

## **Understanding Pediatric Laryngomalacia: A Study of Social Determinants, and Associated Diseases**

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**Key words:** Laryngomalacia, Pediatric, Socioeconomic status, Health disparities, Race and healthcare

## **Abstract**

**Objective:** This study investigates the influence of socioeconomic factors on the incidence of laryngomalacia in pediatric inpatients.

**Methods:** Data from the 2016 Healthcare Cost and Utilization Project (HCUP) Kid Inpatient Database were analyzed. Variables included zip code median income, race/ethnicity, and primary expected payer, and associated ICD-10 codes in admission.

**Results:** Lower median income zip codes showed a 6.4% increase in laryngomalacia admissions, while higher-income zip codes had an 8.0% decrease. Black patients exhibited a 24.5% increase, and Asian or Pacific Islander patients showed a 42.5% decrease in laryngomalacia admissions. Medicaid and other government program payers had a 22.1% increase, while Medicare, private insurance, and self-pay had decreases of 35.5%, 20.9%, and 55.7%, respectively. Laryngomalacia was associated with a number disease processes from a multitude of organ systems in a statistically significant manner.

**Conclusion:** Socioeconomic status, race, and primary expected payer, and comorbid disease process significantly impact laryngomalacia admissions.

**MeSH terms:** Laryngomalacia, Socioeconomic Factors, Health Disparities, Pediatrics, Healthcare Disparities

## **1. Introduction**

Laryngomalacia, is characterized by softening of supraglottic structures leading to the collapse of supraglottic structures, including the epiglottis, aryepiglottic folds, and arytenoid cartilages (1, 2).

Although typically a mild and self-resolving condition (1), Some poor comes are noted in the literature as laryngomalacia is shown to lead to dysphagia or feeding difficulties in 50.3% of patients, and failure to thrive or poor weight gain in 9.6% of affected infants (3, 4). Given the potential complications associated with laryngomalacia it is important to identify risk factors and associated medical conditions to enable early diagnosis and intervention.

Low socioeconomic status, race, and ethnicity are well-established determinants of health outcomes, specifically in pediatric populations (5-8). Despite the significant effects of these inequities on the pediatric patient population, there is a lack of research investigating their potential impact on laryngomalacia in infants. This study aims to bridge this gap by examining the influence of multiple social determinants of health on the frequency of incidence and admissions for laryngomalacia in pediatric inpatients using the HCUP Kid Inpatient Database (KID).

## 2. Methods

### 2.1 Database Selection

The database used for analysis in this study was the Healthcare Cost and Utilization Project (HCUP) Kid Inpatient Database (KID) for the year 2016. This database is part of a compilation of databases offered every 3 years by HCUP. The KID database includes a large sample of pediatric inpatient admissions and discharges across the United States. Due to the large sample size, it provides an opportunity for investigation into rare conditions such as laryngomalacia. Data recorded in the database includes primary and secondary diagnoses, procedure codes, patient demographics (gender, race, expected primary payer status), hospital characteristics (regional, rural, or urban status), in-hospital births and mortality, length of stay, and charges. SPSS V27 for Macintosh (IBM, Armonk, NY, 2020) was used for data analysis.

### 2.2 Patient Selection

The 2016 KID database was the first in the KID series to use International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) coding. Laryngomalacia was identified by its associated International Classification of Disease version 10 (ICD-10) code: Q31.5. Based on this coding, we created binary variables for the presence or absence of a diagnosis of laryngomalacia. The KID calculates weighted discharge information by random sampling of 10% of uncomplicated births and 80% of other pediatric discharge codes from the participating institutions (9). Through random sampling they are able to extrapolate national estimates. Therefore, the final variables that can be extracted from this database are weighted discharges rather than individual patients.

