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## Pediatric complex chronic conditions: Does the classification system work for infants?

**Lisa C. Lindley, PhD, RN, FPCN [Associate Professor],**

College of Nursing, University of Tennessee, Knoxville, Knoxville, Tennessee 37996

**Christine A. Fortney, PhD RN [Assistant Professor]**

Martha S. Pitzer Center for Women, Children Youth, College of Nursing, The Ohio State University, Columbus, Ohio 43210

### Abstract

**Background:** One widely accepted approach to identify children with life-limiting health problems is the complex chronic conditions (CCC) classification system. Although considered the “gold standard” for classifying children with serious illness, little is known about its performance, especially among infants.

**Objective/Hypothesis:** This research examined the prevalence of CCC and the infant characteristics related to a CCC classification.

**Methods:** Multivariate regression analysis was conducted with 2012 Kids’ Inpatient Database (KID), Healthcare Cost and Utilization Project (HCUP) data files, using a national sample of infant decedents less than 1 year.

**Results:** Our findings showed that 40% of infant were classified with a CCC. African American was negatively associated a CCC classification (aOR=0.63; 95% CI=0.543–0.731). When infants had other insurance coverage, they were less likely (aOR=0.63; 95% CI=0.537–0.748) to have a CCC classification. Infants who resided in non-urban areas (aOR=1.21; 95% CI =1.034–1.415) and had comorbidities (aOR=38.19; 95% CI=33.12–44.04) had greater odds of having a CCC classification.

**Conclusions:** The findings suggest that infants are not commonly classified with a CCC and highlight the significant variation in race with African American infants exhibiting different CCC classifications than Caucasian infants. Given the importance of reducing disparities in palliative care, critical attention to using CCC classifications in research is warranted.

### INTRODUCTION

With recent changes in federal policies related to disclosure of health information of deceased individuals, palliative and end-of-life researchers are challenged to identify their population of interest for study.<sup>1</sup> Current federal regulations restrict the inclusion of date of

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llindley@utk.edu.

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death in all secondary databases. In addition, most data sources do not include cause of death information. Therefore, alternative approaches have been explored to identify a cohort of decedents including clinical risk groups, chronic condition indicators, and patient medical complexity algorithms.<sup>2-5</sup> One widely accepted approach is to identify children with life-limiting health problems or complex chronic conditions (CCCs). Developed by an expert in the field of pediatric palliative care, this method uses diagnosis codes to create nine categories of CCCs: neuromuscular, cardiovascular, congenital, respiratory, gastrointestinal, renal, metabolic, hematological, and cancer.<sup>6,7</sup> Children with any one of the nine conditions is considered to have a CCC. The CCC classification system was developed in 2000/2001 among children who died within the acute care setting.<sup>6,7</sup> These categories have been used extensively by pediatric researchers over almost two decades.<sup>8-11</sup> Consequently, the CCC classification system has become the “gold standard” for classifying children with serious illness.

Despite its long-standing use in research, there are several issues with the CCCs. First, it was developed almost 20 years ago.<sup>6,7</sup> Since then the CCCs have been updated to reflect International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnosis codes;<sup>12</sup> and yet, there have been many changes in the diagnostic codes used by physicians to record a child’s diagnosis since 2000. The Centers for Medicare and Medicaid Services (CMS) adds, revises, and deletes ICD codes annually. For example, 368 new codes will be added to the 2019 ICD-10-CM code set.<sup>13</sup> Second, the CCCs may not capture the unique serious health issues of all children such as infants. Prematurity and low birth weight, for example, significantly contribute to the risk of mortality, but are not included in the classification system. Finally, the performance of the CCCs has not been assessed, particularly among infants. Although the CCCs were developed with children <1 to 24 years and have been used in several infant studies,<sup>6,7,16,17</sup> there is no information on how they perform specifically with children < 1 year. It is unknown how prevalent complex chronic conditions are among infants and what non-complex chronic conditions exist in this population. Our concern, based on extensive work with pediatric secondary and claims-based datasets, is that a significant number of very young children might be excluded from palliative and end-of-life studies because they are not classified with a CCC.<sup>17</sup>

