A PROSPECTIVE CROSS-SECTIONAL OBSERVATIONAL STUDY OF THE PREVALENCE AND RISK FACTORS OF DEVELOPING VOICE DISORDERS IN MEDICAL RECORD OFFICERS AND MULTIFUNCTIONAL COMPUTER TERMINAL TECHNICIANS WORKING AT COUNTERS IN CMC, VELLORE

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE RULES AND REGULATIONS FOR THE MS BRANCH -IV (OTORHINOLARYNGOLOGY) EXAMINATION OF THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY TO BE HELD IN MAY 2022

REGISTRATION NUMBER 221914352

THE PREVALENCE AND RISK FACTORS OF DEVELOPING VOICE DISORDERS IN MEDICAL RECORD OFFICERS AND MULTIFUNCTIONAL COMPUTER TERMINAL TECHNICIANS WORKING AT COUNTERS IN CMC, VELLORE

By

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2019-2022

Department of Otorhinolaryngology

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BONAFIDE CERTIFICATE BY THE POSTGRADUATE CANDIDATE

I, Christna Rachel Jacob , do hereby declare that the dissertation titled "The Prevalence and Risk Factors of Developing Voice Disorders in Medical Record Officers and Multifunctional Computer Terminal Technicians working at counters in CMC, Vellore" done towards fulfilment of the requirements of the Tamil Nadu Dr. MGR Medical University, Chennai, for MS branch IV otorhinolaryngology examination to be held in May 2022 is a bonafide work done by me and due acknowledgments have been made in texts to all materials.

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bonafide original work of Dr. Christna Rachel Jacob, submitted in partial fulfilment of the rules and regulations for the MS branch IV, otorhinolaryngology examination of theTamil Nadu Dr. MGR Medical University to be held in May 2022.

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The prevalence and risk factors of developing voice disorders in medical record officers and MCTTs working at counters in CMC, Vellore.
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Dear Dr. Christna Rachel Jacob,

The Institutional Review Board (**Blue**, Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "The prevalence and risk factors of developing voice disorders in medical record officers and MCTTs working at counters in CMC, Vellore" on December 02nd 2019.

The Committee reviewed the following documents:

1. IRB application format
2. Patient Information Sheet and Informed Consent Form (English, Tamil, Telugu, Hindi and Bengali)
3. Proform
4. Permission letter
5. Cvs of Drs. Ajith John, Suchita Chase, Titus D.K, Ms.Dona Maria Philip
6. No. of documents 1- 5

The following Institutional Review Board (Blue, Research & Ethics Committee) members were present at the meeting held on December 02nd 2019 in the New IRB Room, Christian Medical College, Vellore 632 004.

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Ref: IRB Min. No. 12413 [OBSERVE] dated 02.12.2019

Dear Dr. Christna Rachel Jacob,

I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Suceena Alexander, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Suceena Alexander
Secretary (Ethics Committee)
Institutional Review Board

Dr. Suceena Alexander, MD.,DM.,FASN.
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Rev. Joseph Devaraj	BSc, BD	Chaplaincy Department, CMC, Vellore	Internal, Social Scientist

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of Withdrawals for the study entitled: "The prevalence and risk factors of developing voice disorders in medical record officers and MCTTs working at counters in CMC, Vellore" on a monthly basis. Please send copies of this to the Research Office (research@cmcvellore.ac.in).

The Institutional Ethics Committee expects to be informed about the progress of the project, Any **adverse events** occurring in the course of the project, any **amendments in the protocol and the patient information / informed consent**. On completion of the study you are expected to submit a copy of the **final report**. Respective forms can be downloaded from the following link: http://172.16.11.136/Research/IRB_Polices.html in the CMC Intranet and in the CMC website link address: http://www.cmch-vellore.edu/static/research/Index.html.

Fluid Grant Allocation:

A sum of 1,50,000/- INR (Rupees One Lakh Fifty Thousand Only) will be granted for 2 years.

Yours sincerely,

Dr. Suceena Alexander
Secretary (Ethics Committee)
Institutional Review Board

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ABBREVATIONS

MRO - Medical Record Officer

MCTT - Multifunctional Computer Terminal Technicians

GRBAS scale – Grade, Roughness, Breathiness, Asthenia, Strain scale

VDOP – Voice Disorder Outcome Profile

ABSTRACT

Title: A prospective cross sectional study of the prevalence and risk factors of developing voice disorders in medical record officers and Multifunctional Computer Terminal Technicians working at counters in CMC, Vellore.

Background: Voice production or phonation has a crucial role in human communication and function. It is done by specialized coordination of laryngeal and respiratory neuromuscular control. The prolonged use or abuse of voice may lead to vocal fatigue and vocal fold tissue damage. In professions with heavy vocal loading (e.g. school and kindergarten teachers), occupational voice disorders threatening working ability are common. In this study we aim to assess the prevalence of voice disorders and its risk factors among hospital support staff.

Material and Methods: A Prospective Cross-sectional observational study conducted among the medical record officers (MROs) and multifunctional computer terminal technicians (MCTTs) working at counters. The prevalence of voice disorders in the

study population was evaluated by voice analysis and stroboscopy. Meetings were conducted in the department describing the study and volunteers were recruited after consent. Detailed history and ear, nose and throat examination of the subjects were done. Following which participants underwent voice analysis which included phonation duration assessment, voice profile analysis, GRBAS scale, objective analysis using PRAAT software, self-evaluation using Voice Disorder Outcome Profile and stroboscopy.

Results: A total of 74 MROs and MCTTs were recruited in the study, with 73% males and 27% females. The age group of the study population ranged between 25 and 55 years. According to the quality of voice 43%, GRBAS scale 47% and VDOP 74% of the study population were found to have voice disorders and 96% of the 26 who volunteered stroboscopic showed pathological changes. Habitual frequent throat clearing showed statistical correlation with the prevalence of voice disorder suggestive of strong statistical correlation, based on the p value of voice quality (0.006); GRBAS scale (0.011) and VDOP (0.014). Screaming or shouting in causing voice disorder showed statistically significant correlation based p value of voice quality (0.008) and VDOP (0.005). The percentage of participants consuming less than 3 liters of water per day was 33.8% which correlation with incidence of voice disorder according to the p value of GRBAS (0.019).

Conclusion: The study concluded that there is a high prevalence rate of voice disorders among hospital support staff. The significant risk factors for voice disorders isolated from the study were frequent clearing of throat, screaming or shouting and inadequate water intake. Though very few among the subjects perceived voice related

difficulties, a significant percentage of the study population had underlying voice pathologies that required intervention, but were unaware.

INTRODUCTION

Voice production or phonation has a crucial role in human communication and function. It is done by specialized coordination of laryngeal and respiratory neuromuscular control. The prolonged use or abuse of voice may lead to vocal fatigue and vocal fold tissue damage. Vocal demands vary to a great extent between the different voice and speech professions. In professions with heavy vocal loading (e.g. school and kindergarten teachers), occupational voice disorders threatening working ability are common. Vocal loading is a combination of prolonged voice use and additional loading factors such as background noise and acoustics affecting the fundamental frequency, type and loudness of phonation or the vibratory characteristics of the vocal folds as well as the external frame of the larynx(1) .

The medical record officers (MROs) and multifunctional computer terminal technicians (MCTTs) working at counters routinely use their voices intensively at work and are therefore at a higher risk of dysphonia. Multifunctional computer terminal technicians are clerical staff with multiple roles in the out patients department and are unique to our hospital. They operate the computers to register patients and direct them to the concerned departments. They also act as cashiers ie collecting the cash for investigations ordered, print out the receipts as well as the investigation slips and direct them to the appropriate places. Therefore they interact with numerous patients every day and need to use their voice throughout the shift. The medical record officers are the front desk officers at every outpatient's department; they register the

arrivals and give them the necessary instructions. These MROS are also are key role players in managing the out patients and hence spend a lot of time speaking to people.

. In the recent past it has been noted that an increased number of front office workers in our hospital have been attending the ENT out patients department with voice complaints. Though there are few studies on health workers and voice disorders, there are none conducted to determine the prevalence of this and the associated risk factors among support staff working at counters in hospitals.

There have been studies done in hospitals on physicians, nurses and other allied health workers such as speech and language therapists to assess the prevalence of and risk factors for developing voice disorders. Self-administered questionnaires were given to the subjects which included variables such as age, gender, the prevalence of voice disorders in the current year, in the entire career and during education, the causes of voice disorders (vocal load and/or respiratory-tract infection or other), vocal habits (speaking loudly, shouting frequently, fast speaking rate, vocal rest when encountering voice problems), frequent throat clearing, sufficient hydration and history of smoking(2) . In some studies, the questions about daily vocal load, length of career, instructions about voice care, history of allergies and typical symptoms of gastroesophageal reflux (heartburn, acid regurgitation) were also part of the questionnaire(3). However no studies on hospital support staff who are front office workers have been reported in literature.

There have been a few studies conducted among professional voice users such as teachers and singers along with self-administered questionnaire, ENT, phoniatric and video stroboscopic examinations (4)(5).

The voice quality of an individual has a major role in their inter-personal relationships, efficacy at work and overall quality of life. Thus detecting voice disorders among MROs and MCTTs who are working at the counters, controlling the modifiable risk factors and providing necessary treatment options can improve their performance at work (6).

AIM & OBJECTIVES

AIM:

To study the prevalence of voice disorders in Medical Record officers and Multifunctional Computer Terminal Technicians working at counters in CMC, Vellore.

OBJECTIVES:

1. The prevalence of voice disorders in Medical Record officers and Multifunctional Computer Terminal Technicians working at counters by voice analysis and stroboscopy

2. To assess the risk factors associated with developing voice disorders in Medical Record officers and Multifunctional Computer Terminal Technicians working at counters.

LITERATURE REVIEW

EMBRYOLOGY OF LARYNX

The primordial respiratory system develops as an outgrowth from the ventral aspect of the primitive foregut at four weeks of gestation. The epithelium of the larynx, trachea and bronchi is of epidermal origin. The respiratory diverticulum elongates into the surrounding mesenchyme of fourth and sixth branchial arch which forms the connective tissues, cartilage, non-striated muscle and vasculature of bronchi and lungs. Arytenoid swellings on both sides of the diverticulum enlarge and adhere to each other occluding the laryngeal aperture until third month of gestation. The arytenoid swelling cranially elongates forming a cleft which is bound by aryepiglottic folds on both sides. Epiglottis develops from the hypobranchial eminence located ventral to the cleft. Glottis is developed just above the primitive aperture. The fourth pharyngeal arch gives rise to two lateral plates of cartilage which fuses to for thyroid cartilage. The cricoid cartilage is formed from the sixth arch.(7)

ANATOMY OF LARYNX

Larynx is a tubular organ in the neck that connects the pharynx to the trachea. It plays major role in respiration, phonation and deglutition. It is composed of a relatively rigid skeleton held together by muscles, membranes and ligaments with an inner mucosal lining. The inner lining passively is displayed as a series of elastic folds. Active folding and unfolding of these are accomplished by external and internal muscle activity to meet the functional demands of larynx.(8)

Larynx extends from the laryngeal inlet to the lower border of cricoid cartilage.

Cartilages: The laryngeal skeleton consists of three unpaired and three unpaired cartilages. The soft attachments of these cartilages allow changes in their relative angles and distances causing alterations in the shape and tension of the tissues extended between them. The adduction of the vocal folds happens when the arytenoid cartilages are brought together in the midline and they revolve over the cricoid, moving inferiorly and anteriorly. Minor cartilages of larynx includes corniculate and cuniform cartilage. (9)

Unpaired Cartilages:

Epiglottis: The leaf like epiglottis is made up of elastic cartilage connected to the Hyoid bone by thyroepiglottic ligament and its function is to close the laryngeal inlet while swallowing and to prevent the entry of food and liquid into the lungs.

Thyroid cartilage: The thyroid cartilage has two wide plates like structures called the laminae that diverge posteriorly from their vertex, the thyroid prominence. Each

lamina has a superior and inferior conua, which are drawn out above and below respectively. The cartilage sits on top of the cricoid and articulates with it via the inferior cornua. The thyroid cartilage is covered with perichondrium except at the attachment of anterior commissure of vocal cords by broyle's ligament.

Cricoid cartilage: It is ring shaped and the only complete cartilage with a narrow anterior arch and a broad posterior lamina. The lamina has facets which articulate with arytenoids.

Paired Cartilages

Arytenoid cartilages: These are pyramidal shaped cartilages, which articulate with cricoid lamina in a synovial joint. It rest on the superior surface of the posterior portion of the cricoid on each side. It has a vocal process, muscular process, apex and a base. The vocal process points anteriorly toward the thyroid prominence and serves as the point of insertion for the thyroarytenoid muscle, and the muscular process projects laterally.

Corniculate cartilage: It is also known as cartilage of Santorini. It is located above the arytenoids.

Cuneiform cartilage: It is known as cartilage of Wrisberg. It is seen in the superior aspect of the aryepiglottic fold.

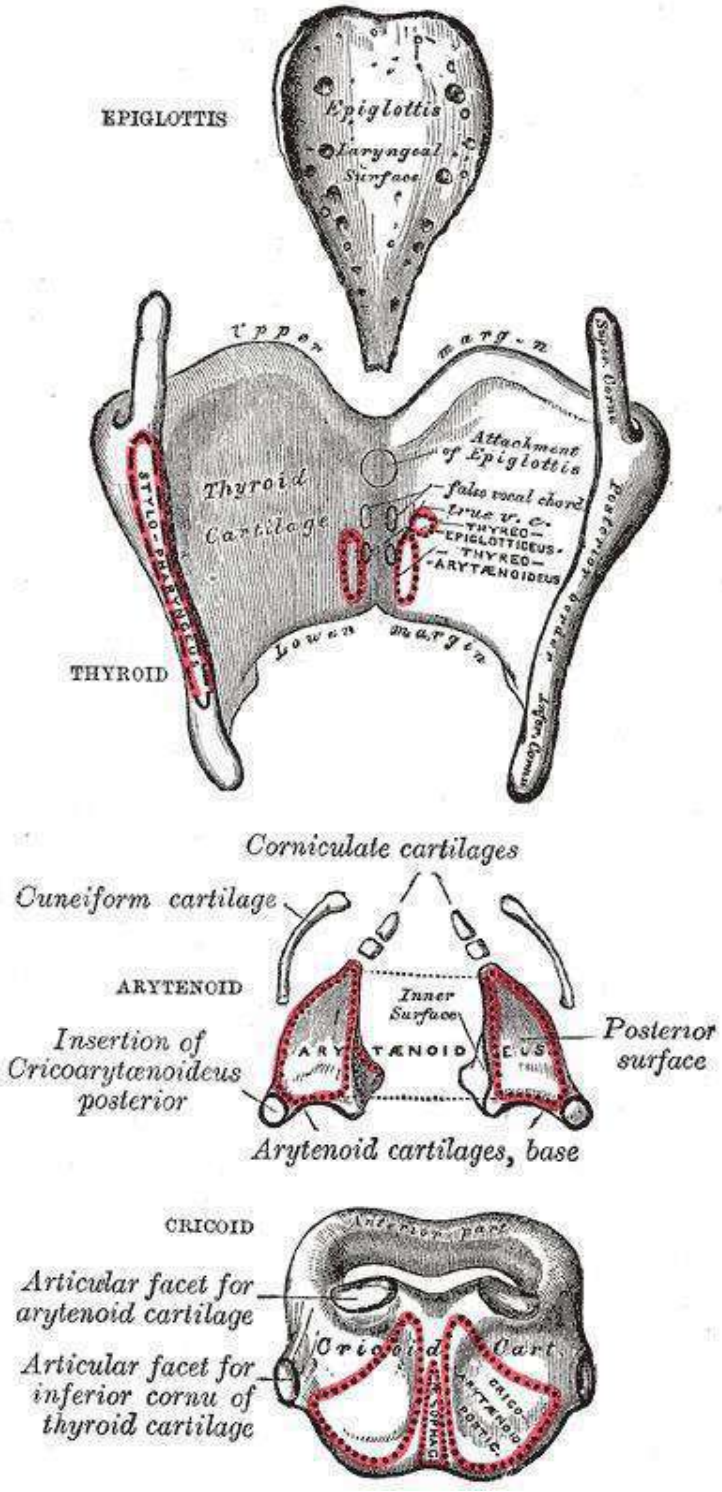


Figure 1: The cartilages of the larynx; Posterior view, Epiglottis, Thyroid, Arytenoid, Cricoid

Source: Flynn W, Vickerton P. Anatomy, Head and Neck, Larynx Cartilage

Extrinsic muscles

Extrinsic laryngeal musculature helps maintaining a stable laryngeal skeleton and facilitating effective functioning of the delicate intrinsic musculature. It primarily made of the strap muscles, and is divided into infrahyoid and suprahyoid muscles, which are below and above the hyoid bone respectively.

The Infrahyoid muscles depress the hyoid bone.

Thyrohyoid: It originates obliquely on the thyroid lamina of the hyoid bone. When it contracts the thyroid and hyoid bone becomes closer anteriorly.

Sternohyoid: It originates from the clavicle and posterior surface of the manubrium of the sternum and it inserts into the lower edge of the body of the hyoid bone. Its contraction of lowers the hyoid bone.

Sternothyroid: This muscle originates from the first costal cartilage and posterior aspect of the manubrium of the sternum, inserts obliquely on the thyroid cartilage and on contraction lowers the larynx.

Omohyoid: Has a superior belly arising from the intermediate tendon and inserting into the greater cornu of the hyoid and an inferior belly that originates from the upper surface of the scapula and inserts into its intermediate tendon. When it acts pulls down the hyoid and lowers it.

Suprahyoid muscles elevate the hyoid bone.

Digrastric: Has two bellies, the posterior that originates from the mastoid process and the anterior from the inferior aspect of the mandible near the symphysis. Both these insert into the intermediate tendon, which connects to the hyoid bone. The anterior belly contracts and pulls the hyoid bone anteriorly to raise it.

Mylohyoid: The muscle originates from the inner aspect of the body of the mandible and inserts into a midline raphe with fibres from the opposite side. On contraction it raises the hyoid bone and pulls it anteriorly.

Geniohyoid: It originates from the mental spine at the mental symphysis of the mandible and inserts on the anterior surface of the body of the hyoid bone. The muscle raises the hyoid bone and pulls it anteriorly.

Stylohyoid: It originates from the styloid process and inserts into the body of the hyoid bone. It contracts to raise the hyoid bone and pulls it posteriorly(10).

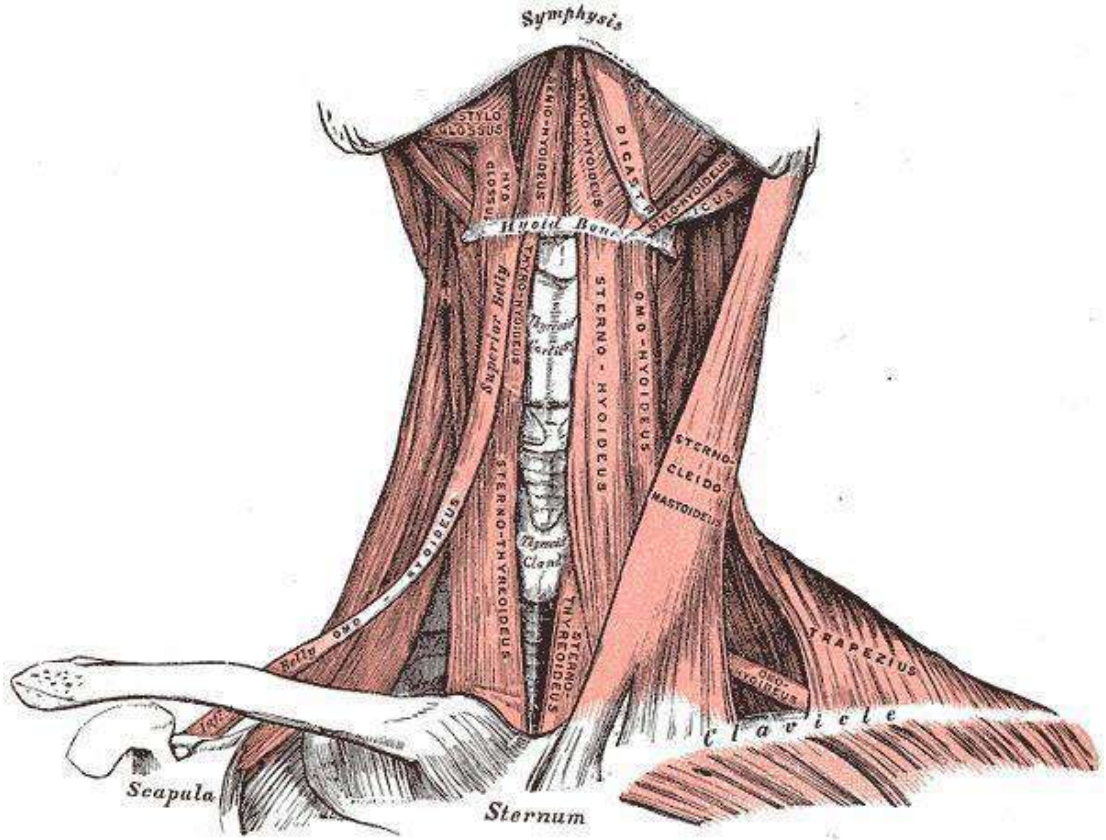


Figure 2: Extrinsic muscles of larynx

Source: Mnatsakanian A, Al Khalili Y. Anatomy, Head and Neck, Thyroid Muscles. StatPearls, 2021 Jul 29.

Membranes:

Extrinsic membranes hold the laryngeal cartilages together and suspend them from the hyoid externally.

Intrinsic membranes: On the inner aspect of the larynx a broad sheet of fibrous tissue with numerous elastic fibres lies deep to the mucosa and is divided by an interval, the ventricle into the upper Quadrangular membrane and the lower Cricovocal membrane

and attach to the cartilages. In addition the joints between the individual cartilages are provided with ligaments.

Quadrangular membrane: Extends from the lateral aspect of epiglottis to the arytenoid posteriorly. The superior free edge of the membrane forms the aryepiglottic ligament, which with its mucosal covering forms the aryepoglottic fold and the free lower border thickens to form the vestibular ligament and the false vocal cord.

Cricovocal membrane or Triangular membrane: The paired triangular membranes together form conus elasticus. Its base is anteriorly attached to the thyroid and cricoid cartilages. The apex of the membrane is attached to the vocal process of the arytenoids.

Laryngeal Cavity

The laryngeal inlet or aditus is the entrance of the cavity of the larynx. Superior to the inlet is the laryngopharynx. The cavity of the larynx is divided into three parts.

Supraglottic space: The space is above the level of the vestibular folds. It is bounded anteriorly by epiglottis, laterally by the aryepiglottic folds and posteriorly by the inter-arytenoid mucosa.

Laryngeal ventricles: The middle of the laryngeal cavity is composed of a pair of ventricles, which is the area between the vestibular and vocal folds.

