**ABSTRACT**

**Background:** The first methodological step needed to compare pediatric health outcomes at children’s hospitals (CH) and non-children’s hospitals (NCH) is to classify hospitals into CH and NCH categories. However, there are currently no standardized or validated methods for classifying hospitals. The purpose of this study was to describe a novel and reproducible hospital classification methodology.

**Methods:** Using data from the 2015 American Hospital Association (AHA) Survey, 4,464 hospitals were classified into four categories (Tiers A-D) based on self-reported presence of pediatric services. Tier A included hospitals that only provided care to children. Tier B included hospitals that had key pediatric services including pediatric emergency departments and pediatric/neonatal intensive care units. Tier C included hospitals that provided limited pediatric services. Tier D hospitals provided no key pediatric services. Classifications were then validated using publicly available data on hospital membership in various pediatric programs as well as Health Care Cost Institute claims data.

**Results:** 51 hospitals were classified as Tier A, 228 as Tier B, 1,721 as Tier C, and 1,728 as Tier D**.** The majority of Tier A hospitals were members of the Children’s Hospital Association, Children’s Oncology Group, and National Surgical Quality Improvement Program-Pediatric. Using claims data, the percentage of admissions that were pediatric was highest in Tier A (88.9%), followed by Tier B (10.9%), C (3.9%), and D (3.9%).

**Conclusions:** Using AHA survey data is a feasible and valid method for classifying hospitals into CH and NCH categories using a reproducible multi-tiered system.

**INTRODUCTION**

Children’s hospitals (CH) provide high volume, specialized, and resource intense care to the sickest children who often require highly-trained care providers and cutting-edge technology. Though CH comprise less than 5% of all hospitals in the United States, they account for 40% of pediatric inpatient days and 50% of national pediatric healthcare costs.1 Because these hospitals represent a disproportionate amount of pediatric healthcare costs, it is important to determine if the high-cost, resource-intensive care provided by CH is justified by improved health outcomes. To compare health outcomes at CH and non-children’s hospitals (NCH), the first step is to classify hospitals into CH and NCH categories. However, the lack of a systematic and standardized process for classifying hospitals poses methodological challenges for these studies.

This study presents a novel and reproducible method for distinguishing CH from NCH that addresses the limitations with existing classification strategies. Using the 2015 American Hospital Association Survey (AHA), 4,464 hospitals were classified into 4 categories based on the level of pediatric services offered. The classifications were then verified using publicly available data on hospital membership in various pediatric programs as well as commercial insurance claims data.

**METHODS**

**Data sources**

The AHA survey is an ongoing comprehensive census of US hospitals. The purpose of the survey is to collect facility-level demographics and characteristics including service offerings, beds, utilization, and staffing. The survey profiles a universe of more than 6,400 hospitals, and historically response rates have been over 75% each year.2

For this analysis, we used the 2015 AHA survey, which contains responses from 6,251 hospitals in the US. Non-community hospitals, or hospitals not accessible to the public, were excluded from the dataset. Specialty hospitals (such as cancer, orthopedics, rehab, behavioral, surgical, psychiatric, and cardiac facilities or other individually described specialty centers) were excluded from the dataset as well. After exclusion of non-community and specialty centers, the sample included 4,464 hospitals.

Once the hospitals were classified into CH and NCH categories using AHA data (described below), Health Care Cost Institute (HCCI) claims data were used to validate the classifications. The HCCI data consist of the universe of hospital inpatient claims to three large national insurers.3 This database utilizes AHA hospital identification numbers, which allowed for merging of the two data sources. This study was deemed exempt from full institutional board review due to the patient-level de-identified nature of the datasets.

**Defining CH versus non-CH**

Using the sample of 4,464 hospitals from the 2015 AHA survey, we categorized the hospitals into 4 different tiers (Tiers A-D) based on self-reported presence of pediatric specific structural elements and service lines. All hospitals that answered yes to “Does the hospital restrict admissions primarily to children?” were classified as Tier A. Tier B hospitals were defined as all non-Tier A hospitals that had all of the following: pediatric emergency department (ED), neonatal intensive care unit (NICU), and pediatric intensive care unit (PICU). Tier C was defined as all non-Tier B hospitals that had any pediatric services (i.e. hospitals that had at least 1 of the following: pediatric beds, NICU, PICU, or pediatric ED). The remaining hospitals were placed into Tier D (Figure 1).

