The occurrence of laryngeal pathologies in a treatment-seeking pediatric population

Anke Adriaansen[a], Kristiane Van Lierde[ab], Iris Meerschman[a], Sofie Claeys[c], Evelien D'haeseleer[acd]

[a]Center for Speech and Language Sciences (CESLAS), Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium

[b]Department of Speech-Language Pathology and Audiology, University of Pretoria, Pretoria, South-Africa

[c]Department of Otorhinolaryngology, Ghent University Hospital, Ghent, Belgium

[d]Royal Conservatory Brussels, Musical Department, Brussels, Belgium

Corresponding author:

Anke Adriaansen

+32471028622

Anke.adriaansen@ugent.be

Corneel Heymanslaan 10

9000 Ghent

Belgium

Co-authors:

Kristiane.vanlierde@ugent.be

Iris.meerschman@ugent.be

Sem.Claeys@UGent.be

Evelien.dhaeseleer@ugent.be

Declarations of interest: none

Abstract

Objectives: The purpose of this study was to 1) describe the age- and sex-specific occurrence of laryngeal pathologies in a treatment-seeking pediatric population in the voice unit of Ghent University Hospital, Belgium, and 2) describe this population in terms of vocal parameters, vocal complaints, influencing factors, and treatment history and recommendation.

Study design: Retrospective, observational study.

Methods: All patient records were analyzed for children (0 – 18 years) who consulted the ear, nose and throat department of Ghent University Hospital for the first time between July 2015 and June 2021 with complaints of dysphonia. In total, 103 children (66 males, 37 females) with a mean age of 10.01 years (SD: 3.4, range 3.93 – 17.96) were included in this study. Laryngeal pathology was diagnosed using flexible videolaryngo(strobo)scopy. The influence of age and sex on laryngeal etiology (organic/functional voice disorder) was examined using a Welch modified t-test and a Fisher's exact test, respectively.

Results Organic lesions were observed in 77.7% of the participants, with vocal fold nodules (VFNs) being the most common diagnosis (66.0%). A functional voice disorder was diagnosed in 22.3% of the children. Children with a functional voice disorder are significantly older than children with an organic voice disorder. There was no statistically significant difference between males and females in laryngeal etiology. Mean dysphonia severity index was -2.7 (SD: 3.2, range -9.3 – +3.7), mean acoustic voice quality index 4.70 (SD: 1.5, range 2.35 – 8.27) and mean pediatric voice handicap index 29.8 (SD: 13.6, range 5 – 60). The occurrence of vocal misuse was mentioned in 80.6% of the patient records.

Conclusion: Organic voice disorders, especially VFNs, are predominant in treatment-seeking children with dysphonia. Functional voice disorders become more common with increasing age during childhood. A disordered vocal quality, reduced vocal capabilities and reduced voice-related quality of life were found.

Keywords: Voice disorders – Children – Laryngoscopy - Prevalence

Introduction

Voice disorders occur when vocal quality, pitch and/or loudness differ from what would be expected based on an individual's age, gender, cultural background and geographic location, or when an individual expresses concern about their voice not meeting daily needs.[1-3] Voice disorders are fairly common in children with reported prevalence rates ranging from 3.9% to 53.2%.[4-12] This wide spread may be attributed to methodological differences between prevalence studies, such as the various criteria to define a voice disorder. The prevalence of voice disorders is lowest (3.9%) at preschool age, with no significant difference between males and females.[9] In primary school children, voice disorders are more prevalent in males compared to females which may be explained by socio-cultural specific activities in males that demand excessive and loud voice use.[4,7,11] During puberty, the male laryngeal system experiences more explicit structural changes compared to females, making men less vulnerable to voice disorders.[13] The most important structural changes are an elongation of the thyroid cartilage and a thickening of the thyroarytenoid muscle, which result in a lower fundamental frequency (f_0) and thus fewer vocal fold oscillations and collisions for an equal amount of voicing. Differences in composition of vocal fold tissue, such as higher concentrations of collagen and hyaluronic acid, also make the male laryngeal system less susceptible to vocal fatigue, vocal fold injury, and scarring. Therefore, voice disorders are more prevalent in adolescent and adult women compared to men.[13-15]

A multidimensional voice assessment should be administered in order to diagnose a pediatric voice disorder. According to the protocol for functional assessment of pathological voices, a voice assessment should consist of perceptual, aerodynamic and acoustic measurements, a subjective self-evaluation and videolaryngostroboscopy.[16,17] No definite diagnosis can be made without visualization of the larynx, using some form of laryngoscopy.[18] Flexible laryngoscopy has the advantage that it is generally tolerated in children of all ages because it does not require substantial collaboration of the patient. Moreover, it avoids a gag reflex because of the nasal insertion and it allows a more functional examination like connected speech, pitch variations, and glissandos.[19-22] Rigid laryngoscopy is more difficult to perform, especially in young children and children with a strong gag reflex.[23,24] A stroboscopic light can be added to both forms of laryngoscopy, which supports the evaluation of vocal fold mucosal pathologies and the diagnosis of functional voice disorders.[20] The specific diagnostic advantages of videolaryngostroboscopy are pointed out by Mortensen, Schaberg and Woo [21]: "videolaryngostroboscopy elucidates subtle features of different disease processes; clarifies the differences between benign mucosal disorders that might require surgical intervention; and helps identify inflammatory processes that contribute to dysphonia." It is recommended to choose visualization instruments taking into account the age, collaboration and tolerance of the child.[23]

An international consensus for an agreed framework to classify pediatric voice disorders is currently lacking, leading to an important heterogeneity in terminology.[25] Voice disorders are often categorized into two major classes based on etiology: organic and functional voice disorders. Organic voice disorders are characterized by the presence of a specific lesion and result from alterations in respiratory, laryngeal or vocal tract mechanisms. This includes the structural voice disorders, such as vocal fold nodules (VFNs), and the neurogenic voice disorders, such as vocal fold paralysis. Functional or non-organic voice disorders are characterized by insufficient or improper use of the vocal mechanism without any identifiable physical abnormality or neurological dysfunction.[26] It is a large heterogeneous group in which the voice disorder can take different forms.[27] The most common functional voice disorder is muscle tension dysphonia (MTD), the pathological condition in which excessive tension of the (para)laryngeal musculature leads to a disturbed voice.[3,28,29] MTD is associated with glottic insufficiency.[30] Other functional voice disorders include psychogenic voice disorders[27], puberphonia[31], presbyphonia[32], and paradoxical vocal fold movement.[33] Although this is the most commonly used classification system for voice disorders, some controversies still remain. Firstly, some authors add a third major class where the cause of the voice problem is related to a psychological or emotional conflict: psychogenic voice disorders.[34,35] However, since no structural or neurological lesion underlies the symptoms here, psychogenic voice disorders are usually considered a form of functional voice disorders.[3,36,37] Secondly, the boundary between organic and functional voice disorders is not always clear as organic lesions may arise as a result of improper use of the vocal mechanism, and improper use may also be the result of organic lesions.[28] For this reason, some authors differentiate between primary and secondary organic voice disorders. Primary organic lesions are not related to vocal behavior, like congenital malformations, trauma, and vocal fold paralysis. Secondary organic voice disorders are mucosal changes or organic signs as a result of prolonged vocal strain or phonotraumatic behavior, like VFNs and edema, chronic laryngitis, and contact ulcer.[25,38] A similar categorization can be found for MTD. Primary MTD is defined as excessive or atypical (para)laryngeal muscle tension in the absence of organic lesions, while secondary MTD is characterized by the same pathological muscle tension in the presence of an organic lesion.[29,39,40] Thirdly, the term 'behavioral voice disorders' is sometimes preferred over functional voice disorders, since these voice disorders are directly related to vocal behavior.[39,41] Lastly, the Union of European Phoniatricians advised to adopt a new universally agreed and clearly defined term for 'functional voice disorders' since 'functional' does not have a clear etiological implication and is considered to be vague, imprecise and misleading. Hacki, Moerman and Rubin [42] recently proposed the term 'malregulative dysphonia' instead of 'functional dysphonia', referring to disturbances in the psychomotor and sensorimotor control system as the main cause of dysphonia. Despite these criticisms, the most frequently used terminology (organic and functional voice disorders) will be used in this paper.

Various studies have investigated the occurrence of different laryngeal pathologies in children. An overview of the different studies investigating the occurrence of laryngeal pathologies in children are summarized in Table 1. All of these studies investigated laryngeal pathologies using imaging techniques (direct, flexible or rigid (video)laryngo(strobo)scopy) in a treatment-seeking pediatric population. Terminology was adopted from the various articles without modification. The most common laryngeal condition in children is VFNs, which account for 18%-80% of all cases of pediatric voice disorders.[43-45] Only one study mentioned subglottic stenosis instead of VFNs as the most common diagnosis in children, but the medical center where the data were collected was internationally recognized for treating this condition, leading to an overrepresentation of subglottic stenosis (31%) and an underestimation of the occurrence of VFNs (18%).[43] However, studies reported large differences regarding the distribution of other laryngeal pathologies in children. Moreover, there is still limited literature on the occurrence of pediatric voice disorders in Western Europe. Research has shown that the prevalence and severity of voice problems may vary among different culturally diverse groups, stressing the importance of prevalence studies in different regions. [9,46] Understanding the occurrence of voice problems is important for an optimal approach regarding prevention, evaluation, treatment, follow-up and research. The aim of the current study was 1) to describe the age- and sex-specific occurrence of laryngeal pathologies in a treatment-seeking pediatric population at the ear, nose and throat (ENT) department of Ghent University Hospital, Belgium, 2) to describe this population in terms of vocal parameters, vocal complaints, influencing factors (vocal misuse, reflux, and allergies) and treatment history and recommendation.