Subglottic space: It is also referred to as the infraglottic space, It extends from beneath the vocal cords till the junction between the cricoid and trachea (11)

Laryngeal Mucosa

The laryngeal epithelium in the mechanically exposed areas consists of stratified squamous non-keratinized epithelium. Rest of the larynx, has pseudo-stratified, ciliated, columnar epithelium, which is rich in goblet cells. Except in the true vocal cords, lamina propria consists of loose connective tissue and groups of small, branched tubuloalveolar gland(12).The vibratory margin of the vocal fold consists of five layers. The area of contact between the vibrating vocal folds is formed by lubricated thin epithelium covering the vocal cords which helps to maintain the shape of vocal fold. Stratified squamous epithelium covers the vibratory margin of the vocal fold which enables it to withstand the trauma of vocal fold contact. The next layer, lamina propria is divided in to three parts. The superficial layer is known as Reinke's space, which is composed of loose fibrous components and matrix. The intermediate layer of consists primarily of elastic fibers. The deep layer is composed primarily of collagenous fibers and is rich in fibroblasts. The intermediate and deep layer of lamina propria forms the vocal ligament. The body of the vocal fold is formed by thyroarytenoid or vocalis muscle which is one of the intrinsic muscles of the larynx. (13)

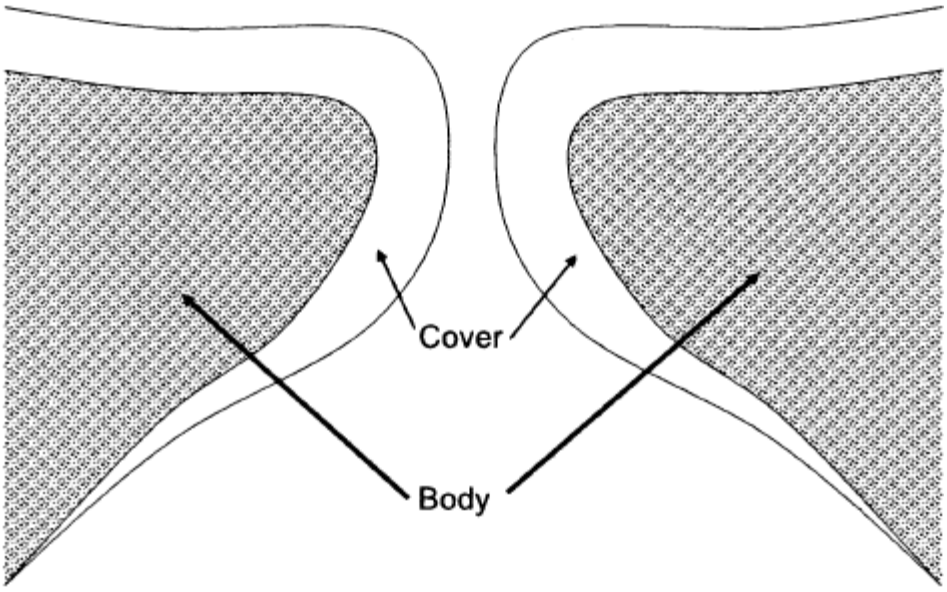


Figure 3: Division of the vocal fold into the cover and body portions

Source: Story BH. An overview of the physiology, physics and modeling of the sound source for vowels.Acoustical Science and Technology. 2002;23(4):195-206.

VOCAL CORDS ANATOMY

Vocal cord vibrations modulate the airflow and produces voice. It is divided into an anterior two thirds membranous portion and a posterior one third cartilaginous portion.

The vocal cords are layered structures, consisting of an inner muscular layer which is the thyroarytenoid muscle with its fibers aligned primarily along the anterior-posterior direction, a soft tissue layer of the lamina propria, and an outermost

epithelium layer. The thyroarytenoid muscle is divided into a medial and a lateral bundle. (14)

Each vocal fold measures about 17–21 mm in men and 11–15 mm in women. It stretches across the larynx in anteroposterior direction. The vocal cords consist of the mucosal surface, the lamina propria and the vocalis muscle or the medial thyroarytenoid(15).

The anterior commissure is in the midline area where the cords meet anteriorly and attach to the inner surface of thyroid cartilage.

The posterior commissure is the mucosal surface which is anterior to the cricoid cartilage in between the arytenoid cartilages. Posteriorly, the vocal cords attach to the arytenoid cartilages. Cranial to the vocal cords, there is a slit-like opening of the laryngeal ventricles. It separates the true vocal cords below from the false vocal cords above(16)

LARYNGEAL NEUROANATOMY

Phonation is a product of laryngeal and respiratory neuromuscular coordinate with both central and peripheral nervous system playing. Cortical loci is responsible for voluntary phonation and there are studies suggesting subcortical representation in reflex laryngeal function and involuntary phonation(17). A study conducted by Davis et al suggested the involvement of periaqueductal grey matter (PAG), region of mid brain, in emotional or involuntary voice production and generation of respiratory and

laryngeal motor patterns fundamental to speech and singing(18). Projections from PAG reaches nucleus retroambigualis (NRA), which is responsible for respiratory pressure and laryngeal adduction necessary for both vocalization and vegetative responses such as cough(19).

The voluntary vocalization pathway arises from the pre-central gyrus in the motor cortex and its fibres descend in pyramidal system as a part of corticobulbar tract. On reaching medulla some fibres remain on the same side and synapses with the ipsilateral vagus nucleus and the lower motor neurons subsequently and the rest cross over and synapses with the contralateral vagal nucleus. Cranial nerves IX-XII receives fibres from frontobulbar portion of the pyramidal tract, thus controls articulation, phonation and respiration(20).

LARYNGEAL INNERVATION

The vagus nerve arises from the nucleus ambigus in medulla and exits the skull through jugular foramen supplies the sensory structures and intrinsic muscles of larynx. It divides into the pharyngeal nerve, superior laryngeal nerve, recurrent laryngeal nerve and superior cardiac nerve within the neck(21).

The pharyngeal nerve arises from the inferior ganglion of vagus nerve containing both sensory and motor fibers, which innervate the pharyngeal and palate muscles except the tensor velipalatini. The pharyngeal plexus branches have innervation to the intercarotid plexus (22).

The superior laryngeal nerve descends between the external and internal carotid arteries and divides into internal and external branches at the level of the hyoid.

The internal laryngeal nerve pierces the thyrohyoid membrane entering the larynx. ***The external laryngeal nerve*** travels distally with the superior thyroid vessels. The external branch supplies the cricothyroid muscle, whereas the internal branch supplies the mucosa superior to the glottis.(23)

The recurrent laryngeal nerve has a different course on each side. The right recurrent laryngeal nerve branches out near the right subclavian artery, travelling superiorly to enter the larynx in between the cricopharyngeus muscle and the esophagus. The left recurrent laryngeal nerve descends and loops around the aortic arch and then enters the larynx. All the intrinsic muscles of larynx are supplied by recurrent laryngeal nerve except the cricothyroid muscle.(24)

The vagus nerve gives off the superior cardiac branch within the carotid sheath and is associated with parasympathetic fibres, and also bronchial, esophageal, gastric and celiac branches.(25)

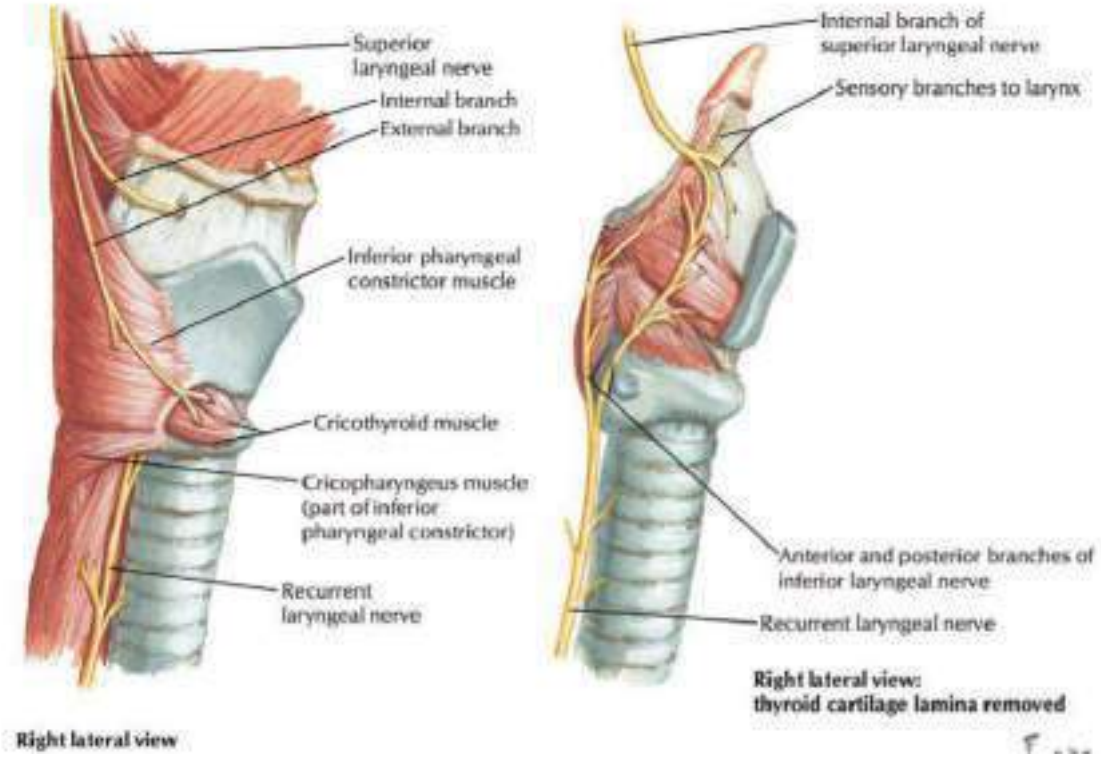


Figure 4: Recurrent laryngeal nerve and superior laryngeal innervation of the larynx.

Source:Câmara R, Griessenauer CJ. Anatomy of the vagus nerve In Nerves and nerve injuries 2015 Jan 1 (pp. 385-397). Academic Press.

PHYSIOLOGY OF PHONATION

Physiological function of the vocal folds is the regulation of airflow, where the two folds act like a valve that regulates airflow during breathing. The vocal folds undergo self-sustained, high-frequency, and small-amplitude oscillations during phonation. A widely accepted explanation for voice production is the myoelastic aerodynamic theory of van den Berg. That the vocal folds close due to action of a negative Bernoulli pressure followed by a building subglottic pressure, which when sufficiently

high, vocal cords are pushed open and the intra glottis pressure drops. Repetition of the cycle results in sustained vocal fold oscillation. It explains the influence of the larynx, trachea, and vocal cavities and the coupling of these organs to form a sound generator. The dynamics of the glottal airflow, the geometry of vocal folds, and their biomechanical properties defines the voice parameters, such as the fundamental frequency of phonation. According to the body-cover theory, which consider the vocalis muscle as the firm body that is covered by the mucous membrane, the modal frequency of the vocal folds that defines the fundamental frequency of phonation is controlled by the effective tension of the cover layer(26).

Biomechanics of phonation

The vibratory cycle is formed due to the upward travel of mucosal wave along the surface of each vocal cord. Each cycle has three phases, adduction, separation and recoil of the vocal cords. When air passes from lungs to pharynx via narrow glottis the velocity increases and the glottic pressure drops. This pulls the fold mucosa medially. The vocal cords stay in contact until the subglottic pressure increases enough to aerodynamically separate the vocal cord and the cycle continues. (25)

The vibratory cycle is broadly divided into open and closed phases based on the period of contact of vocal folds(27). The open phase is defined as the time from the moment when the upper lips of the vocal cords start to open to the moment when lower lips close. During this period airflow through the glottic aperture occur. The open period can be further divided into opening phase and closing phase. Opening phase is when the vocal cords begin to slowly separate from the lower parts and the

closing phase is when the vocal fold rapidly closed starting from the lower parts. This is followed by closed phase when the medial edge of both vocal folds comes in full contact.(28)

Role of lungs in voice production

Lungs act as the source of voice production. During expiration the airflow flow from the lungs force open the opposed vocal folds producing sound. Lung pressure is the primary regulator of vocal intensity. The frequency at which the vocal fold mucosa oscillates defined by the coordinated activity between cricothyroid and thyroarytenoid muscles and lung pressure(29)

Vocal Registers

Human voice production over the whole frequency range involves different adjustments of the vocal apparatus, encompassing zones which are called registers. It is a series of consecutive and homogeneous tones ranging from low to high, produced by the same mechanical principle, and whose nature differs essentially from another series of tones equally consecutive and homogeneous which are produced by another mechanical principle. All the tones belonging to the same register are of the same nature, irrespective of the modifications of timbre or of the force to which one subjects them. (30)

The naming of vocal registers is a controversial topic and each profession uses different sets of names for the vocal resisters. There are three types of vocal registers accepted by vocal scientists, namely pulse, modal and loft registers.

The **pulse register** occupies the lowest range of phonation along the fundamental frequency continuum. The vibratory pattern is pulse-like, and has relatively low frequencies. Synonyms for the pulse register are vocal (or glottal) fry, creak and stroh bass.

The **modal register** also named as “normal” because it includes the range of fundamental frequencies that are normally used in speaking and singing.

The **loft register** is recognized as falsetto by phoneticians and speech pathologists. It occupies the higher fundamental frequencies of the voice continuum.

It is possible that more than three voice registers exist. For example, there is a relatively rare very high frequency register which is exhibited by a few women and children, it is referred to as the "flute," "whistle" or "pipe" register. (28)

CHARETERISTICS OF GLOTTAL SIGNAL

Glottal signal

As airflow from the lungs, it passes through the vocal folds, which oscillate in a frequency called the **fundamental frequency** of the voice. This oscillation modifies the air coming from the lungs, changing it into air pulses. The pressure signal formed by the air pulses is called the glottal signal.(32)

Voice quality

The quality of voice depends on the nature of vocal cord vibration during glottal air flow. The voice is considered ‘breathy’, if there is incomplete closure at the level of vocal cords. The voice is ‘hoarse’ if there is irregular mucosal waveform resulting in aperiodic sound. It is called hyper-functional or pressed voice production if the voice sounds strained, as if the vocal folds are compressed and the sound is produced with great laryngeal effort. Whereas hypo-functional or lax voice production is opposite to hyper-function, there is insufficient vocal fold adduction, and the voice is produced with low laryngeal effort, resulting in a weak and slack and non-sonorous voice.

Pitch

It is the auditory correlate of fundamental frequency, which is the number of vibratory cycles per second.

Voice Range

Voice range is the range at which the fundamental frequency varies during running-speech.

Voice Amplitude

The loudness of the voice depends on the amplitude of the oscillation wave. It is determined by the force of airflow through the glottis(33)

Paralinguistic Features of Voice

The terms linguistic, extralinguistic, and paralinguistic are used to qualify features functioning to signal phonetic quality, voice quality, and tone of voice, respectively.(34)

Every word of our spoken language, through accent, tone of voice and habitual voice quality is an audible declaration of our membership of particular social regionalgroups, of our individual physical and psychological identity, and of our mood in that moment.

It has shown that variations in a speaker's output are a function of two things: their communicative intent (a combination of what they want to convey and the situation in which they are speaking) and the dimensions and condition of their individual vocal tract (35)

ASSESSMENT OF LARYNX

The examination of the internal structures of the larynx, including the vocal folds, is called laryngoscopy.

Indirect laryngoscopy:

It is one of the earliest methods of examining the larynx which involves inserting a small angled mirror, into the back of the mouth. This mirror deflects a beam of light from the head lamp, down onto the vocal folds and reflects the image of the vocal cords back up to the examiner. It provides a good view of the vocal folds, and likely

the most accurate picture with respect to colour. However, it is not possible to magnify the view or record the examination.(36)

Endoscopic assessment, with a rigid or flexible laryngoscope, has supplanted mirrors due to their higher sensitivity and better optical resolution. Assessment of larynx can be supplemented with stroboscopy, laryngography or digital acoustic voice analysis.

Flexible endoscopy

Fibre optic flexible laryngoscopy is done for dynamic voice assessment and neurolaryngologic examination. Once passed beyond oropharynx, step-wise assessment of the larynx is made. The vallecula is inspected by tongue protrusion, then the supraglottic larynx, followed by the glottic larynx.(37)

Rigid endoscopy

It provides superior images of the true cords and is necessary for precise diagnosis in patients with true vocal fold pathology.

Different scopes can be used to inspect the sub sites of the endo-larynx, such as the anterior commissure scope which is designed to maximize the view of the anterior glottis. The angled endoscopes allow better view of the ventricle, free edge and under surface of the vocal cord.(38)

Direct Laryngoscopy

Direct Laryngoscopy Approach Regardless of the type of laryngoscope blade used during direct laryngoscopy, the approach relies on a direct and unimpaired line of sight from the eye of the examiner to the patient's tracheal opening or glottic opening. The sniffing position has traditionally been considered the optimal head position for direct laryngoscopy, with alignment of the oropharyngeal, pharyngeal, and laryngeal axes as the anatomical basis for the position(39)

Figure 5: Glottic opening view by direct laryngoscopy.

Source: Collins SR. Direct and Indirect Laryngoscopy: Equipment and TechniquesDiscussion. Respiratory care. 2014 Jun 1;59(6):850-64.

OBJECTIVE EVALUATION OF VOICE

Objective measures are used in the evaluation of voice to characterize the voice and voice problem, thus provide evidence for differential diagnosis as well as a measure of severity of the disorder and degree of variance from established normal values to help with the treatment. Voice evaluation can also be done to assess responsiveness to treatment .Visual assessment of the larynx including occasional diagnostic microlaryngoscopy remains mandatory for confirmation of diagnosis in all cases. Either a sustained vowel or fluent speech can be used as the voice material. Evaluation of voice can be done using the following methods.

PERCEPTUAL EVALUATION OF THE VOICE

Auditory-perceptual evaluation is a highly valued procedure which is used worldwide and regarded by many, as the gold standard for voice disorder documentation. However, the evaluation of test voice depends on the experience and training level of the evaluator. (40)

There are various rating scales to grade the presence and severity of defined qualities of the voice that we can hear, such as hoarseness, roughness, breathiness. Numerous schemes such as the following have been developed to rate the voice characteristics using either categorical or visual analogue scales.

GRBAS system: In this Grade(G) denotes overall degree of deviance of voice, Roughness(R) denotes irregular fluctuation of the fundamental frequency, Breathiness(B) denotes turbulent noise produced by air leakage, Asthenia(A), the

overall weakness of the voice, and Strain(S), the impression of tenseness or excess effort.

Each parameter is scored on a scale of 0 to 3,with 0 as normal, 1 with slight disturbance, 2 with moderate disturbance, and 3 with severe disturbance.(41)

Consensus Auditory Perceptual Evaluation Voice (CAPE-V): This is a new measure which replaces the four-point scale with a l00-mm line visual analogue scale and also considers other factors such as pitch and loudness. CAPE-V includes predetermined vocal tasks and analysis criteria. (42)

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

Name:_____ **Date:**_____

The following parameters of voice quality will be rated upon completion of the following tasks:
1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.
2. Sentence production:
   a. The blue spot is on the key again.
   b. How hard did he hit him?
   c. We were away a year ago.
   d. We eat eggs every Easter.
   e. My mama makes lemon muffins.
   f. Peter will keep at the peak.
3. Spontaneous speech in response to: "Tell me about your voice problem." or "Tell me how your voice is functioning."

Legend: C = Consistent I = Intermittent
MI = Mildly Deviant
MO =Moderately Deviant
SE = Severely Deviant

			SCORE
Overall Severity	_____ (MI MO SE)	C I	/100
Roughness	_____ (MI MO SE)	C I	/100
Breathiness	_____ (MI MO SE)	C I	/100
Strain	_____ (MI MO SE)	C I	/100
Pitch	(Indicate the nature of the abnormality): _____ _____ (MI MO SE)	C I	/100
Loudness	(Indicate the nature of the abnormality): _____ _____ (MI MO SE)	C I	/100
_____	_____ (MI MO SE)	C I	/100
_____	_____ (MI MO SE)	C I	/100

COMMENTS ABOUT RESONANCE: NORMAL OTHER (Provide description):_____
_____

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, aphonia, pitch instability, tremor, wet/gurgly, or other relevant terms):

Clinician:_____

Figure 6: CAPE V proforma

Source: Karnell MP, Melton SD, Childes JM, Coleman TC, Dailey SA, Hoffman HT. Reliability of clinician-based (GRBAS and CAPE-V) and patient-based (V-RQOL and IPVI) documentation of voice disorders. Journal of Voice. 2007 Sep 1;21(5):576-90.

Buffalo Voice Profile (BVP): It was originally developed to provide criteria and profiles that can be used to rate various parameters of voice in children. The voice profile is divided into 12 parameters, which are rated on a five-point equal interval scale, with a score of onedenoting normal and five denoting a severe disorder.

Vocal Profile Analysis Scheme (VPA): It is a phonetic description of voice quality specifying both laryngeal and supra laryngeal parameters. All voice features are compared to a specifically defined neutral baseline rather than an internal perception of normality. The form is divided into three sections charting vocal quality features, prosodic features and temporal organisation and each feature is rated along a six-point scale(43)

ACOUSTIC ANALYSIS

It aims at extracting and objectively evaluating various factors related to the acoustic waveform recorded using a microphone placed near the mouth .The most frequently analysed parameters include fundamental frequency, measures of frequency perturbation such as jitter, and measures of amplitude perturbation such as shimmer. The validity and reliability of acoustic analyses performed using different tools are affected by several factors, including the type of microphone, ambient noise levels, data acquisition system, sampling rate, and the software used.

The Multi-Dimensional Voice Program (MDVP) developed by the Computerized Speech Lab is currently the most commonly used and cited acoustic analysis software.

Another program called **PRAAT**, the Dutch word for “speak” or “talk”, designed by Paul Boersma and David Weenink from the University of Amsterdam, is a freeware

that can be downloaded from the Internet which is proven useful for discriminating pathological from normal voices in clinical studies(44)

ELECTROLARYNGOGRAPHY / ELECTROGLOTTOGRAPHY

It is a technique used to assess the vocal fold vibrations while analysing voice disorders.

The electrolaryngograph measures changes in high frequency electrical conductance between two electrodes placed on the skin externally over the thyroid alae. An alternating current at 3 MHz is passed between them. This change in electrical conductance is caused by an alteration in vocal fold contact area due to vibration of the folds. It indirectly measures the vocal fold vibration by calculating fundamental frequency, degree of contact, perturbation measures. (45)

AERODYNAMIC MEASURE

It measures the transglottal pressure, the pressure drop across the glottis and the glottal airflow waveform from the oral air pressure and inverse-filtered oral flow. The measures have been found to indirectly reflect the underlying vocal function and vocal fold vibration patterns for both normal voice and voice disorders.(46)

VOICE ACCUMULATOR

The voice accumulator has been developedfor an objective measurement of vocal load. This portable instrument records total speaking time and sound level over a period of several hours or before and after a vocal stress test. Its data can be

transferred to a personal computer which analyses voiced time in seconds, between 60dB and 112dBs. Thus, more precise and objective documentation of vocal demands in different professions can be obtained. (47)

QUALITY OF LIFE MEASURES

Perceived disability due to voice disorders is influenced by many factors, such as societal attitudes, environmental barriers, the patient's psychosocial traits, family and community support, premorbid lifestyle, education, age, sex, vocation, avocations, and ethnic and cultural background. Thus, patient-based outcome measures can potentially provide useful information to be added to the biological and physiological variables related to the voice. The quality of life is assessed by using self-administered, validated disease-specific or generic questionnaires, that focus on the patient's perception of the impact of the voice disorder, in terms of physical complaints and restriction in participation in daily activities.(48)

Voice Handicap Index (VHI): The VHI, a self-administered questionnaire was proposed by Jacobson et al. In 1997.This 30 question tool, is equally distributed over three domains i.e. functional, physical, and emotional aspects of voice disorders. It provides an evaluation based on a patient's own perception of his or her disease, enabling treatment planning, pre-treatment and post-treatment evaluation. It has been translated into and validated in several languages.(49)

Cultural background plays a major role in every individual's quality of life. Thus a culture-specific quality of life assessment tool for individuals with voice disorders in India is necessary. India is home to a large number of people who depends on their

voices for their daily living. This includes teachers, sales persons, politicians, singers, actors, and street vendors. Certain factors in the Indian context increase individuals' susceptibility to voice problems are dust and noise pollution, lack of acoustic amplification, life style such as spicy foods, excessive consumption of coffee, tea, and carbonated soft drinks, the tropical climate, and excessive voice use.

