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Understanding paediatric laryngomalacia: a study of social determinants and associated diseases

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Main Article

Dean G. Kennedy takes responsibility for the integrity of the content of the paper

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Abstract

Objective. This study investigated the influence of socioeconomic factors on the incidence of laryngomalacia in paediatric in-patients.

Methods. Data from the 2016 Healthcare Cost and Utilization Project Kid Inpatient Database were analysed. Variables included zip code median income, race and/or ethnicity, primary expected payer and associated International Statistical Classification of Diseases and Related Health Problems 10th Revision codes in admission.

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

Conclusion. Socioeconomic status, race, primary expected payer and co-morbid disease process significantly impact laryngomalacia admissions.

Introduction

Laryngomalacia is characterised by the softening of supraglottic structures leading to their collapse, including the epiglottis, aryepiglottic folds and arytenoid cartilages.[1,2] Although typically a mild and self-resolving condition,[1] some poor outcomes are noted in the literature. Laryngomalacia is shown to lead to dysphagia or feeding difficulties in 50.3 per cent of patients and failure to thrive or poor weight gain in 9.6 per cent 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, especially in paediatric populations.[5–8] Despite the significant effects of these inequities on the paediatric patient population, there is a lack of research investigating their potential impact on laryngomalacia in infants. This study aimed to bridge this gap by examining the influence of multiple social determinants of health on the frequency of incidence and admissions for laryngomalacia in paediatric in-patients using the Healthcare Cost and Utilization Project Kid Inpatient Database.

Methods

Database selection

The database used for analysis in this study was the Healthcare Cost and Utilization Project Kid Inpatient Database for 2016. This database is part of a compilation of databases offered every three years by the Healthcare Cost and Utilization Project. The Kid Inpatient Database includes a large sample of paediatric in-patient admissions and discharges across the USA. Because of the large sample size, it provides an opportunity for investigation into rare conditions such as laryngomalacia. The data recorded in the database include primary and secondary diagnoses, procedure codes, patient demographics (gender, race, expected primary payer status),

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

Median household income in patient's zip code	Laryngomalacia per 100 000 (*n*)	Laryngomalacia admissions (*n*)	Total admissions (*n*)
Above the national median	237.4	4882	2 056 504
Below the national median	274.4	6606	2 407 018

hospital characteristics (regional, rural or urban status), in-hospital births and mortality, length of stay and charges. SPSS V27 for Macintosh (IBM, Armonk, NY, USA) was used for data analysis.

Patient selection

The 2016 Kid Inpatient Database was the first in the Kid Inpatient Database series to use International Statistical Classification of Diseases and Related Health Problems 10th Revision coding. Laryngomalacia was identified by its associated International Classification of Disease version 10 code Q31.5. Based on this coding, we created binary variables for the presence or absence of a diagnosis of laryngomalacia. The Kid Inpatient Database calculates weighted discharge information by random sampling of 10 per cent of uncomplicated births and 80 per cent of other paediatric 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 Inpatient Database contains paediatric admissions for children age 0 to 20 years, but for the purposes of this study, only children less than three years of age were selected. This was done because this age group comprises 86.3 per cent of the admissions containing an associated diagnosis of laryngomalacia in the Kid Inpatient Database.

The Kid Inpatient 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. The Healthcare Cost and Utilization Project 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 Inpatient Database also contains a categorical variable that classifies patients based on their race and/or ethnicity, for which the categories were White, Black, Hispanic, Asian or Pacific Islander, Native American and other. Lastly, the Kid Inpatient Database includes a categorical variable indicating the primary expected payer for the visit, for which the categories were Medicare, Medicaid, private insurance, self-pay, no charge and other. The category 'other' included worker's compensation, Title V and other government programmes.

Data analysis

The data were normalised to the US population using the validated Healthcare Cost and Utilization Project database weighting because Kid Inpatient Database guidelines report only a portion of all paediatric hospital admissions. To examine relationships between laryngomalacia frequency and patient demographics, Pearson's chi-square test was used, odds ratios were calculated for 2×2 contingency tables and adjusted residuals calculated for larger contingency tables, and adjusted residuals greater than $|1.96|$ were 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 International Statistical Classification of Diseases and Related Health Problems 10th Revision codes between patients diagnosed with laryngomalacia and the general population using a dataset that included counts of each International Classification of Disease version 10 code for both groups. The methodology included using python code to tabulate all non-laryngomalacia International Classification of Disease version 10 codes for both patients in the entire database and laryngomalacia patients. The raw counts of each International Classification of Disease version 10 code were converted into odd ratios. The significance of the associations observed was evaluated using the chi-square test, comparing the subset of patients in the Kid Inpatient Database with a laryngomalacia International Classification of Disease version 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.

