DEVELOPMENT OF A NOVEL SWALLOWING ENDOSCOPY RECORD DATABASE (ANSwEReD™) FOR CLINICAL RESEARCH AND TRAINING

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University of Mysore, Mysore

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JUNE, 2026

CERTIFICATE

This is to certify that this dissertation entitled **"Development of A Novel Swallowing Endoscopy Record Database (ANSwEReD)™ for clinical research and training"** is a bonafide work submitted as part of fulfilment of the degree of Master of Science (Speech-Language Pathology) of the student with Registration Number (Registration No: P01II24S123032). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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CERTIFICATE

This is to certify that this dissertation entitled **"Development of A Novel Swallowing Endoscopy Record Database (ANSwEReD)™ for clinical research and training"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Development of A Novel Swallowing Endoscopy Record Database (ANSwEReD)™ for clinical research and training"** is the result of my own study under the guidance of Dr. Gayathri Krishnan, Assistant Professor in Speech/Language Pathology, Centre for Swallowing Disorder and co-guidance of Mr. Karthik Venkat Sridaran, Speech Technologist, Centre for Rehabilitation Engineering, Acoustics and Bio medical engineering, All India Institute of Speech and Hearing, Manasagangothri, Mysore and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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CHAPTER I

INTRODUCTION

Swallowing is a very complex and coordinated neuromuscular process requiring integrated function of the oral, pharyngeal, and esophageal structures. It is defined as "the process of transporting food and liquid from the mouth through the pharynx and esophagus into the stomach in a safe and efficient manner" (World Health Organization, 2010). Swallowing is classified as "digestive symptoms and signs" in the framework of International Classification of Functioning (ICF). This categorization does not necessarily indicate pathology, as many individuals have unrecognized swallowing problems (World Health Organization, 2010). Safe and efficient swallowing is essential for adequate nutrition and hydration throughout the lifespan. Eating and swallowing are important factors in a person's comfort, wellbeing and quality of life.

A number of medical and non-medical conditions may interfere with this finely tuned process. The difficulties in swallowing make it effortful, inefficient or unsafe to swallow. The medical literature refers to this condition as 'dysphagia'. Dysphagia refers to any impairment in the swallowing process. The prevalence of dysphagia is very high among various clinical populations. The post-stroke population had the highest prevalence, with 8.1–80% (Gu & Ren, 2024; Song et al., 2024; Takizawa et al., 2016a) experiencing dysphagia of varying severity. The condition is also present in 11–60% of those with Parkinson's disease (Ortega et al., 2017; Takizawa et al., 2016a), 30% of individuals with brain injury (Eskildsen et al., 2021; Takizawa et al., 2016a), and up to 91% of elderly individuals with community-acquired pneumonia worldwide (Takizawa et al., 2016a). In the Indian context, the prevalence of dysphagia in stroke patients is between 11.6% and 87.5%, and the incidence of pneumonia associated with it is between 22.8% and 32%, which is higher than the global estimates (Krishnamurthy et al., 2022). This epidemiological data highlights the burden of dysphagia on the health care systems and society and the importance of attending to the rehabilitation of this condition at the earliest. Because dysphagia is associated with a wide range of health conditions, early identification and treatment of dysphagia are crucial for long-term recovery (Altman et al., 2010; Patel et al., 2018). and comprehensive health care outcomes (Ekberg et al., 2002; Martino et al., 2005; Terre & Mearin, 2009). In this process of early identification and management, the speech-language pathologists (SLPs) play a central role among the other team members.

Persistent, unmanaged dysphagia is associated with a range of serious health consequences. There is a significant increase in the risk of pulmonary complications such as aspiration pneumonia (Langmore et al., 1998), malnutrition, and dehydration (Smithard et al., 1996), and severe unmanaged dysphagia has been linked to increased mortality (Martino et al., 2005). In children, dysphagia can adversely affect growth and developmental outcomes overtime (Ortiz Pérez et al., 2024; Thommessen et al., 1991). Presence of dysphagia was associated with negative prognosis and recovery trajectories with overall deterioration in functional health (Clayton et al., 2023; Obata et al., 2024). Beyond the physical implications of this condition on the patient, there is considerable psychosocial burden on the entire family, leading to reduced quality of life (Namasivayam-MacDonald et al., 2018). Therefore, early detection, accurate diagnosis, and timely intervention are critical in both acute care (Leder, 1998) and rehabilitative settings (Logemann, 1997).

A swallowing assessment is often a layered process encompassing both subjective clinical (bedside) and more objective instrumental methods aimed at the identification, profiling, characterization and management planning. The clinical swallowing assessments often serve as the first assessment where the SLP systematically records the reported symptoms and observed signs that may be contributing to the reported swallowing impairment. Symptoms mostly include overt or “loud” clinical indicators such as coughing during or after swallowing, throat clearing, changes in respiratory pattern, tearing of the eyes, prolonged meal duration, and unintended weight loss (Azer et al., 2025). The clinician is often left with a preliminary clinical impression regarding swallowing safety and efficiency, aiding in identifying individuals at risk.