Voice Disorder Outcome Profile (VDOP):

A statistically robust tool for assessing voice disorder outcomes in the Indian

population was developed by Konnai et al. This self-evaluation questionnaire has 32 items categorised into three domains, namely, physical, emotional, and social. There are 10 questions in the physical domain which deal with the patients' perceptions of problems concerning usage of voice and its output. The emotional domain includes questions related to patients' affective responses to the voice disorder and the functional domain has12 questions pertaining to daily living situations, job activities, and social activities

The initial version of VDOP was developed in English was then translated into Kannada as well. The visual analogue scale had a 100-mm undifferentiated line with the left extreme marked as ''never'' and the right extreme as ''always''. The responses were recorded by putting an ''x'' on the 100-mm line depending on the severity of the problems the patient faces. For example, an "x" toward the extreme left side means they are never affected, whereas a cross toward the extreme right side denotes they are always affected. The total VDOP score was obtained by summing the scores of the 3 domains. The total score for an individual could be a maximum of 320,

as there were 32 items with a maximum score of 10 for each item and a minimum of 0.(50)

Name: Age/ Gender:

Date: Occupation:

Address:

This questionnaire is aimed at collecting information on self perceived severity of the voice problem. The information collected will be kept confidential.

I) SELF-PERCEIVED SEVERITY OF VOICE PROBLEM

INSTRUCTION: *Please answer the following questions by putting an 'x' on the 100 mm line depending on how severe your voice problem is. For example, a cross towards the extreme left means you have* ***"normal"*** *voice while a cross towards the extreme right side means you have a* ***"severe"*** *voice problem.*

How severe is your voice problem now?

Normal ——————————————— Severe

VOICE DISORDER OUTCOME PROFILE

INSTRUCTION: *Please answer the following questions by putting an 'x' on the 100 mm line depending on the extent of the problem you face. For example, a cross towards the extreme left means you are* ***"never"*** *affected while a cross towards the extreme right side means you are* ***"always"*** *affected. Tick "Not Appropriate (NA)", if any of the questions are not applicable to you.*

I. PHYSICAL

1. Do you get tired when you speak for long?

Never ——————————————— Always | NA

2. Do you run short of breath when you speak?

Never ——————————————— Always | NA

3. Do you have to strain to produce your voice?

Never ——————————————— Always | NA

4. Does your voice vary throughout the day?

Never ——— Always | NA

5. Do you have difficulty in speaking loudly?

Never ——— Always | NA

6. Do you lose your voice after prolonged speaking?

Never ——— Always | NA

7. Does your voice lack clarity?

Never ——— Always | NA

8. Do you need to frequently clear your throat?

Never ——— Always | NA

9. Does your throat feel dry after continuous speaking?

Never ——— Always | NA

10. Does your throat pain while speaking?

Never ——— Always | NA

II. EMOTIONAL

11. Does your voice problem upset you?

Never ——— Always | NA

12. Are you worried because of your voice problem?

Never ——— Always | NA

13. Do people understand your voice problem?

Never ——— Always | NA

14. Do you lack self confidence because of your voice problem?

Never ——— Always | NA

15. Do you feel less worthy because of your voice problem?

Never ——— Always | NA

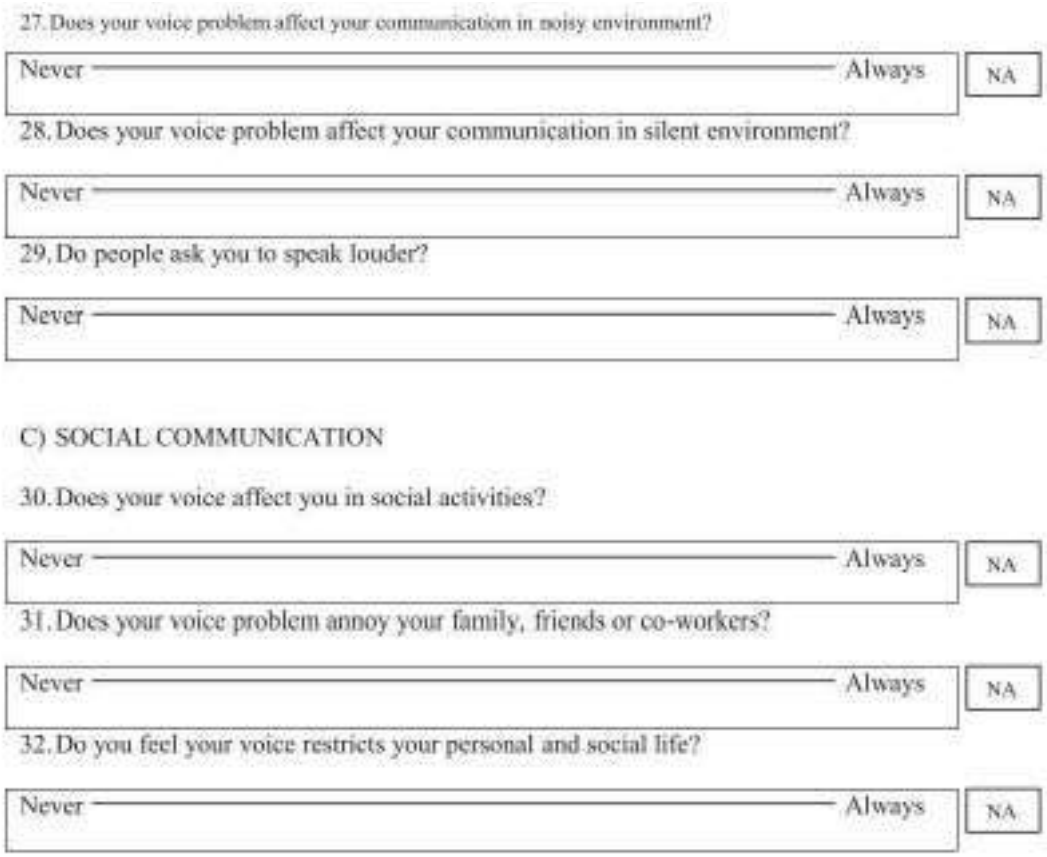


Figure 7: VDOP proforma

Source: Konnai RM, Jayaram M, Scherer RC. Development and validation of a voice disorder outcome profile for an Indian population. Journal of Voice. 2010 Mar 1;24(2):206-20.

There was an inherent need to develop this culture sensitive tool in other Indian languages for clinical use. India has diverse languages and dialects and Tamil is one other Indo- Dravidian language that is spoken in Tamil Nadu and elsewhere. Approximately 69 million people around the globe use Tamil as their first language and it is the 15th most commonly used language in the world. Mahalingam et al

translated the V-DOP in Tamil language. V-DOP in Tamil has been shown as a reliable and valid tool for measuring quality of life in Tamil-speaking population.(51)

VISUAL ASSESSMENT

Stroboscopy is an examination of the vocal cord vibration and closure using strobe light i.e. controlled high speed flashes of light which is timed with the frequency of vocal fold movement , woth either a rigid or flexible laryngoscope.

Stroboscopic imaging of vocal fold vibratory function during phonation continues to play a main role in diagnostic, therapeutic, and surgical decisions during the management and treatment of voice disorders.(52) It uses a flexible or rigid endoscope along with a microphone and strobe light which is flashing. The microphone is placed next to the larynx to estimates the fundamental frequency of the voice. The strobe frequency is then synchronized at a rate slightly lower than the fundamental frequency, in order to capture successive phases of the glottic cycle.[3] These images are played in the order to produce a "slow-motion" video clip of the vocal folds during phonation.(53)

Figure 8: Stroboscopy procedure

Source: Taken in our tertiary care hospital

The classic literature attributes the strobe effect to Talbot's law(54) which states that an image will remain imprinted in the retina for two-tenths of a second. Mehta et al debunked this concept in a commentary that explained that two different visual perception phenomena actually play crucial roles in laryngeal stroboscopy. Those are

the perception of a flickerfree, uniformly illuminated image which is satisfied at strobe rates above 50 Hz and the perception of apparent motion from sampled images when no real motion exists which is satisfied at display rates above 17 Hz. (55)

Stroboscopy evaluation rating form developed by Poburka assesses the following laryngeal properties during phonation.

(1) Amplitude: The extent of lateral vocal fold displacement.

(2) Mucosal wave: The extent of vocal fold tissue deformation.

(3) Vibratory behavior: The presence or absence of vibration in particular locations.

(4) Supraglottic activity: The extent of laryngeal compression.

(5) Edge: The rating of smoothness and straightness.

(6) Vertical level: The on-plane versus off-plane vocal fold contact.

(7) Phase closure: The rate of open/closed phase duration.

(8) Phase symmetry: The rating of left to right vibratory phase symmetry.

(9) Regularity: The rating of periodicity.

(10) Glottal closure: The rating of the shape of the glottis at closure.

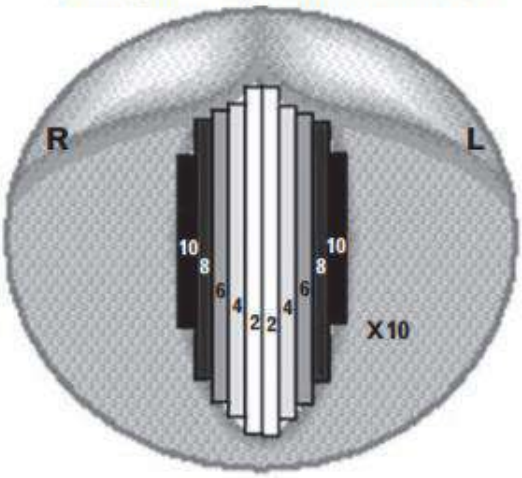
(a)

Stoboscopy evaluation rating form (SERF)

Bruce J. Poburka. Ph.D.

Rater:_____
Client:_____
Date:_____

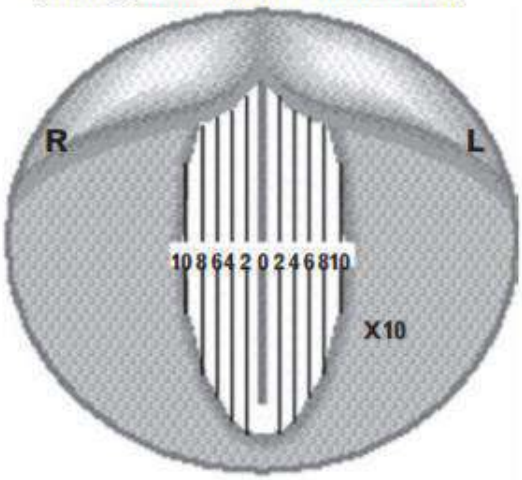
Amplitude
(Rate @ normal pitch and loudness)



Right:_____% Left:_____%

Fo:_____

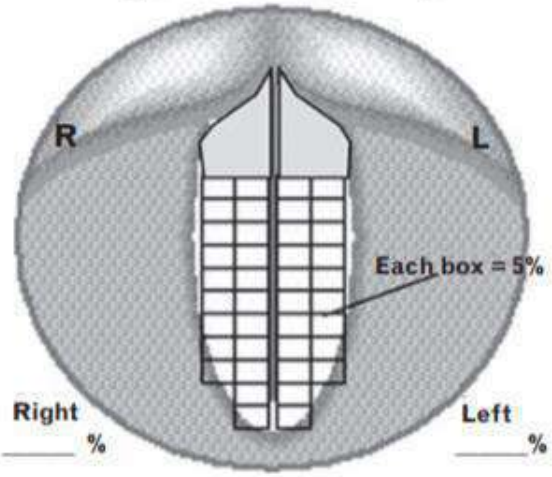
Mucosal wave
(Rate @ normal pitch and loudness)



Right:_____% Left:_____%

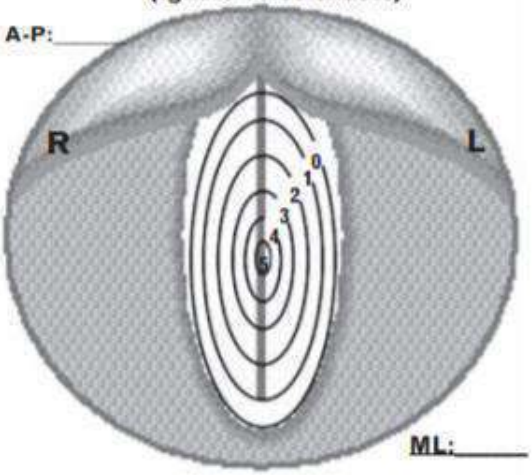
Fo:_____

Non-vibration portion
(Shade in affected areas)



Supraglottic activity
(Ignore voice onsets)

A-P:_____



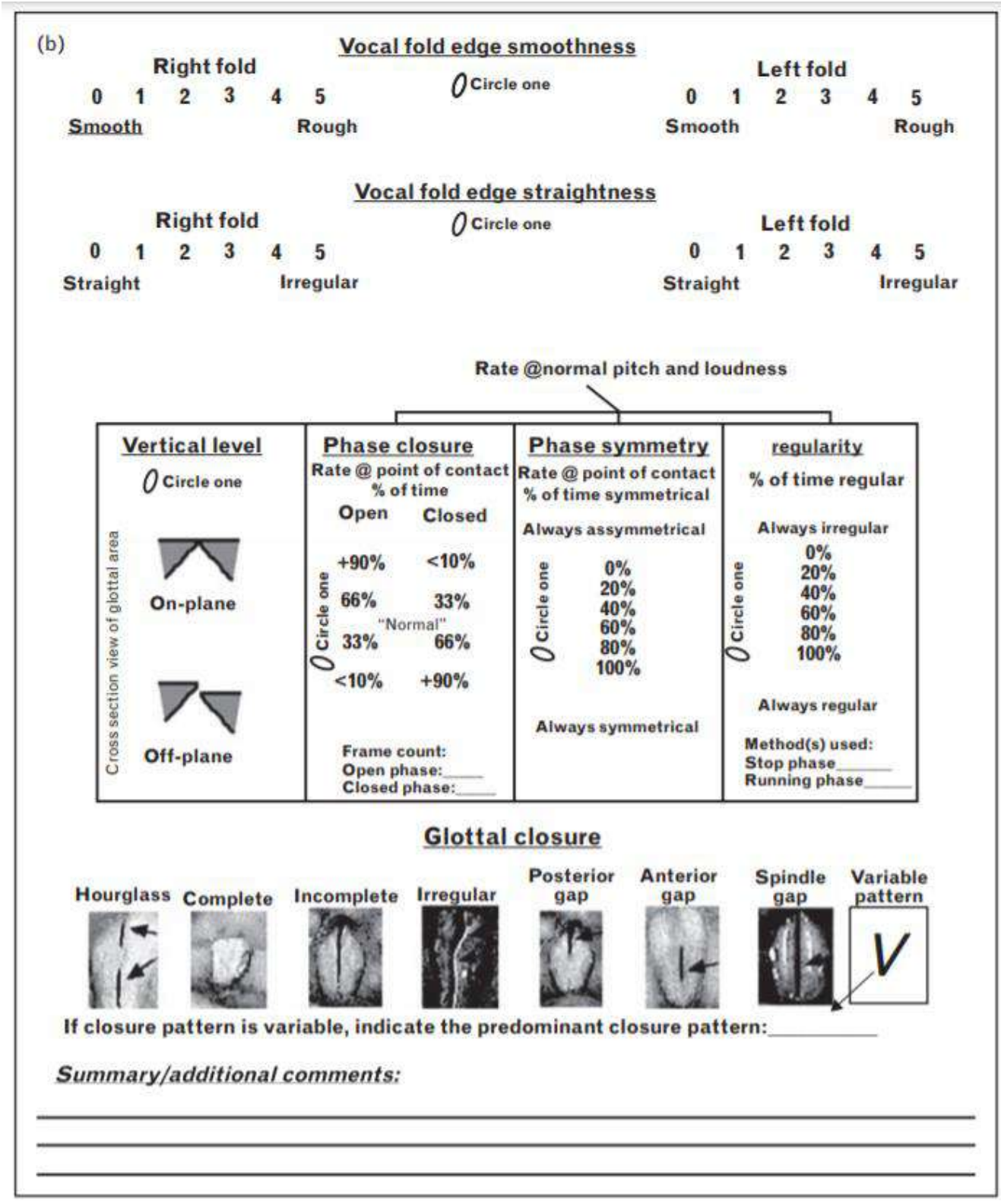


Figure 9: Stroboscopy evaluation rating form developed by Poburka

Source: Poburka BJ. A new stroboscopy rating form. J Voice Off J Voice Found. 1999 Sep;13(3):403–13

High-Definition Videostroboscopy: Recent advances of coupling stroboscopic systems with high-definition video camera sensors provide spatial resolution of the vocal fold structures involved in phonatory vibration. The system by KayPENTAX, for example, records interlaced video frames with spatial resolution of 1920 x 1080 pixels. This wide format resolution is in contrast to standard video resolution of 72 x 480 pixels. Thus the significant improvements in image quality associated with high definition are expected to enhance the clinical diagnostic capabilities(56)

COMBINED MEASURES

Combined measures provide a multidimensional measure of voice function, like Dysphonia Symptom Index, Hoarseness diagram and self-organizing maps for voice disorder classification.

Dysphonia Severity Index (DSI): was designed to establish an objective and quantitative correlation of the perceived vocal quality. This is based on the weighted combination of selected set of voice parameters such as highest frequency, lowest intensity, maximum phonation time and jitter.

DSI score =

{Maximum phonation time (s) x 0.13 + Highest frequency (FO) achievable (Hz) x 0.0053 - Lowest intensity (dB) x 0.26 - Jitter (%) x 1.18 }+ 1 2.6 (correction factor)

The DSI for perceptually normal voice is +5 and -5 for severely dysphonic. The more negative the patient's index, the worse is his vocal quality. It is useful to evaluate the therapeutic evolution of dysphonic patients(57)

Hoarseness diagram: classifies voices acoustically by their degree of breathiness or 'noise features' and roughness or 'aperiodicity features' as determined by the combination of weighted values of shimmer, jitter and the mean period correlation.(58)

Use of self-organizing maps (SOM) for voice disorder classification: It provides an objective means of assessing voice quality, on the basis of multiple acoustic measures. It allows an easy way to visualize and evaluate the classification of exemplars of the various groups. SOM uses six multidimensional measures which are taken from the Kay Elemetrics MDVP - Multidimensional Voice Program and cepstral analysis programmes. It proved useful in distinguishing normal female voices from those with dysphonia, pre- and post-treatment functional dysphonia voices by analysing one second of a sustained vowel.(59)

RISK FACTORS FOR DEVELOPING VOICE DISORDERS

Subjects with voice disorders are often found to have one or more of the following risk factors:

- Unhealthy vocal habits such as speaking loudly, shouting frequently, fast speaking rate, frequent throat clearing.

- Nicotine and/or alcohol consumption.
- Insufficient hydration.
- Gastroesophageal reflux - heartburn, acid regurgitation, allergies, neuropathies.
- Neck trauma.
- Post-surgical intervention - intubation, neck surgery(60)

A voice is considered disordered when it has one or more of the following characteristics:

• It is not clear, audible or stable in a wide range of acoustic settings.

• It is not appropriate for the age and gender of the speaker.

• It is not fulfilling its linguistic and paralinguistic functions.

• It is easily fatigable.

• Phonation is associated with discomfort and pain.

TYPES OF VOICE DISORDERS

Dysphonia:

Any impairment of the voice or difficulty in speaking, which is characterized by altered vocal quality, loudness, pitch or vocal effort that affects communication and/or quality of life is referred as dysphonia. It can affect patients of all ages and sex but has

an increased prevalence among teachers, older adults, and other persons with significant vocal demands.(61)

Dysarthria:

Dysarthria is a motor speech disorder in which there is difficulty in articulating words. It can be classified according to the underlying neuropathology and associated symptoms such as disturbances of respiration, laryngeal function, airflow direction, and articulation resulting in difficulties of speech quality. There are six major types of dysarthria such as flaccid dysarthria associated with lower motor neuron impairment, spastic dysarthria which is associated with damaged upper motor neurons linked to the motor areas of the cerebral cortex, ataxic dysarthria caused by cerebellar dysfunction, and hypokinetic dysarthria and hyperkinetic dysarthria, which are related to a dysfunction of the extrapyramidal system. The sixth one is termed as a mixed dysarthria and is associated with damage in more than one area, resulting in speech characteristics of two groups or more.(62)

Dysglossia: Speech disorders which arising from damage to the peripheral structures involved in speaking are called dysglossias. They can be due to congenital malformations, in particular craniofacial malformations accompanying various syndromes, by acquired dental defects and trauma, and by the defects and tissue alterations caused by surgical and radio-chemotherapeutic treatment in the head and neck region. Based on the localization of the damage dysglossias can be classified as labial, dental, lingual, palatal, velopharyngeal and nasal, with impairments of sound production at all places of articulation and with impairments of phonation.(63)

Hoarseness:

The term hoarseness is commonly used to describe any perceived change in voice but more specifically refers to a coarse, raspy, rough, or strangled vocal quality. It also includes any change in pitch, loudness, or vocal effort that impairs the vocal function. (64)

CAUSES OF VOICE DISORDERS

Functional dysphonia

A non-physiological increase in tone of the vocal cords on phonation, in speaking or breathing, in the absence of a specific anatomical cause is referred as functional dysphonia. Patients develop marked difficulties in speaking, with accompanying hoarseness. Women are more frequently affected than men. Stroboscopy shows oscillation of the vocal cords impaired or irregular due to abnormal muscle tone(65).

Secondary or organic manifestation of functional dysphonia

Vocal cord nodule: The vocal cord undergoes changes secondary to untreated hyperfunctional dysphonia forming vocal cord nodules. Juvenile form is called screamer's nodules and the adult form is called singer's nodules. Initially, there is reactive phonation hyperplasia of the medial margin of the vocal cord, at the junction of the anterior one third and posterior two third, the site of greatest stress on phonation. The tissue swells and edema arises. With time, the soft swellings undergo

fibrosis and turn into hard nodules preventing complete adduction of the vocal cords(61).

Acute laryngitis:

Acute laryngitis is the most common cause of hoarseness, accounting for 40% of cases and is mostly viral in origin. It occurs in upper respiratory tract infections and is self-limiting, subsiding after 1 to 2 weeks.(66).