[Please insert Table 1 approximately here]

Table 1: Overview of studies examining the occurrence of laryngeal pathologies

Article	N	Sex	Age (years)	Distribution of laryngeal pathologies	
Holinger and Johnston [47]	116	not specified	range: 0 - 20	79 nodules (68.1%) 18 polyps (15.5%) 15 cysts (12.9%)	2 polypoid degeneration (1.7%) 2 laryngocele (1.7%)
Herrington-Hall, Stemple, Niemi and Miller Mc Hone [44]	93	66 males 27 females	range: 0 – 14	74 nodules (79.6%) 5 edema (5.4%) 4 normal on exam (4.3%) 3 polyps (3.2%) 2 vocal fold paralysis (2.2%)	2 functional (2.2%) 1 laryngitis (1.1%) 1 ventricular phonation (1.1%) 1 stenosis (1.1%)
Dobres, Lee, Stemple, Kummer and Kretschmer [43]	731	464 males 267 females	range: 0 – 18	228 subglottic stenosis (31.2%) 128 vocal nodules (17.5%) 87 laryngomalacia (11.9%) 56 normal larynx (7.7%) 45 vocal fold paralysis (6.2%) 28 papilloma (3.8%) 25 stridor (3.4%) 21 croup (2.9%) 16 cyst (2.2%) 15 edema (2.1%) 10 hemangioma (1.4%) 10 laryngeal cleft (1.4%) 10 web (1.4%) 9 laryngitis (1.2%) 8 granuloma (1.1%)	5 vocal fold paresis (0.7%) 4 caustic ingestion (0.6%) 4 laryngeal trauma (0.6%) 4 vocal fold thickening (0.6%) 3 bowed vocal folds (0.4%) 3 laryngotracheobronchitis (0.4%) 2 supraglottic stenosis (0.3%) 2 epiglottitis (0.3%) 2 psychogenic (0.3%) 1 behavioral (0.1%) 1 erythema (0.1%) 1 interarytenoid cleft (0.1%) 1 laryngocele (0.1%) 1 polyp (0.1%) 1 postsurgical scarring (0.1%)
Papsin, Pengilly and Leighton [48]	48	31 males 17 females	mean: 9.2 (SD: 4.4; range: 0.08 – 17.9)	9 vocal fold nodules (20.5%) 9 normal examination (20.5%) 7 supraventricular phonation (15.9%) 6 cricoarytenoid joint fixation (13.6%) 3 vocal fold paralysis (6.8%)	3 mucopolysaccharidoses (6.8%) 2 glottic webs (4.5%) 2 scar (laryngocele, papilloma) (4.5%) 2 impaired posterior closure (4.5%) 1 hyperkeratosis (2.3%)
Coyle, Weinrich and Stemple [49]	41	26 males 15 females	range: 0 – 14	26 nodules (63.4%) 6 functional (15.6%) 2 polyps (4.9%) 2 cough (4.9%)	2 laryngomalacia (4.9%) 1 laryngitis (2.4%) 1 tracheal stenosis (2.4%) 1 normal on exam (2.4%)
Mandell, Kay, Dohar and Yellon [50]	127	74 males 53 females	mean: 6.9 (range: 1.8 – 17)	104 vocal nodules (81.9%) 53 laryngitis (41.7%) 40 both nodules and laryngitis (31.5%)	6 normal-appearing larynx (4.7%) 2 true vocal fold polyp (1.6%) 1 true vocal fold paralysis (0.8%)
Wolf, Primov-Fever, Amir and Jedwab [51]	31	not specified	range: 6 – 16	10 nodules (32.3%) 8 cysts (25.8%) 6 polyps (19.4%) 5 normal (16.1%)	3 edema (9.7%) 2 mutation (6.5%) 2 web (6.5%) 1 monocorditis (3.2%)

				4 sulcus (12.9%)	1 papillomatosis (3.2%)
Angelillo, Di Costanzo, Angelillo, Costa, Barillari and Barillari [52]	312	178 males 134 females	range: 2 – 16	154 irregularity at the junction of the anterior and middle third of the vocal folds (59.9%) 64 nodules (24.9%) 55 no lesion (17.6%)	21 cysts (8.1%) 14 edema (5.5%) 3 sulcus (1.2%) 1 laryngeal web (0.4%)
Connelly, Clement and Kubba [53]	137	83 males 54 females	median: 5.3 (range: 0 – 15)	62 voice abuse (including nodules) (37.2%) 31 no specific diagnosis (22.6%) 18 inflammatory (13.1%)	15 iatrogenic (10.9%) 10 congenital (7.3%) 1 neoplastic (0.7%)
Van Houtte, Van Lierde, D'haeseleer and Claeys [54]	81	42 males 39 females	range: 0 -14	51 vocal fold nodules and hypertrophy (63.0%) 13 functional disorder (16.0%) 6 Edema and Reinke's edema (7.4%) 4 normal on exam (4.9%)	3 GERD, laryngitis, inflammation (3.7%) 3 polyps and cysts (3.7%) 1 vocal fold paralysis (1.2%)
Mortensen, Schaberg and Woo [21]	80	52 males 28 females	mean: 11 (range: 3 – 17)	41 nodules (51.3%) 27 laryngopharyngeal reflux (33.8%) 15 polyps (18.8%) 11 functional dysphonia (13.8%) 8 cysts (10%) 6 allergic rhinitis (7.5%) 5 adenoid hypertrophy and/or rhinitis (6.3%)	4 sulcus (5%) 3 laryngeal trauma (3.8%) 3 nonspecific laryngitis (3.8%) 2 neurologic disorder (2.5%) 1 granuloma (1.25%) 1 congenital glottic stenosis (1.25%)
Mackiewicz-Nartowicz, Sinkiewicz and Bielecka [36]	150	not specified	mean: 8.2 (range: 2.5 – 14)	85 vocal fold nodules (56.7%) 60 hyperfunctional dysphonia (40.0%)	5 other lesions (3.3%)
Martins, Ribeiro, Mello and al. [55]	304	194 males 110 females	range: 4 – 18	175 nodules (57.6%) 47 epidermal cysts (15.4%) 33 nodules/cyst (10.7%) 10 functional dysphonia (3.3%) 8 sulci/bridge (2.6%) 6 microweb and nodules (2.0%) 5 paralysis (1.7%) 4 papillomatosis (1.3%)	4 cyst + bridge/sulci (1.3%) 4 laryngitis (1.3%) 3 hemangioma (1.0%) 2 granuloma intubation (0.7%) 1 adherence postintubation (0.3%) 1 pharyngeal dystonia (0.3%) 1 lymphangioma (0.3%)
Wynne and Cohen [56]	86	48 males 38 females	range: 0 – 15	40 vocal fold nodules (46.5%) 6 vocal fold palsy (7.0%) 4 muscle tension dysphonia (4.7%) 4 no abnormality (4.7%) 4 awaiting outcome (4.7%) 3 spasmodic (3.5%) 3 crico-arytenoid joint fixation (3.5%) 3 reflux (3.5%) 3 adenoids (3.5%) 2 post-laryngotracheal reconstruction (2.3%)	1 puberphonia (1.2%) 1 double aortic arch (1.2%) 1 intracordal cyst (1.2%) 1 posterior chink (1.2%) 1 Ehlers-danlos syndrome (1.2%) 1 hemangioma (1.2%) 1 speech delay (1.2%) 1 glottic web (1.2%) 1 recurrent respiratory papillomatosis (1.2%)
Martins, do Amaral, Tavares, Martins,	379	213 males 166 females	range: 0 – 18	225 nodules (59.4%) 89 other pathologies (23.5%)	39 cysts (10.3%) 26 acute laryngitis (6.9%)

Goncalves and Dias [57]					
Mozzanica, Ginocchio, Barillari, Barozzi, Maruzzi, Ottaviani and Schindler [58]	41	not specified	range: 0 – 14	15 vocal fold nodules (36.6%) 9 movement disorders (22.0%) 8 functional disorders (19.5%)	5 vocal fold polyp/cyst (12.2%) 4 vocal fold edema (9.8%)
Ramos, Alvarez, Leon, Badia and Napolitano [23]	126	68 males 58 females	mean: 9 (range: 0 – 18)	50 vocal nodules (39.7%) 33 vocal cord cysts (26.2%) 31 other (24.6%)	8 sulcus vocalis (6.3%) 4 vocal cord paralysis (3.2%)
Antón Almero, Doménech Máñez, Ferrer Ramírez, Solavera, Reig Montaner and Faubel Serra [59]	87	57 males 30 females	mean: 8.5 (SD: 2.08; range: 4 – 13)	40 vocal nodules (45.9%) 38 fusiform edema of vocal folds (43.7%) 17 hypervascularization (19.5%)	14 sulcus (16.1%) 5 cyst (5.7%)

Methods

Ethical approval was obtained from the Ethics Committee of Ghent University Hospital (registration number: BC-10664).

Participants

Between July 1, 2015 and June 30, 2021, all children (0 – 18 years) who presented themselves for the first time at the ENT department of Ghent University Hospital with complaints of dysphonia were included in this study. During this appointment, children were examined by an experienced otorhinolaryngologist using flexible videolaryngo(strobo)scopy. Due to an accurate referral system between the ENT department and the voice therapy department, all children with dysphonia in this hospital are also seen by a voice therapist with experience in voice assessment. Patients were excluded if flexible videolaryngo(strobo)scopy was not performed during this first appointment, if they presented themselves with voice-gender incongruence, or if there were no organic or functional abnormalities on videolaryngo(strobo)scopy.

Procedures

In this retrospective, observational study, data from electronic patient records were analyzed. Patient records were reviewed for demographic data, laryngeal pathology and voice-related information. The following data were collected for each patient: 1) birth date, 2) sex, 3) date of ENT and voice examination, 4) laryngeal pathology, 5) vocal parameters, 6) vocal complaints, 7) phonotraumatic behavior, 8) reflux, 9) allergy, 10) comorbidity, 11) history and duration of voice therapy, and 12) treatment recommendation.

Birth date, sex, and date of ENT and voice examination were directly extracted from the patient records. For laryngeal pathology, all videolaryngo(strobo)scopic findings as determined by the otorhinolaryngologist were included in the dataset, so multiple findings could be listed for one patient. Nevertheless, a primary diagnosis was also determined for each patient. Consistent with the study of Van Houtte et al. (2010)[60], organic voice disorders are taking precedence over functional findings. Moreover, it was established that a diagnosis of VFNs or vocal fold cyst took precedence over vocal fold edema for the organic findings, and puberphonia or psychogenic dysphonia took precedence over glottic insufficiency or MTD for the functional findings. For vocal parameters, the reported results of the grade parameter of the GRBASI scale (G), dysphonia severity index (DSI), acoustic voice quality index (AVQI), and pediatric voice handicap index (pVHI) were adopted. At Ghent University Hospital, a Samson C01U Pro microphone was used during the consultations with the voice therapist. The parameters of the DSI are determined using the Voice Range Profile (minimal intensity, maximal pitch) and Multi Dimensional Voice Program (jitter (%)) of the Computerized Speech Lab (CSL, model 4500, KayPENTAX, Montvale, NY). The AVQI is calculated based on a sustained /a:/ vowel and the first two

sentences of the Dutch phonetically balanced text "Papa and Marloes" using the software program PRAAT[61]. For vocal complaints, the anamneses of the otorhinolaryngologist and the voice therapist were checked for hoarseness, aphonia, laryngeal or pharyngeal discomfort, globus sensation, and other complaints. Phonotraumatic behavior is usually investigated during anamnesis, by asking if the child often shouts, whispers, imitates voices, talks a lot or has vocally demanding hobbies. If one or more of these behaviors were described in the patient record, the participant was considered a child in whom phonotraumatic behaviors were frequent. For reflux and allergy, no standardized assessment was administered as part of this retrospective study. Regarding reflux, patient records were checked for positive reflux tests (24 hour PH-metry), a previous reflux diagnosis at another health center or a strong suspicion of reflux based on the reported symptoms and/or laryngoscopic findings. Regarding allergy, patient records were checked for positive allergy tests. At Ghent University Hospital, children with symptoms that may indicate allergy are referred to a multidisciplinary allergy network, where they undergo skin prick tests and/or blood tests. It is also possible that the allergy was diagnosed at another health care center and discussed during the anamnesis. Patient records were also searched for known comorbid diagnoses. These conditions may have been diagnosed at the ENT department or at another department of Ghent University Hospital, or even at another health care center and reported during anamnesis. History and duration of voice therapy and given treatment recommendations during the consultation with the otorhinolaryngologist and voice therapist were also investigated.