**Characteristics of hospitals in each Tier**

To characterize the hospitals within each Tier, cross tabulations were performed between the 4 Tiers and other pediatric-related variables in the AHA dataset. Variables from the AHA dataset used to describe the Tiers included presence of general pediatric medical and surgical care, presence of full-time neonatal intensivists, presence of full-time pediatric intensivists, Council of Teaching Hospital membership, presence of pediatric cardiac services, and hospital location (metropolitan, micropolitan, or rural). Hospitals were categorized as having pediatric cardiac services if they had at least one of the following: general pediatric cardiac services, pediatric cardiac surgery, pediatric diagnostic catheterization, pediatric interventional catheterization, or pediatric cardiac electrophysiology. In addition to these variables, we also calculated the mean number of pediatric hospital beds and the mean percentage of hospital beds devoted to pediatric patients in each Tier. The percentage of hospital beds devoted to pediatric patients was calculated by summing the total number of pediatric beds (sum of general pediatric beds, NICU beds, neonatal intermediate care beds, and PICU beds), dividing by the total number of hospital beds, and converting to a percentage. Chi squared tests and one-way ANOVA were used to assess between-Tier differences in each of these characteristics. All analyses were conducted in SPSS Version 24.4

**Validating classifications using publicly available data**

The Tiers were then validated against publicly available data, which included Children’s Hospital Association membership 5, Children’s Oncology Group membership 6, presence of an American College of Surgeons (ACS) verified pediatric trauma center (level I or II) 7, availability of pediatric heart, liver, or kidney transplants8, presence of a NICU (level 3 or 4) 9, availability of congenital heart surgery 10, and participation in the American College of Surgeons National Surgical Quality Improvement Program Pediatric (ACS NSQIP-P).11 Cross tabulations were performed between the Tiers and each of these variables, and Chi squared tests were used to assess significance.

**Validating classifications using healthcare claims data**

The AHA hospital identification number was used to link the 2015 AHA dataset to the 2015 HCCI dataset. Approximately, 40% (n=1,769) of the AHA hospitals were represented in the HCCI claims data. Once merged, the percentage of hospital admissions that were pediatric was calculated for each Tier and for the unclassified hospitals (i.e. hospitals that did not receive a Tier designation due to missing AHA data). This percentage was calculated by dividing the number of pediatric admissions (patients aged 0-18, excluding newborns) by the total number of admissions observed within each Tier (including newborns). Newborns were purposefully excluded in order to avoid capture of deliver/birthing hospitals.

**RESULTS**

**Characteristics of hospitals within each Tier**

Based on the 2015 AHA data, 51 hospitals were classified as Tier A, 228 as Tier B, 1,721 as Tier C, 1,728 as Tier D, and 736 hospitals could not be classified due to missing data. Almost all hospitals in Tier A (98.0%) and Tier B (99.6%) had general pediatric medical and surgical care, while fewer Tier C (71.8%) and Tier D (16.7%) hospitals had these services (p<0.001). The proportion of hospitals that had pediatric cardiac services was greatest in Tiers A and B (86.3% and 77.6%, respectively) and lowest in Tiers C and D (11.1% and 2.5% respectively, p<0.001). Similarly, the proportion of hospitals that had full-time neonatal intensivists, full-time pediatric intensivists, were members of the Council of Teaching Hospitals, and were located in a metropolitan area was highest in Tiers A and B. Furthermore, the average percentage of hospital beds devoted to pediatric patients was greatest in Tier A (mean 84.5, standard deviation (SD) ±19.2), followed by Tier B (mean 15.8, SD ± 7.9), Tier C (mean 6.7, SD ± 6.6), and Tier D (mean 0) (p<0.001). See Table 1 for more specific descriptive statistics.