Chronic laryngitis:

Chronic laryngitis has an incidence of 3.5 in one thousand and present as hoarseness, foreign body sensation in throat and constant urge to clear the throat. Common etiological factors for chronic laryngitis includes nicotine abuse, inhaled corticoid treatment, inhaled environmental noxae and Gastroesophageal reflux with laryngopharyngeal. Clinical signs of chronic laryngitis are dysphonia, sensations in the throat, and constant urge to clear the throat.(67)

Benign tumors:

Vocal cord polyps – Vocal cord polyps are unilateral tissue proliferations on the free margin of the vocal cord that hamper phonation. Men are more frequently affected than women. The factors promoting the formation of vocal cord polyps include smoking, chronic laryngitis and phonotrauma that is microvascular trauma caused as a result of misuse of the voice. (68)

Vocal cord cysts- They are also called retention cysts, which arise due to obstruction of excretory ducts of the mucous glands. These are usually unilocular and unilateral, but multilocular and bilateral multiple vocal cord cysts of various sizes are also seen. Small vocal cord cysts 1 to 2 mm in diameter are often difficult to distinguish from small polyps or nodules Their symptoms are hoarseness along with reduced volume and fatigue of the voice(69).

Malignant tumors:

Vocal cord malignancies – Around two thirds of laryngeal cancers are located in the vocal cords. Squamous epithelial carcinoma accounts for more than 90% of cases. In contrast to the strong association of HPV with tonsillar carcinoma, only a weak association has been demonstrated for laryngeal cancer. In microlaryngostroboscopy, the term phonatory standstill is used to describe, the state in which the fine vibration of the malignant tumor-infiltrated vocal cords are abolished. The earliest symptom is dysphonia. The swift occurrence of hoarseness leads to diagnosis of glottis cancer at an early stage in most cases. Thus the 5-year survival rate is practically 100% check percentage.(70)

Presbyphonia: Physiological hoarseness of old age is found in around 25% of those over 65 years of age, equally in men and women. Vocal cord musculature atrophy as a process of aging gives rise to a more oval shape of the vocal cord fissure during phonation. As mucus-producing cells of the vocal cord also atrophy with age, thus surface film increases in viscosity, negatively influencing the sound production. The main symptom is a weak, less intense voice produced at the cost of pronounced strain.

It must be distinguished from organic disorders of the vocal cords and from other illnesses(71).

Manifestation of internal diseases:

Laryngopharyngeal reflux: 9 to 26% of the population suffer from reflux-related mucosal irritation of the pharynx and larynx with chronic laryngitis. This is an important trigger factor for vocal cord dysfunction and laryngospasm. Patients usually present with hoarseness, chronic urge to cough, frequent throat clearing, sensation of lump in the throat, and swallowing difficulties(72). When compared to healthy subjects, LPR patients often reported abnormal subjective voice characteristics such as musculoskeletal tension, glottal fry, vocal forcing, forcing sensations, prolonged voice warm-up time, clamping, vocal fatigue and restricted tone placement(73).

Characteristic features of LPR seen on laryngoscopy includes posterior commissure hypertrophy (89 %), vocal fold edema (79 %), hyperemia (79 %), and diffuse laryngeal edema (76 %). Mechanism of LPR causing changes is debatable. Some studies suggest that vocal fold edema might be responsible for irregular vocal fold vibration leading to hoarseness. Other suspected mechanisms include dryness, thickening of the epithelium, keratosis, thickening of the epithelium, ulcerative lesions and alterations of the Reinke space(74).

Other illnesses in which patients present with voice disorders includes tuberculosis(75), amyloidosis, lymphoma, rheumatoid illnesses such as rheumatoid arthritis, Wegener disease, systemic lupus erythematous and laryngeal sarcoidosis(76).

Neurogenic causes:

Vocal cord paralysis: Vocal cord paralysis may be partial or complete, caused by damage to the recurrent laryngeal nerve. Dysphonia arises from the incomplete glottic closure or irregular vibration of the vocal cords. The most common cause of vocal cord paralyses is iatrogenic such as surgery or trauma in the region of the vagus nerve or the recurrent laryngeal nerve (77). Vocal cord paresis may also present as the first symptom of malignancy(78)

Spasmodic dysphonia: It is a kind of focal dystonias which mostly occurs in adulthood and predominantly in women. This severe dysphonia leads to involuntary spasms of the laryngeal muscles with increased adduction or abduction of the vocal cords, depending on subtype. The adductor type of spasmodic dysphonia, seen in 90% of cases, is characterized by the vocal cords pressing against each other during phonation. Patients present with creaky voice and intermittent voice breaks during speech. The remaining 10% of patients with abductor type dysphonia which leads to voiceless phases with breathy intonation.(79).

Vocal cord dysfunction: It is also called laryngeal asthma, which is intermittent, paradoxical movement of vocal folds causing closure of the larynx during inspiration, causing stridor. It occurs due to hyper reactivity of larynx on inspiration. A proposed trigger mechanism includes repeated exposure of the larynx to inhaled irritant stimuli such as perfumes or allergens and micro aspiration in the presence of laryngopharyngeal reflux. Patients experience life threatening bouts of respiratory distress as and often develop secondary anxiety and panic attacks. The episodic

dyspnoea with stridor is accompanied by other symptoms such as dysphonia or aphonia.(80)

Psychogenic dysphonia: It usually affects women between the ages of 20 and 40 years. These patients present with sudden extreme hoarseness or even acute aphonia. Laryngoscopy shows no inflammation, but there is limited adduction of the vocal cords during phonation.(81)

OCCUPATIONAL VOICE DISORDERS

In modern societies, almost one-third of the labour force works in occupations for which voice is a primary tool(82)Voice disorders have extreme financial repercussions as well as impact on social and professional identity. No voice equals no work for singers, stage performers, sports coaches, sales assistants, teachers, lecturers, lawyers, telephone operators, call centre workers, priests, receptionists and health professionals. Teachers are the most frequent visitors to the voice clinic, followed by university professors, radio broadcasters, telemarketers, fitness instructors and cycling instructors, tour guides, street vendors, scientists exposed to chemical irritants and sports coaches(83)

Voice users can be professional or occupational. **P*rofessional voice*** *users* as those who have a need for a skilful voice as distinct from the ***occupational voice-users*** ‘who need a lot of voice and often must use a loud voice’ such as teachers and sports

coaches. This is separate from *active* voice users who use their voice during a working day but without regularly raised intensity such as telemarketers and health workers, This proposed classification system is novel and provides criteria for delineating different vocal loads, work characteristics and phonatory needs.(84)

Among several classifications of professions on the basis of vocal demands, Koufman and Isaacson is the most used. It has four levels of voice users. The first level being elite vocal performers such as singers, actors, the second, professional voice users like clergy, lecturers, telephone operators, the third is non-vocal professionals like teachers, doctors, lawyers and the fourth, non-vocal non-professionals labourers and clerks.(85)

Sustained heavy vocal load in the workplace has been identified as the primary threat to employees' vocal health. But some studies have shown that for certain voice users, heavy vocal load can have a positive effect on immediate vocal function post loading and it may even help build voice strength and endurance (86) Other described risks for developing occupational voice disorders includes nonconductive speaking environments, background noise impact, workload, stress, anxiety, shyness, posture and reduced respiratory or cardiopulmonary function.(87)

VOCAL HYGIENE

Vocal hygiene, a patient-centered behavioral treatment is a therapeutic as well as preventive tool in which modification of vocal habits and the implementation of

principles facilitate improved vocal health. A comprehensive vocal hygiene program includes education regarding the vocal mechanism, identification and reduction of phonotraumatic behaviours and high risk vocal situations, conservation of voice or vocal rest, controlling the amount of talking, monitoring vocal pitch and intensity, local lubrication and systemic hydration, optimal dietary changes, controlling laryngopharyngeal or, gastroesophageal reflux and allergies, minimizing the influence of medications, lifestyle choices and environmental factors on voice. This can be used as a preventive tool to avoid voice problems(88)

Majority of vocal hygiene programs include four components:

- Addressing the amount and type of voice use such as extensive voice use, aberrant pitch in both speech and/or singing, and voice use while doing strenuous physical exercises.
- Decreasing phonotraumatic habits such as throat clearing, loud voice use, cheering and screaming, speaking over background noise, and practice of unconventional voice production.
- Enhanced lifestyle modifications leading to improved vocal health, including elimination of caffeinated beverages, tobacco, alcohol, recreational drugs, sleeping habits, diet, medical conditions, and medications(89).
- Vocal rest and adequate hydration have proven to improve voice quality in individuals(2).

Vocal rest:

Complete voice rest is currently limited to cases of acute laryngitis, laryngeal trauma, and following laryngeal surgery.(90)Some physicians do not prescribe any voice rest at all. On contrary, voice conservation and modified vocal rest is practiced more often. The rationale behind reducing voice use is to promote laryngeal health in individuals with laryngeal injuries, laryngeal pathology or vocal fatigue and prevent further damage(91)

Modified vocal rest programs aim to reduce the amount of voice use and loudness. It is often done as an introductory strategy of therapy, particularly to reduce size of lesions. A structured program of voice conservation called **Voice Use Reduction Program** was conceptualized as part of a comprehensive approach to the treatment of voice disorders. Subjects had improved vocal quality, reduced vocal fatigue, and improvement in vocal-fold appearance after a controlled period of reduced voice use. It provides guidelines for the classification of voice use situations, the assignment of voice use units to different situations, and the calculation of the maximum number of units per day and per week.(91)

Hydration:

Adequate hydration is required for voice production and to prevent voice fatigue.

Hydration can be either systemic like intracellular water, topical or surface hydration, which is the presence of water in the vocal fold mucosa, or environmental. Even

though the relative contribution of each type is not clear, studies suggest that combined systemic and environmental hydration may reduce phonation pressure threshold and vocal fatigue in normal individuals. In dysphonic patients with benign mass lesions, manipulation of environmental hydration can help to modify perceived phonatory effort, vocal fold appearance and short-time amplitude perturbation(92)

Vocal warm-up and cool-down programs

Warm up and cool down exercises are generally done by professional voice uses before and after a performance. Theoretically, a muscle warm-up routine prepares the body and mind for more strenuous or specific activities, improves muscle dynamics, provides optimum preparation for performance, and prevents injury. Warm-ups should be performed within 15 min of activity. Benefits of body warm-up includes increased speed of muscle contraction and relaxation, greater economy of movement due to lower viscosity resistance, higher muscle temperatures which in turn increases blood flow, facilitating oxygen utilization, nerve transmission and muscle metabolism(93)

Muscle cool-down or warm-down strategies are less commonly described in voice literature. Theoretically, cool-down routine aim to decrease body temperature and remove waste products from working muscles, as well as aid in muscle relaxation, to realign fibers and to re-establish normal range of movement.(94)

VOICE THERAPY

Voice therapy is designed to reduce the severity of a dysphonia and improve functional voice production. Voice therapy are typically a combination of both direct therapy including behavioural techniques focused on the different subsystems of voicing and indirect therapy with advice and guidance for managing external and personal factors contributing to a voice disorder(95).

Voice therapy is done in sessions, usually lasting 30 minutes to 1 hour, for once or twice weekly. The general objectives of this is balancing phonation, enhancing knowledge, and providing strategies for the participants to improve their health, production, and vocal behaviour. It focus on the faulty voice production mechanisms, the environmental aspects which may be contributing to the vocal problem such as dryness, pollution, noise, smoke, and the psychological aspects of the problem like the effects of stress and tension on voice production. The speech pathologist needs to assess and correct the mechanics of voice involves in domains such as posture, respiration, coordination of respiration and phonation, pitch, quality, loudness and resonance in phonation. Supra-segmental aspects of voice in speech, like intonation and prosody also needs to be addressed. (96)

MATERIAL AND METHODS

STUDY SETTING: This was a hospital-based study conducted in the Department of ENT, CMC vellore.

STUDY PERIOD: This was done from June 2019 to September 2021.

STUDY DESIGN: Prospective Cross-sectional observational study conducted to assess the prevalence of voice disorders in the study population was evaluated by voice analysis (and stroboscopy). And to compare the risk factors among those diagnosed with voice disorders to the ones without any voice disorder.

STUDY POPULATION: The study was conducted among Medical Record Officers (MROs) and Multifunctional Computer Terminal Technicians (MCTTs) working at counters, under medical records department in CMC, Vellore.

Inclusion criteria-

MROs and MCTTs working at counters

Exclusion criteria-

MROs and MCTTs under medical records department who are not working at counters, unwilling to participate in the study, and those in whom stroboscopy cannot be done.

INFORMED CONSENT: Informed consent was taken from all the participants who were recruited for the study. The consent form is attached as appendix.

ETHICS COMMITTEE APPROVAL: Once the study proposal was made it was put forward to the Institutional Research Board, after obtaining the approval of the ethics committee, the study was initiated.

METHODOLOGY: The principal investigator along with the guide conducted meetings in the medical records department to describe the study and its aims to the MROs and MCTTs to encourage to participation and alleviate fear if any. They were called in batches of five to ENT OPD where they were briefed about the study and their written consent was obtained to participate.

Detailed history was taken by the principal investigator. It included age, sex, history of voice disorder, its nature of onset, progression and duration, history of other diseases such as Recurrent respiratory infections, gastoesophagealreflux, vocal habits such as coughing or sneezing loudly, throat clearing screaming/shouting, speaking in whispering voice and other activities that involve voice exertion like singing, teaching, preaching were taken. Intake of coffee, spicy food, carbonated drink and water was considered. History of chewable tobacco usage, smoking, alcohol consumption noise level in the work area, working hours and shift, average number of patients, and use of microphone were also evaluated to determine the risk factors.

The ear, nose, oral cavity and oropharynx were examined carefully look for other pathology. All participants had their voice analysed by the speech therapist using following parameters.

1. **Phonation duration assessment-**The subjects were asked to say the sounds /a/ /i/ /u/ /s/ and /z/ in single breath and duration taken to say each sound was recorded (in seconds) and s/z ratio was calculated.The maximum phonation duration of sustained blowing(in seconds) was also assessed.

2. **Voice profile analysis-** A subjective analysis of the pitch, pitch variability, pitch breaks, dysphonia, pitch range, loudness, loudness variability, quality, tremors, voice breaks, hyper/ hypo functional, endurance was done.

3. **GRBAS scale**-A widely used auditory perceptual voice evaluation that measures grade, roughness, breathiness, asthenia and strain in voice. Each component is rated on an integrated four point scale in which 0 is normal and 3 is severe.

4. **Objective analysis:** Software named PRAAT was used to analyse the properties of the participants' voice i.e. the fundamental frequency, frequency range, jitter, intensity, dynamic range, shimmer and harmonics to noise ratio.

5. **Resonation, articulation and prosody:** The characteristics of resonance-normal/abnormal, presence articulatory errors, tone, intonation and stress were assessed.

6. **Voice Disorder Outcome Profile (VDOP):** An outcome profile was filled by the each subject. It enabled them to self-evaluate the severity of the voice problem in physical, emotional and functional domain. The proforma was provided both in English and Tamil (given in appendix).

Following which, stroboscopy was done for consenting participants, by doctor (one of the two co-investigators) from ENT-5, Laryngology unit. Careful visualization of mucosal wave was done, the amplitude, symmetry, periodicity, vertical plane, phase, closure, and supraglottic activity, were documented.

For sample size calculation, we referenced the study done by Lucka et al, the prevalence of voice disorder in was found to be 53.1% among Physicians, 37.8% among Speech and language therapists and 50% among Nurses respectively. With precision at 10% and a desired confidence interval at 95% sample size of the study calculated to be 90 to 96 individuals. The following formula was used for the calculation.(2)

$$n = \frac{Z^2_{1-\alpha/2}\, p(1-p)}{d^2}$$

Where,

p : Expected proportion

d : Absolute precision

1- α/2 : Desired Confidence level

However, due to COVID pandemic, the number of subjects enrolled for the study was limited to 74. The observations made from the study were recorded in the master chart and statistical analyses were done. Categorical data was expressed as frequency percentage. The association of voice disorder and risk factors were analyzed using Chi-square statistics.

RESULTS

The study was done among a total number of 74 individuals, out of which 27 were MROs and 47 were MCTTs working at the counter. The results were analyzed inthe following sub groups.

- Demographic profile
- Clinical profile
  - History and examination
  - Voice analysis
  - Self-evaluation
  - Stroboscopic analysis
- Comparison of risk factors

DEMOGRAPHIC PROFILE

The age group of the study population ranged between 25 and 55 years. We further divided them in to 25-35, 36-45,46-55 years sub groups. The majority (41%, n=30) of the study population belonged to 46-55 year age group.

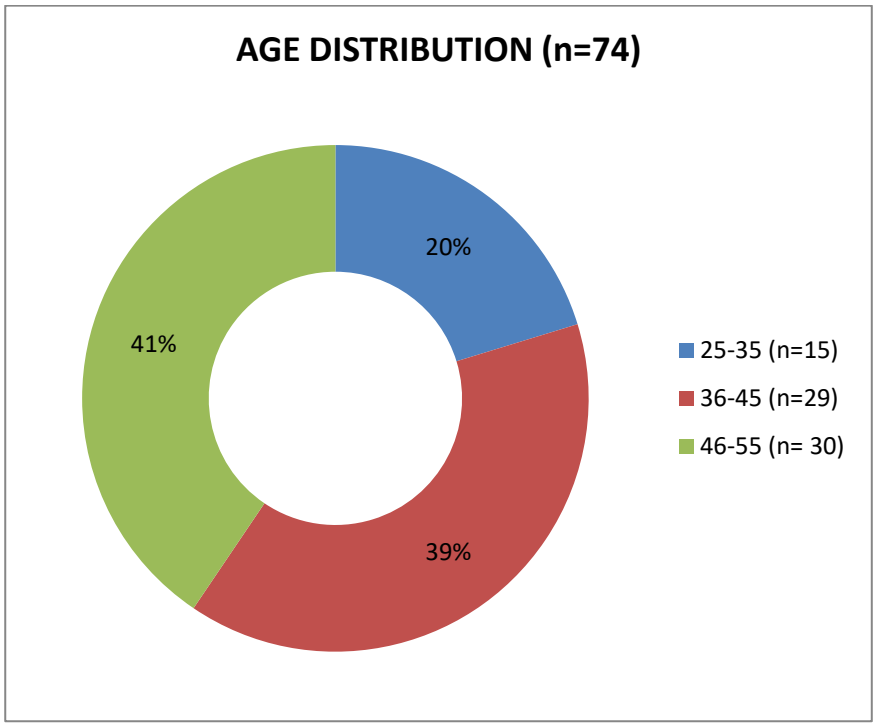


Figure 10: Age distribution of the study population

The study population comprised of 73% males and 27% females

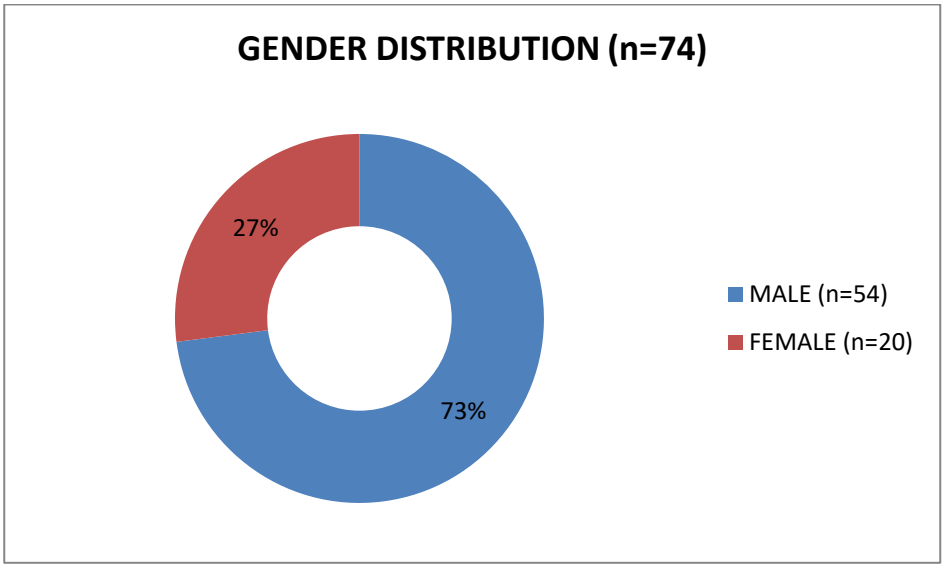


Figure 11: Gender distribution of the study population

The study was done among the staff working at the counters, which comprised of 36% (n-27) of medical record officers and 64%(n=47) of multifunctional computer terminal technicians).

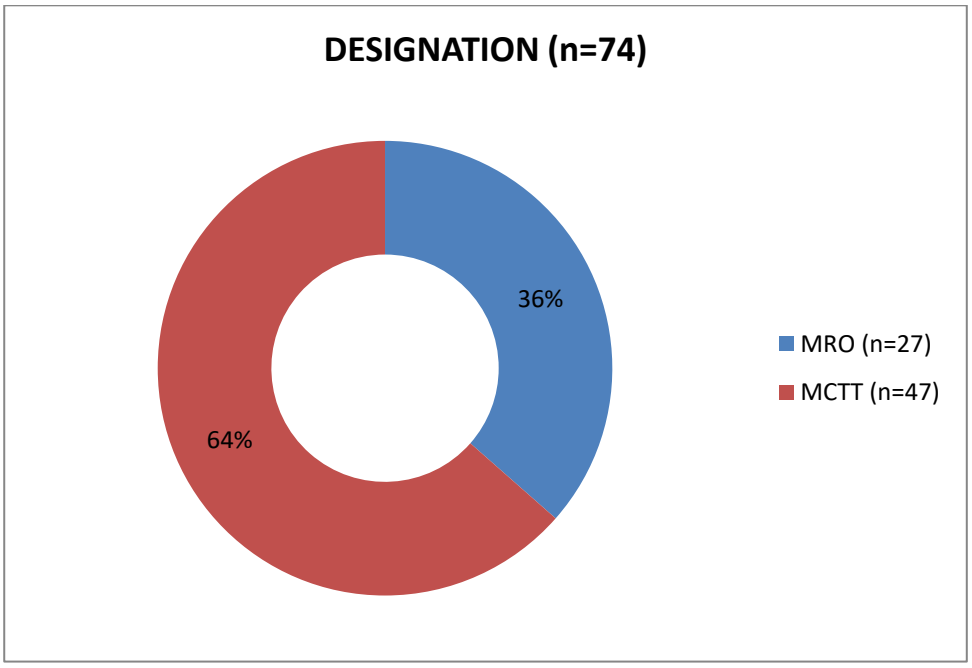


Figure 12: Designation of the study population

HISTORY AND EXAMINATION

Out of the 74 individuals who participated in the study only 5 (6.75%) of them complained of any voice disorder.