Statistical analysis

SPSS Version 26 (SPSS Corporation, Chicago, IL) was used for the statistical analysis of the data. Age at ENT examination was calculated from the birth date and date of ENT examination and participants were divided into six different age groups: toddlers (0 – 2 years), preschoolers (3 – 5 years), early school-age (6 – 8 years), late school-age (9 – 11 years), early adolescence (12 – 14 years), and late adolescence (15 – 17 years).

The occurrence of laryngeal pathologies in the entire study group was examined by two descriptive analyses: one based on the primary laryngeal diagnosis (one diagnosis per patient) and one based on all laryngeal findings (so possibly multiple findings per patient). Relations between laryngeal etiology (organic voice disorders and functional voice disorders) and age and sex were also investigated and these analyses were conducted at $\alpha = 0.05$. A Welch modified t-test was used to make a comparison in age between laryngeal etiologies. A Fisher's exact test was used to determine if there was a significant interaction between sex and laryngeal etiology.

Results

Demographic data

In total, patient records of 103 children (66 males, 37 females) were included. Flexible videolaryngoscopy without stroboscopic light was carried out in five children and videolaryngostroboscopy in 98 children. Participants had a mean age of 10.01 years (SD: 3.4) with a range of 3.93 – 17.96 years. The distribution of age at referral can be found in Figure 1. During the data collection process, three patient records were excluded because the patients presented themselves with voice-gender incongruence and three other patient records were excluded because there were no organic or functional abnormalities on videolaryngostroboscopy.

[Please insert Figure 1 approximately here]

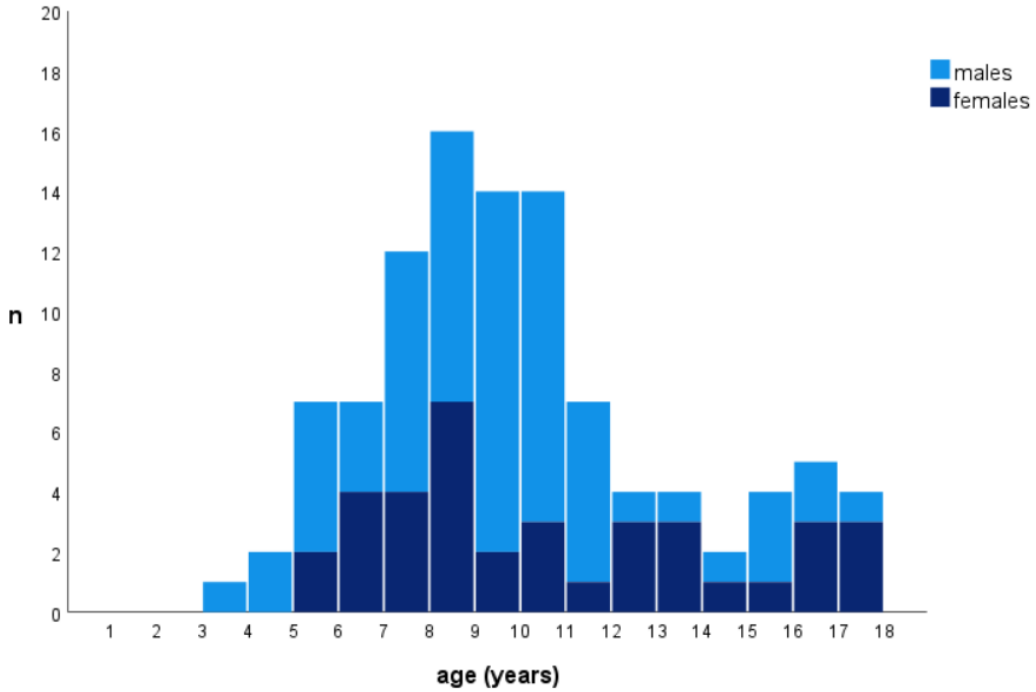

Figure 1: Distribution according to age

Laryngeal pathology

Analysis of primary laryngeal diagnosis

Of the 103 children who presented themselves at the ENT department with voice complaints, 80 (77.7%) were diagnosed with an organic lesion, with VFNs being the most common diagnosis (68/103, 66.0%). Twenty-three children (22.3%) were diagnosed with a functional voice disorder. An overview of the different voice disorders can be found in Table 2.

[Please insert Table 2 approximately here]

Table 2: Overview of the primary laryngeal diagnoses

Diagnosis	N (%)
Organic voice disorder	**80 (77.7)**
VFNs	68 (66.0)
Vocal fold edema	8 (7.8)
Hyperaemia of vocal folds	2 (1.9)
Vocal fold cyst	1 (1.0)
Unilateral vocal fold paralysis combined with ankylosis of cricoarytenoid joint	1 (1.0)
Functional voice disorder	**23 (22.3)**
Glottic insufficiency	7 (6.8)
Combination glottic insufficiency and MTD	6 (5.8)
MTD	4 (3.9)
Puberphonia	4 (3.9)
Psychogenic dysphonia	1 (1.0)
Paradoxical vocal fold movement	1 (1.0)

The distribution of age across the two groups of laryngeal etiology can be found in Figure 2. Mean age of participants with an organic voice disorder is 9.18 years (SD: 2.8) and with a functional voice disorder 12.89 years (SD: 3.6). The Welch modified t-test showed a significant difference in mean age between children with an organic and a functional voice disorder [$t(30.331) = -4.565$; $p < 0.001$]. Children with a functional voice disorder are on average 3.71 years older than children with an organic voice disorder [95% CI (2.05; 3.37)].

[Please insert Figure 2 approximately here]

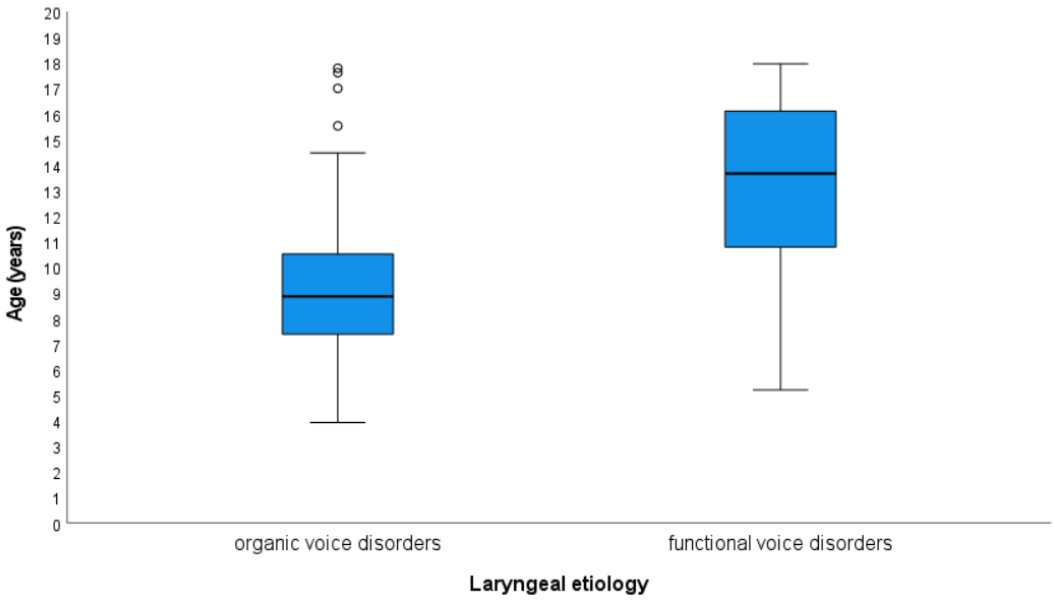

Figure 2: Distribution of age across laryngeal etiology

Figure 3 shows the different laryngeal etiologies in males and females. A Fisher's exact test showed that there was no statistically significant interaction between sex and laryngeal etiology [$\chi^2(1) = 0.017$; $p > 0.999$].

[Please insert Figure 3 approximately here]

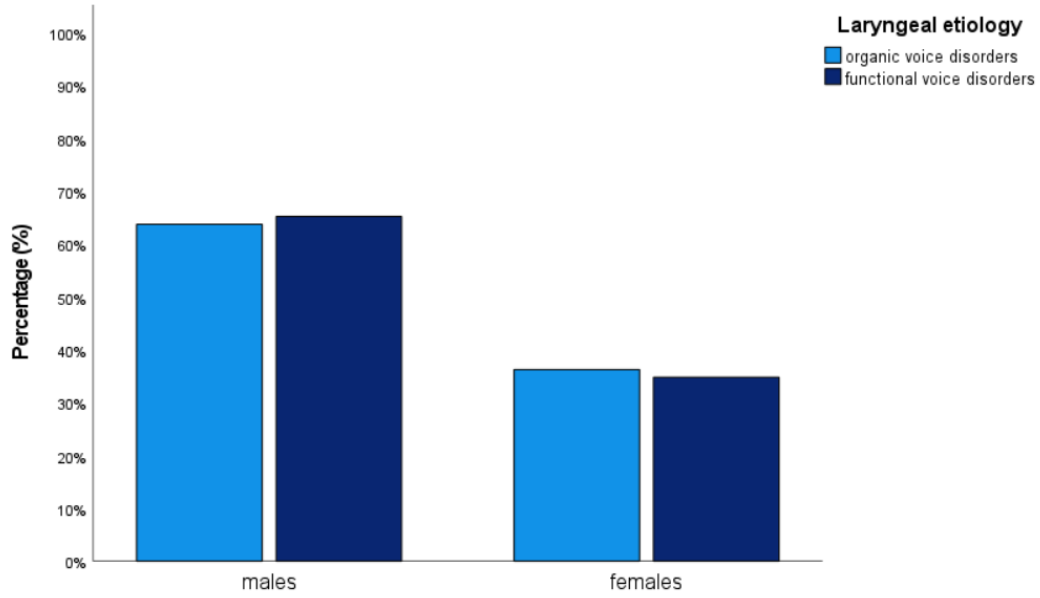

Figure 3: Laryngeal etiology in males and females

Analysis of all laryngeal findings

Firstly, a combination of an organic lesion with primary or secondary functional findings was found in 60 children (58.2%). The most common combination was VFNs with glottic insufficiency (45/60);

followed by vocal fold edema and glottic insufficiency (5/60); VFNs, glottic insufficiency and MTD (4/60); VFNs and MTD (2/60); VFNs, vocal fold edema and glottic insufficiency (1/60); vocal fold edema, glottic insufficiency and MTD (1/60); hyperaemia and glottic insufficiency (1/60); and hyperaemia, glottic insufficiency and MTD (1/60). Secondly, of the 23 children with a functional voice disorder, ten had multiple functional symptoms: glottic insufficiency and MTD (6/10); puberphonia and glottic insufficiency (2/10); puberphonia and MTD (1/10); and psychogenic dysphonia and MTD (1/10). Lastly, two children (1.9%) had multiple organic lesions: one had VFNs and vocal fold edema, the other vocal fold cyst and vocal fold edema. Table 3 shows an overview of all laryngeal findings according to age and sex.