Understanding whether the CCC classification system applies to infants is critical in advancing the science of palliative and end-of-life care.<sup>18</sup> Given that over half of the children who die each year in the US are infants,<sup>19</sup> ensuring an effective method of identifying these very young children in research will reduce bias and improve the reliability of our findings. Ultimately, this work will improve the quality of care delivered for infants because with this information we can target research and interventions specifically to this underserved group at end of life. Therefore, the purpose of this study was to generate data on the CCC classification applied to infants by examining the prevalence of CCCs and investigating the characteristics related to a CCC classification in a national sample of infants less than 1 year.

## METHODS

### Design and Data Source

In this retrospective non-experimental design study, we examined inpatient admissions for pediatric decedents in 2012 using the Kids' Inpatient Database (KID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ). These files are the largest multistate, nationally representative database of US hospitalizations for children and were the most currently available. The HCUP KID includes data from 4179 acute care hospitals in 44 states. Each observation in the data represents one patient hospitalization. KID data are provided at the hospital discharge level and identifiable data was removed from the discharge summaries by HCUP. Each discharge includes up to 25 International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis codes, demographic data, procedure codes, and payment information. The data set includes a weight variable for each observation to produce national estimates of inpatients hospitalizations for children. This study was approved by the Institutional Review Board of the University of Tennessee, Knoxville.

### Study Population

Our analysis was limited to infants less than 1 year. The sample was restricted to those infants, who had a discharge disposition of death in the hospital occurring from January 1 to December 21, 2012. Infants with an *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* that indicated external cause of injury or poisoning were excluded. Observations with any missing or invalid ICD-9-CM codes were also excluded from the analysis.

### Measures

**CCC Classification.**—CCC classification was the main outcome measure in our study. Using Feudtner and colleagues' classification system,<sup>6</sup> the ICD-9-CM codes for each child in the HCUP KID database were used to create the measure. There were up to 25 ICD-9-CM codes for each child in the data. We created an overall variable that measured whether or not the infant had a CCC classification. We also created individual variables for the nine CCC categories: neuromuscular (brain/spinal cord malformation, intellectual disability, CNS disease, cerebral palsy, epilepsy, muscular dystrophy), cardiovascular (heart malformations, cardiomyopathies, and dysrhythmias), cancer, congenital anomalies (chromosomal abnormalities, bone/joint abnormalities, diaphragm/abdominal abnormalities, other abnormalities), respiratory (respiratory malformations, chronic respiratory disease, cystic fibrosis), gastrointestinal (congenital anomalies, liver disease, inflammatory bowel disease), metabolic (amino acid, carbohydrate, lipid, storage disorders, other disorders); hematologic, (sickle cell disease, anemias, hereditary immunodeficiency, HIV), and renal (congenital abnormalities, chronic renal failure).<sup>6</sup> Due to the small frequency of several CCC categories, we combined neuromuscular, cancer, gastrointestinal, metabolic, hematologic, and renal to create an other CCC variable because our Data Use Agreement did not allow us to report numbers or frequencies <10.

**Infant Characteristics.**—Infant characteristics included gender, race/ethnicity, household income, insurance type, region of residence, urban/non-urban, and comorbidities. Gender was defined as male or female. Race/ethnicity was categorized as Caucasian, African American, Hispanic, or Other. Household income was a categorical variable that provides a quartile classification of the estimated median household income of residents in the infant's zip code. The categories were <\$39,000, \$39,000-\$47,999, \$48,000-\$62,999, or >\$63,000. Insurance type included the categories Medicaid, commercial and other. Region of residence were South, Midwest, West, or Northeast. Urban and non-urban were a measure of the infant's residence. Comorbidities were defined as 2 conditions.