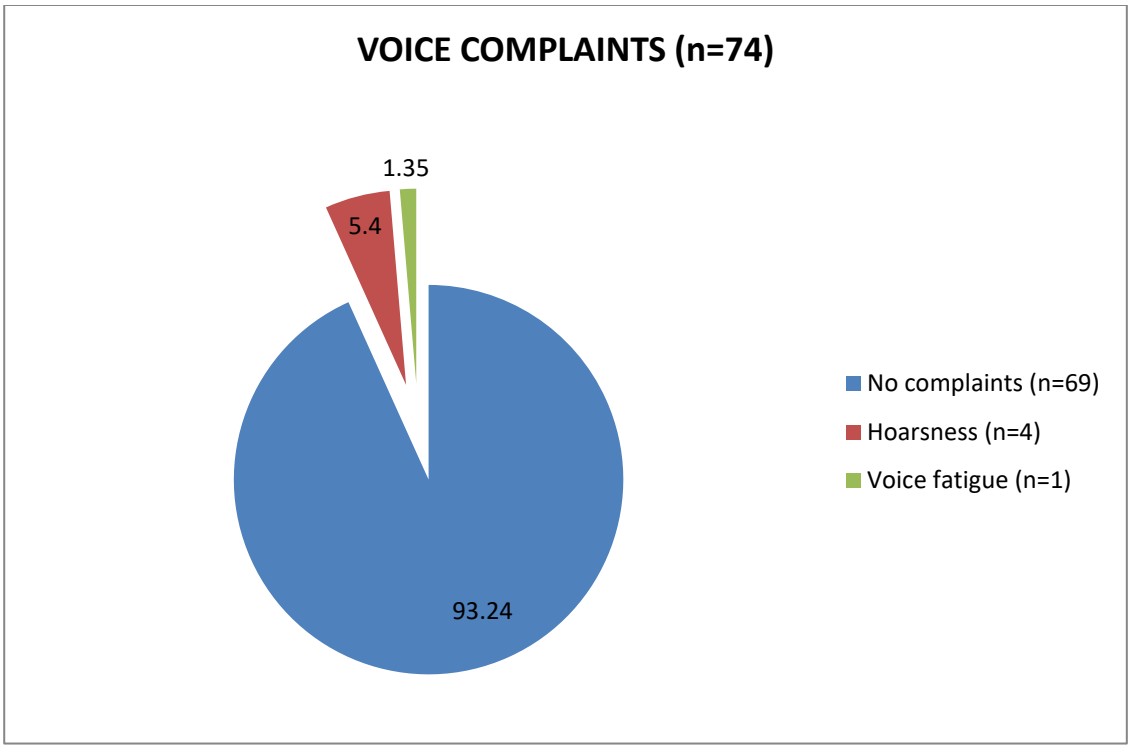


Figure 13: Distribution of voice complaints

Pre-existing medical conditions of this study population were also looked at. Majority 79.7% (n=59) of them did not have any comorbidities. Four (5.4%) were hypertensive, seven (9.5%) diabetic, one (1.4%) with thyroid disorder four (5.4%) with miscellaneous conditions.

COMORBIDITY	NUMBER	PERCENTAGE
NIL	59	79.7
HYPERTENSION	4	5.4
DIABETES MELLITUS	7	9.5
THROID DISORDERS	1	1.4
Others	3	4.1
TOTAL(n)	74	100

Table 1: Comorbidities among the study population

We found that 10.8 % (n=8) had history of recurrent respiratory infections and 21.6% (n=16) had gastroesophageal reflux disorder.

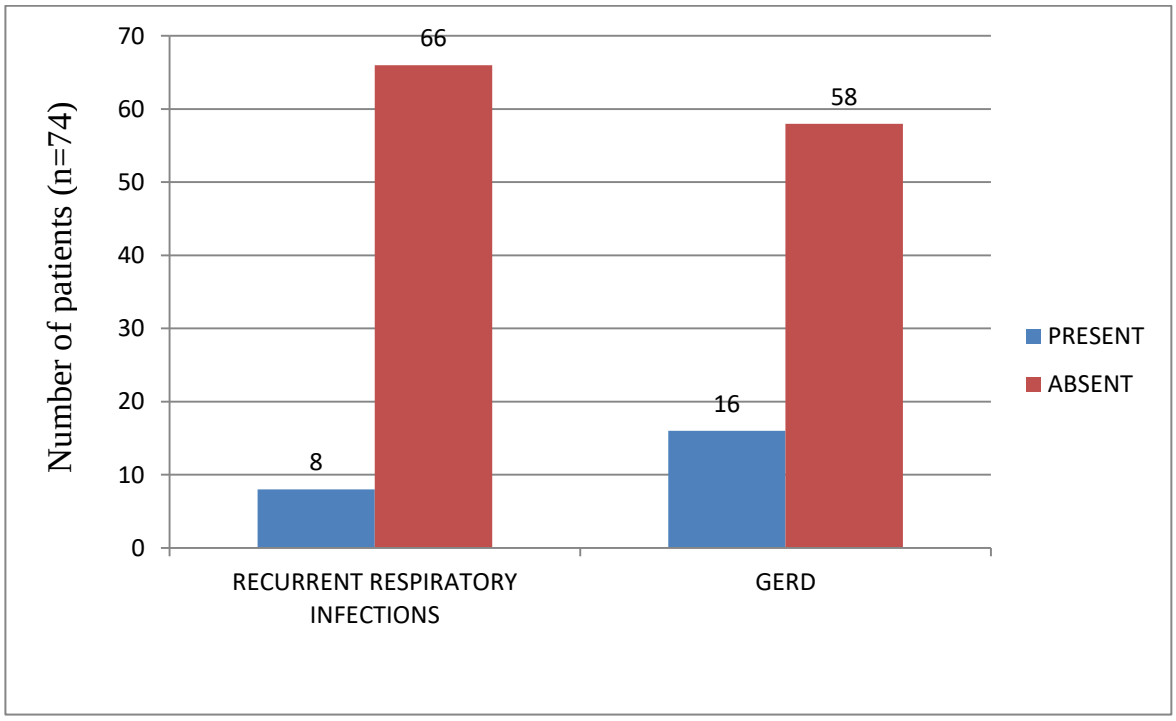


Figure 14: History of recurrent respiratory infections and GERD in the study population

While studying the vocal hygiene and habits of the study population, we found that 85.1% (n=63) of the population complained of speaking continuously (without breaks for at least 4 hours a day). From the study group, 48.6% (n=36) felt they would scream or shout in excess.

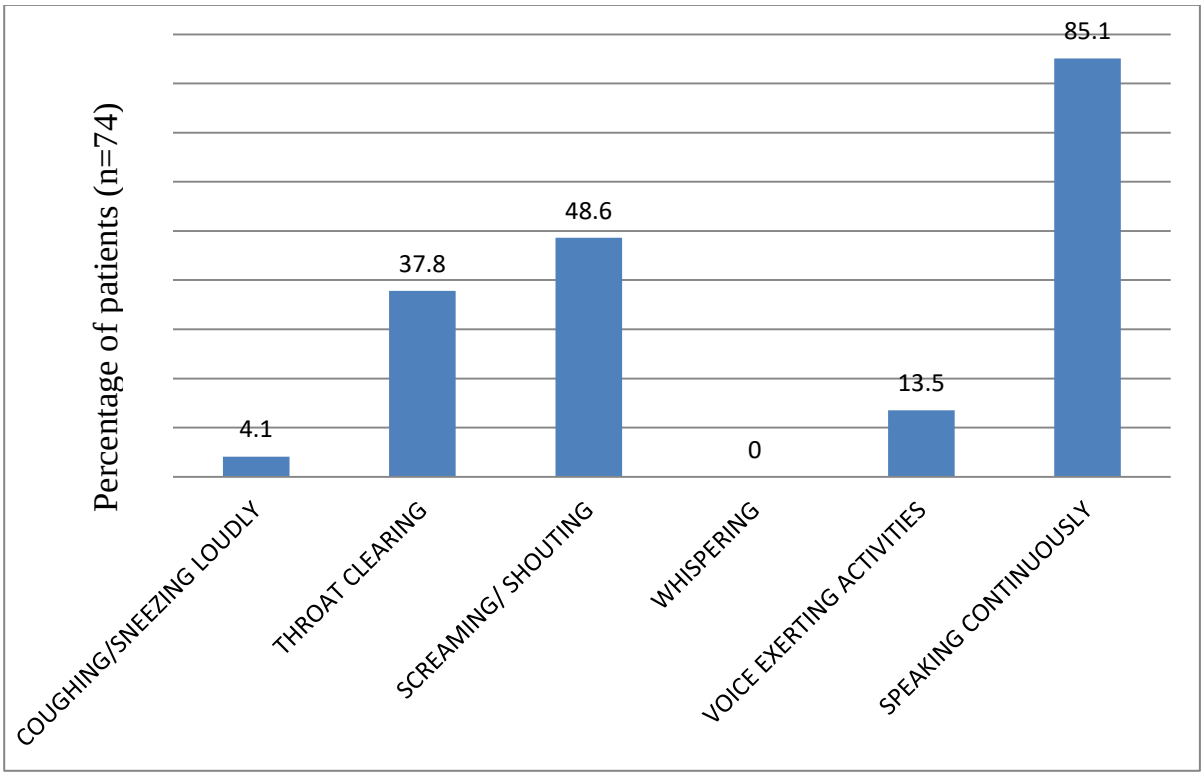


Figure 15: Vocal habits among the study population

The personal habits which could cause voice problems were also analysed. 39.18% of the population consumed coffee more than 2 times a day, 33.8% of them drank less than 3 liters of water per day, 20% of them agreed to consuming spicy food everyday and 6.8% drank at least one carbonated drink a day.

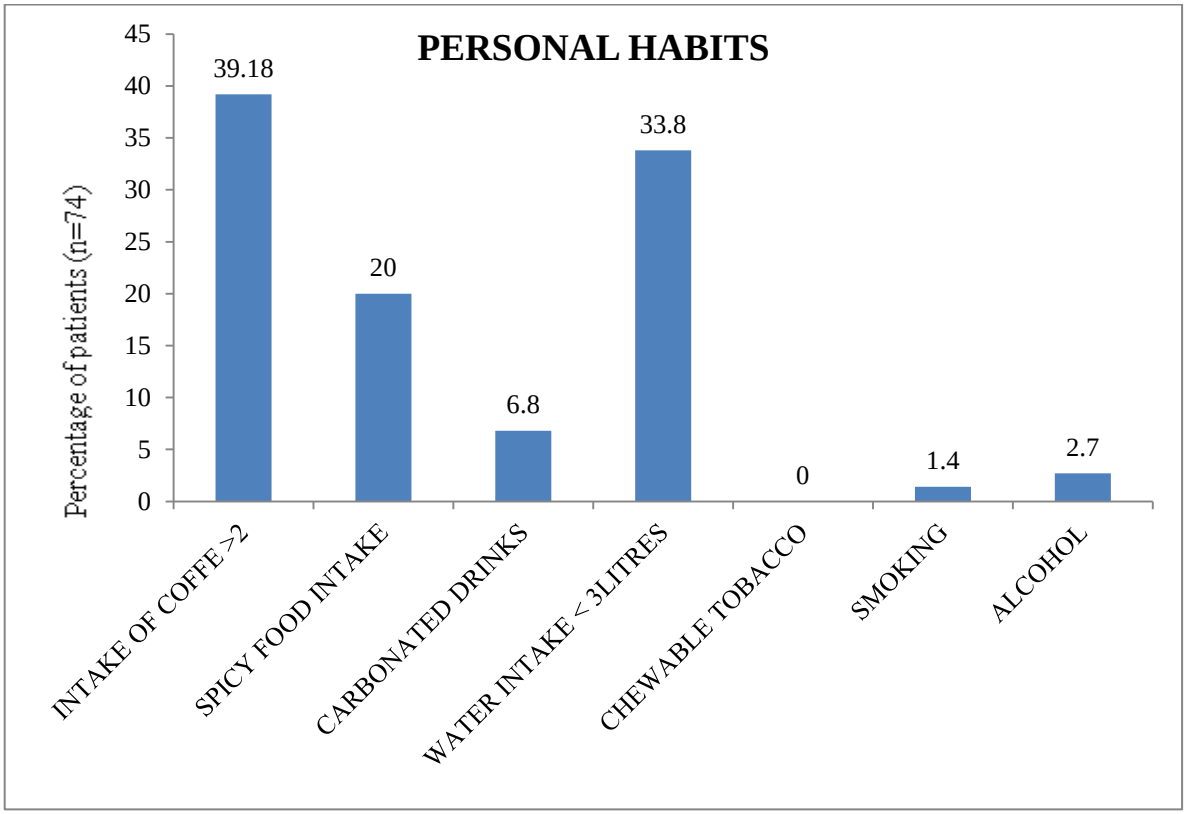


Figure 16: Personal habits among the study population

The work factors influencing voice were studied. All the subjects worked in the morning shift, which lasts 8-9 hours. Of the study population, 83%(n=62) of them did not have a microphone at the counter they were working.

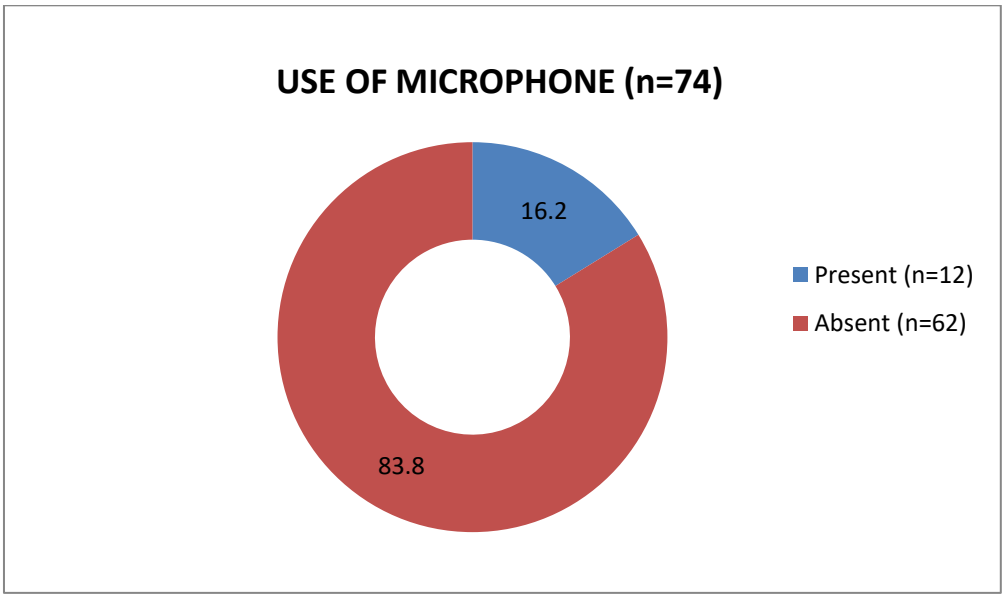


Figure 17: Percentage of study population using microphone

All subjects underwent detailed ear, nose and throat examination, and 8.1% of of them had features of allergic rhinitis, 8.8% deviated nasal septum, 2.7% , inferior turbinate hypertrophy and 9.5% had granular posterior pharyngeal wall.

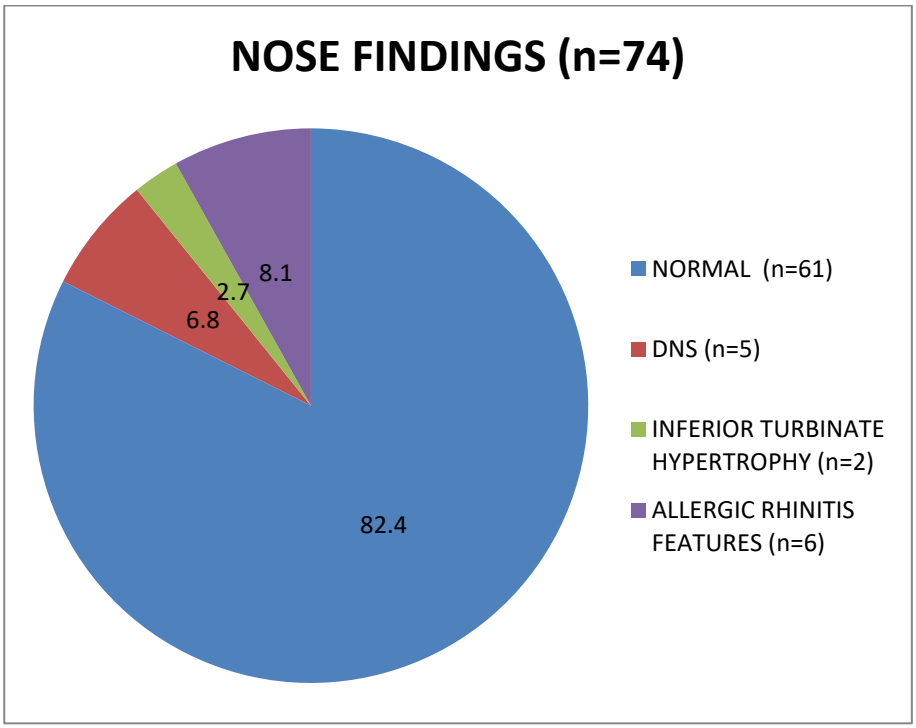


Figure 18: Pecerntage of nose findings

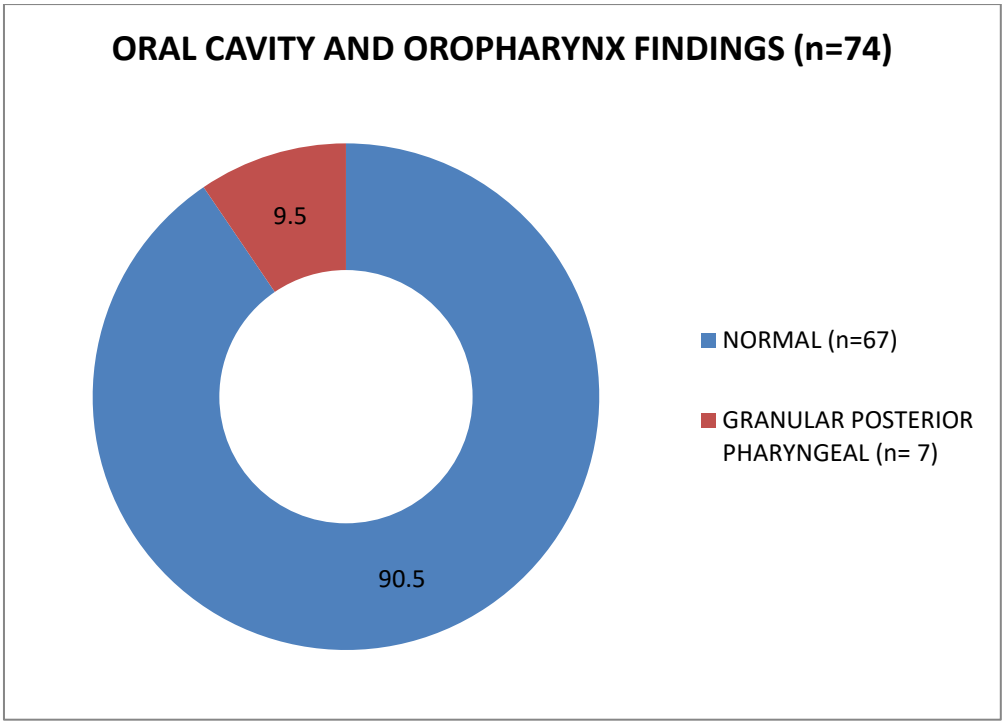


Figure 19: Percentage of oral cavity and oropharynx findings

VOICE ANALYSIS

Percentage of the study population with voice disorder was calculated based on both subjective and objective paramter assessment outcomes. Subjective analysis included Quality of voice, GRBAS scale, VDOP and stroboscopy. The objctive analysis included s/z ratio and measure of fundemntal frequency, shimmer, jitter and harmonics to noise ratio calculated by PRAAT software. This table shows the percentage of the population in which the subjective and objective analysis were out of normal limits.

TYPE OF ANALYSIS	PERCENTAGE OF VOICE DISORDER IN THE POPULATION
SUBJECTIVE ANALYISIS	
QUALITY OF VOICE	43%
GRBAS SCALE	47%
VDOP	81%
STROBOSCOPIC ANALYSIS	96%
OBJECTIVE ANALYSIS	
s/z RATIO	58.11
FUNDEMENTAL FREQUENCY	Males: 48.16%, Females 50%
JITTER	68.93
SHIMMER	56.75%
HARMONICS TO NOISE RATIO	68.92

Table 2: Percentage of voice disorder in the study population based on subjective and objctive analysis

COMPARISON OF RISK FACTORS

The p value of each risk factor in comparison to different type of voice analysis was calculated. The significant ones with p value less than 0.05 are circled in this table.

RISK FACTOR	QUALITY	GRABAS	VDOP	STROBOSCOPY
COUGHING AND SNEEZING LOUDLY	0.273	1	1	1
FREQUENT THROAT CLEARING	0.006	0.011	0.014	>0.05
SCREAMING OR SHOUTING	0.008	0.178	0.005	>0.05
VOICE EXERTING ACTIVITIES	0.706	1	0.54	>0.05
COFFEE INTAKE MORE THAN 2	0.163	0.122	0.271	>0.05
SPICY FOOD INTAKE	0.406	0.126	0.266	0.423
CARBONATED DRINK CONSUMPTION	0.299	1	1	0.391
WATER INTAKE LESS THAN 3L	0.157	0.019	0.884	0.4
ALCOHOL INTAKE	1	0.43	0.552	-
SMOKING	1	1	-	-
MICROPHONE USAGE	0.212	1	0.881	0.253

Table 3: Comparison of risk factors based on P value

The voice analysis was done among the 74 subjects. Each person was asked to say the sounds /a/ /i/ /u/ /s/ and /z/ in single breath and duration taken to say each sound was recorded. s/z ratio was calculated. 31 out of 74 (41.89%) of the study population had ratio of one, which was considered normal.

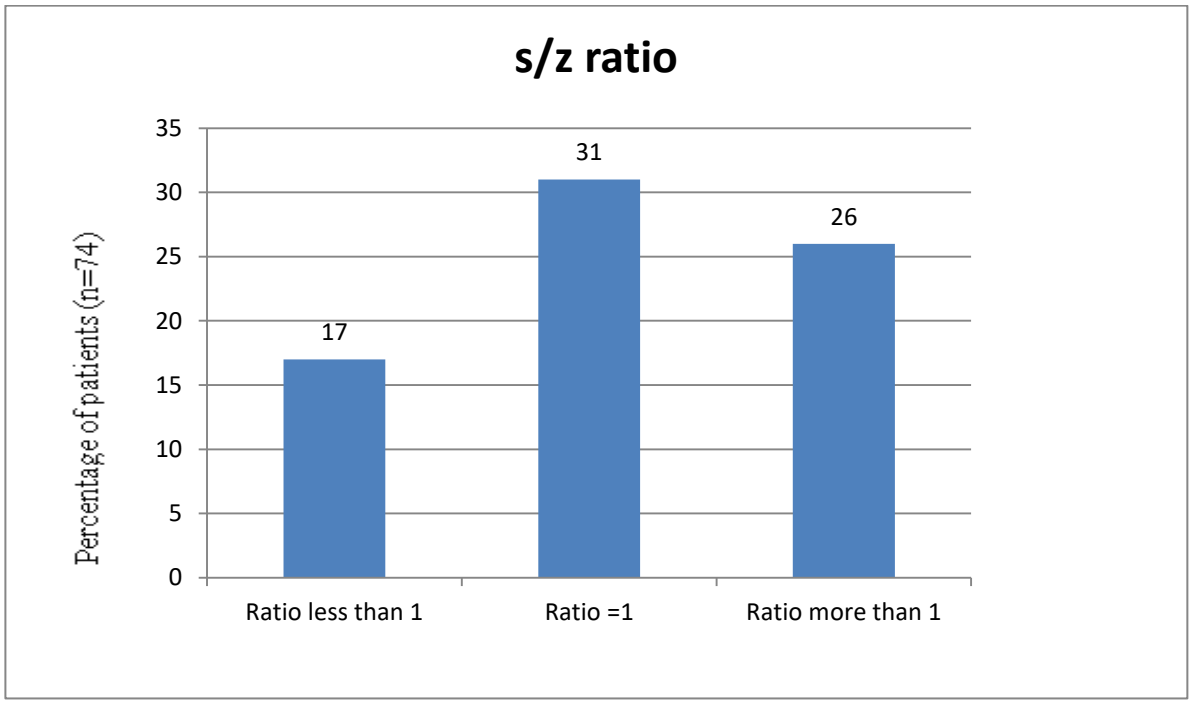


Figure 20: Distribution of s/z ratio

The maximum phonation duration of sustained blowing was calculated.51 out of 54 (94.4 %) men had a value less than 24 seconds, which is inadequate. 11 out of 17 (64.7%) female subjects had a value less than 15 seconds which is considered inadequate.