Results

General results

In total, there were 1 844 531 in-patient paediatric patients including children less than three years of age. A validated Healthcare Cost and Utilization Project weighting system was used to transform these admissions to estimate national neonatal admission data to be 4 512 196 in-patient paediatric 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 and/or ethnicity, and the expected primary payer for the visit. Of the 4 512 196 in-patient paediatric 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 and/or ethnicity, and 4 506 855 visits recorded the expected primary payer for the visit.

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. 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 = 0.865, 95 per cent confidence interval = 0.833–0.897, $p < 0.001$).

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Race and/or ethnicity, and laryngomalacia

The frequency of laryngomalacia admissions based on the patient's race and/or ethnicity is shown in Table 2. The frequency of laryngomalacia admissions in patients who were Black (adjusted residual = 11.2) was found to be significantly greater than expected. The frequency of laryngomalacia admissions in patients who were White (adjusted residual = −2.3) or Asian or Pacific Islander (adjusted residual = −10.5) was found to be significantly less than expected. No other race and/or ethnicity groups were found to have significant differences in laryngomalacia admissions.

Primary expected payer and laryngomalacia

The frequency of laryngomalacia admissions based on the primary expected payer for the visit is shown in Table 3. The frequency of laryngomalacia admissions in patients for whom the primary expected payer was Medicaid (adjusted residual = 22.7) or other (various government programmes) (adjusted residual = 8.8) was found to be significantly greater than expected. The frequency of laryngomalacia admissions in patients for whom the primary expected payer was Medicare (adjusted residual = −2.3), private insurance (adjusted residual = −20.3), or self-pay (adjusted residual = −12.7) was found to be significantly less than expected.

Other Diseases Associated with Larygomalcia

Table 4 presents the associations between laryngomalacia and a range of medical conditions across several organ systems, comparing patients diagnosed with LM to the general population (GP) of the database–that is, all other patients without a diagnosis code for laryngomalacia. In the ear, nose, and throat category, patients with LM exhibited significantly higher rates of congenital malformations of the salivary glands (6.30% in LM vs 2.52% in GP, OR 2.5), speech and language developmental disorders (3.54% vs 0.71%, OR 5.0), palatal edema (7.57% vs 0.99%, OR 7.65), streptococcal throat infections (2.44% vs 0.23%, OR 10.61), and bilateral otitis media (2.40% vs 0.09%, OR 26.67). Similar trends were noted in respiratory conditions, including acute bronchiolitis due to RSV (OR 2.29), acute respiratory distress syndrome (OR 5.29), respiratory failure with hypoxia (OR 4.35), unspecified acute upper respiratory infections (OR 2.69), cyanosis (OR 18.70), and dependence on supplemental oxygen (OR 8.53). Additionally, significant associations were observed with dysphagia (OR 6.72), edema of the vocal cords (OR 3.62), and obstructive sleep apnea (OR 11.44). In the gastrointestinal domain, LM was linked to feeding difficulties (OR 7.66), gastroesophageal reflux disease (OR 5.99), gastrostomy status (OR 5.09), and neonatal aspiration (OR 5.76), although neonatal jaundice associated with preterm delivery was less prevalent (OR 0.26). Lastly, notably high odds were seen in neurological conditions, particularly congenital hydrocephalus (OR 32.88), microcephaly (OR 7.78), and idiopathic intracranial hypertension (OR 2.56). All associations were statistically significant ($p < 0.001$).

Discussion

This study aimed to further understand how socioeconomic status and race affect laryngomalacia outcomes. For socioeconomic status, the results showed the frequency of laryngomalacia admissions for patients from zip codes above the national median income was significantly less than for 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]

Table 2. Race and laryngomalacia incidence

Race and/or ethnicity	Laryngomalacia per 100 000 (adjusted residual) (*n*)	Laryngomalacia admissions (*n*)	Total admissions (*n*)
White	248.8 (−2.3)	5152	2 071 034
Black	321.4 (11.2)	1944	604 886
Hispanic	253.2 (−0.3)	2127	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

Table 3. Frequency of laryngomalacia admissions by expected primary payer

Expected primary payer	Laryngomalacia per 100 000 (*n* (adjusted residual))	Laryngomalacia admissions (*n*)	Total admissions (*n*)
Medicare	166.5 (−2.3)	26	15 611
Medicaid	315.0 (22.7)	6778	2 151 963
Private insurance	204.2 (−20.3)	4105	2 010 753
Self-pay	114.2 (−12.7)	220	192 642
No charge	137.4 (−1.1)	3	2183
Other	378.5 (8.8)	506	133 703