### Statistical Analysis

The primary question of interest was how prevalent were CCCs among infants and what characteristics were related to a CCC classification. Using cross-sectional data, descriptive statistics were calculated for study variables to examine the data and test statistical assumptions. Categorical variables were described by frequencies. Multivariate logistic regression was used to examine the relationship between infant characteristics and CCC classification. Adjusted odds ratios and their 95% CI were reported. Goodness of fit indicators were assessed after each regression to ensure model fit. A sensitivity analysis was undertaken to assess the robustness of the study's findings and a logistic analysis with the CCC classification was repeated on a cohort of neonates (<28days). Stata 11.0 was used for all analyses (StataCorp LP, College Station, TX).

## RESULTS

### Description of Sample

Data from the 13,494 infant decedents, comprised the cohort for this study. Table 1 displays the characteristics of the infants in the sample. Less than half of the infants were females (44.41%). Approximately a third of infants were Caucasian (36.97%). The most common household income group was less than \$39,000/annual (36.14%), while the least common was more than \$63,000/annual (16.71%). Of the total sample, 6,951 infants (51.51%) had Medicaid insurance coverage. Over 40% of infants resided in the South (41.21%), while 15% resided in non-urban areas. Almost 30% of infants had comorbidities.

Table 2 illustrates the prevalence of CCCs among the sample of infants. Less than half (41.87%) of infants in the study had a CCC classification. A quarter of infants had a cardiovascular condition. The next most common condition was congenital (12.33%), followed by respiratory 10.01%). Other CCCs such as neuromuscular, cancer, gastrointestinal, metabolic, hematologic, and renal were present in 19% of the sample.

### Multivariate Analyses

Results of the logistic regression analysis estimating the association between infant characteristics and CCC classification are presented in Table 3. In this study, African American was negatively associated a CCC classification (aOR=0.63; 95%CI=0.543–0.731). The odds of being classified with a CCC were lower for an African American infant, compared to Caucasian infants. This finding was repeated for insurance type. When infants

had other coverage, they were also less likely (aOR=0.63; 95%CI=0.537–0.748) to have a CCC classification, compared with those on Medicaid. However, infants who resided in non-urban areas (aOR=1.21; 95%CI =1.034–1.415) and had comorbidities (aOR=38.19; 95%CI=33.12–44.04) were significantly more likely to have a CCC classification, compared to their peers. No other characteristics were related to a CCC classification.

The sensitivity results were comparable to the study's estimates. To check the robustness of the results that characteristics of neonates would be associated with a CCC classification, a regression was estimated. Consistent with the infant estimates, African American, other insurance type, non-urban areas, and comorbidities were related to a CCC classification and in the same direction. These sensitivity results provide further evidence of the classification of infants with a CCC.

## DISCUSSION

To the best of our knowledge, this is the first study to examine the use of the CCC classification among infant decedents. This study has provided important baseline data on the performance of the CCC classification, including a first-time analysis of the characteristics of infants associated with a CCC classification. While a few studies have examined the performance of the CCC, none has examined CCCs among infants. Given the high mortality rate and unique health conditions of infants, this study provides important new information about an understudied and underrepresented population in palliative and end-of-life research. Findings from this study highlight the relevance of examining CCCs among infants. The main finding from this study suggests that relatively few infants are classified with a CCC. Using the national HCUP KID data from 2012, our results showed that approximately 40% of infants were classified with a CCC given their ICD-9-CM codes for inpatient care. In addition, several infant characteristics emerged as predictors of a CCC classification. Specifically, race/ethnicity, insurance type, urban/non-urban, and comorbidities were associated with a CCC classification.

