541), *n* (%) | Control (*n* = 2684), *n* (%) | *P* |
| Age at first AHT diagnosis, y | | | N/A | | | N/A |
| 0 | 343 (51.3) | — | | 183 (33.8)[a] | — | |
| 1 | 121 (18.1) | — | | 179 (33.1)[a] | — | |
| 2 | 99 (14.8) | — | | 79 (14.6)[a] | — | |
| 3 | 73 (10.9) | — | | 63 (11.6)[a] | — | |
| 4 | 32 (4.8) | — | | 37 (6.8)[a] | — | |
| Gender, male | 412 (61.7) | 1964 (61.2) | .80 | 318 (58.8) | 1579 (58.8) | .98 |
| Race | | | N/A | | | 1.00 |
| White | — | — | | 359 (66.4) | 1795 (66.9) | |
| Black | — | — | | 102 (18.9) | 499 (18.6) | |
| Hispanic | — | — | | 30 (5.5) | 148 (5.5) | |
| Other | — | — | | 50 (9.2) | 242 (9.0) | |
| Location of medical services received on the day of first AHT diagnosis[b] | | | N/A | | | N/A |
| Inpatient hospital | 324 (48.5) | — | | 273 (50.5) | — | |
| Outpatient hospital care | 403 (60.3) | — | | 264 (48.8) | — | |
| Hospital ED | 205 (30.7) | — | | 105 (19.4) | — | |
| Doctor’s office | 191 (28.6) | — | | 110 (20.3) | — | |
| Ambulance | 98 (14.6) | — | | 97 (17.9) | — | |
| Patient home | 26 (3.9) | — | | 54 (10.0) | — | |
| Other[c] | 23 (3.4) | — | | 62 (11.5) | — | |
| Health insurance plan type[d] | | | .98 | | | N/A |
| Comprehensive | 8 (1.2) | 27 (0.8) | | 541 (100.0) | 2684 (100.0) | |
| Exclusive provider organization | 12 (1.8) | 53 (1.7) | | — | — | |
| Health maintenance organization | 97 (14.5) | 474 (14.8) | | — | — | |
| Noncapitated point of service | 62 (9.3) | 299 (9.3) | | — | — | |
| Preferred provider organization | 463 (69.3) | 2242 (69.8) | | — | — | |

| Characteristic | Commercial Insurance | | | Medicaid | | |
|---|---|---|---|---|---|---|
| | AHT (*n* = 668), *n* (%) | Control (*n* = 3211), *n* (%) | *P* | AHT (*n* = 541), *n* (%) | Control (*n* = 2684), *n* (%) | *P* |
| Consumer-driven health plan | 21 (3.1) | 91 (2.8) | | — | — | |
| High-deductible health plan | 5 (0.7) | 25 (0.8) | | — | — | |
| Basis of Medicaid eligibility[d] | | | | | | .99 |
| Blind or disabled person | — | — | | 28 (5.2) | 137 (5.1) | |
| Child | — | — | | 445 (82.3) | 2217 (82.6) | |
| Adult household member | — | — | | 25 (4.6) | 123 (4.6) | |
| Foster care child | — | — | | 32 (5.9) | 152 (5.7) | |
| Eligibility status unknown | — | — | | 11 (2.0) | 55 (2.0) | |

N/A = not applicable.

[a] Age not reported among Medicaid patients; age data in the table are based on year of birth for those patients.

[b] Some patients received care at multiple locations within the first 2 days of AHT diagnosis.

[c] Includes urgent care facilities, outpatient rehabilitation facilities, laboratories, unspecified outpatient locations, state, local, and rural public health clinics, federally qualified health centers, and other (not further specified).

[d] Patients' residential location, health plan type, and Medicaid eligibility were based on patients' first chronological record of such information.

**TABLE 3**

Estimated Number of Medical Services and Costs Attributable to Pediatric AHT by Time Since Diagnosis