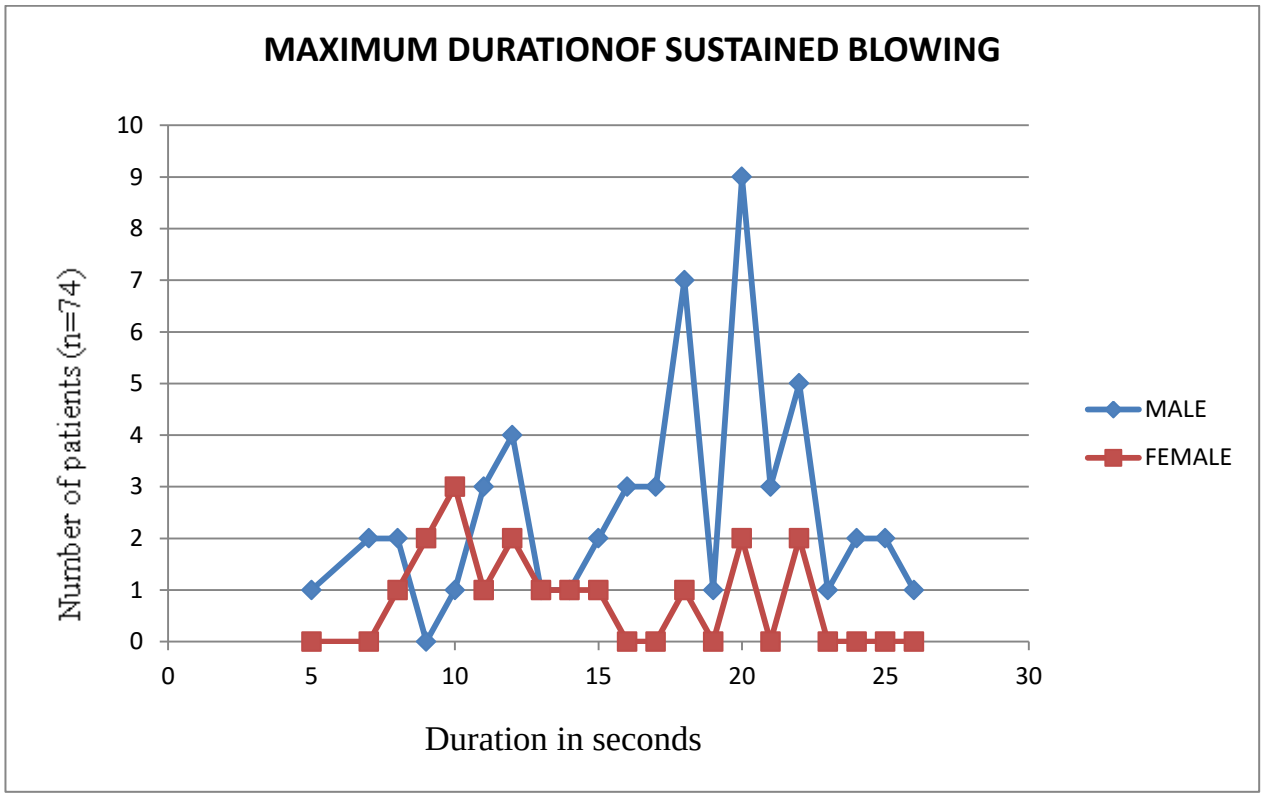


Figure 21: Maximum phonation duration of sustained blowing among the study population

The majority of the population had normal pitch, pitch range, loudness and loudness range. The quality of voice was normal for 57% of the population and the pedominant abnormality was found to be roughness of voice followed by hoarseness.

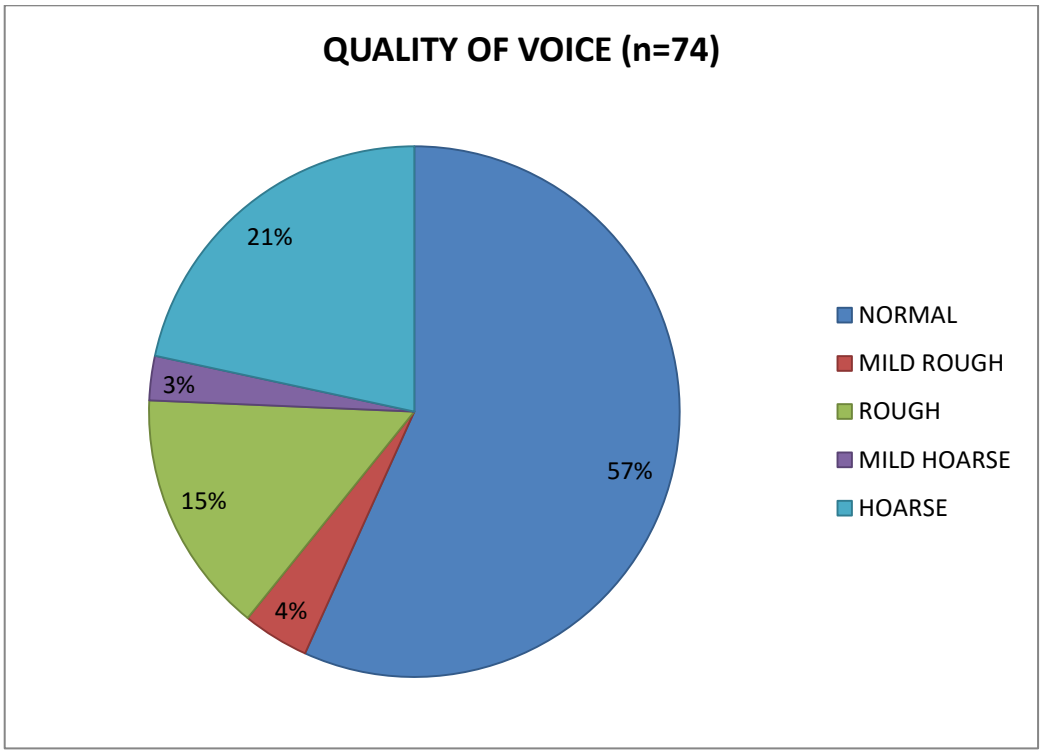


Figure 22: Quality of voice among the study population

GRBAS scale was done for each subject to evaluate grade, roughness, breathiness, asthenia and strain in their voice. The overall grade was found to be 0 (normal) for 53%, 1 for 42%, followed grade 2 for 4% and grade 3 for 1%.

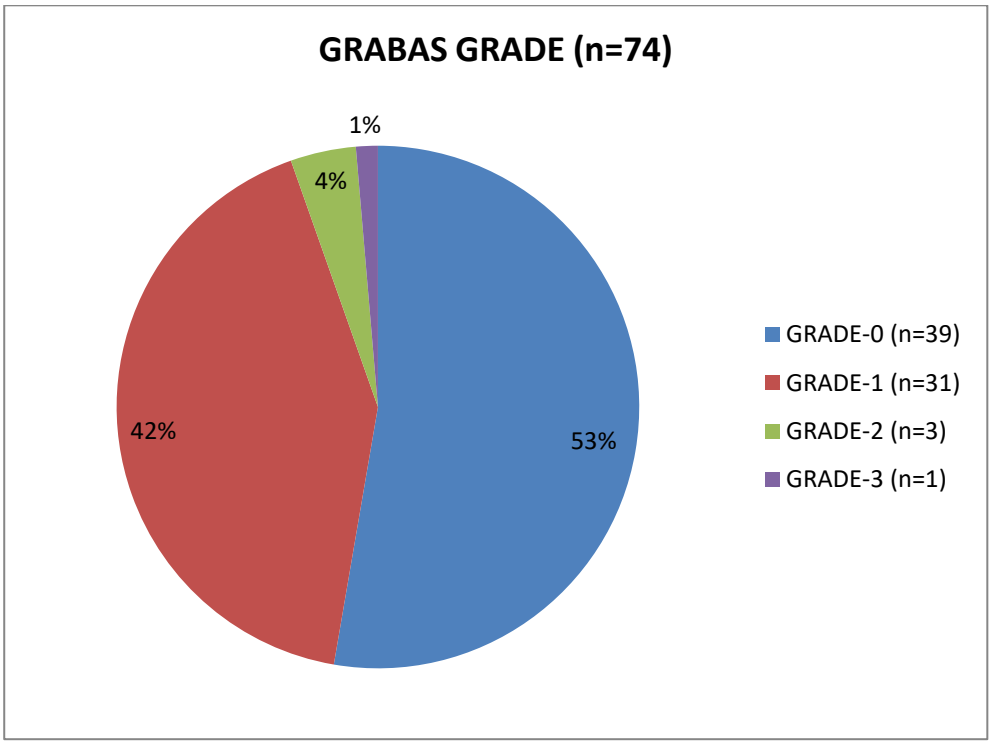


Figure 23: GRBAS grade among the study population

On digital analysis of the voices of the study subjects, 31.07% had jitter less than 0.31 which was considered normal and 31.08% of them had jitter in the range of 0.3 to 0.4.

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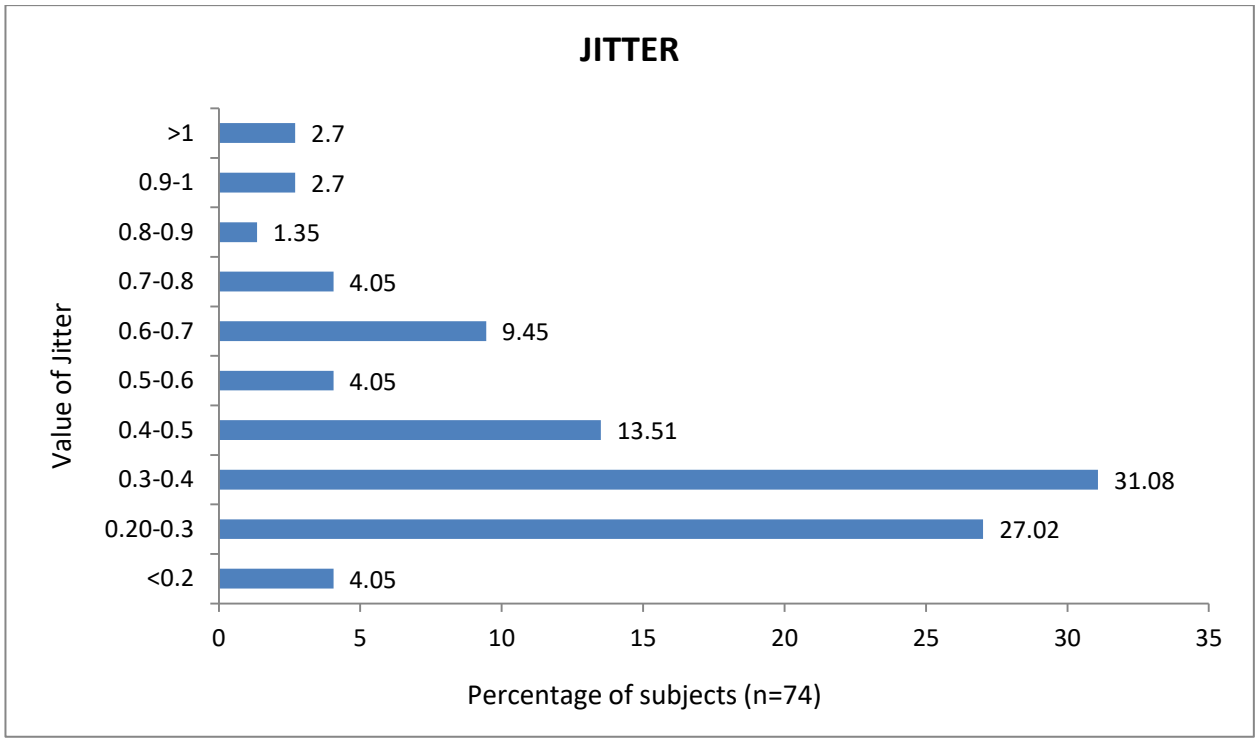

Figure 24: Value of jitter among the study population

Shimmer in normal voice ranges from 1.18 to 2.37, 43.243% of the population were in this range, 5405% had less than 1.18 and 27.02% had shimmer ranging from 2.38 to 3.3

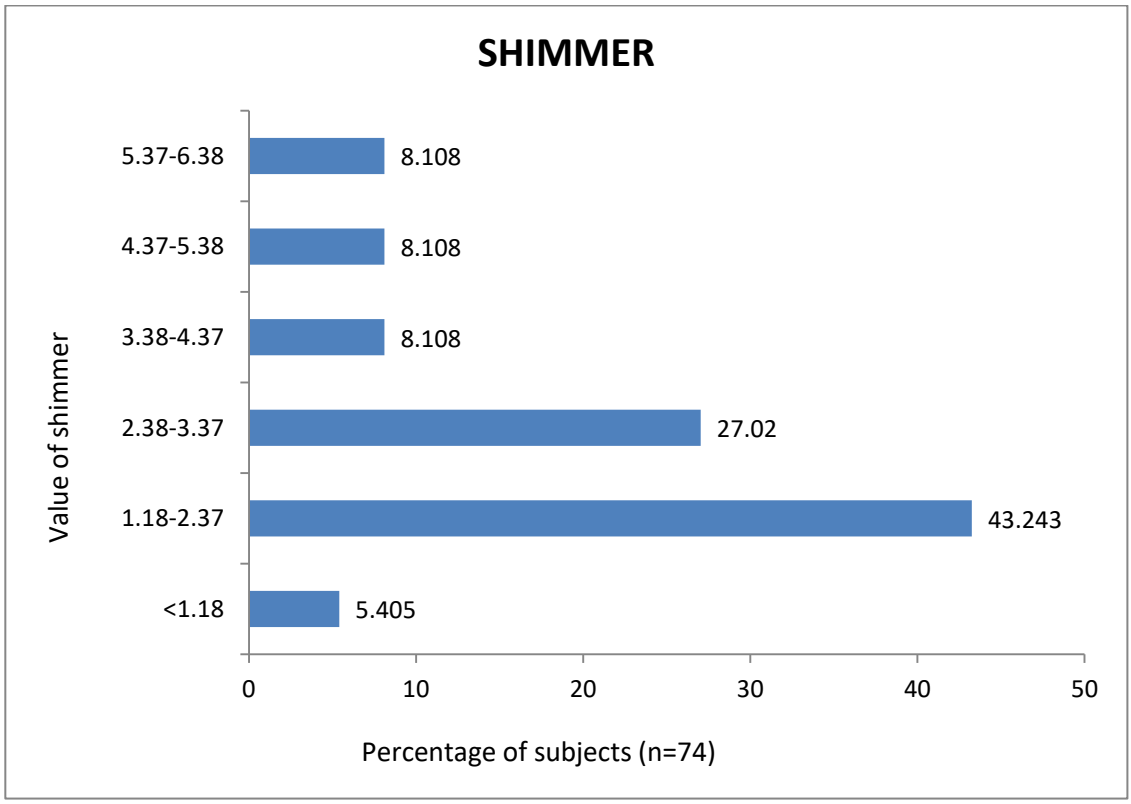

Figure 25: Value of shimmer among the study population

The normal harmonics to noise ratio ranges from 21.9 to 26.8, 31.08% of this study population fell within it. Whereas 56.75% had values less than 21.7 which are considered abnormal.

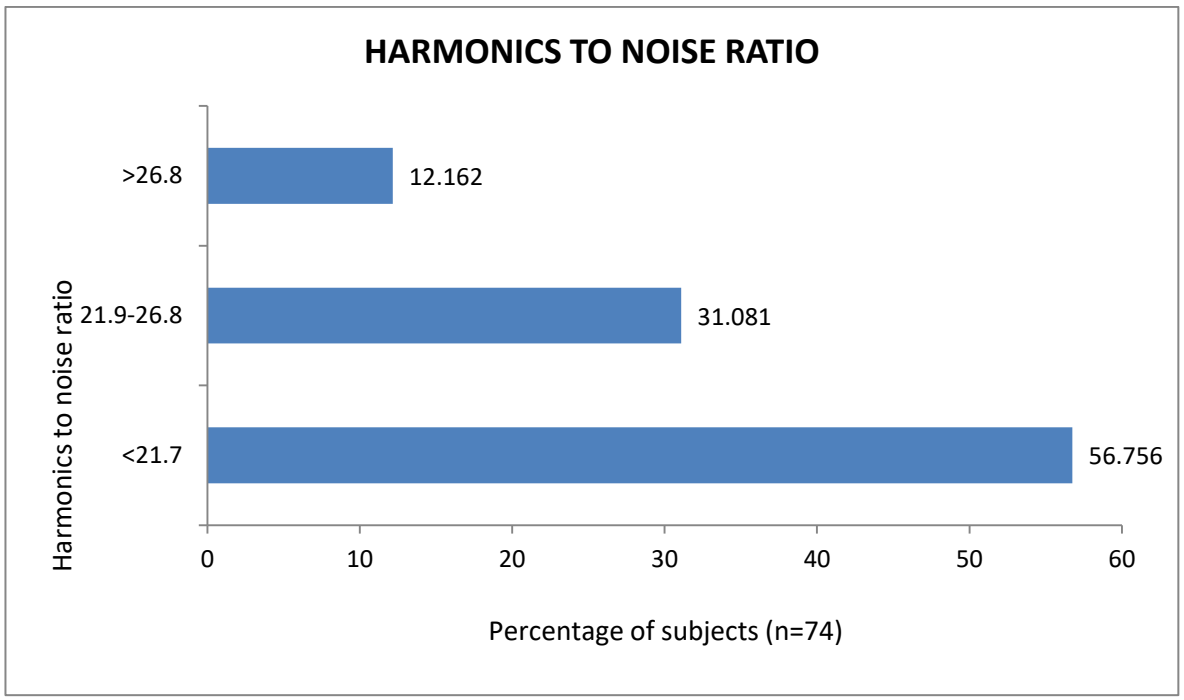

Figure 26: Harmonics to noise ratio among the study population

The normal average fundamental frequency is 125Hz for males and 200Hz for females. In the study population most of the men (51.85%) had fundamental frequency in the range 101 to 125 hz, followed by 35% in the range of 126 to 150Hz. 50% of the females had fundamental frequency in the range 176 to 200Hz followed by 25% in the range 201 to 225Hz.

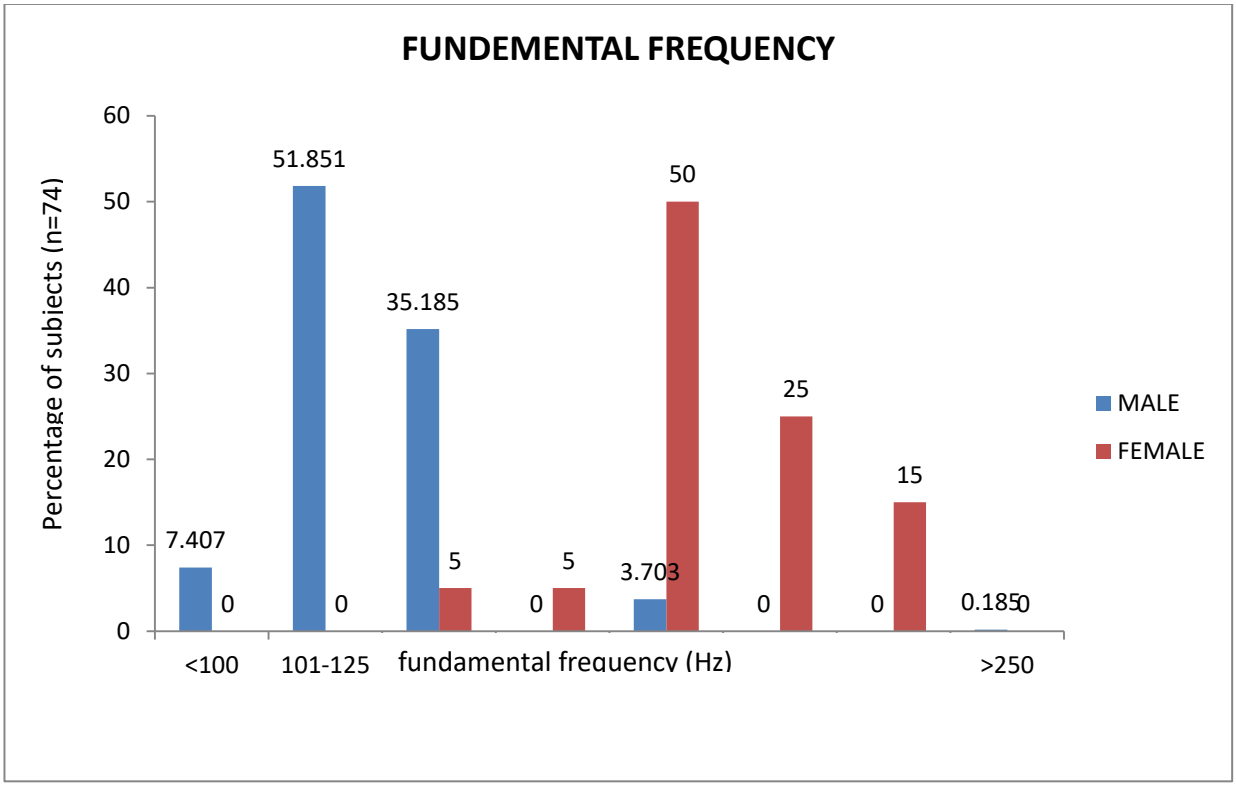

Figure 27: Fundemental frequency among the study population

SELF EVALUATION

According to voice disorder outcome profile, which assesses voice related problems faced by the subjects in physical, emotional and social domain,19 out of 74(25.67%) scored 0 which was normal. 55(74.32%) had faced some voice related problem in some domain.