The findings revealed that among the specific CCC categories, cardiovascular conditions (25%) and Other CCCs (185) were the most common CCCs. This finding was not consistent with national reports of infant cause of death. Murphy and colleagues reported that congenital malformations, deformations, and chromosomal abnormalities (20.4%) and disorders related to short gestation and low birth weight (18.0%) were the two most common causes of infant mortality.<sup>19</sup> One explanation for the difference in findings is that data came from different sources. Murphy et al. used death certificate data to capture infant mortality, whereas this study used inpatient records. Cause of death on a death certificate is limited to a single cause. However, in the HCUP KIDS file there were up to 25 ICD-9-CM diagnosis codes for an infant. Thus, the study offered greater variation in health conditions at end of life. An alternative explanation is that the CCC classification used for this study was based on the original CCC classification developed by Feudtner and colleagues in 2001. Although this version of the CCC categories is the most frequently used in pediatric palliative and end-of-life research, Feudtner et al. has recently developed a modified CCC classification system, which includes additional ICD-9/10-CM codes, procedures, devices, and transplant information.<sup>12</sup> The intent of the revision was to broaden the construct of CCC to encompass

medical complexity as defined by Cohen and colleagues and added categories for infant-specific health conditions.<sup>20</sup> To understand these two versions of the CCCs better, additional research validating and comparing the performance of the original versus modified CCC classification system would be beneficial to this unique population of children.

The results of our study shed important new evidence on the connection between race/ethnicity and a CCC classification. We found that African American infants were significantly less likely to be classified with a CCC. This is consistent with recent data showing that racial and/or ethnic variations in quality of care may exist in NICUs.<sup>21</sup> Although the nature of our data did not permit us to examine the reasons for this result, there are some prevailing thoughts about why African American infants are twice as likely to die as their white counterparts, constituting the highest infant mortality rate for any racial or ethnic group in the US.<sup>22</sup> Preterm birth, lower socioeconomic status, age, educational attainment, obesity, alcohol and drug use, mental and physical health, and differences in perinatal and postpartum care all have been shown to be linked to negative infant outcomes.<sup>23</sup> Further, the cumulative effects of the stress of racism that African American women experience have long term implications both their health and the health of any children they may have. Evidence for these effects of cumulative racism may be supported by data that black immigrant women have better birth outcomes than African American woman who were born in the US. However, black mothers regardless of where they were born experience greater rates of adverse birth outcomes and infant mortality.<sup>24</sup> This suggests that pediatric researchers should be vigilant about disparities inherent in measures used for studies. The problem of under- representation in research might be exacerbated by how key inclusion and exclusion criteria are defined. In other words, if the CCC categories are used in sample selection to define the study sample, African American infants might not be included because they will not be classified with a CCC. African American infants would be disproportionately and systematically excluded from a study, which would bias study results. Given that race and ethnicity information is often incomplete or missing in secondary data, extra attention should be paid to the reliability and validity of selection criteria to ensure that these populations benefit from inclusion in research.

We also found that infants from non-urban areas had greater odds of being classified with a CCC, compared to urban infants. Although no studies were identified that examined rural/urban and CCC classification, recent studies found that non-urban areas in the US have significantly higher infant mortality than urban centers.<sup>25</sup> (Mohamound et al., 2019). In addition, federal reports indicated that infant mortality among non-urban African-American is a significant problem, when compared to Caucasian and Hispanic infant populations.<sup>26</sup> This finding in our study might provide additional support to the argument that African American infants, especially those in non-urban areas, might be at greater risk of not being classified with a CCC. Additional research is warranted that examines the relationship between race and geographic location among children at end of life.

The study findings have implications for pediatric end-of-life research. Infants in general have historically been excluded from research studies primarily because of their complexity and the inherent difficulties surrounding diagnosis and prognosis within this population. However, infants have the highest rate of death of any group in pediatric institutions and to

exclude this group leaves out a significant number of participants who could contribute important data to questions concerning end of life and palliative care issues.<sup>19</sup> As has been outlined, the CCC categories may be contributing to the exclusion of infants in research studies and the use of additional criteria to determine CCCs, or possibility of CCCs, are likely needed to ensure that infants who should be included in this type of research are not being overlooked. Such criteria might include: 1) extended length of stay, as infants who tend to be more medically complex require longer hospital stays; 2) a diagnosis of prematurity at any time during the hospital stay, or use of gestational age at birth, as diverse populations, and particularly African American infants, are disproportionately affected by preterm birth and have negative health outcomes; and 3) high technology burden as an indication of ongoing complex medical issues. Using these additional criteria, more infants may be accurately identified and lessen the effect that the exclusion of these infants will have on the data.