In total, there were 6,266,285 weighted admissions recorded in this database for 2016. The KID database contains pediatric admissions for children age zero to 20, however for the purposes of this study, only children less than three years of age were selected. This was done as this age group comprises 86.3% of the admissions containing an associated diagnosis of laryngomalacia in the KID database. The KID

database contains a categorical variable providing a quartile classification of the median income of the patient's ZIP Code of residence based on annual ZIP Code-demographic information obtained from Claritas. HCUP provides the Claritas-derived ZIP Code median income quartiles, and these were stratified to lower-income (first and second quartile) meaning the zip code area had a median income of \$53,999 or less and higher-income (third and fourth quartile) meaning the ZIP Code area had a median income of \$54,000 or more. The KID database also contains a categorical variable which classifies patients based on their race/ethnicity, of which the categories were: White, Black, Hispanic, Asian or Pacific Islander, Native American, and Other. Lastly, the KID database includes a categorical variable indicating the primary expected payer for the visit, of which the categories were: Medicare, Medicaid, Private Insurance, Self-Pay, No Charge, and Other. The category "Other" includes worker's compensation, Title V, and other government programs.

### 2.3 Data Analysis

The data was normalized to the United States Population using the validated HCUP database weighting, as KID guidelines report only a portion of all pediatric hospital admissions. To examine relationships between laryngomalacia frequency and patient demographics, Pearson's Chi-Square test was utilized and odds ratios calculated for 2x2 contingency tables and adjusted residuals calculated for larger contingency tables, with adjusted residuals greater than  $|1.96|$  being considered significant. A p-value less than 0.05 was the statistical cut-off for significance for the analysis in this study. In the associated conditions analysis presented, we aimed to compare the prevalence of various ICD-10 codes between patients diagnosed with Laryngomalacia and the general population, utilizing a dataset that included counts of each ICD-10 code for both groups. The methodology includes using python code to tabulate all non-laryngomalacia ICD-10 codes for patients both in entire database and in laryngomalacia patients. Then raw counts of each ICD-10 code were converted into odd ratios. The significance of the associations observed was evaluated using the Chi-Squared test, comparing the subset of patients in the KID with a laryngomalacia ICD-10 code with the entire dataset. Codes with a p-value less than 0.05 were considered statistically significant although all codes displayed in this study showed a p-value less than 0.001.

## 3. Results

### 3.1 General Results

In total, there were 1,844,531 inpatient pediatrics patients consisting of children less than three years of age. A validated HCUP weighting system was used to transform these admissions to estimate national neonatal admission data to be 4,512,196 inpatient pediatrics visits for children less than three years of

age. From this database, 11,643 laryngomalacia admissions were obtained to create the group for analysis and the frequency of laryngomalacia admissions was found to be 258.0 per 100,000. From the database, the following was also gathered: whether the median income in the patient's zip code was above or below the national median income, race/ethnicity, and the expected primary payer for the visit. Of the 4,512,196 inpatient pediatrics visits, 2,206,018 visits recorded if the median income in the patient's zip code was above or below the national median income, 1,802,856 visits recorded the patient's race/ethnicity, and 4,506,855 visits recorded the expected primary payer for the visit.

### 3.2 Zip code median income and laryngomalacia

The frequency of laryngomalacia per 100,000 for patients from zip codes with household incomes above or below the national median income is shown in table 1.

Table 1: Frequency of laryngomalacia admissions in patients from zip codes with median incomes above or below the national median income.

The frequency of laryngomalacia admissions in patients from zip codes above the national median income was significantly greater than in patients from zip codes below the national median income (Odds Ratio [OR], 0.865; 95% Confidence Interval [CI], 0.833-0.897,  $p < 0.001$ ).

### 3.3 Race/ethnicity and laryngomalacia

The frequency of laryngomalacia admissions based on the patient's race/ethnicity is shown below in table 2.