[Please insert Table 3 approximately here]

Table 3: Overview of all laryngeal findings according to age and sex

	Preschoolers 3 – 5 years			**Early school-age 6 – 8 years**			**Late school-age 9 – 11 years**			**Early adolescence 12 – 14 years**			**Late adolescence 15 – 17 years**			**Total**			
	M	F	**T**	M	F	**T**	M	F	**T**	M	F	**T**	M	F	**T**	M	F	**T**	**%**
Organic findings																			
VFNs	6	2	**8**	16	12	**28**	21	4	**25**	1	3	**4**	0	3	**3**	44	24	**68**	**66.0**
Vocal fold edema	1	0	**1**	2	3	**5**	2	0	**2**	0	1	**1**	0	1	**1**	5	5	**10**	**9.7**
Hyperaemia of vocal folds	1	0	**1**	1	0	**1**	0	1	**1**	1	0	**1**	0	0	**0**	4	0	**4**	**3.9**
Vocal fold cyst	0	0	**0**	1	0	**1**	0	0	**0**	0	0	**0**	0	0	**0**	1	0	**1**	**1.0**
Unilateral vocal fold paralysis	0	0	**0**	0	0	**0**	1	0	**1**	0	0	**0**	0	0	**0**	1	0	**1**	**1.0**
Ankylosis of cricoarytenoid joint	0	0	**0**	0	0	**0**	1	0	**1**	0	0	**0**	0	0	**0**	1	0	**1**	**1.0**
Arytenoid erythema	1	0	**1**	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	1	0	**1**	**1.0**
Functional findings																			
Glottic insufficiency	5	2	**7**	14	11	**25**	21	6	**27**	2	4	**6**	3	6	**9**	45	29	**74**	**71.8**
MTD	0	0	**0**	3	0	**3**	5	1	**6**	1	5	**6**	2	2	**4**	11	8	**19**	**18.4**
Puberphonia	0	N.A.	**0**	0	N.A	**0**	0	N.A	**0**	0	N.A	**0**	4	N.A	**4**	4	N.A	**4**	**3.9**
Psychogenic dysphonia	0	0	**0**	0	0	**0**	0	0	**0**	0	1	**1**	0	1	**1**	0	2	**2**	**1.9**
Paradoxical vocal fold movement	0	0	**0**	0	0	**0**	0	0	**0**	0	0	**0**	1	0	**1**	1	0	**1**	**1.0**

M = males; F = females; T = total ; N.A. = not applicable

Comorbidity was present in 15 children (14.6%). An overview of the comorbid conditions can be found in Table 4.

Table 4: overview of comorbid conditions

	Occurrence (n)	
	OVD	**FVD**
Developmental disorders		
• Attention deficit hyperactivity disorder	1	1
• Autism spectrum disorder	1	1
• Developmental coordination disorder	1	
Speech and Language disorders		
• Stuttering	1	
• Delayed speech and language development	1	
• Hypernasality	1	
Anatomical anomalies		
• Congenital posterior glottic stenosis	1	
• Bifid uvula	1	
• Velopharyngeal insufficiency		1
• Hypertrophic tonsils	1	
• History of pharyngeal abscess	1	
General medical conditions		
• Bronchial hyperresponsiveness		1
• Chronic bronchitis	1	
• History of recurrent otitis media	1	
• Hodgkin lymphoma	1	
• Metabolic disorder (phenylketonuria)	1	

OVD = organic voice disorders, FVD = functional voice disorders

Voice-related data

Vocal parameters

For the total group, mean grade of GRBASI scale was 1.71 (SD= 0.7; range 0 – 3), mean DSI was -2.74 (SD= 3.2; range -9.3 - 3.7), mean AVQI was 4.70 (SD= 1.5; range 2.35 – 8.27), and mean pVHI was 29.82 (SD= 13.6; range 5 - 60). The mean scores with standard deviation for grade of GRBASI scale, DSI, AVQI, and pVHI are reported by age and laryngeal etiology in Table 5. Boxplots of the multiparametric indices DSI and AVQI for organic and functional voice disorders are shown in figure 4 and 5, respectively. The clinical cut-off score (DSI: 1.6; AVQI: 2.95) is represented by the red line in the figures.

[Please insert Table 4, Figure 4 and Figure 5 approximately here]

Table 5: Overview of vocal parameters (G, DSI, AVQI, pVHI)

	3 – 5 years		6 – 8 years		9 – 11 years		12 – 14 years		15 – 17 years		Total	
	OVD	FVD	OVD	FVD	OVD	FVD	OVD	FVD	OVD	FVD	OVD	FVD
G (n= 97)												
n	8	1	31	3	28	6	4	3	4	9	75	22
Mean (SD)	1.50 (0.9)	2.00	1.61 (0.7)	1.67 (0.6)	1.79 (0.7)	1.83 (1.0)	2.25 (0.5)	1.33 (1.2)	1.50 (0.6)	1.89 (0.9)	1.69 (0.7)	1.77 (0.9)
DSI (n= 94)												
n	6	1	31	3	28	6	5	3	4	7	74	20
Mean (SD)	-3.30 (4.6)	-8.6	-2.7 (3.1)	-3.0 (3.3)	-3.5 (3.1)	-3.4 (3.9)	-1.8 (1.9)	-1.4 (5.1)	-2.4 (2.1)	-1.4 (2.2)	-2.8 (3.1)	-2.6 (3.5)
AVQI (n= 56)												
n	5	1	16	0	18	3	4	1	2	6	45	11
Mean (SD)	4.44 (1.5)	5.26	4.46 (1.4)	/	5.01 (1.6)	4.91 (1.3)	3.76 (1.1)	3.92	4.83 (1.3)	5.09 (1.7)	4.64 (1.5)	4.95 (1.5)
pVHI (n= 51)												
n	5	1	18	1	16	4	1	3	0	2	40	11
Mean (SD)	22.20 (14.7)	28.00	23.72 (13.4)	25.00	33.50 (8.6)	33.50 (20.0)	56.00	37.67 (14.0)	/	45.50 (2.1)	28.25 (13.2)	35.55 (14.1)

OVD = organic voice disorders, FVD = functional voice disorders, SD = standard deviation, G = grade from GRBASI scale, DSI = dysphonia severity index, AVQI = acoustic voice quality index, pVHI = pediatric voice handicap index