Although the information gained from an expert clinical assessment is invaluable, these procedures are inherently limited by their inability to directly visualize the internal anatomical structures and dynamic physiological events associated with swallowing. Clinical examinations hence depend on perceptual assessment and indirect indicators that are not necessarily representative of the underlying pathophysiology. Bedside swallowing assessments have been shown to have poor sensitivity to identify aspiration, particularly silent aspiration, as compared to instrumental assessments such as Videofluoroscopic Swallow Study (VFSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES) (Leder & Espinosa, 2002; McCullough et al., 2005; Ramsey et al., 2003). Direct visualization of swallowing may indicate silent dysphagia or aspiration, which is defined as the entry of material into the airway in the absence of observable/overt clinical signs. Such events may be missed on routine bedside examination without instrumental analysis. Failure to recognize such cases in a timely manner results in severe medical complications such as aspiration pneumonia and increased morbidity (Pikus et al., 2003; Schmidt et al., 1994). Thus, clinical evaluation may lead to underdiagnosis or mischaracterization of swallowing disorders.

Instrumental assessments are considered indispensable for comprehensive evaluation of swallowing function. The gold standard methods for direct visualization of swallowing are the VFSS and FEES. These evaluations add objectivity over complete reliance on expert subjectivity and allow the clinicians to correlate observed clinical signs with their underlying mechanisms and confirm diagnostic impressions (Haas et al., 2024). Both the VFSS and FEES methods provide complementary information regarding bolus flow, structural movement, airway protection, and residue, thereby facilitating a detailed understanding of swallowing impairment.

A detailed evaluation of swallowing function, including clinical and instrumental assessments, is essential for planning management and intervention. These instrumental methods assist the rehabilitation team to make informed, evidence-based treatment decisions (Logemann, 1998; Huckabee & Cannito, 1999; Dziewas et al., 2021). and provide real-time feedback during intervention (Denk et al., 1997) by providing biofeedback on hyolaryngeal elevation (Meng et al., 2024; Reddy et al., 2000) and vocal fold activity (Imada et al., 2016). These benefits of instrumental assessments have influenced the practice advocacy and policies of the American Speech-Language-Hearing Association (ASHA, 2024) and they endorse the use of instrumental evaluations not only for diagnostic purposes but also for rehabilitation planning, biofeedback training, and monitoring treatment outcomes over time with repeated evaluation (Langmore, 2001; Likar et al., 2024).

The VFSS procedure, considered the ‘gold standard’ in dysphagia assessment, is a radiology-based procedure performed in a special suite by an expert SLP and radiology team. The radiation hazards involved in the procedure caution against regular repetitions unless strongly justified. On the other hand, another popular instrumental assessment, the FEES procedure, provides the SLP with direct visualization of the structures and real-time movements of swallowing and other related functions of interest (Langmore et al., 2001). The procedure uses a transnasal endoscope to directly visualize the structure and function of pharyngolaryngeal physiology during a swallow and its outcome (Langmore, 2001). The portability of FEES equipment allows safe implementation of FEES at the bedside for evaluation of secretion management as well as regular food trials, which can be recorded for later review. The procedure is a patient-friendly method of identifying silent aspiration (Leder et al., 1998). The procedure also overcomes the limitations of barium use as in VFSS, which can alter swallowing physiology and pose risks for patients allergic to contrast agents (Stokely et al., 2014). In many ways, FEES has become ubiquitous in swallow assessment and is now alongside VFSS as a gold standard assessment of swallow safety and efficiency (Langmore, 2001; Warnecke et al., 2009).

The diagnostic accuracy across FEES and VFSS procedures has been scientifically explored. Comparisons revealed that FEES demonstrated a higher ability to diagnose pharyngeal residue and airway intrusion events compared with VFSS and also had marginally better performance in detecting premature spillage (Ferrari De Castro et al., 2025). FEES has been established as a valid and reliable procedure for evaluating oropharyngeal dysphagia in several studies, showing a high agreement with VFSS in identifying aspiration, penetration, pharyngeal residue and swallowing safety (Kelly et al., 2007; Langmore, 2001; Warnecke et al., 2009). During evaluation, the SLP derives relevant information related to velar, pharyngeal, and laryngeal functions along with the onset of the swallow reflex, number of swallows, and response to any airway penetration-aspiration events. The amount of residue in the pharyngeal cavity post-swallow is also clinically significant in inferring swallowing efficiency (Murray et al., 1996; Neubauer et al., 2015). These observations are made by expert FEES clinicians and often judged and documented using subjective scales (Baijens et al., 2016; Neubauer et al., 2015; Rosenbek et al., 1996). For example, the depth and response to airway intrusion are often documented in the form of an 8-point rating scale named the Penetration-Aspiration Scale (PAS; Rosenbek et al., 1996). Similarly, the location and relative amount of pharyngeal residue post swallow is documented using the Yale Pharyngeal Residue Severity Rating Scale (Neubauer et al., 2015). Although these rating scales are widely used, studies have revealed heterogeneity in FEES interpretation among clinicians, particularly for ratings of residue severity and airway invasion events, emphasizing the necessity for standardized training and objective quantification methods (Kelly et al., 2006; Baijens et al., 2016; Stokely et al., 2015).