**Validating classifications using publicly available data**

The Tier classifications were then validated using publicly available hospital data (Table 2). The majority of Tier A hospitals were members of the Children’s Hospital Association (90.2%), approximately half of Tier B hospitals were members (52.6%), and few Tier C, D, and unclassified hospitals were members (1.2%, 0.1%, and 1.4% respectively, p<0.001). Similar trends were seen for Children’s Oncology Group membership, where 80.2% of Tier A, 40.8% of Tier B, 0.8 % of Tier C, 0.1% of Tier D, and 1.0% of unclassified hospitals were members (p<0.001). Also, 47.3% of hospitals in Tier A, 24.1% of hospitals in Tier B, 0.7% of hospitals in Tier C, 0.1% of hospitals in Tier D, and 0.4% of unclassified hospitals were pediatric trauma level 1 or 2 centers (p<0.001). Furthermore, pediatric transplants (heart, liver, and kidney) and congenital heart surgery were most common among Tier A hospitals. The proportion of hospitals with level 3 or 4 NICUs was highest in Tiers A and B (84.3% and 86.8%, respectively) and lowest in Tier C, Tier D, and unclassified hospitals (26.1%, 0.9%, 7.9% respectively, p<0.001). ACS NSQIP-P membership also varied by Tier, with 76.1% of the hospitals in Tier A, 23.7% of the hospitals in Tier B, 0.1% of the hospitals in Tier C, none of the hospitals in Tier D, and 0.4% of unclassified hospitals having this designation (p<0.001).

**Validating classifications using healthcare claims data**

The Tier classifications were then validated using 2015 HCCI claims data. Of the hospitals that were in the HCCI dataset, 36 were Tier A, 215 were Tier B, 1,011 were Tier C, 344 were Tier D, and 163 were unclassified hospitals. The percentage of admissions that were pediatric was highest in Tier A (88.95%). Pediatric admissions were substantially lower in Tier B (10.96%), Tier C (3.92%), and Tier D (3.98%). Additionally, 28.06% of admissions at unclassified hospitals were pediatric (Figure 2).

**DISCUSSION**

In this study, we developed a reproducible method to classify hospitals using AHA survey data. This methodology was then validated using publically available hospital data as well as healthcare claims data. Our validations show that hospitals in Tier A have the most comprehensive pediatric services and have substantially higher pediatric admissions than the other Tiers, suggesting that these 51 hospitals are CH. Tier A hospitals are most likely to have level I pediatric trauma centers, conduct organ transplants, and conduct congenital heart surgery; and are most likely to have memberships in the Children’s Hospital Association, Children’s Oncology Group, and ACS NSQIP-P. Many of the Tier B hospitals have similar pediatric services and memberships, but they have a lower proportion of admissions that are pediatric (10.96% in Tier B versus 88.95% in Tier A). The provision of comprehensive pediatric services and low pediatric admissions suggests Tier B hospitals are general hospitals with children’s units. Therefore, for specific studies and research questions, investigators may elect to consider both Tier A and Tier B hospitals as CH as compared to only considering Tier A as CH. While stand-alone children's hospitals may be directly of interest in some studies, our analysis shows that limiting the definition of CH only to those with CHA membership will exclude a significant number of hospitals for which comparable pediatric services are available. Tiers C and D hospitals have minimal pediatric services and virtually none of these hospitals are members of the Children’s Hospital Association, Children’s Oncology Group, or ACS NSQIP-P. Therefore, we would categorize Tiers C and D hospitals as NCH.

We were able to conduct these analyses because the claims data provider used, HCCI, provided hospital-level matching on features abstracted from the AHA survey data and from our manual designations of publically available pediatric services. This level of collaboration with administrative and claims data providers is rare and health services researchers are left to use proportions of pediatric admissions to reliably differentiate CH from NCH. Our study suggests that this practical application of proportion of pediatric admissions (or discharges) is valid. For example, our study found that nearly 90% of admissions at Tier A hospitals were pediatric compare to around 11% or lower at Tier B, C, and D hospitals. Thus, distinguishing between hospital types is possible even when hospital-level identifiers are not available. While possible, we would advise caution of additional stratifications of hospital types such as Tier B vs Tier C using discharge proportions alone.