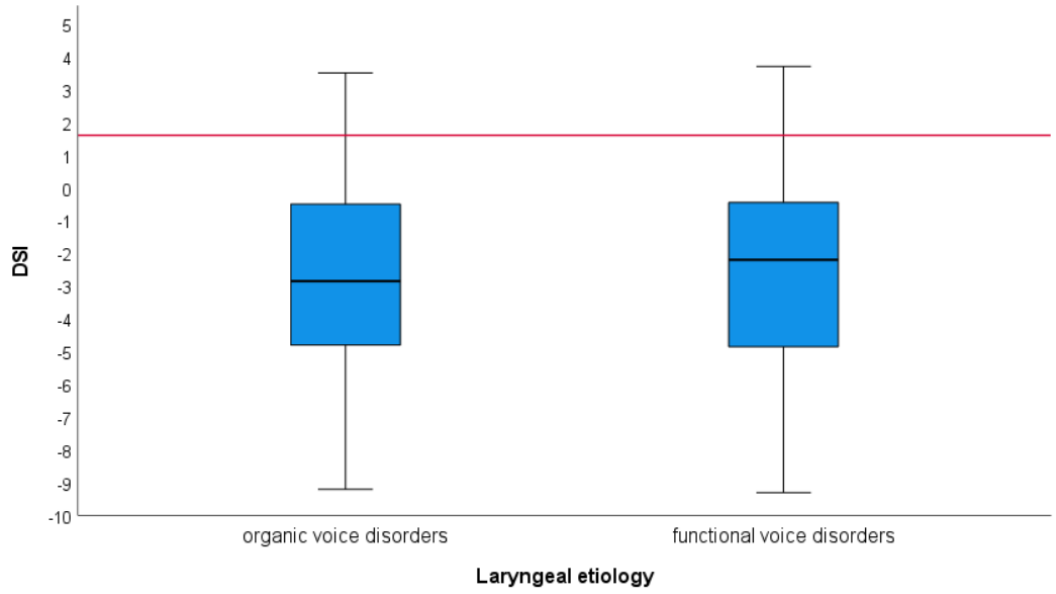

Figure 4: Mean DSI in a treatment-seeking pediatric population

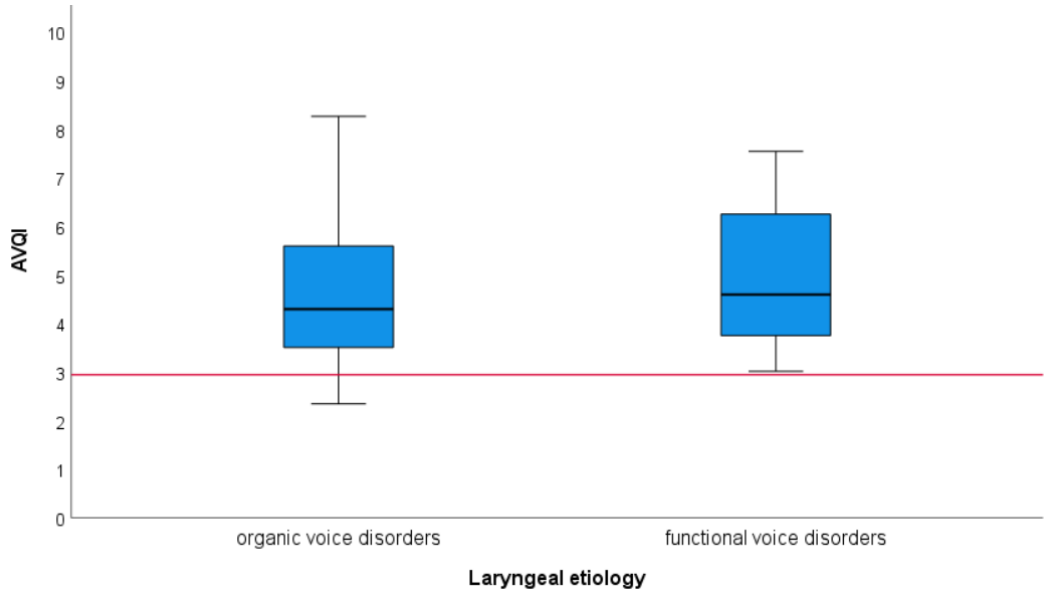

Figure 5: Mean AVQI in a treatment-seeking pediatric population

Vocal complaints

Hoarseness was the most frequently mentioned vocal complaint (96/103, 93.2%; organic voice disorders (OVD): 78/80, functional voice disorders (FVD): 18/23), followed by episodes of aphonia (35/103, 34.0%; OVF: 25/80, FVD: 10/23), and laryngeal or pharyngeal discomfort including globus sensation (29/103, 28.2%; OVD: 24/80, FVD: 5/23). Inappropriate pitch was mentioned in four children with puberphonia and in one female with VFNs and glottic insufficiency (5/103, 4.9%). Dyspnea and stridor were reported in the male with paradoxical vocal fold movement and in one female with VFNs and glottic insufficiency (2/106, 1.9%). Voice breaks were mentioned in one male with VFNs, glottic insufficiency and MTD (1/106, 1.0%).

Influencing factors

The occurrence of frequent phonotraumatic behavior was mentioned in 83 children (80.6%; OVD: 71/80, FVD: 12/23). Yelling behavior was reported most often, especially during sport activities, youth movement meetings and play moments with peers. Reflux was diagnosed in five children (4.9%; OVD: 1/80, FVD: 4/23). Allergies occurred in 17 children (16.5%; OVD: 14/80, FVD: 3/23) with pollen grains being the most common allergen (9/17), followed by dust mites (8/17), cats (7/17), dogs (5/17) and food (3/17). In two children, the type of allergy was not specified.

Treatment-related data

Of all children who presented themselves for the first time at the ENT department of Ghent University Hospital, 94 (91.3%) had not yet received voice therapy. Twenty of them (19/94) did already attend speech therapy for other problems. Nine children (8.7%) were already attending voice therapy, ranging

from a few sessions to 36 months. In 92 children (89.3%), speech therapy was recommended to be started or continued. In 11 children (10.7%), a wait-and-see approach was recommended, whether or not combined with adherence to some vocal hygiene recommendations. Voice surgery was not suggested for any patient.

Discussion

The primary aim of this study was to provide an overview of the age- and sex-specific occurrence of laryngeal pathologies in a treatment-seeking pediatric population at an academic ENT department in Ghent, Belgium. Firstly, VFNs were the most commonly diagnosed laryngeal pathology in this population, accounting for 66.0% of all cases. This result is similar to those reported by Holinger and Johnston [47] (68.1%), Coyle, Weinrich and Stemple [49] (63.4%), and Van Houtte et al. [60] (63.0%). Slightly higher percentages for VFNs were found by Herrington-Hall, Stemple, Niemi and Miller Mc Hone [44] (79.6%), and Mandell, Kay, Dohar and Yellon [50] (81.9%). However, the bulk of the studies reported lower proportions of VFNs in a treatment-seeking pediatric population, with the lowest proportion being 18%.[43] More recent studies reported proportions between 35% and 50%.[23,56,58,59] Secondly, the proportion of vocal fold cysts in this study group was only 1.0%. Previous studies observed inconsistent results on the occurrence of pediatric vocal fold cysts, ranging from 0% [36,44,48-50,53] to more than 25%.[23,51] Thirdly, no vocal fold polyps were identified in this study group. This result is in line with most previous studies, although some reported proportions of more than 15%.[21,47,51]

For several reasons, the differential diagnosis between benign vocal fold lesions is often difficult. First of all, VFNs, polyps, cysts and edema are all lesions of the superficial lamina propria of the vocal folds, also known as Reinke's space.[62,63] As a result, it is not always possible to distinguish between these conditions based on anatomical features.[64] Even histologically there appears to be an overlap between VFNs, polyps and edema.[65,66] Therefore, Hantzakos, Remacle, Dikkers, Degols, Delos, Friedrich, Giovanni and Rasmussen [67] proposed the term "exudative lesions of Reinke's space" to include these conditions. Secondly, there is great heterogeneity in the appearance of benign vocal fold lesions.[64] For example, vocal fold cysts can occur both unilaterally and bilaterally. Especially when they occur symmetrically, they are sometimes mistaken for VFNs.[68] Moreover, the appearance of VFNs may vary between poorly circumscribed edematous lesions to hard nodules.[66] Several authors stress the importance of using stroboscopy to distinguish between different benign vocal fold lesions, as the mucosal wave is affected differently depending on the type of the lesion.[62,69] However, intermediate forms with indistinct characteristics are often observed where stroboscopy is also inconclusive.[67] Thirdly, no consensus has yet been reached on a standardized nomenclature, making diagnosis more dependent on the experience and vision of the attending physician.[67,70,71] Rosen, Gartner-Schmidt, Hathaway, Simpson, Postma, Courey and Sataloff [72] proposed a validated multidimensional classification system including nine vocal fold lesions, but this is not widely used in research. Lastly, differential diagnosis is greatly complicated by the possible presence of a contralateral lesion, especially the difference between bilateral VFNs and a unilateral vocal fold cyst with a reactive lesion is not always clear.[64,73] In summary, the difficult differential diagnosis of benign vocal fold lesions necessitates some caution in interpreting the results of this study and, in particular, in comparing the results with other studies.

At the University Hospital of Ghent, Belgium, one other study was conducted on the occurrence of laryngeal pathologies in a treatment-seeking population and this study primarily focused on the adult population.[54] The results of the present study in a pediatric population differ significantly from Van Houtte's 2010 results in the adult (≥ 15 years old) population. The most common diagnosis in the adult population was a functional voice disorder (31.5%), defined as posterior glottic insufficiency, a supraglottic mediolateral contraction, or an anteroposterior contraction visible on videolaryngostroboscopic images in the absence of structural or neurological pathology. VFNs and hypertrophy were the second most common pathology, accounting for only 10.5% of all diagnoses, compared with 66.0% in the pediatric population. In the adult population, significantly higher rates were found of vocal fold polyps and cysts (8.6%) and vocal fold paralysis (8.5%) compared with the pediatric population (both 1.0%). Moreover, a number of pathologies were found in the adult population that did not occur in the present study: gastroesophageal reflux disease, laryngitis or inflammation (9.6%), (pre-)malignant disorders (3.7%), and laryngeal papillomatosis (1.1%).

The secondary aim of this study was to describe in detail the treatment-seeking pediatric population with complaints of dysphonia. A male-to-female ratio of 1.78/1 was found in this study group, supporting the results of Dobres, Lee, Stemple, Kummer and Kretschmer [43] (1.78/1), Papsin, Pengilly and Leighton [48] (1.82/1), Coyle, Weinrich and Stemple [49](1.73/1), Mortensen, Schaberg and Woo [21] (1.86/1), Martins, Ribeiro, Mello and al. [55] (1.76/1), and Antón Almero, Doménech Máñez, Ferrer Ramírez, Solavera, Reig Montaner and Faubel Serra [59] (1.90/1). Moreover, it was shown that organic voice disorders were more common in younger children and functional voice disorders in older children. These results corroborate the findings of a great deal of the previous work in pediatric dysphonia. Functional voice problems are rarely observed in young children, but they increase significantly from the onset of puberty. This is a period of vocal instability and emotional stress leading to a burst in the onset of functional dysphonia.[54,74]

At Ghent University Hospital, the otorhinolaryngologists refer all voice patients for a voice examination by a specialized voice therapist, during which vocal quality, vocal capabilities and voice-related quality of life are assessed. The GRBASI scale is routinely used for perceptual assessment of vocal quality and the results show that the mean grade of dysphonia in this study group is mild to moderate (G = 1.71 ± 0.7).[75,76] A mean DSI of -2.75 and a mean AVQI of 4.70 were observed in these children, respectively indicating reduced vocal capabilities and disordered vocal quality.[77-79] Moreover, the average score on the pVHI (29.82) indicates a negative impact of the voice on the children's psychosocial well-being. This result corroborates the finding of Carroll, Mudd and Zur [80] who found a mean pVHI of 29.3 in children with elevated vocal fold lesions. Despite the importance of self-reported quality of life tools for pediatric populations, no self-reported voice-related instrument was used during the consultations of younger children with the voice therapist.[81] This means that children's views on the consequences of

their voice disorder were not systematically investigated. Recently, the first Dutch self-reported voice-related quality of life tool for children has been developed and implemented into clinical practice at Ghent University Hospital.[82]

The majority of the children had frequent phonotraumatic behavior identified in their patient record. It is generally assumed that benign vocal fold lesions arise from phonatory trauma and vocal misuse, which can be explained by increased mechanical stress during phonation.[62] The left and right vocal folds collide during phonation, leading to an impact stress on the vocal fold surfaces. The greatest mechanical impact occurs in the mid-membranous vocal fold. This mechanical impact will be even greater in case of phonotraumatic behavior, leading to superficial wound formation. During the healing process, remodeling of the lamina propria and epithelium occurs and this results in the development of benign vocal fold lesions.[70,83] Since phonotraumatic behavior is considered a major cause of pediatric vocal fold lesions, indirect therapy including patient and parent counselling is an important part of voice therapy in this population.[84] The question can also be raised whether children would benefit from a preventive vocal hygiene program. Several studies showed that children (5-10 years) are able to learn from an indirect vocal hygiene program and that the knowledge gained can be retained for several months.[85-87] However, it is not yet clear whether this knowledge effectively prevents the development of benign vocal fold lesions.