Table 2: Race and Laryngomalacia incidence

<b>Race/Ethnicity</b>	<b>Laryngomalacia per 100,000 (Adjusted Residual)</b>	<b>Laryngomalacia Admissions</b>	<b>Total Admissions</b>
White	248.8 (-2.3)	5,152	2,071,034
Black	321.4 (11.2)	1,944	604,886
Hispanic	253.2 (-0.3)	2,127	840,127
Asian or Pacific Islander	148.4 (-10.5)	349	235,224
Native American	287.6 (1.2)	94	32,686
Other	239.9 (10.5)	643	267,990

The frequency of laryngomalacia admissions in patients who are black (Adjusted Residual [AR] = 11.2) was found to be significantly greater than expected. The frequency of laryngomalacia admissions in patients who are White (AR = -2.3) or Asian or Pacific Islander (AR = -10.5) was found to be significantly less than expected. No other race/ethnicity groups were found to have significant differences in laryngomalacia admissions.

### 3.4 Primary expected payer and laryngomalacia

The frequency of laryngomalacia admissions based on the primary expected payer for the visit is shown below in table 3.

Table 3.

Frequency of laryngomalacia admissions by expected primary payer.

<b>Expected Primary Payer</b>	<b>Laryngomalacia per 100,000 (Adjusted Residual)</b>	<b>Laryngomalacia Admissions</b>	<b>Total Admissions</b>
Medicare	166.5 (-2.3)	26	15,611
Medicaid	315.0 (22.7)	6,778	2,151,963
Private Insurance	204.2 (-20.3)	4,105	2,010,753
Self-Pay	114.2 (-12.7)	220	192,642
No Charge	137.4 (-1.1)	3	2,183
Other	378.5 (8.8)	506	133,703

The frequency of laryngomalacia admissions in patients for whom the primary expected payer was Medicaid (AR = 22.7) or Other (various government programs) (AR = 8.8) was found to be significantly greater than expected. The frequency of laryngomalacia admissions in patients for whom the primary expected payer was either Medicare (AR = -2.3), Private Insurance (AR = -20.3), and Self-Pay (AR = -12.7) was found to be significantly less than expected.

Table 4. Laryngomalacia association with other diseases (all p-values less than 0.001)

<b>Disease Names</b>	<b>Prevalence in LM</b>	<b>Prevalence in GP</b>	<b>Odds Ratios</b>
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**Ear, Nose, and Throat**

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Congenital absence and malformations of salivary glands and ducts	6.30%	2.52%	2.5
Other specified developmental disorders of speech and language	3.54%	0.71%	5
Palatal edema	7.57%	0.99%	7.65
Streptococcal throat infection, unspecified	2.44%	0.23%	10.61
Suppurative and unspecified otitis media, bilateral	2.40%	0.09%	26.67

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**Respiratory System**

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Acute bronchiolitis due to RSV	3.99%	1.74%	2.29
Acute respiratory distress syndrome	6.35%	1.20%	5.29
Acute respiratory failure with hypoxia	4.44%	1.02%	4.35
Acute upper respiratory infection, unspecified	4.44%	1.65%	2.69
Cyanosis	3.19%	0.17%	18.70
Dependence on supplemental oxygen	2.90%	0.34%	8.53
Dysphagia, unspecified	4.37%	0.65%	6.72
Edema of vocal cords	4.16%	1.15%	3.62
Encounter for attention to tracheostomy with mechanical ventilation	5.30%	14.71%	0.36
Encounter for attention to tracheostomy without mechanical ventilation	6.59%	25.42%	0.26

Obstructive sleep apnea (adult) (pediatric)	9.27%	0.81%	11.44
Pneumonia, unspecified organism	3.32%	2.05%	1.62
Pneumonitis due to inhalation of food and vomit	3.31%	0.38%	8.71
Tracheostomy status	3.41%	0.46%	7.41
<b>Endocrine System</b>			
Disorder of fluid, electrolyte and acid-base balance, unspecified	2.35%	1.49%	1.58
<b>Gastrointestinal System</b>			
Congenital malformation of pituitary gland, unspecified	2.31%	0.57%	4.05
Constipation, unspecified	3.16%	2.41%	1.31
Feeding difficulties	8.36%	1.09%	7.66
Gastro-esophageal reflux disease without esophagitis	18.05%	3.01%	5.99
Gastrostomy status	9.10%	1.79%	5.09
Neonatal aspiration of meconium	2.59%	0.45%	5.76
Neonatal jaundice associated with preterm delivery	2.43%	9.19%	0.26
<b>Integumentary System</b>			
Diaper dermatitis	2.33%	1.21%	1.92
<b>Nervous System</b>			
Congenital hydrocephalus	2.63%	0.08%	32.88
Idiopathic intracranial hypertension, unspecified	3.38%	1.32%	2.56
Microcephaly	2.80%	0.36%	7.78