Prior studies that investigated differences between CH and NCH used a variety of strategies to classify hospitals. One commonly used method for determining CH status is participation in the Pediatric Health Information System (PHIS), which is a pediatric database that includes clinical and resource utilization data for 49 freestanding CH who are members of the Children’s Hospital Association (CHA).12-16 CHA membership is also commonly used as a method to determine CH, with over 200 US hospitals currently having this membership. 17,18 Another commonly used database is the Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database (KID).19,20 This database includes pediatric hospital discharge abstracts from 46 states, with all freestanding children’s hospitals being classified as CH and all other hospitals being classified as NCH. The KID is typically released in three year intervals, but the definition used to classify hospitals in the 2012 version dramatically changed compared to the definition used in prior versions making multiyear comparisons challenging.21 Other methods to identify CH include the availability of pediatric services, such as pediatric trauma centers.17,22

Although commonly used, these prior classification strategies have several limitations. First, the PHIS and KID datasets only include a subset of US hospitals. Furthermore, these strategies often focus on freestanding CH and do not granularly account for varying types of pediatric hospitals, such as children’s units within general hospitals. In most studies, children’s units are placed in the NCH category, which may not accurately represent the level of pediatric care provided at these facilities. Furthermore, the lack of a standardized classification method limits cross-study comparisons.

The classification methodology proposed in this study addresses many of the limitations with previous strategies to distinguish CH from NCH. First, the AHA survey profiles a universe of more than 6,400 hospitals each year, allowing investigators to easily classify all hospitals in the US using a single data source. This method may be replicated for all years of the AHA survey. Additionally, the use of a standardized classification strategy will allow for cross-study comparisons. Granular comparisons of care delivery at CH versus NCH are needed in order to inform health care delivery system structure and resource deployment. Trends toward regionalization of care and increasing care complexity at CH must be critically appraised with hospitals categorized in a reproducible and validated fashion.23 Furthermore, the use of up to four Tiers gives investigators the opportunity to consider varying types of pediatric hospitals, such as freestanding children’s centers and children’s units within general hospitals. Investigators can consider Tiers separately or combine them based on specific research questions and analyses.

Although we present a validated strategy to classify hospitals, there are some limitations to this method. Because the Tier classifications rely on self-reported data collected by the AHA survey, there is the potential for hospitals to be misclassified. Additionally, there were many hospitals (n=736) in the AHA survey that had missing data, making it impossible to classify these hospitals into Tiers. Although the response rate for the AHA survey is high, the response rate for individual questions is frequently very low (less than 50%).24 To combat the high amounts of missing data in the AHA survey, survey administrators conduct imputation and estimation of some variables based on previous years, but they do not estimate variables related to service offerings, beds, and facilities (i.e. variables used to categorize hospitals in this study).24 Despite this limitation, we were able to classify the vast majority of non-specialty hospitals in the US (n=3,728) and validate the Tiers using healthcare claims data. If a data source were to include one of the 736 unclassified hospitals, then it is safe to assume that these hospitals are NCH. A final limitation of our proposed methodology is that many administrative and claims data providers strip hospital-level identifiers, which facilitate linkage to AHA data. Under ideal circumstances, data custodians will provide linkages with key data elements prior to providing investigators with fully stripped data for further analyses. If this is not feasible, the using proportions of pediatric admissions/discharges and searching for critical services of interest as proposed in this study may be possible.

**CONCLUSION**

Based on validations with publically available hospital information and healthcare claims data, using the AHA survey is a feasible and valid method for classifying hospitals into CH and NCH categories using a reproducible multi-tiered system.  For specific studies and research questions, investigators may elect to consider both Tier A and Tier B hospitals as CH. When hospital-level linkages are not available, using proportions of pediatric admissions/discharges may reliably distinguish CH from NCH. This study addresses many of the limitations with prior classification strategies by allowing investigators to classify virtually all hospitals in the US into CH and NCH categories using a single data source. The multi-tiered system also gives researchers the flexibility to investigate between-Tier differences or combine Tiers based on specific research questions.

**TABLES/FIGURE LEGENDS**

Figure 1. Strategy for classifying hospitals into Tiers A-D.

Figure 2. Percentage of admissions that are designated pediatric, by Tier

Table 1: Characteristics of hospitals in each tier, based on 2015 American Hospital Association survey

Table 2. Characteristics of hospitals in each tier, based on publicly available data sources

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