We recognize several limitations to our analysis. First, the HCUP KID sampling frame has a disproportionate representation of states with a high population that contains hospitals with more annual discharges. The information in this study represent hospital discharges, and not patients, thus there might be sampling bias present in the study. Second, the study sample was derived from US infants. This limits the generalizability of the findings to other pediatric decedents. Third, only discharge diagnoses are included and may have changed considerably from what initially brought the infant to the hospital. Admission diagnoses were not identified, which may limit the ability to determine CCC diagnoses among infants. Fourth, the age of the data (2012) may not completely capture recent trends in CCC diagnoses. Finally, it must also be noted that infants' deaths outside the hospital were not included. This effect is most likely very small because most seriously ill infants often remain in the hospital after birth until their death.

In summary, the goal of the study was to explore the prevalence of CCCs and to understand the infant characteristics associated with a CCC classification. Using a national sample of infants less than 1 year, the findings suggest that infants are not commonly classified with a CCC. The results revealed that cardiovascular and congenital were the most common CCCs assigned to infants based on ICD-9-CM codes. In addition, this study highlighted the significant variation in race with African American infants exhibiting different CCC classification than Caucasian infants. Given the importance of reducing disparities in palliative and end-of-life care, critical attention to the use of CCCs alone in research is warranted. Additional criteria may need to be utilized to ensure that all infants who would be eligible for a study are identified.

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**Table 1.**

Sample Characteristics of Infants (N=13,494 weighted)

<b>Variables</b>	<b>n</b>	<b>Frequency</b>
Female	5,993	44.41%
Race/Ethnicity		
Caucasian	4,989	36.97%
African American	3,132	23.21%
Hispanic	2,179	16.15%
Other	3,194	23.67%
Household Income (median)		
<\$39,000	4,877	36.14%
\$39,000-\$47,999	3,445	25.53%
\$48,000-\$62,999	2,989	22.15%
>\$63,000	2,182	16.17%
Insurance Type		
Medicaid	6,951	51.51%
Commercial	4,770	35.35%
Other	1,773	13.14%
Region of Residence		
South	5,561	41.21%
Midwest	3,012	22.32%
West	2,803	20.77%
Northeast	2,119	15.70%
Non -Urban	1,988	14.73%
Comorbidities	3,993	29.59%

**Table 2.**

Prevalence of CCC Classifications Among Infants (N=13,494 weighted)

<b>Variables</b>	<b>n</b>	<b>Frequency</b>
Complex Chronic Condition	5,650	41.87%
Cardiovascular	3,387	25.10%
Congenital	1,664	12.33%
Respiratory	1,351	10.01%
Other	2,500	18.53%

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**Table 3.**

Infant Characteristics Associated with a CCC Classification (N=13,494 weighted)

Variables	aOR	95% CI
Female	1.08	0.971–1.198
Race/Ethnicity		
Caucasian	(reference)	
African American	0.63 <sup>***</sup>	0.543–0.731
Hispanic	1.05	0.892–1.233
Other	0.92	0.794–1.047
Household Income		
<\$39,000	(reference)	
\$39,000-\$47,999	1.11	0.965–1.267
\$48,000-\$62,999	1.03	0.883–1.190
>\$63,000	1.12	0.946–1.326
Insurance Type		
Medicaid	(reference)	
Commercial	0.95	0.843–1.070
Other	0.63 <sup>***</sup>	0.537–0.748
Region of Residence		
South	(reference)	
Midwest	0.92	0.799–1.062
West	0.94	0.808–1.085
Northeast	0.94	0.802–1.094
Non-Urban	1.21 <sup>*</sup>	1.034–1.415
Comorbidities	38.19 <sup>***</sup>	33.12–44.04

\*  $p < 0.05$ \*\*  $p < 0.01$ \*\*\*  $p < 0.001$ 

Note: aOR: adjusted odds ratio. CI: confidence intervals.