## **Discussion**

This study aims to further understand how socioeconomic status and race affect laryngomalacia outcomes. For socioeconomic status, the results show the frequency of laryngomalacia admissions in patients from zip codes above the national median income is significantly less than patients from zip codes below the national median income ( $p < 0.001$ ). Although the exact reason for lower median income zip codes having greater rates of laryngomalacia admissions is unknown, one possible explanation is decreased interaction with the healthcare system. Attending doctors' appointments requires time and money, factors that individuals in lower income brackets often lack. Aside from financial constraints, previous studies have noted how transport serves as a barrier to attend follow up appointments. Commonly cited factors are not having a car or unreliable public transportation (10, 11). On a community level, previous studies have found a shortage of providers in lower median income areas (10). A shortage of providers could inhibit interaction with the healthcare system due to increased distances to providers as well as longer wait times to see providers. If pediatric patients have less frequent wellness visits, there is a chance that laryngomalacia might be missed in early diagnostic stages, leading to an increase in inpatient admissions upon developing symptoms.

The United States for-profit healthcare system contains numerous ways to pay for the service. Medicare and Medicaid are insurances that are subsidized by the US federal government and are intended to help elderly and low income people respectively. Private insurance indicates that the patients get insured through paying a monthly fee through an open marketplace, this is often offered as a benefit of employment. Self-pay indicates that the patient is uninsured and instead paid cash for service. The frequency of laryngomalacia in patients for whom the primary expected payer was Medicaid or other (various government programs) was found to be significantly greater than expected. In contrast, the frequency of laryngomalacia in patients for whom the primary payer was Medicare, private insurance, and self-pay was found to be significantly less than expected. Focusing on Medicaid, one possible explanation for the higher rates of laryngomalacia admissions could be tied to healthcare usage. Previous studies have found that patients utilizing Medicaid are more likely to utilize the emergency department relative to

patients utilizing commercial insurance (12). According to Kim et al, the drivers of this disparity include not having a PCP, facing less out-of-pocket cost in the ED, and the perception that the ED will be able to solve all of the patient's problems with less visits. Patients utilizing private insurance are more likely to seek care in outpatient office visits (13). The reduced utilization of outpatient clinics could also indicate a decrease in preventative appointments that could both detect laryngomalacia symptoms and facilitate early treatment to prevent deterioration. This point is further emphasized by the barriers Medicaid patients face in accessing primary care, and how those barriers encourage emergency department usage (14).

In terms of race, the study found a significant increase in the frequency of laryngomalacia admissions in black patients. These findings build upon a previous study that indicated that laryngomalacia may occur with greater frequency among black patients compared to other racial groups (15). One potential explanation for the higher rates of black laryngomalacia admissions could be tied to preterm birth. The previous study also found there were significantly more preterm black and hispanic patients compared to other racial groups (15). According to Manuck et al, the exact mechanism for greater rates of preterm birth in minority populations is poorly understood with both environmental and genetic factors having been shown to contribute (16). The neurological theory of laryngomalacia explains that laryngomalacia may be a consequence of an underdeveloped or abnormally integrated CNS system (17). Due to the association between neurologic disease and laryngomalacia, it is possible that premature babies would have higher rates of laryngomalacia, However, this connection remains controversial in the literature (15, 18). Thus, a higher rate of black premature babies could explain the higher frequency of black laryngomalacia admissions.