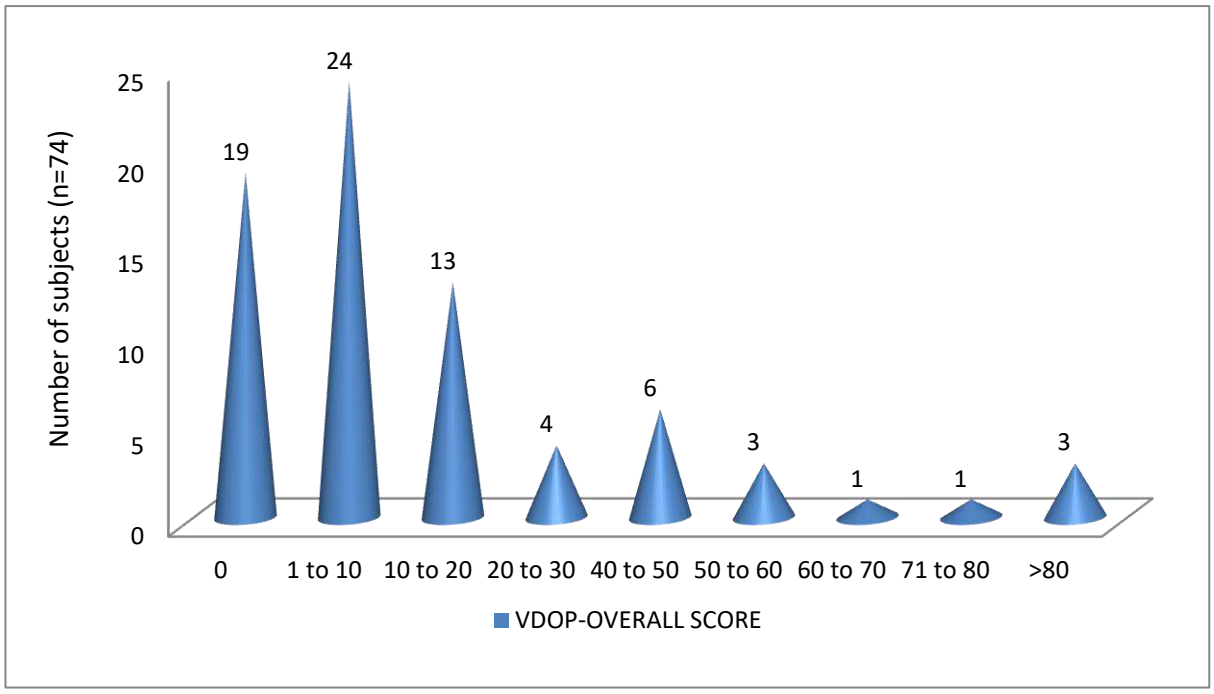

Figure 28: VDOP overall score among the study population

STROBOSCPIC FINDINGS

26 out of 74 individuals recruited for the study consented for stroboscopic evaluation. Only 4% (n=1) of them had normal findings. Majority (36%, n=9) of them, had features suggestive of laryngopharyngeal reflux, followed by 16% (n=4) vocal cord scarring, 12% (n=3) vocal cord irregularity, 12% (n=3) vocal cord nodules and 12% (n=3) with features of muscle tension dysphonia.

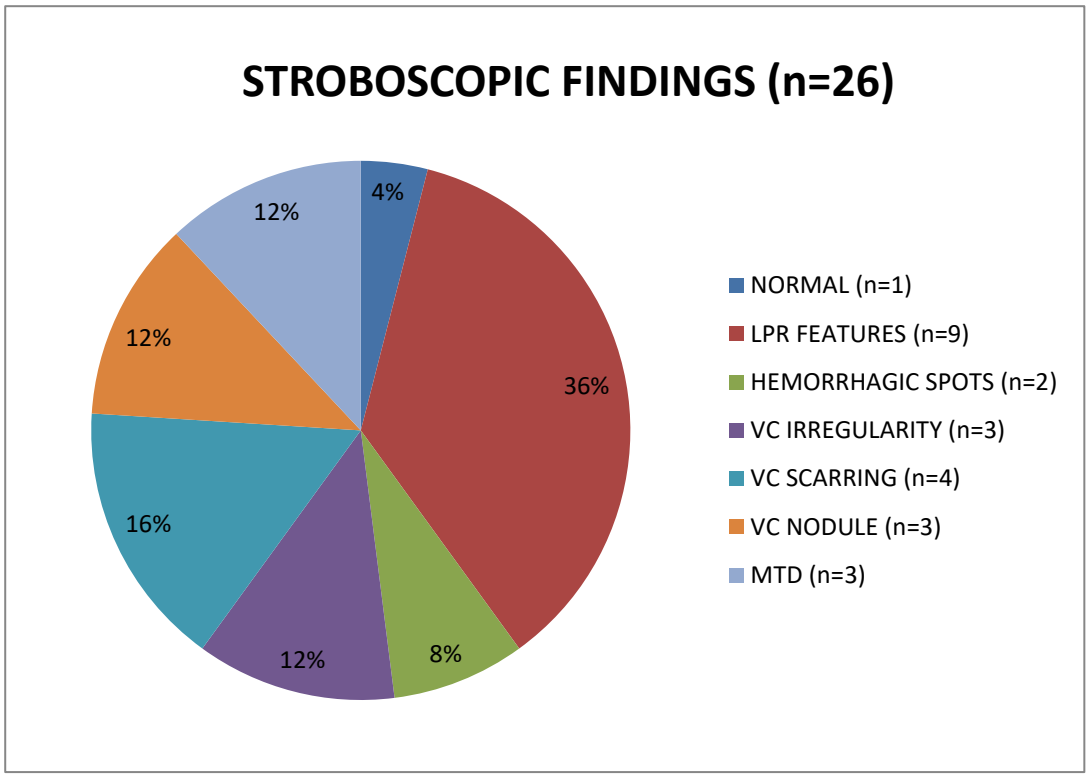

Figure 29: Stroboscopic findings among the study population

MANAGEMENT

Based on the voice analysis, self-evaluation and the stroboscopic findings the study subjects were advised appropriate management. 33.78% (n=25) of the study population did not require any intervention. The rest were managed conservatively, 43.24% of them were advised voice therapy, anti-reflux measures and oral PPIs combined.

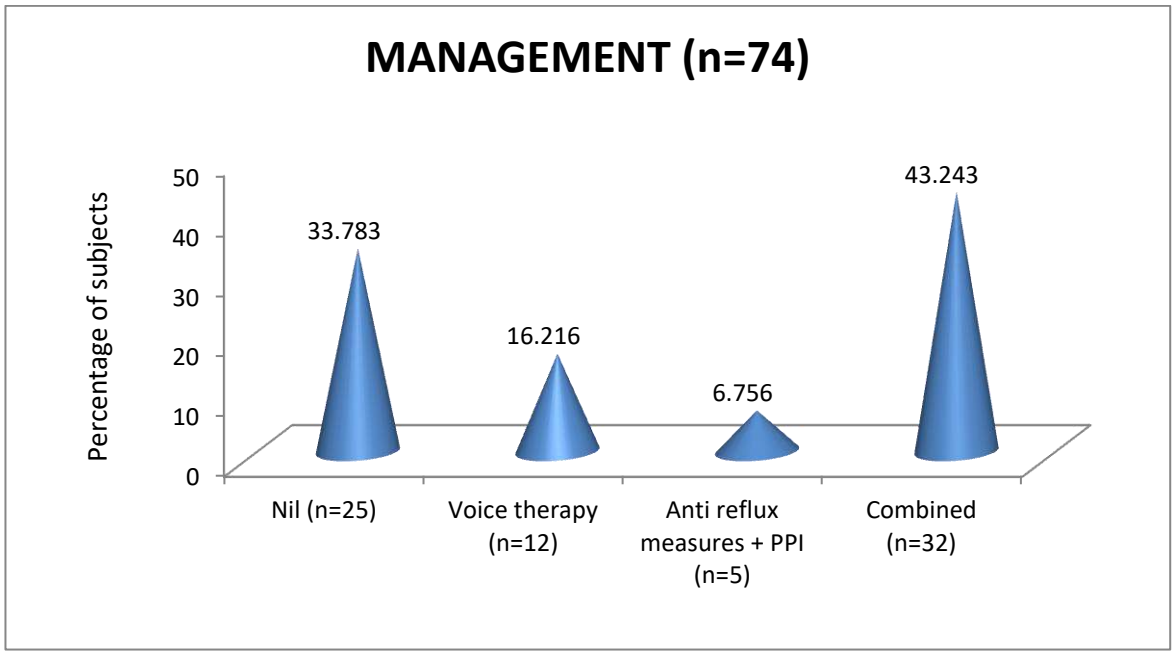

Figure 30: Management advised for the study population

DISCUSSION

Voice plays a crucial role in the modern society where about one third of the labour force have occupations which use voice as a primary tool.(82) Anyone whose ability to earn a living is impacted negatively by a loss of vocal quality and endurance should be considered a professional voice user. It includes singers, clergy, teachers, receptionists, sales personnel, physicians etc.(97)

This study assessed the prevalence of voice disorders in hospital support staff and its various risk factors associated with it. There were no studies in the similar population available in the literature, however, there were studies among teachers(98),(99), and a meta-analysis of six studies on physicians, nurses, speech therapists, priests and salespersons by Boltežar et al(2). Most of the studies done to check the prevalence of voice disorder in a particular population used a single modality such as subjective analysis by the examiner or by self-evaluation questionnaire(100)(101). Whereas our study was comprised of history, clinical examination, voice analysis, self-evaluation questionnaire, phoniatric examination and stroboscopy. The study done by Sliwinska-Kowalska et al among teachers to find the prevalence and risk factor of voice disorders found to have similar components(102).

Demographic profile

This study was done among 74 hospital support staff, 73% (n=54) male and 27% (n=20) females. The minimum age in our study was 28 whereas; the maximum was 55, giving an average age of 42.58.

Of the study population, 79.7% (n=59) did not have any comorbidity, 5.4% (n=4) had hypertension, 9.5% (n=7) had diabetes mellitus, and 1.4% (n=1) had thyroid disorders.

Prevalence of voice disorder

The participants underwent both subjective and objective voice evaluation. Subjective analysis included quality of voice, GRBAS scale, voice disorder outcome profile and stroboscopic analysis. The objective analysis had s/z ratio and assessment of fundamental frequency, jitter, shimmer and harmonic to noise ratio using PRAAT software. Subjective analysis is considered a better modality for voice evaluation since voice is essentially a perceptual phenomenon in response to an acoustic stimulus (103)(104).

We had the quality of the voice perceptually analysed by the speech therapist and categorised into normal, mild rough, rough, mild hoarse and hoarse. It was further graded using GRBAS scale, which is a standardised auditory perceptual tool for voice analysis(105). An overall grade of zero was considered normal and the rest as abnormal(106). The prevalence of voice disorder in the study population was 43% (n=32) according to quality of voice and 47% (n=34) based on GRBAS scale. In a similar study by Sliwinska-Kowalska et al, on the prevalence and risk factors for occupational voice disorders in teachers, it showed that 69% had voice disorders. In our study it was comparatively less. This is probably because of the fact that teachers need to project their voices and speak continuously for hours. Whereas the hospital counter staff use their voice to address people at a closer range (within 2 feet) and though they speak for long periods it is with frequent breaks(4).

In our study self-perceptual analysis was done using VDOP questionnaire which consists of 3 domains such as physical, emotional and functional. Physical domains focused on the effect of voice change in on their ability to speak continuously and loudly, emotional domain addressed the impact of voice change on their mental health and functional domain dealt with the effect of voice change on job, social and daily communications. A score of zero in each domain is considered normal (50). Even though only 6.75% (n=5) of the participants complained of voice disorders, when asked leading questions to assess difficulty they face in physical, emotional and social domains while using their voice, 74.34%(n=55) said to have some sort of discomfort. 32.43% (n=24) scored 1 to 10 which could be considered as minimal discomfort, such as frequent throat clearing and getting asked to repeat what they said. The findings were similar to the study of voice characteristics of elderly college teachers by Boominathan P et al, in which the Voice Disorder Outcome Profile, scores showed certain physical changes with less or no obvious functional limitation.(107)

Out of 74 subjects recruited for the study, only 26 volunteered to have stroboscopy done, the reason being some did not see the need for it, some were apprehensive to have an aerosol generating procedure to be done during COVID pandemic and some did not want an invasive procedure done. The most common findings (36%, n=9) were that of laryngopharyngeal reflux findings such as pseudosulcus, ventricular obliteration, hyperemia, vocal fold edema, diffuse laryngeal edema, posterior commissure hypertrophy, granulation tissue or thick endolaryngeal mucus, 16% (n=4) of them had vocal cord scarring, 12% (n=3) had vocal cord irregularity, 12% (n=3) had nodules and 12% (n=3) showed features suggestive of muscle tension dysphonia

such as lateral compression of the larynx , anteroposterior compression of the larynx, supraglottic closure of larynx and vestibular fold contribution to voice production(108). In our study the prevalence of abnormal stroboscopic findings were high compared to that of the studies done among teachers(109)(110).

The normal average fundamental frequency of voice is 125Hz for males and 200Hz for females(107)(111)(112). In the study population the fundemental frquency was found to be abnormal for 48% (n=36) male and 50% (n=37) of females. 38.8% (n=29) of males and 40% (n=30) females showed raised fundamental frequency. The average fundemental frequency was 125.12 Hz for men and 197.51 Hz women in our study. The results were comparable with study done on teachers by Portela t al, which showed raised fundemental frequencies.(112)

The maximum phonation duration for sustained blowing and the s/z ratio are considered a very reliable tool to assess glottic efficiency(113). A maximum phonation duration of 24 seconds in males and 15 seconds in females are considered normal(114)(115)(116). In this study, duration of maximum phonation sustained blowing was inadequate for 94% (n=70) of the men and 64.7% (n=48). The mean maximum phonation duration in the study population was 16.3s for males and 11.5s for females, which was comparable to similar studies available(114)(107).

A s/z ratio of 1 is considered as normal and dysphonic patients show either high or low s/z ratio(117)(118). 58.11% (n=43) of our study population was found to have abnormal s/z ratio.

A jitter of 0.20-0.3, shimmer of 1.18-2.37and harmonics to noice ratio of 21.9-26.8 is considered normal(119)(120). In our study, jitter of 68.9% (n=51) , shimmer of 56.75 (n=42) and the harmonics to noise ratio of 68.9% (n=51) of the subjects were found to be raised. According to Alexander et al, acousting analyisis of teachers in the post teaching cirumstances showed similar raise in the value of shimmer, jitter and HNR(121).

Comparison of risk factors

Once the prevalance of voice disorder in the study population was established, the risk factors for the same was evaluated. The habit of coughing and sneezing loudly (4.1%, n=3) was compared with voice change. Our study did not show any statistical significance between the two parameters (p value of voice quality = 0.273, GRBAS=1, VDOP=1). However, the available literature, mentions coughing or sneezing loudly to be commonly seen in teachers with voice disorders(122)Habitual frequent throat clearing was compared with prevalence of voice disorder. The results were suggestive of strong statistical correlation, based on the p value of voice quality (0.006); GRBAS scale (0.011) and VDOP (0.014).

The role of screaming or shouting in causing voice disorder was considered. There was statistically significant correlation between the two according to the p value of voice quality (0.008) and VDOP (0.005). This was in agreement with similar studies available(123).

History of voice exerting activities, such as singing, preaching and teaching were given by 13.5 % (n=10) of the study population. However we could not establish any

statistical significant correlation between voice exerting activities and quality of voice (p=0.706), GRBAS (p=1) and VDOP (p=0.54). The personal habits such as food and beverage intake were evaluated. Intake of 3-4 cups of coffee is considered to be safe(124). Consumption of more than 2 coffees per day (39.18%, n=29), spicy food (20%, n=15), carbonated drinks (6.8%, n=5), tobacco (1.3, n=1) and alcohol (2.7%, n=3) were compared with the incidence of voice disorders, which did not show any significant co-relation. Similar results were found in study done by Roy en et al(125).

The recommended daily water intake is 2-3 litrers per day(126). A study called the effect of hydration on voice quality in adults: a systematic review, By Alves et al explains the role of dehydration in causing voice changes(127). The percentage of participants consuming less than 3 litres of water per day was 33.8% (n=25), which showed a statistically significant correlation with an abnormal GRBAS score (p=0.019). This is in accordance with the study on Voice Disorders in Occupations with Vocal Load in Slovenia by Boltežar et al(2). The role of working in shifts, working hours and patient load in causing voice disorders could not be assessed since the entire study population worked in 8-9 hour shifts in the morning with an average patient load of 306 per day.

Management of voice disorders

Based on the subjective and objective analysis, 33.78% (n=25) of the study population did not require any intervention. 6.75% (n=5) were advised antireflux measures and proton pump inhibitors, 16.21% (n=12) were advised voice therapy, and 43.24% (n=32) were advised voice therapy, antireflux measures with PPI combined.

CONCLUSIONS

From this study we concluded that there is a high prevalence rate of voice disorders among hospital support staff.

- According to the quality of voice 43%, GRBAS scale 47% and VDOP 74% of the MROs and MCTTs were affected.
- 96% of the 26 who underwent stroboscopic showed pathological changes. Out of these, 15.38 % did not perceive any voice problems.

The significant risk factors for voice disorders isolated from the study were frequent clearing of throat, screaming or shouting and inadequate water intake.

Though only 6.75% perceived difficulties with the voice, a significant percentage (62.2%) of the study population were unaware of underlying voice pathologies and required intervention in the form of voice therapy, antireflux measures with PPI or both combined.

The study highlights the importance of increasing the awareness about voice disorders among hospital support staff, encouraging them to practice vocal hygiene. It also brings out the need for a regular voice clinic check-up for hospital counter staff.

LIMITATIONS

- Inability to call MROs and MCTTs to OPD due to the restriction on numbers people visiting OPD during Covid-19 pandemic.
- Skewing of data due to decreased work load and less voice exertion in the study population during the pandemic.
- Inability to do Stroboscopy which is an aerosol generating procedure, during Covid-19 pandemic.
- Unwillingness of the study population, majority of which who consider themselves to have normal voice, to undergo voice analysis and stroboscopy.

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ANNEXURES

PROFORMA FOR DATA COLLECTION

Study Number:	Name:	Age :	Sex:
Hospital number:	Designation:	Department:	Phone number:

BRIEF COMPLAINTS-

Nature of onset and progression

Duration

MEDICAL HISTORY

Condition	Duration	Severity
Recurrent respiratory infections		
GERD		
Others		

VOCAL HABITS

HABIT	FREQUENCY	
Coughing or sneezing loudly	Frequent	Occassionally
Throat clearing	Frequent	Occassionally
Screaming/shouting	Frequent	Occassionally
Speaking in whispering voice	Frequent	Occassionally

Other activities that involve voice exertion- singing, teaching, preaching	Frequent	Occassionally
Speaking continously	Frequent	Occassionally

NON VOCAL HABITS

	QUANTITY
Intake of coffee	
Spicy food intake	
Carbonated drink consumption	
Water intake	
Chewable tobacco usage	
Smoking	
Alcohol consumption	

WORK RELATED FACTORS

Noise level in the work area	
Working hours and shift	
Average number of patients at peak hours	
Use of Microphone	Yes / No

MAXIMUM PHONATION DURATION

/a/	/i/	/u/
/s/	/z/	s/z ratio:

Impression:

Maximum phonation duration of sustained blowing (seconds) :

Respiratory support for phonation (adequate/inadequate):

Respiratory support for speech (adequate/inadequate) :

VOICE PROFILE

Pitch	
Pitch variability	
Pitch breaks	
Diplophonia	
Pitch range	
Loudness	
Loudness variability	
Quality	
Tremors	
Voice breaks	
Endurance	
Hyper/hypofunctional	

GRBAS SCALE

(0- normal, 1- mild, 2- moderate, 3 severe)

Grade:	Roughness:	Breathinesss:	Asthenia:	Strain:

SELF PERPECTIAL RATING (VDOP)

Overall severity	
Physical	
Emotional	
Functionl	
Total score	

OBJECTIVE ANALYSIS

Fundemental frequency	
Frequency range	
Jitter	
Intensity	
Shimmer	
Harmonics to noise ratio	

RESONATION & ARTICULATION

Resonance	Normal/ Abnormal
Articulatory errors	Present/ Absent

PROSODY:

Tone	Normal/ Hypo/ Hyper/ Mixed
Intonation	Normal/ Mono/ Reduced/ Inappropiate
Stress	Normal/ Inappropriate

Stroboscopic findings:

Closure pattern	
Movement	Symmetric/ Asymmetric
Periodicity	Periodic/Aperiodic
Mucosal Wave	
Amplitude	

Diagnosis:

Recommendations:

INFORMATION SHEET

<u>TITLE OF THE STUDY</u> – The Prevalence and Risk Factors of Developing Voice Disorders in Medical Record Officers andMCTTs working at counters in CMC, Vellore

You are being requested to participate in a study to see if you have any voice disorder. MROs and MCTTs working at the counters are prone to voice exertion and thus have a high chance of developing voice disorders. Hence, we are conducting a study where we will be assessing if you have any voice disorders.

If you take part, what will you have to do?

If you agree to participate in this study, you will undergo voice analysis andstroboscopy(procedure to view voice producing cords inside the throat which will take 2-3 minutes). The voice analysis includes general examination by the examiner, voice profile analysis with a software, and a questionnaire which needs to be filled by you.

Will you have to pay for these tests?

No

What will happen after the study is over?

Once the study is over, if we find any significant changes in your voice or voice box, your doctor will advise you voice hygiene and vocal exercises and discuss the various options available for treatment and advice regarding the same.

Are there any risks associated with this study?

There are no risks associated with this study.

Will your personal details be kept confidential?

YES.

If you have any doubts, kindly call- Dr.ChristnaJacob 9988716446

INFORMED CONSENT FORM TO PARTICIPATE IN A RESEARCH STUDY

Study Title:The Prevalence and Risk Factors of Developing Voice Disorders in Medical Record Officers andMCTTs working at counters in CMC, Vellore

Study Number: 12413

Subject's Initials: _____

Subject's Name: _____

Date of Birth / Age _____

(i)I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions. [ ]

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. [ ]

(iii) I understand that the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published. [ ]

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s). [ ]

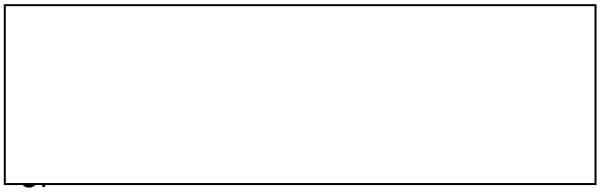
(v) I agree to take part in the above study. [ ]

Date: _____/_____/_____

Signature of the Subject:

Signatory's Name: _____

(or Thumb impression)



Representative: _____

Date: _____/_____/_____

Signatory's Name: _____

Signature of the Investigator: _____

Date: _____/_____/_____

Study Investigator's Name: _____

Signature or thumb impression of the Witness: _____

Date: _____/_____/_____

Name & Address of the Witness: _____

VOICE DISORDER OUTCOME PROFILE

INSTRUCTION: Please answer the following questions by putting a ‘x’ on the 100 mm line depending on the extent of the problem you face. For example, a ‘x’ on the extreme left means you are never affected, while a cross towards the extreme right side means you are always affected.