In the current study, 4.9% of participants had tested positive for reflux in the past. Gastroesophageal and laryngopharyngeal reflux, the retrograde flow of gastric contents into the esophagus and laryngopharynx respectively, are considered to be risk factors for pediatric dysphonia.[88] In the systematic review of Saniasiaya and Kulasegarah [89], the authors state that there is a strong association between reflux and dysphonia in children. The most common laryngeal findings were interarytenoid erythema and edema, vocal fold erythema and edema, and postglottic edema. Lechien, Saussez, Harmegnies, Finck and Burns [90] investigated the pathophysiological mechanisms underlying the development of hoarseness related to reflux. It is likely that caustic mucosal exposure leads to increased susceptibility of the vocal fold mucosa to injury and subsequent nodules, polyps and Reinke's edema. However, only a few studies with methodological shortcomings were conducted. Further research is needed to confirm these results and to examine the relationship between reflux and cysts or sulci.[91]

In this study, 17.5% of the patient records explicitly reported a diagnosed allergic disease. A considerable amount of literature has been published on the relation between allergic diseases and dysphonia. Allergic diseases may cause both lower and upper airway inflammation including larynx inflammation, leading to dryness, swelling, mucosal injury, and abusive behavior promoting mechanical trauma such as coughing and throat clearing.[92,93] Some studies examined the presence of voice problems in patients with diagnosed allergic diseases. Kallvik, Savolainen and Simberg [94] found that 18.2% of

children with a difficult-to-treat allergic disease have frequently occurring vocal symptoms. No significant association was found between an asthma diagnosis and frequently occurring vocal symptoms. Randhawa, Nouraei, Mansuri and Rubin [95] stated that adult allergic patients have more voice-related complaints than a non-allergic population. Other studies focused on the presence of allergies in patients with diagnosed vocal lesions or voice problems. In an Italian voice clinic, allergic rhinitis was diagnosed in 56.6% and asthma in 9.2% of adolescent and adult patients.[96] In allergic rhinitis, postnasal drainage of excessive mucus onto laryngeal tissue may cause abusive vocal behavior like throat clearing and coughing.[97] The estimated prevalence of allergic rhinitis is 10 – 20% of the general population, with a higher prevalence in industrialized western countries.[92] Thus, the prevalence found by Lauriello, Angelone Am Fau - Businco, Businco Ld Fau - Passali, Passali D Fau - Bellussi, Bellussi Lm Fau - Passali and Passali [96] in a population of voice patients is much higher than expected. Moreover, Yilmaz, Eyigör, Osma, Selcuk, Renda, Pırtık and Yalcin [92] concluded that skin prick tests to highlight allergic reactions are highly positive in adolescent and adult patients with benign vocal fold lesions. In the study of Ercan, Bostanci, Kaygusuz and Ceylan [98] asthma was detected in 42.4% of children with VFNs while it was completely absent in the control group. They concluded that children with allergic diseases have a more than 20-fold increased risk of having VFNs. Lastly, De Bodt, Ketelslagers, Peeters, Wuyts, Mertens, Pattyn, Heylen, Peeters, Boudewyns and Van de Heyning [99] described dysphonic girls with an allergic disease as the highest risk group to have persistent VFNs in adolescence. The percentage of allergies found in the present study (17.5%) is rather low, but it should be mentioned that the children were not routinely tested for allergies. Moreover, due to the retrospective nature of the study, it is possible that a diagnosis of allergy was not included in the anamnesis or patient record.

Regarding treatment options, voice therapy was advised in the vast majority of the children and phonosurgery was carried out in none of them. At Ghent University Hospital, the policy is to avoid phonosurgery for pediatric VFNs and most other laryngeal findings due to the high recurrence rate after phonosurgery, the influence of behavioral factors, the immaturity of the laryngeal structures and the frequent failure to respect postoperative vocal rest.[45,100,101] For VFNs in the adult population, it was recently recommended by Birchall and Carding [102] to start with specialized voice therapy, combined with lifestyle modification and optimized reflux management where appropriate. Phonosurgery could be considered when the patients do not respond to voice therapy. In the pediatric population, voice therapy is also considered to be the preferable treatment option for benign vocal fold lesions. Eclectic direct voice therapy is the most commonly used treatment method.[103] However, well-designed experimental research on the effects of voice therapy in this population is still scarce and the effectiveness of different techniques and the preferred dosage is not known.[104]

The major limitation of this study was its retrospective nature. The laryngeal and voice examinations were not conducted in a standardized manner, raising the possibility that not all relevant information

was described in the patient's medical records. Moreover, these voice examinations were performed by several voice therapists. The laryngeal examinations were predominantly performed by the same experienced otorhinolaryngolist, but changes in material may have occurred. Procedures were tailored to the patient's needs, resulting in a considerable amount of missing (voice) data. Moreover, information on race and ethnicity was not available and thus could not be included in the study. Children were not routinely checked for allergies, reflux, asthma, or comorbid conditions. Lastly, this was a monocentric study in an academic hospital setting, so this may not be a completely accurate representation of the pediatric treatment-seeking population.

Conclusion

Organic voice disorders are more common than functional voice disorders in treatment-seeking children with complaints of dysphonia, with VFNs being the main cause of dysphonia (66.0%). Children with functional voice disorders are significantly older than children with organic voice disorders. Voice problems are more common in males than in females during childhood, but sex does not have an influence on the type of voice disorder. Objective and perceptual voice assessment showed disordered vocal quality and reduced vocal capabilities and the majority of the children experienced a negative impact on their psychosocial well-being. Phonotraumatic behavior was reported in 80% of the children. Starting or continuing voice therapy was the most frequently given treatment recommendation. Phonosurgery was not performed in any of the children.

Acknowledgments

This work was supported by the Research Fund Flanders [grant number G069319N].

References

1. Lee L. Quick Screen for Voice and Supplementary Documents for Identifying Pediatric Voice Disorders. *Language, Speech, and Hearing Services in Schools*. 2004;35(4):308-319. doi:10.1044/0161-1461(2004/030)
2. Stachler RJ, Francis DO, Schwartz SR, et al. Clinical Practice Guideline: Hoarseness (Dysphonia) (Update). *Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery*. Mar 2018;158(1_suppl):S1-S42. doi:10.1177/0194599817751030
3. American Speech-Language-Hearing Association [ASHA]. *Definitions of communication disorders and variations [Relevant Paper]*. 1993.
4. Mohammadzadeh A, Sandoughdar N. Prevalence of Voice Disorders in Iranian Primary School Students. *Journal of voice : official journal of the Voice Foundation*. Mar 2017;31(2):263 e13-263 e18. doi:10.1016/j.jvoice.2016.04.004
5. Pribuisiene R, Pasvenskaite A, Pribuisis K, Balsevicius T, Liutkevicius V, Uloza V. Dysphonia screening in vocally trained and untrained children. *International journal of pediatric otorhinolaryngology*. Feb 2020;129:109776. doi:10.1016/j.ijporl.2019.109776
6. Kallvik E, Lindstrom E, Holmqvist S, Lindman J, Simberg S. Prevalence of hoarseness in school-aged children. *Journal of voice : official journal of the Voice Foundation*. Mar 2015;29(2):260 e1-19. doi:10.1016/j.jvoice.2013.08.019
7. Carding PN, Roulstone S, Northstone K, Team AS. The prevalence of childhood dysphonia: a cross-sectional study. *Journal of voice : official journal of the Voice Foundation*. Dec 2006;20(4):623-30. doi:10.1016/j.jvoice.2005.07.004
8. Johnson CM, Anderson DC, Brigger MT. Pediatric Dysphonia: A Cross-Sectional Survey of Subspecialty and Primary Care Clinics. *Journal of voice : official journal of the Voice Foundation*. Mar 2020;34(2):301 e1-301 e5. doi:10.1016/j.jvoice.2018.08.017
9. Duff MC, Proctor A, Yairi E. Prevalence of voice disorders in African American and European American preschoolers. *Journal of voice : official journal of the Voice Foundation*. Sep 2004;18(3):348-53. doi:10.1016/j.jvoice.2003.12.009
10. Silverman E, Zimmer C. Incidence of chronic hoarseness among school-age children. *Journal of Speech and Hearing Disorders*. 1975;40(2):211-215.
11. Tavares ELM, Brasolotto A, Santana MF, Padovan CA, Martins RHG. Estudo epidemiológico de disfonias em crianças de 4 a 12 anos. *Brazilian Journal of Otorhinolaryngology*. 2011;77(6):736-746. doi:10.1590/s1808-86942011000600010
12. Powell M, Filter M, Williams B. A longitudnial study of the prevalence of voice disorders in children from a rural school division. *Journal of Communication Disorders*. 1989;22:375-382.
13. Hunter EJ, Tanner K, Smith ME. Gender differences affecting vocal health of women in vocally demanding careers. *Logopedics, phoniatrics, vocology*. Oct 2011;36(3):128-36. doi:10.3109/14015439.2011.587447
14. Roy N, Merrill RM, Gray SD, Smith EM. Voice disorders in the general population: prevalence, risk factors, and occupational impact. *The Laryngoscope*. Nov 2005;115(11):1988-95. doi:10.1097/01.mlg.0000179174.32345.41
15. Lyberg-Ahlander V, Rydell R, Fredlund P, Magnusson C, Wilen S. Prevalence of Voice Disorders in the General Population, Based on the Stockholm Public Health Cohort. *Journal of voice : official journal of the Voice Foundation*. Nov 2019;33(6):900-905. doi:10.1016/j.jvoice.2018.07.007
16. Dejonckere P, Bradley P, Clemente P, et al. A basic protocol for functional assessment of voice pathology, especially for investigating the efficacy of (phonosurgical) treatments and evaluating new assessment techniques Guideline elaborated by the Committee on Phoniatrics of the European Laryngological Society (ELS). *European Archives of Oto-Rhino-Laryngology*. 2001;258:77-82.
17. Patel R, Awan Shaheen N, Barkmeier-Kraemer J, et al. Recommended Protocols for Instrumental Assessment of Voice: American Speech-Language-Hearing Association Expert Panel to