Recent research has increasingly been directed at using technology to improve objectivity of swallowing assessment through advances in FEES and VFSS analysis. A number of studies have employed frame-by-frame analysis of video to quantify in an objective manner events such as pharyngeal delay time, laryngeal vestibule closure, and bolus transit duration, thus quantifying swallowing physiology over time (Molfenter & Steele, 2012, 2014). Furthermore, advances in computational methods and machine learning have enabled automated detection and analysis of swallowing events from videofluoroscopic recordings, to decrease reliance on subjective clinician interpretation (Lee et al., 2020; Lee et al., 2023). At the same time, there has been research into the application of digital image analysis, spatial mapping and frame level segmentation techniques for visual imaging based quantification of pharyngeal residue and airway invasion to enhance diagnostic accuracy and decrease inter-rater variability (Baijens et et al., 2015). Further quantitative kinematic studies of hyoid movement, laryngeal elevation and bolus flow dynamics have also contributed to a more detailed characterization of swallowing biomechanics (Hashimoto et al., 2018; Lee et al., 2019). All these developments point to a trend towards objective and reproducible methods of dysphagia assessment aided by technology.

NEED FOR THE STUDY

Recently FEES has gained significant traction in both clinical application and professional interest in the field of speech-language pathology. Recent systematic reviews show that the procedure continues to receive technical and methodological improvements that increase its clinical utility, reliability, and efficiency (Burdick et al., 2024; Prikladnicki et al., 2022). Nevertheless, concerns persist in the dysphagia field about variability in FEES outcomes due to differences in protocols, bolus characteristics, patient demographics, task conditions and scoring approaches (Baijens et al., 2015; Prikladnicki et al., 2022).

The direct visualization of pharyngeal structures, portability, feasibility of safe implementation at bedside assessment, repeatability and no radiation exposure have popularized FEES procedure as a preferred instrumental tool in dysphagia evaluation. This has resulted in a growing demand for structured training programs that provide the participants with procedural competencies, especially the transnasal endoscope insertion. But the real clinical effectiveness of FEES is not only in performing the procedure but depends on the correct interpretation of the endoscopic findings. Current training paradigms seem to relatively emphasize less on building upon the FEES interpretative expertise. This indicates a substantial gap in training clinicians to be consistently reliable in their clinical decision-making in dysphagia practice.

Interpretation efficiency is a separate skill in advanced technical training models, requiring its own modules and training. A review of structured training programs in both technical and clinical domains revealed a common emphasis on the acquisition of procedural skills in short-duration formats, ranging from a few days to a few weeks. Wooi et al. (2001) applied instructional teaching and learning paradigms with undergraduate students to interpret videofluoroscopic swallow studies. Since then, similar training-based approaches and structured competency programs for VFSS interpretation have been investigated in clinical and academic settings around the world to enhance reliability, diagnostic accuracy, and standardization of dysphagia assessment (Boaden et al., 2020; Edwards et al., 2021; Swan et al., 2019). The learning outcomes of these programs focus on learning by doing with respect to equipment handling and procedure familiarization. Analysis and interpretation of data are given relatively less importance and less structured time. This indicates that analytical skills are not simply about procedural skills but require systematic training.