PHYSICAL

1. Do you get tired when you speak for so long?

Never _____ Always

2. Do you run short of breath when you speak?

Never _____ Always

3. Do you have to strain to produce voice?

Never _____ Always

4. Does your voice vary throughout the day?

Never _____ Always

5. Do you have difficulty in speaking loudly?

Never _____ Always

6. Do you lose your voice after prolonged speaking?

Never _____ Always

7. Does your voice lack quality?

Never _____ Always

8. Do you need to frequently clear your throat?

Never _____ Always

9. Does your throat feel dry after continuous speaking?

Never _____ Always

10. Does your throat pain while speaking?

Never _____ Always

EMOTIONAL

11. Does your voice problem upset you?

Never _____ Always

12. Are you worried because of your voice problem?

Never _____ Always

13. Do people understand your voice problem?

Never _____ Always

14. Do you lack self-confidence because of your voice problem?

Never _____ Always

15. Do you feel less worthy because of your voice problem?

Never _____ Always

16. Do you become conscious when speaking to others because of your voice problem?

Never _____ Always

17. Do you feel embarrassed when people ask you to repeat?

Never _____ Always

18. Do you get annoyed because of your voice problem?

Never _____ Always

19. Do you feel ashamed of your voice problem?

Never _____ Always

20. Does your voice problem affect your personality?

Never _____ Always

FUNCTIONAL

A) JOB

21. Is your job performance affected because of your voice problem?

Never _____ Always

22. Did you have to frequently change your job to another which comparatively required less us of voice?

Never _____ Always

23. Do you feel that you are earning because of your voice problem?

Never _____ Always

B) DAILY COMMUNICATION

24. Do you avoid speaking to people because of your problem?

Never _____ Always

25. Do people ask you to repeat what you have said?

Never _____ Always

26. Do people have difficulty in understanding you on the phone?

Never _____ Always

27. Does your voice problem affect your communication in noisy environment?

Never _____ Always

28. Does your voice problem affect your communication in silent environment?

Never _____ Always

29. Do people ask you to speak louder?

Never _____ Always

C) SOCIAL COMMUNICATION

30. Does your voice affect you in social activities?

Never _____ Always

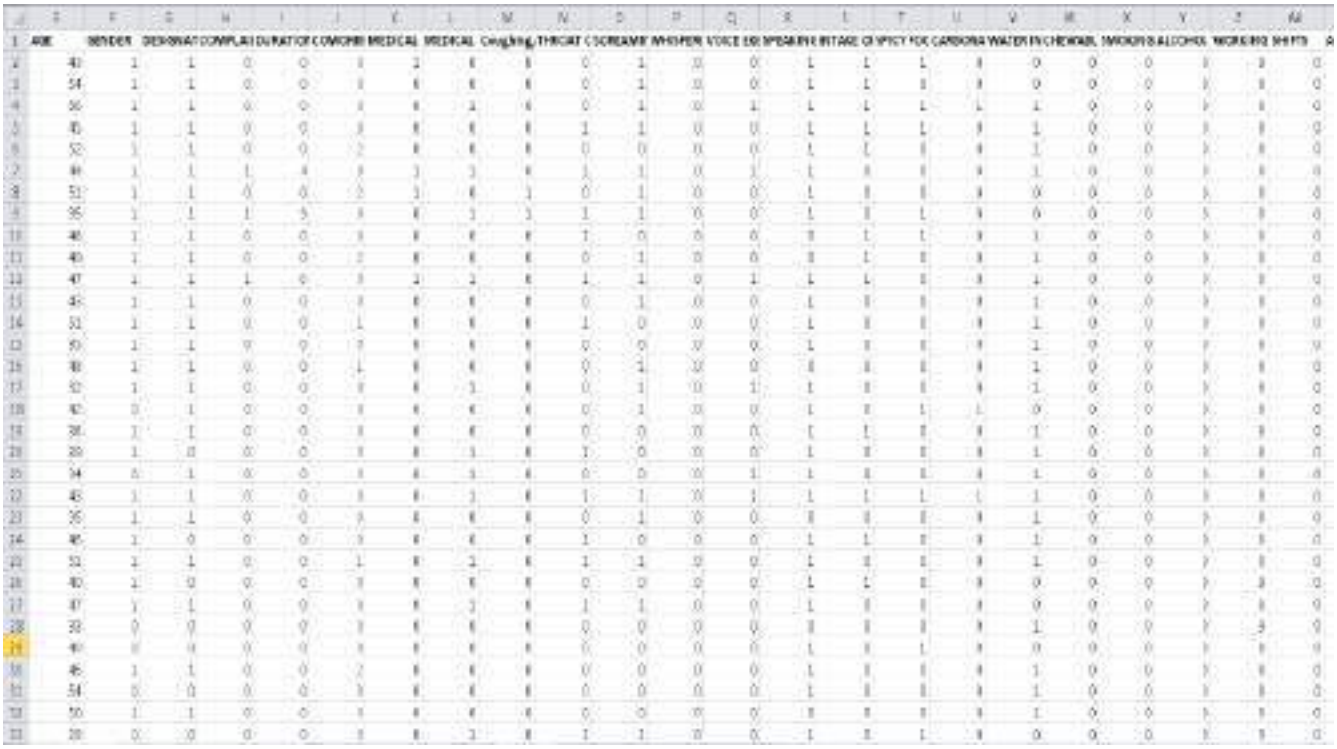
31. Does your voice problem annoy your family, friends or co-workers?

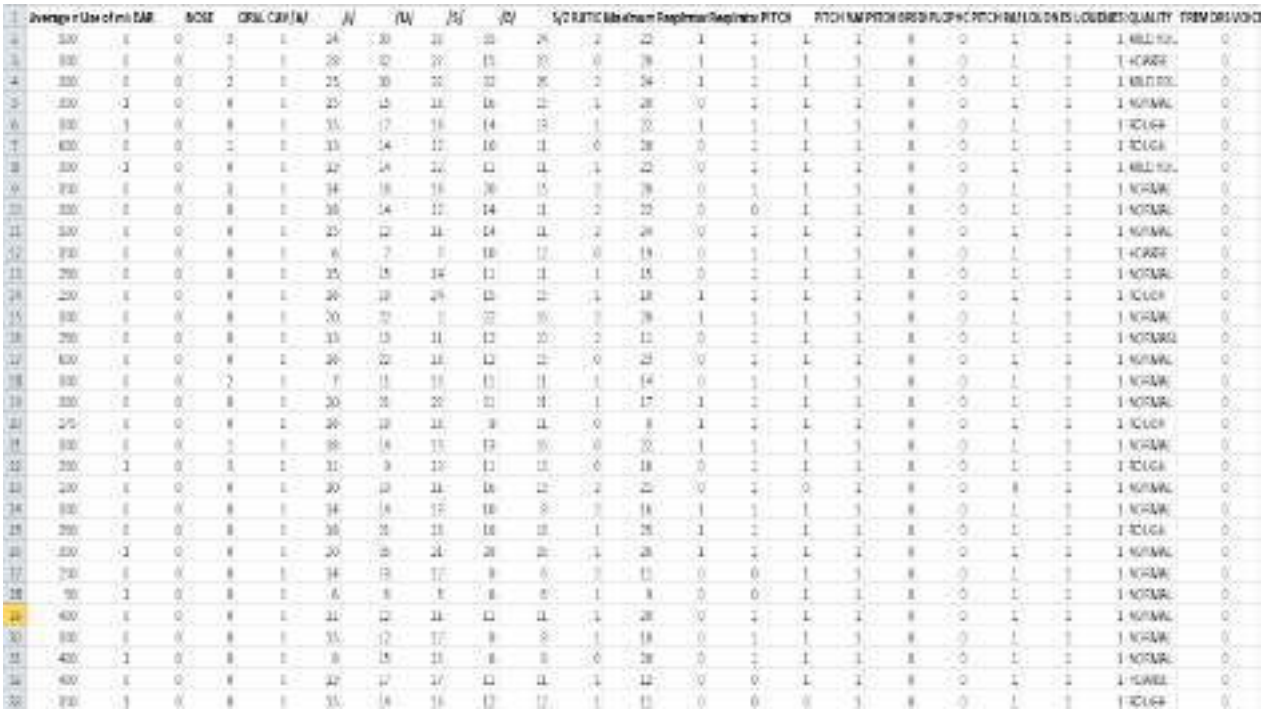
Never _____ Always

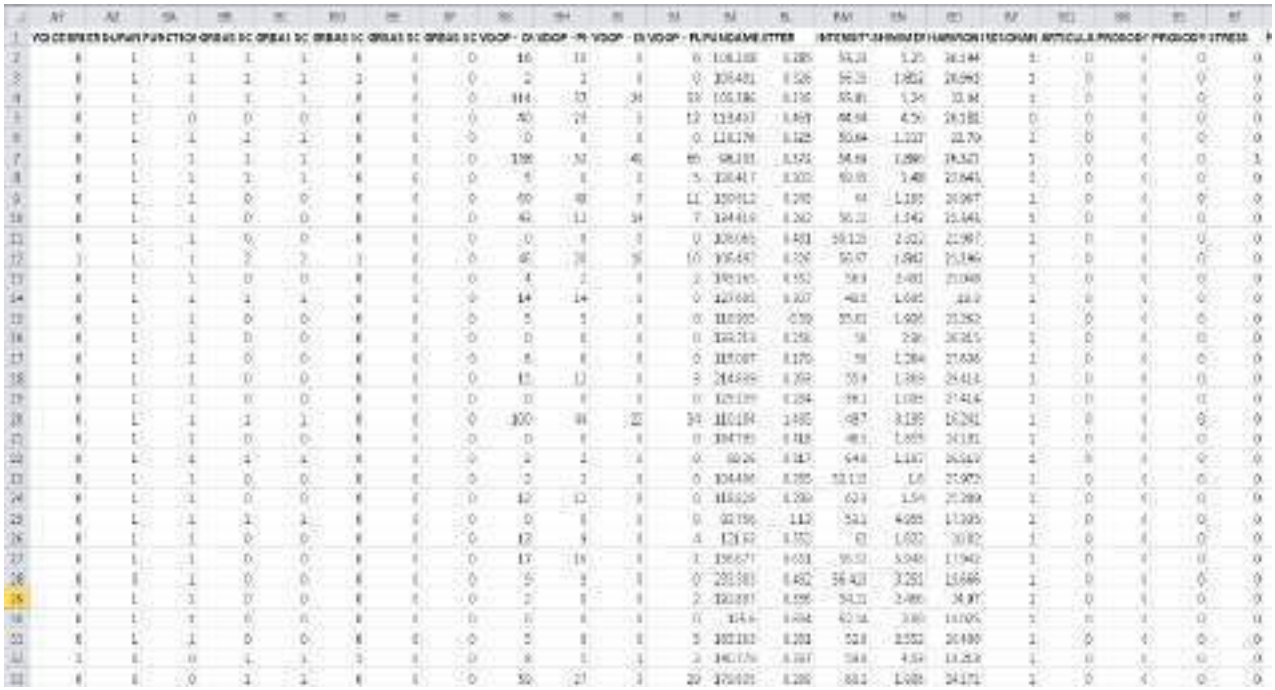
32. Do you feel your voice restricts your personal and social life?

Never _____ Always

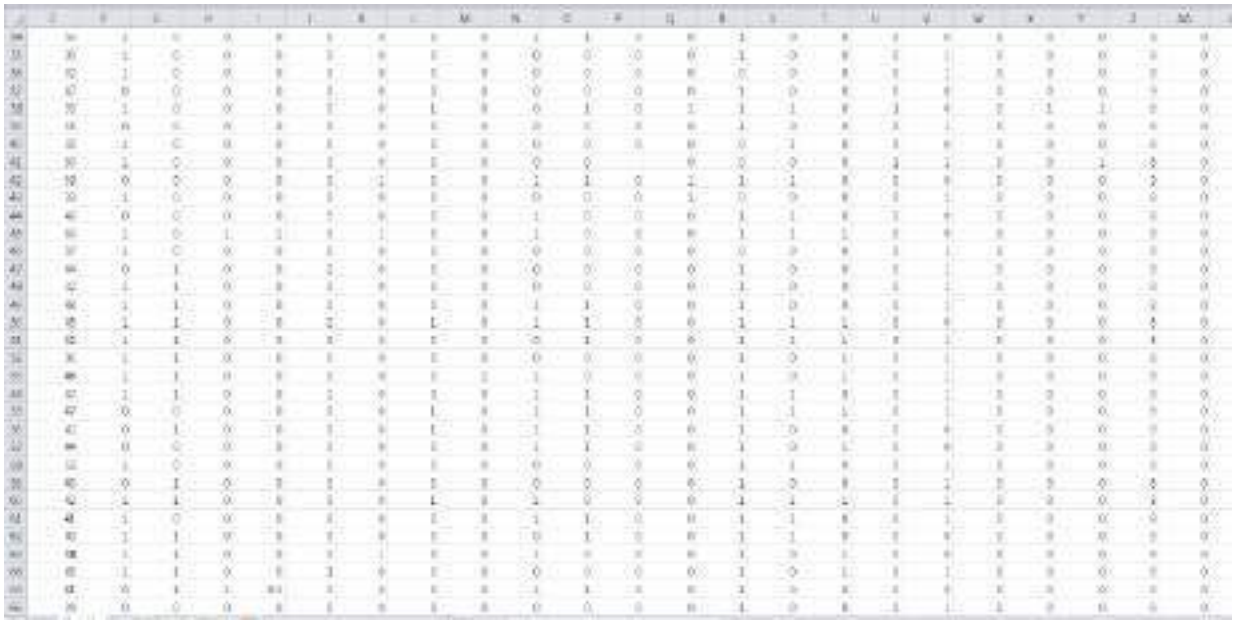
Data Sheet

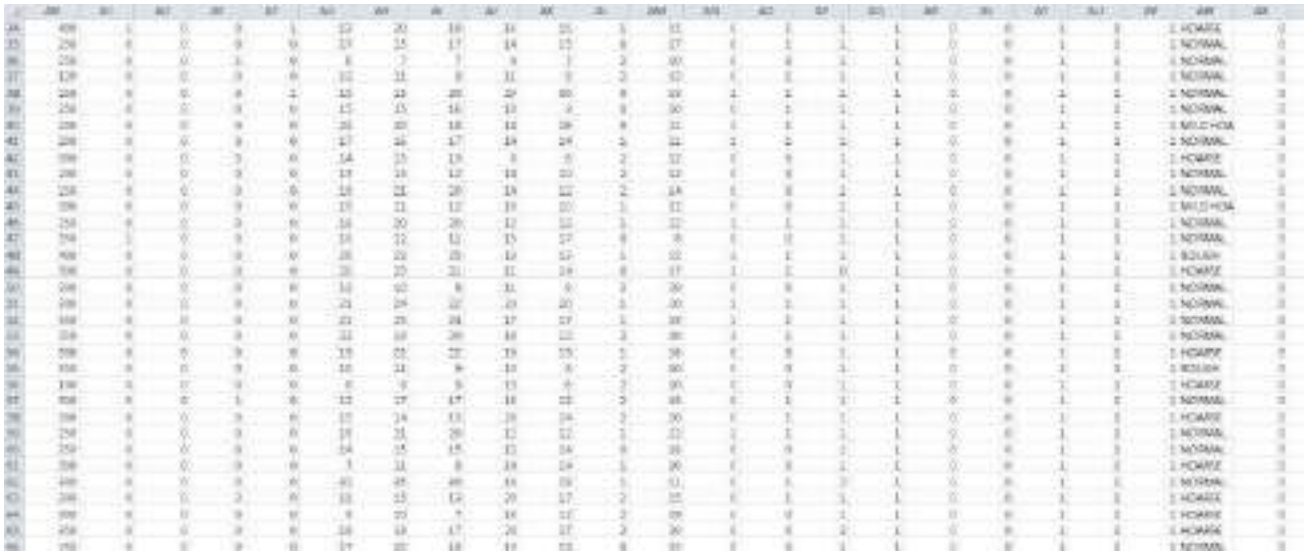


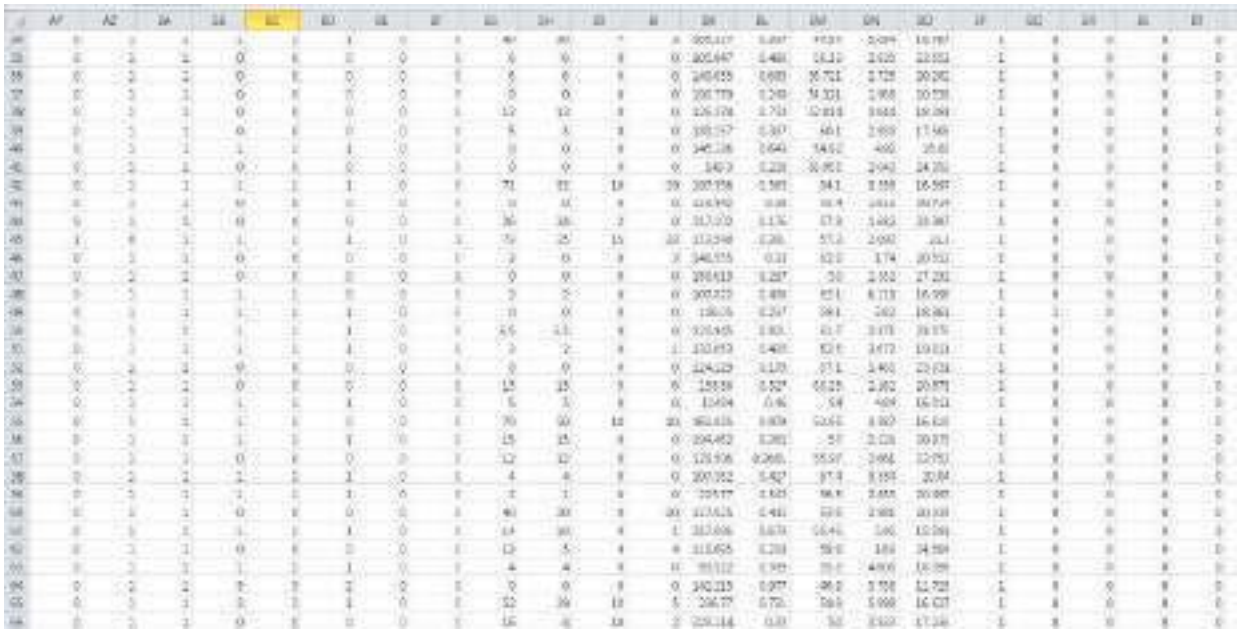




DU	DV	DW	DX	DY	DZ	EA	EB
PATTERN	VC- MOVE	VC PERIOI	VC - MUC	VC AMPLI	STROBC	MANAGEMENT	
1	1	1	1	1	5	3	
1	0	1	1	1	5	3	
0	1	1	1	0	1	2	
						0	
1	0	1	1	1	2	3	
1	1	1	1	1	3	3	
0	0	1	1	0	5	3	
1	1	1	1	1	4	3	
1	1	1	1	1	2	1	
						0	
						3	
						3	
						1	
						0	
						0	
						2	
						1	
						0	
						3	
1	1	1		1	1	2	
						5	
						1	
						1	
						1	
						0	
1	1	0	1	0	5	3	
						1	
1	1	1	1	1	0	0	
						0	
						0	
						1	
0	1	1	1	0	4	3	







BU	BV	BW	BX	BY	BZ	CA
						1
						0
0	1	1	1	1	1	1
						0
						2
						0
						0
						0
1	1	1	1	1	1	3
						0
						0
0	1	1	1	0	1	3
1	1	0	1	0	6	3
						0
						1
1	1	1	1	0	6	3
						0
1	1	1	1	0	1	3
						0
1	1	1	1	0	1	3
						3
						3
1	1	1	1	0	4	3
						0
						3
						0
						3
						3
1	1	1	1	1	4	1
0	1	1	1	0	1	3
						3
						3
						0

67	44	1	1	0	0	0	1	0	1	1	1	0	1	1	0	1	1	1	0	0	1	0	0		
68	48	1	1	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	0	0	1	0	0		
69	49	1	1	0	0	0	1	0	1	0	1	0	1	1	0	1	1	1	0	0	1	0	0		
70	50	1	1	0	0	0	1	0	1	0	0	0	1	1	0	1	1	1	0	0	1	0	0		
71	42	1	1	0	0	0	1	0	1	0	0	0	1	1	1	1	1	1	0	0	1	0	0		
72	47	1	1	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	0	0	1	0	0		
73	48	1	1	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	0	0	1	0	0		
74	46	1	1	0	0	0	1	0	1	0	0	0	1	1	0	1	1	1	0	0	1	0	0		
75	47	1	1	0	0	0	1	0	1	0	0	0	1	1	0	1	1	1	0	0	1	0	0		

67	300	0	1	1	0	16	11	18	11	14	2	10	1	1	1	1	0	0	1	1	1 HOMBRE	0			
68	250	0	1	1	0	14	11	14	11	11	1	12	1	1	1	1	0	0	1	1	1 NORMAL	0			
69	350	0	1	1	0	11	11	13	11	9	2	10	1	1	1	1	1	0	1	1	1 HOMBRE	0			
70	400	1	1	1	0	17	11	18	7	9	1	7	1	1	1	1	0	0	1	1	1 NORMAL	0			
71	450	1	1	1	1	17	21	29	13	13	1	10	1	1	1	1	0	0	1	1	1 NORMAL	0			
72	400	0	1	1	0	13	11	11	13	10	1	9	1	1	1	1	0	0	1	1	1 NORMAL	0			
73	350	0	1	1	0	12	11	13	6	5	1	8	1	1	1	1	0	0	1	1	1 HOMBRE	0			
74	300	0	1	1	0	15	11	13	11	14	0	1	1	1	1	1	0	0	1	1	1 NORMAL	0			
75	250	0	1	1	0	12	11	15	9	7	1	7	1	1	1	1	0	0	1	1	1 NORMAL	0			

67	0	1	1	1	1	1	1	0	28	17	5	1	216.282	0.628	544	2.75	21.889	1	0	1	0	1	1		
68	0	1	1	0	0	1	1	0	0	1	0	0	120.055	0.50	60	2.157	24.981	1	0	1	0	1	1		
69	0	1	1	1	1	1	1	0	0	1	0	0	211.121	0.661	371	3.868	18.284	1	0	1	0	1			
70	0	1	1	0	0	1	1	0	0	1	0	0	117.001	0.227	151	1.311	25.501	1	0	1	0	1			
71	0	1	1	1	1	1	1	0	1	1	1	0	108.135	0.618	5043	5.515	17.796	1	0	1	0	1			
72	0	1	1	1	1	1	1	0	46	28	11	7	197.671	0.318	46.95	5.308	17.654	1	0	1	0	1			
73	0	1	1	2	2	2	1	0	30	18	11	1	108.822	0.659	621	4.248	11.781	1	0	1	0	1			
74	0	1	1	0	0	1	1	0	2	1	0	0	150.084	0.218	361	1.527	28.365	1	0	1	0	1			
75	0	1	1	0	0	1	1	0	39	21	4	1	171.796	0.607	38.9	2.338	13.715	1	0	1	0	1			

1	1	0	1	0	1	1
1	0	1	1	1	6	3
						3
						0
						2
						1
						3
						0
						0