Develop a Protocol for Instrumental Assessment of Vocal Function. *American Journal of Speech-Language Pathology*. 2018/08/06 2018;27(3):887-905. doi:10.1044/2018_AJSLP-17-0009
18. Sulica L. Laryngoscopy, stroboscopy and other tools for the evaluation of voice disorders. *Otolaryngologic clinics of North America*. Feb 2013;46(1):21-30. doi:10.1016/j.otc.2012.09.001
19. Possamai V, Hartley B. Voice disorders in children. *Pediatr Clin North Am*. Aug 2013;60(4):879-92. doi:10.1016/j.pcl.2013.04.012
20. Mansour J, Amir O, Sagiv D, Alon EE, Wolf M, Primov-Fever A. The Accuracy of Preoperative Rigid Stroboscopy in the Evaluation of Voice Disorders in Children. *Journal of voice : official journal of the Voice Foundation*. Jul 2017;31(4):516 e1-516 e4. doi:10.1016/j.jvoice.2016.12.013
21. Mortensen M, Schaberg M, Woo P. Diagnostic Contributions of Videolaryngostroboscopy in the Pediatric Population. *Archives of Otorhinolaryngology-Head & Neck Surgery*. 2010;136(1)
22. Eller R, Ginsburg M, Lurie D, Heman-Ackah Y, Lyons K, Sataloff R. Flexible Laryngoscopy: A Comparison of Fiber Optic and Distal Chip Technologies. Part 1: Vocal Fold Masses. *Journal of Voice*. 2008/11/01/ 2008;22(6):746-750. doi:https://doi.org/10.1016/j.jvoice.2007.04.003
23. Ramos PH, Alvarez ML, Leon NI, Badia PI, Napolitano CA. Voice Disorders in Children: Experience in the Voice Unit at Universidad Catolica Clinical Hospital. *Journal of voice : official journal of the Voice Foundation*. May 23 2020;doi:10.1016/j.jvoice.2020.04.035
24. Hartnick CJ, Zeitels SM. Pediatric video laryngo-stroboscopy. *International journal of pediatric otorhinolaryngology*. Feb 2005;69(2):215-9. doi:10.1016/j.ijporl.2004.08.021
25. Payten CL, Chiapello G, Weir KA, Madill CJ. Frameworks, Terminology and Definitions Used for the Classification of Voice Disorders: A Scoping Review. *Journal of Voice*. 2022/03/20/ 2022;doi:https://doi.org/10.1016/j.jvoice.2022.02.009
26. Naqvi Y, Gupta V. Functional Voice Disorders. *StatPearls*. StatPearls Publishing; 2022.
27. Baker J. Chapter 34 - Functional voice disorders: Clinical presentations and differential diagnosis. In: Hallett M, Stone J, Carson A, eds. *Handbook of Clinical Neurology*. Elsevier; 2016:389-405.
28. Meerschman I. *Effect of voice training and voice therapy : content and dosage*. Ghent University; 2018.
29. Van Houtte E, Van Lierde K, Claeys S. Pathophysiology and Treatment of Muscle Tension Dysphonia: A Review of the Current Knowledge. *Journal of Voice*. 2011/03/01/ 2011;25(2):202-207. doi:https://doi.org/10.1016/j.jvoice.2009.10.009
30. Roy N. Functional dysphonia. *Current Opinion in Otolaryngology & Head and Neck Surgery*. 2003;11(3)
31. Gökdoğan Ç, Gökdoğan O, Tutar H, Aydil U, Yılmaz M. Speech Range Profile (SRP) Findings Before and After Mutational Falsetto (Puberphonia). *Journal of Voice*. 2016/07/01/ 2016;30(4):448-451. doi:https://doi.org/10.1016/j.jvoice.2015.05.014
32. Kosztyła-Hojna B, Zdrojkowski M, Duchnowska E. Presbyphonia as an Individual Process of Voice Change. *Journal of Voice*. 2023/03/01/ 2023;37(2):303.e1-303.e14. doi:https://doi.org/10.1016/j.jvoice.2020.12.046
33. Vertigan AE, Theodoros DG, Gibson PG, Winkworth AL. Voice and Upper Airway Symptoms in People With Chronic Cough and Paradoxical Vocal Fold Movement. *Journal of Voice*. 2007/05/01/ 2007;21(3):361-383. doi:https://doi.org/10.1016/j.jvoice.2005.12.008
34. Reiter R, Rommel D, Brosch S. Long term outcome of psychogenic voice disorders. *Auris Nasus Larynx*. 2013/10/01/ 2013;40(5):470-475. doi:https://doi.org/10.1016/j.anl.2013.01.002
35. Aronson AE. *Clinical voice disorders: an interdisciplinary approach*. Thieme inc. ; 1990.
36. Mackiewicz-Nartowicz H, Sinkiewicz A, Bielecka A. Laryngovideostroboscopy in children--diagnostic possibilities and constraints. *International journal of pediatric otorhinolaryngology*. Aug 2011;75(8):1015-7. doi:10.1016/j.ijporl.2011.05.006
37. Tezcaner ZÇ, Gökmen MF, Yıldırım S, Dursun G. Clinical Features of Psychogenic Voice Disorder and the Efficiency of Voice Therapy and Psychological Evaluation. *Journal of Voice*. 2019/03/01/ 2019;33(2):250-254. doi:https://doi.org/10.1016/j.jvoice.2017.09.022

38. Morrison MD, Rammage LA. Muscle Misuse Voice Disorders: Description and Classification. *Acta Oto-Laryngologica*. 1993/01/01 1993;113(3):428-434. doi:10.3109/00016489309135839
39. Behlau M, Madazio G, Oliveira G. Functional dysphonia: strategies to improve patient outcomes. *Patient Relat Outcome Meas*. 2015;6:243-53. doi:10.2147/prom.S68631
40. Chung DS, Wettroth C, Hallett M, Maurer CW. Functional Speech and Voice Disorders: Case Series and Literature Review. *Movement disorders clinical practice*. May-Jun 2018;5(3):312-316. doi:10.1002/mdc3.12609
41. Pedrosa V, Pontes A, Pontes P, Behlau M, Peccin SM. The Effectiveness of the Comprehensive Voice Rehabilitation Program Compared With the Vocal Function Exercises Method in Behavioral Dysphonia: A Randomized Clinical Trial. *Journal of voice : official journal of the Voice Foundation*. May 2016;30(3):377.e11-9. doi:10.1016/j.jvoice.2015.03.013
42. Hacki T, Moerman M, Rubin JS. 'Malregulative' Rather Than 'Functional' Dysphonia: A New Etiological Terminology Framework for Phonation Disorders—A Position Paper by the Union of European Phoniatricians (UEP). *Journal of Voice*. 2022/01/01/ 2022;36(1):50-53. doi:https://doi.org/10.1016/j.jvoice.2020.04.032
43. Dobres R, Lee L, Stemple JC, Kummer AW, Kretschmer LW. Description of laryngeal pathologies in children evaluated by otolaryngologists. *J Speech Hear Disord*. Aug 1990;55(3):526-32. doi:10.1044/jshd.5503.526
44. Herrington-Hall B, Stemple J, Niemi K, Miller Mc Hone M. Description of Laryngeal Pathologies by Age, Sex and Occupation in a Treatment-seeking Sample. *Journal of Speech and Hearing Disorders*. 1988;53:57-64.
45. Mudd P, Noelke C. Vocal fold nodules in children. *Current opinion in otolaryngology & head and neck surgery*. Dec 2018;26(6):426-430. doi:10.1097/MOO.0000000000000496
46. Agin R. *Clinical Management of Communication Disorders in Culturally Diverse Children.* Allyn & Bacon; 2000:197 - 225.
47. Holinger PH, Johnston KC. Benign tumors of the larynx. *Ann Otol Rhinol Laryngol*. Jun 1951;60(2):496-509. doi:10.1177/000348945106000219
48. Papsin BC, Pengilly AJ, Leighton SEJ. The developing role of a paediatric voice clinic: a review of our experience. *The Journal of laryngology and otology*. 1996;110:1022-1026.
49. Coyle SM, Weinrich BD, Stemple JC. Shifts in Relative Prevalence of Laryngeal Pathology in a Treatment-Seeking Population. *Journal of Voice*. 2001;15(3):424-440. doi:10.1016/s0892-1997(01)00043-1
50. Mandell D, Kay D, Dohar J, Yellon R. Lack of Association Between Esophageal Biopsy, Bronchoalveolar Lavage, and Endoscopy Findings in Hoarse Children. *Archives of Otorhinolaryngology-Head & Neck Surgery*. 2004;130
51. Wolf M, Primov-Fever A, Amir O, Jedwab D. The feasibility of rigid stroboscopy in children. *International Journal of Pediatric Otorhinolaryngology*. 2005/08/01/ 2005;69(8):1077-1079. doi:https://doi.org/10.1016/j.ijporl.2005.03.004
52. Angelillo N, Di Costanzo B, Angelillo M, Costa G, Barillari MR, Barillari U. Epidemiological study on vocal disorders in paediatric age. *J Prev Med Hyg*. Mar 2008;49(1):1-5.
53. Connelly A, Clement WA, Kubba H. Management of dysphonia in children. *The Journal of laryngology and otology*. Jun 2009;123(6):642-7. doi:10.1017/S0022215109004599
54. Van Houtte E, Van Lierde K, D'haeseleer E, Claeys S. The prevalence of laryngeal pathology in a treatment seeking population with dysphonia. *Laryngoscope*. 2010;120(2):306-312.
55. Martins RH, Ribeiro CBH, Mello BMZ, al. e. Dysphonia in children. *Journal of voice : official journal of the Voice Foundation*. 2012;26:674.
56. Wynne DM, Cohen W. The paediatric voice clinic: our experience of 81 children referred over 28 months. *Clinical Otolaryngology*. 2012;37:305-330.
57. Martins RH, do Amaral HA, Tavares EL, Martins MG, Goncalves TM, Dias NH. Voice Disorders: Etiology and Diagnosis. *Journal of voice : official journal of the Voice Foundation*. Nov 2016;30(6):761 e1-761 e9. doi:10.1016/j.jvoice.2015.09.017