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

Disease name	Prevalence in laryngomalacia (%)	Prevalence in general population (GP) (%)	Odds ratio
Ear, nose and throat			
– 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 oedema	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
Respiratory system			
– Acute bronchiolitis due to Respiratory syncytial virus (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
– Oedema of vocal folds	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 apnoea (adult) (paediatric)	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
Endocrine system			
– Disorder of fluid, electrolyte and acid–base balance, unspecified	2.35	1.49	1.58
Gastrointestinal system			
– 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-oesophageal reflux disease without oesophagitis	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
Integumentary system			
– Diaper dermatitis	2.33	1.21	1.92
Nervous system			
– 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

A shortage of providers could inhibit interaction with the healthcare system because of increased distances to providers as well as longer wait times to see providers. If paediatric patients have less frequent wellness visits, there is a chance that laryngomalacia might be missed in early diagnostic stages, leading to an increase in in-patient admissions on developing symptoms.

The US for-profit healthcare system contains numerous ways to pay for the service. Medicare and Medicaid are insurances that

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are subsidised by the US federal government and are intended to help older and low-income people, respectively. Private insurance patients are insured through paying a monthly fee in an open marketplace; this is often offered as a benefit of employment. Self-pay indicates that the patient is uninsured and instead pays cash for service. The frequency of laryngomalacia in patients for whom the primary expected payer was Medicaid or other (various government programmes) 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 or 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 using Medicaid are more likely to use the emergency department relative to patients using commercial insurance.[12] According to Kim *et al.*,[12] the drivers of this disparity include not having a primary care provider (PCP), facing less out-of-pocket cost in the emergency department and the perception that the emergency department will be able to solve all of the patient's problems with fewer visits. Patients using private insurance are more likely to seek care in out-patient office visits.[13] The reduced use of out-patient 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 emphasised 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 on a previous study that indicated that laryngomalacia may occur with greater frequency among Black patients compared with other racial groups.[15] One potential explanation for the higher rates of laryngomalacia admissions in Black patients could be tied to preterm birth. The previous study also found there were significantly more preterm Black and Hispanic patients compared with other racial groups.[15] According to Manuck, 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 it may be a consequence of an underdeveloped or abnormally integrated central nervous system system.[17] Because of the association between neurological disease and laryngomalacia, it is possible that premature babies have higher rates of laryngomalacia, but 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 apnoea and gastroesophageal reflux disease (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 otolaryngological and respiratory conditions, some affecting or involving the throat, such as palatal oedema, dysphagia, speech disorders and strep throat, and others affecting 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]

Other disorders, such as congenital absence of salivary glands and bilateral otitis media, are also prevalent, with a far less clear potential mechanism. Laryngomalacia was also found to be associated with a variety of gastrointestinal 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. Mechanistically, these conditions can broadly be attributed to the effects of preterm birth, which is also associated with the development of laryngomalacia.[1,21,22]

The present study has some limitations. First, the study relied on data from a single database, the Healthcare Cost and Utilization Project Kid Inpatient Database for 2016. Although the Healthcare Cost and Utilization Project database comprises valuable data and is well-reported in literature, future studies should expand the patient selection by using larger alternative databases.

Another limitation is that the Healthcare Cost and Utilization Project database only contains information on paediatric 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 laryngomalacia that is severe enough to necessitate hospital admission. Moreover, the Healthcare Cost and Utilization Project 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 analysed. However, since the Kid Inpatient Database is a database of in-patients, the patient population likely skews toward more severe forms of laryngomalacia.

Lastly, racial groups were standardised to the US-derived Kid Inpatient Database, but 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 in-patients presenting with laryngomalacia and determine if a lack out-patient 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 should investigate the mechanisms underlying the association between laryngomalacia and its related diseases. This research could help clarify which factors serve as risk factors for laryngomalacia and which are complications resulting from the condition.

Conclusion

Future studies of the interplay of the factors descibed above will enhance current understand of larygomalcica 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

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initiatives aimed at reducing health inequalities among children. Ultimately, this understanding will enable prompt recognition and intervention, resulting in improved health results for infants impacted by laryngomalacia.

- The study aimed to understand how socioeconomic status, race and the primary expected payer affect the incidence of laryngomalacia in paediatric in-patients
- The impact of different levels of socioeconomic status on the incidence of laryngomalacia was explored and racial disparities in the occurrence of laryngomalacia among paediatric patients were analysed
- The way in which the type of primary expected payer (insurance type) influences the incidence rates of laryngomalacia was examined
- The interplay of these factors with other disease processes in the incidence of laryngomalacia was investigated, with a focus on the in-patient paediatric population to derive insights specific to hospitalised children

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