| Time Since AHT Diagnosis | Number of Services per Patient, n (95% CI) | | | Cost per Patient, 2012 US Dollars (95% CI) | | |
|---|---|---|---|---|---|---|
| | Commercially Insured AHT: *n* = 668 Control: *n* = 3211 | Medicaid AHT: *n* = 541 Control: *n* = 2684 | All Patients AHT: *n* = 1209 Control: *n* = 5895 | Commercially Insured AHT: *n* = 668 Control: *n* = 3211 | Medicaid AHT: *n* = 541 Control: *n* = 2684 | All Patients AHT: *n* = 1209 Control: *n* = 5895 |
| Inpatient admissions | | | | | | |
| 0–6 mo | 0.56 (0.51–0.61)** | 0.66 (0.59–0.74)** | 0.61 (0.56–0.65)** | $17 843 ($14 393–$21 294)** | $13 586 ($10 594–$16 579)** | $15 872 ($13 509–$18 235)** |
| 6 mo–1y | 0.03 (0.01–0.05)* | 0.04 (0.01–0.07)* | 0.04 (0.02–0.06)** | $485 ($47–$924)* | $502 (–$85 to $1089) | $488 ($119–$857)* |
| 1–2 y | 0.04 (0.01–0.07)* | 0.08 (0.03–0.13)* | 0.06 (0.03–0.09)** | $735 (–$714 to $2184)[a] | $1293 ($138–$2448)*,[a] | $1299 ($32–$2565)*,[a] |
| 2–3 y | 0.01 (0–0.02) | 0.04 (0–0.08) | 0.02 (0–0.04)* | $192 (–$142 to $526) | $922 (–$23 to $1867) | $535 ($42–$1029)* |
| 3–4 y | 0 (0–0.01) | 0.03 (0–0.06)* | 0.02 (0–0.03)* | $2 (–$81 to $85) | $325 (–$643 to $1293) | $148 (–$205 to $500) |
| Outpatient visits | | | | | | |
| 0–6 mo | 10.31 (9.1–11.53)** | 20.34 (17.71–22.97)** | 14.68 (13.4–15.96)** | $4666 ($4070–$5263)**,[c] | $6335 ($5281–$7389)**,[b,c] | $5415 ($4839–$5992)**,[c] |
| 6 mo–1 y | 4.62 (3.5–5.73)** | 16.07 (12.98–19.15)** | 9.03 (7.67–10.39)** | $1382 ($991–$1774)** | $5270 ($3980–$6559)** | $2914 ($2362–$3466)** |
| 1–2 y | 5.17 (2.97–7.37)** | 22.18 (16.44–27.92)** | 11.57 (8.91–14.22)** | $1288 ($739–$1838)** | $8537 ($5383–$11 691)** | $4036 ($2852–$5220)** |
| 2–3 y | 2.92 (0.63–5.2)* | 17.65 (10.3–24.99)** | 9.2 (5.76–12.63)** | $464 ($151–$777)* | $3860 ($2445–$5274)** | $1818 ($1230–$2406)** |
| 3–4 y | 0.94 (0.01–1.88)* | 9.92 (5.84–14)** | 4.59 (2.83–6.35)** | $162 (–$10 to $334) | $1905 ($822–$2988)* | $883 ($426–$1341)** |
| Prescription drugs | | | | | | |
| 0–6 mo | 1.25 (0.85–1.66)** | 4.78 (3.87–5.69)** | 2.66 (2.19–3.13)** | $96 (–$10 to $202) | $382 ($211–$554)** | $204 ($109–$298)** |
| 6 mo–1y | 0.86 (0.49–1.24)** | 3.53 (2.58–4.48)** | 1.93 (1.47–2.4)** | $103 ($29–$177)* | $331 ($148–$515)** | $199 ($111–$286)** |
| 1–2 y | 1.03 (0.24–1.82)* | 4.95 (3.12–6.78)** | 2.62 (1.67–3.56)** | $105 (–$9 to $220)[a] | $428 ($4–$852)*,[a] | $215 ($48–$382)*,[a] |
| 2–3 y | 0.51 (–0.16 to 1.18) | 4.11 (1.76–6.46)* | 2.01 (0.94–3.07)** | $101 (–$26 to $228)[a] | $173 (–$63 to $409)[a] | $254 (–$30 to $537)[a] |
| 3–4 y | 0.36 (0.13 to 0.84) | 2.14 (0.98–3.29)** | 1.16 (0.51–1.82)* | $112 (–$117 to $340)[a] | $–26 (–$359 to $307)[a] | $470 (–$527 to $1467)[a] |
| Total cost, 0–4 y | N/A | N/A | N/A | $38 231 ($29 898–$46 564)**,[b] | $56 691 ($44 290–$69 092)**,[b] | $47 952 ($40 219–$55 685)**,[b] |

*$P < .05$.

** $P < .001$.

N/A = not applicable.

Data are predicted values from multivariable regression models of patients' medical services and costs that controlled for patients' AHT diagnosis and post-AHT diagnosis observation period for medical services and costs (ie, number of days) and insurance payer type (Medicaid versus commercial) in the combined models. Predicted values are estimated average marginal effects of AHT diagnosis with all other variables at observed values (estimated using the Stata margins program with factor notation). Number of service estimates are based on negative binomial models with robust standard errors. Cost estimates are based on 2-part (unless otherwise noted) multivariable GLMs with γ variance (unless otherwise noted), the log link function, and robust standard errors.[20] One-part GLMs were used when <5% of patients had 0 services or costs. Costs are 2012 US dollars, inflated using the gross domestic product deflator.

[a] Inverse Gaussian variance.

[b] 1-part GLM.

[c] Poisson variance.