58. Mozzanica F, Ginocchio D, Barillari R, et al. Prevalence and Voice Characteristics of Laryngeal Pathology in an Italian Voice Therapy-seeking Population. *Journal of voice : official journal of the Voice Foundation*. Nov 2016;30(6):774 e13-774 e21. doi:10.1016/j.jvoice.2015.11.018
59. Antón Almero M, Doménech Máñez I, Ferrer Ramírez MJ, Solavera R, Reig Montaner E, Faubel Serra M. Dysphonia in Children. Descriptive Analysis of the Factors Involved, Clinical Parameters and Impact on Quality of Life. *Acta Otorrinolaringologica (English Edition)*. 2021;72(2):80-84. doi:10.1016/j.otoeng.2020.01.004
60. Van Houtte E, Van Lierde K, D'Haeseleer E, Claeys S. The prevalence of laryngeal pathology in a treatment-seeking population with dysphonia. *The Laryngoscope*. Feb 2010;120(2):306-12. doi:10.1002/lary.20696
61. *PRAAT: doing phonetics by computer (Version 6.0.14)*. http://www.praat.org/
62. Johns MM. Update on the etiology, diagnosis, and treatment of vocal fold nodules, polyps, and cysts. *Current Opinion in Otolaryngology & Head and Neck Surgery*. 2003;11(6)
63. Dewan K, Chhetri DK, Hoffman H. Reinke's edema management and voice outcomes. https://doi.org/10.1002/lio2.840. *Laryngoscope Investigative Otolaryngology*. 2022/08/01 2022;7(4):1042-1050. doi:https://doi.org/10.1002/lio2.840
64. Bohlender J. Diagnostic and therapeutic pitfalls in benign vocal fold diseases. *GMS current topics in otorhinolaryngology, head and neck surgery*. 2013;12(1865-1011 (Print))
65. Marcotullio D, Magliulo G, Pietrunti S, Suriano M. Exudative laryngeal diseases of Reinke's space: a clinicohistopathological framing. *The Journal of Otolaryngology*. 2002;31(6)
66. Dikkers FG, Nikkels PGJ. Lamina Propria of the Mucosa of Benign Lesions of the Vocal Folds. https://doi.org/10.1097/00005537-199910000-00025. *The Laryngoscope*. 1999/10/01 1999;109(10):1684-1689. doi:https://doi.org/10.1097/00005537-199910000-00025
67. Hantzakos A, Remacle M, Dikkers FG, et al. Exudative lesions of Reinke's space: a terminology proposal. *European Archives of Oto-Rhino-Laryngology*. 2009/06/01 2009;266(6):869-878. doi:10.1007/s00405-008-0863-x
68. Martins RHG, Santana MF, Tavares ELM. Vocal Cysts: Clinical, Endoscopic, and Surgical Aspects. *Journal of Voice*. 2011/01/01/ 2011;25(1):107-110. doi:https://doi.org/10.1016/j.jvoice.2009.06.008
69. Núñez-Batalla F, Señaris-González B, Corte-Santos P, et al. The Diagnostic Role of Direct Microlaryngoscopy. *Acta Otorrinolaringologica (English Edition)*. 2007/01/01/ 2007;58(8):362-366. doi:https://doi.org/10.1016/S2173-5735(07)70368-X
70. Kunduk M, McWhorter AJ. True vocal fold nodules: the role of differential diagnosis. *Current Opinion in Otolaryngology & Head and Neck Surgery*. 2009;17(6)
71. Naunheim M, Carroll T. Benign vocal fold lesions: Update on nomenclature, cause, diagnosis, and treatment. *Current Opinion in Otolaryngology & Head and Neck Surgery*. 09/01 2017;25:1. doi:10.1097/MOO.0000000000000408
72. Rosen CA, Gartner-Schmidt J, Hathaway B, et al. A nomenclature paradigm for benign midmembranous vocal fold lesions. https://doi.org/10.1002/lary.22421. *The Laryngoscope*. 2012/06/01 2012;122(6):1335-1341. doi:https://doi.org/10.1002/lary.22421
73. Cho J-H, Choi Y-S, Joo Y-H, Park Y-H, Sun D-I. Clinical Significance of Contralateral Reactive Lesion in Vocal Fold Polyp and Cyst. *Journal of Voice*. 2018/01/01/ 2018;32(1):109-115. doi:https://doi.org/10.1016/j.jvoice.2017.02.011
74. Yang J, Xu W. Characteristics of Functional Dysphonia in Children. *Journal of Voice*. 2020/01/01/ 2020;34(1):156.e1-156.e4. doi:https://doi.org/10.1016/j.jvoice.2018.07.027
75. Hirano M. *Clinical Examination of Voice*. Springer; 1981.
76. Dejonckere P, Crevier-Buchman L, Marie J-P, Moerman M, Remacle M, Woisard V. Implementation of the European Laryngological Society (ELS) - Basic protocol for assessing voice treatment effect. *Revue de laryngologie - otologie - rhinologie*. 02/01 2003;124:279-83.
77. Wuyts FL, De Bodt MU, Molenberghs G, et al. The dysphonia severity index : an objective measure of vocal quality based on a multiparameter approach. *(2000) JOURNAL OF SPEECH LANGUAGE AND HEARING RESEARCH*. 2000;

78. Maryn Y, Corthals P, Van Cauwenberge P, Roy N, De Bodt M. Toward improved ecological validity in the acoustic measurement of overall voice quality: combining continuous speech and sustained vowels. *Journal of voice : official journal of the Voice Foundation*. Sep 2010;24(5):540-55. doi:10.1016/j.jvoice.2008.12.014
79. Sobol M, Sielska-Badurek EM. The Dysphonia Severity Index (DSI)—Normative Values. Systematic Review and Meta-Analysis. *Journal of Voice*. 2022/01/01/ 2022;36(1):143.e9-143.e13. doi:https://doi.org/10.1016/j.jvoice.2020.04.010
80. Carroll LM, Mudd P, Zur KB. Severity of Voice Handicap in Children Diagnosed with Elevated Lesions. *Otolaryngology–Head and Neck Surgery*. 2013/10/01 2013;149(4):628-632. doi:10.1177/0194599813500641
81. Verduyckt I, Morsomme M, Remacle M. Validation and standardization of the Pediatric Voice Symptom Questionnaire: a double-form questionnaire for dysphonic children and their parents. *Journal of voice : official journal of the Voice Foundation*. Jul 2012;26(4):e129-39. doi:10.1016/j.jvoice.2011.08.001
82. Adriaansen A, Van Lierde K, Meerschman I, Everaert C, D'Haeseleer E. Validity and Reliability of the Dutch Children's Voice Handicap Index-10. *Journal of Voice*. 2022/05/29/ 2022;doi:https://doi.org/10.1016/j.jvoice.2022.04.020
83. Titze IR. Mechanical stress in phonation. *Journal of Voice*. 1994/06/01/ 1994;8(2):99-105. doi:https://doi.org/10.1016/S0892-1997(05)80302-9
84. Middendorf J. Phonotrauma in Children: Management and Treatment. *The ASHA Leader*. 2007;12(15)
85. Scrimgeour K, Meyer SE. Effectiveness of a Hearing Conservation and Vocal Hygiene Program for Kindergarten Children. *Special Services in the Schools*. 2002/09/01 2002;18(1-2):133-150. doi:10.1300/J008v18n01_09
86. Nilson H, Schneiderman Carl R. Classroom Program for the Prevention of Vocal Abuse and Hoarseness in Elementary School Children. *Language, Speech, and Hearing Services in Schools*. 1983/04/01 1983;14(2):121-127. doi:10.1044/0161-1461.1402.121
87. Ma EP, Yiu EM, Abbott KV. Application of the ICF in voice disorders. *Seminars in speech and language*. Nov 2007;28(4):343-50. doi:10.1055/s-2007-986531
88. Singendonk M, Goudswaard E, Langendam M, et al. Prevalence of Gastroesophageal Reflux Disease Symptoms in Infants and Children: A Systematic Review. *Journal of pediatric gastroenterology and nutrition*. Jun 2019;68(6):811-817. doi:10.1097/MPG.0000000000002280
89. Saniasiaya J, Kulasegarah J. Dysphonia and reflux in children: A systematic review. *International Journal of Pediatric Otorhinolaryngology*. 2020;139doi:10.1016/j.ijporl.2020.110473
90. Lechien JR, Saussez S, Harmegnies B, Finck C, Burns JA. Laryngopharyngeal Reflux and Voice Disorders: A Multifactorial Model of Etiology and Pathophysiology. *Journal of Voice*. 2017/11/01/ 2017;31(6):733-752. doi:https://doi.org/10.1016/j.jvoice.2017.03.015
91. Lechien JR, Saussez S, Nacci A, et al. Association between laryngopharyngeal reflux and benign vocal folds lesions: A systematic review. https://doi.org/10.1002/lary.27932. *The Laryngoscope*. 2019/09/01 2019;129(9):E329-E341. doi:https://doi.org/10.1002/lary.27932
92. Yilmaz MD, Eyigör H, Osma U, et al. Prevalence of Allergy in Patients with Benign Lesions of Vocal Folds. *Acta Medica Mediterranea*. 01/01 2016;32:195-201. doi:10.19193/0393-6384_2016_1_30
93. Chadwick SJ. Allergy and the contemporary laryngologist. *Otolaryngologic Clinics of North America*. 2003;36(5):957-988. doi:10.1016/S0030-6665(03)00049-5
94. Kallvik E, Savolainen J, Simberg S. Vocal Symptoms and Voice Quality in Children With Allergy and Asthma. *Journal of Voice*. 2017/07/01/ 2017;31(4):515.e9-515.e14. doi:https://doi.org/10.1016/j.jvoice.2016.12.010
95. Randhawa PS, Nouraei S, Mansuri S, Rubin JS. Allergic laryngitis as a cause of dysphonia: a preliminary report. *Logopedics Phoniatrics Vocology*. 2010/12/01 2010;35(4):169-174. doi:10.3109/14015431003599012

96. Lauriello M, Angelone Am Fau - Businco LDR, Businco Ld Fau - Passali D, Passali D Fau - Bellussi LM, Bellussi Lm Fau - Passali FM, Passali FM. Correlation between female sex and allergy was significant in patients presenting with dysphonia. *Acta Otorhinolaryngologica Italica*. 2011;31(3)
97. Hamdan A-L, Sibai A, Youssef M, Deeb R, Zaitoun F. The Use of a Screening Questionnaire to Determine the Incidence of Allergic Rhinitis in Singers With Dysphonia. *Archives of Otolaryngology–Head & Neck Surgery*. 2006;132(5):547-549. doi:10.1001/archotol.132.5.547
98. Ercan N, Bostanci I, Kaygusuz U, Ceylan K. Interaction between childhood vocal fold nodules and allergic diseases. *International journal of pediatric otorhinolaryngology*. Nov 2020;138:110404. doi:10.1016/j.ijporl.2020.110404
99. De Bodt MS, Ketelslagers K, Peeters T, et al. Evolution of vocal fold nodules from childhood to adolescence. *Journal of voice : official journal of the Voice Foundation*. Mar 2007;21(2):151-6. doi:10.1016/j.jvoice.2005.11.006
100. Martins RHG, Siqueira DB, Dias NH, Gramuglia ACJ. Laryngeal Microsurgery for the Treatment of Vocal Nodules and Cysts in Dysphonic Children. *Folia phoniatrica et logopaedica : official organ of the International Association of Logopedics and Phoniatrics (IALP)*. 2020;72(4):325-330. doi:10.1159/000502477
101. Martins RH, Branco A, Tavares EL, Gramuglia AC. Clinical practice: vocal nodules in dysphonic children. *European journal of pediatrics*. Sep 2013;172(9):1161-5. doi:10.1007/s00431-013-2048-x
102. Birchall MA, Carding P. Vocal nodules management. https://doi.org/10.1111/coa.13324. *Clinical Otolaryngology*. 2019/07/01 2019;44(4):497-501. doi:https://doi.org/10.1111/coa.13324
103. Feinstein H, Abbott KV. Behavioral Treatment for Benign Vocal Fold Lesions in Children: A Systematic Review. *American journal of speech-language pathology*. Mar 26 2021;30(2):772-788. doi:10.1044/2020_AJSLP-20-00304
104. Adriaansen AA-O, Meerschman I, Van Lierde K, D'Haeseleer E. Effects of voice therapy in children with vocal fold nodules: A systematic review. *Internattional Journal of Language and Communication Disorders*. 2022;57(6):1160-1193.