Laryngomalacia has been linked to feeding difficulty, cyanosis, hypoxia, obstructive sleep apnea and GERD, All of which was reaffirmed in our study (17, 19, 20). Children with laryngomalacia were shown to have a very statistically significant association with a multitude of medical conditions (Table 3). Although it is not possible to describe whether laryngomalacia causes these conditions, whether these conditions cause laryngomalacia, or if they simply exist together, the association with these conditions nevertheless provides insight and avenues for future research. Laryngomalacia was associated with a

variety of otolaryngologic and respiratory conditions, some effecting or involving the throat such as palatal edema, dysphagia, speech disorders and strep throat, others effecting the lungs in a variety of infections. Increased disorders of the throat and lungs in laryngomalacia might be due to increased reflux, aspiration and immune response from chronic irritation but the exact mechanism is unclear (17). Others such as congenital absence of salivary glands, bilateral otitis media are prevalent as well, with a far less clear potential mechanism. Laryngomalacia was also found to be associated with a variety of GI conditions including aspiration diseases of newborns, jaundice from preterm delivery, and congenital malformation of the pituitary. Laryngomalacia is also associated with neurological conditions such as hydrocephalous, idiopathic intracranial hypertension and microcephaly. These broadly might be described mechanistically as preterm birth causing these conditions as well as laryngomalacia (1, 21, 22)

The present study possesses some limitations. First, the study relied on data from a single database, the Healthcare Cost and Utilization Project (HCUP) Kid Inpatient Database (KID) for the year 2016. Although the HCUP database is composed of valuable data and well-reported in literature, future studies should expand the patient selection by using larger alternative databases. Another limitation is that the HCUP database only contains information on pediatric inpatient admissions and discharges. Thus our findings exclude incidences of laryngomalacia in the general population and outpatient settings and only focuses on those children with LM that is severe enough to necessitate hospital admission. Moreover, the HCUP database used was specific to one year and therefore future studies should aim to investigate these relationships across a broader timeframe. The database does not include additional information regarding patients' clinical course and therefore we are unable to comment on the severity or duration of the cases of laryngomalacia analyzed. However, since the KID is a database of inpatients, the patient population likely skews toward more severe forms of laryngomalacia. Lastly, Racial groups were standardized to the US derived KID database however they may not be fully reflective of a international understanding of demographic groups, potentially limiting replicability to the broader international community.

Future studies should aim to look at other measures of socioeconomic status, such as parent education to obtain a more holistic view of how socioeconomic status relates to laryngomalacia.

Furthermore, it would be interesting to explore the frequency of wellness visits for inpatients presenting with laryngomalacia and if a lack of outpatient care could explain our finding that low median household income has a higher incidence of laryngomalacia admissions. Mechanisms for the association with the diseases associated with laryngomalacia can also be studied. Future research would help differentiate what is a risk factor for laryngomalacia and what might be a complication of laryngomalacia.

## **Conclusion**

In conclusion, additional clarification of the interplay of these factors will enhance the current understanding of laryngomalacia and provide insight into the impact of socioeconomic and racial factors on its incidence. Moreover, through the identification of these factors, we can offer valuable information for public health approaches and initiatives aimed at reducing health inequalities among children. Ultimately, this understanding can enable prompt recognition and intervention, resulting in improved health results for infants impacted by laryngomalacia.

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**Objective:** The study aims to understand how socioeconomic status, race, and the primary expected payer affect the incidence of laryngomalacia in pediatric inpatients.

- **Socioeconomic Status:** Exploration of how different levels of socioeconomic status impact the incidence of laryngomalacia.
- **Race:** Analysis of racial disparities in the occurrence of laryngomalacia among pediatric patients.
- **Primary Expected Payer:** Examination of how the type of primary expected payer (insurance type) influences the incidence rates of laryngomalacia.
- **Associated Disease Processes:** Investigation into how these factors interplay with other disease processes in the incidence of laryngomalacia.
- **Pediatric Inpatients:** Focus on the inpatient pediatric population to derive insights specific to hospitalized children.