A similar trend can be seen in the current FEES training programs world wide. The initial learning during these programs is largely centered on scope handling, patient preparation, and safe transnasal insertion before progressing toward interpretation and clinical decision-making (Benadom & Potter, 2011; Robinson & Dennick, 2015). Simulation-based learning approaches have been studied more to promote the acquisition of endoscopic skills in a controlled environment prior to patient interaction. Benadom & Potter (2011) compared human versus non-human simulator-based FEES training in speech-language pathology graduate students, and found no significant differences in skill acquisition between simulation methods, supporting simulation-assisted endoscopy training. Robinson and Dennick (2015) highlighted the importance of supervised one to one mentorship models for endoscopic skill development, the role of guided feedback, clinical judgment training, and mentor-supported progression of procedural competency. Similarly, Bolton et al. (2020) proposed competency-based frameworks for FEES practice, suggesting prior knowledge in dysphagia assessment and videofluoroscopic interpretation before undertaking FEES certification. The surveys of speech-language pathologists also demonstrate an increasing interest in developing endoscopic competencies, despite limited routine clinical exposure, highlighting the importance of structured training opportunities that combine technical and clinical reasoning skills (Robinson & Dennick, 2015). However, much of the available literature on endoscopic skill training for speech-language pathologists is still focused on voice and laryngeal endoscopy rather than FEES-specific clinical training. Although these competencies are critical for an informative and efficient swallowing study, the clinical value of FEES is inherently dependent on the accurate interpretation of dynamic swallowing events, including penetration-aspiration, residue distribution, secretion management, and temporal coordination. Interpretative processes in FEES, however, are complex and multi-layered in nature. The wide variability in the conceptual understanding and observational abilities, large variation in performance within the normal population, the multitude of conditions that result in dysphagia, and the complexity of pharyngeal swallow make interpretation training for FEES a continuous and repeated learning process. The process is further challenged by the absence of universally standardized protocols for the procedure of FEES itself (Burdick et al., 2024; Prikladnicki et al., 2022).

The procedural skills of transnasal endoscopy can be learned through repetition and supervised practice, but the interpretation of FEES studies requires higher-order perceptual and analytic skills that are supported by consistent frameworks and objective metrics. The relative underemphasis on structured interpretative training in the existing FEES training programs, combined with the lack of standardization in the protocol, contributes to inconsistencies in clinical judgments. This variability in FEES interpretation is exacerbated by variability in clinician calibration, rater experience and quality of equipment, with inter- and intra-rater variability in FEES scoring and diagnosis being substantial (Baijens et al., 2016; Burdick et al., 2024; Prikladnicki et al., 2022; Warnecke et al., 2016). Thus, the subjective evaluation of FEES-data in dysphagia diagnostics remains problematic with regard to rigor, transparency, and reproducibility in clinical practice (Burdick et al., 2024; Colodny, 2002). Insufficient training in interpretation may affect diagnostic accuracy and consistency in management planning, emphasizing the need for more objective and standardized approaches to FEES analysis. Even in the research domain, there is variability across studies using the same methodologies, in terms of technical parameters, bolus characteristics, task conditions and scoring approaches (Baijens et al., 2016; Prikladnicki et al., 2022). Further diversity can be introduced both in the clinical and in the research practice by institution-specific adaptations and examiner-dependent practices (Warnecke et al., 2016).

The need for systematic reform in clinical training is urgent. It is necessary to strongly advocate for initiatives towards a uniform adoption of reproducible, validated and transparent FEES protocols (Burdick et al., 2024; Prikladnicki et al., 2022). Creating accessible and standardized rater training programs to reduce subjectivity and improve interpretative reliability among clinicians is equally important (Oliveira et al., 2022). This need is further supported by current concerns about inter-rater variability in the observational assessment of FEES studies, documentation, and inter-professional communication (Burdick et al., 2024; Colodny, 2002). The challenges emphasize the need for global standardization of these variables and control of variability in an urgent manner with the objective of improving clinical efficiency.

The other instrumental imaging techniques used for the evaluation of swallowing have shown that standardization, reproducibility and data-based analysis are useful to reduce subjectivity and to support evidence-based decisions. These approaches systematically describe the physiological function of a swallow using measurable temporal, spatial and kinematic parameters. For example, ultrasonography provides quantifiable indices of muscle thickness and dynamic movement patterns (Maeda, 2023), while pharyngeal and esophageal manometry quantifies pressure dynamics, coordination, and contractility indices to assess motility disorders (Jones et al., 2018). But these methods only give indirect measures of the swallow and cannot give the clinician direct visualisation of pharyngeal events. This limitation is a barrier to the detailed and thorough analysis of swallowing physiology required for accurate and efficient clinical decision-making. FEES is rich in real-time visual data of pharyngeal processes during the swallowing process but lacks a robust quantitative evaluation framework and therefore limits its interpretative precision. Hence, the use of objective measurement methods in FEES has the potential to bridge the gap by integrating direct visualization with quantifiable analysis. Such methodological improvements would not only increase inter- and intra-rater reliability, but would also facilitate the standardization of clinical protocols and strengthen the evidence base for FEES in the diagnosis of dysphagia. Therefore, the future of FEES practice must involve the development of standardized, objective and potentially automated analytical methods, together with structured training curricula that emphasize interpretive skills.

A major barrier to standardization of the FEES procedure is the variability in endoscopic technology and related recording systems. Modern flexible endoscopic systems usually incorporate cameras which transmit real time images to a monitor while also recording images for subsequent analysis (Langmore et al., 2022). The digital imaging technology and computing have been witnessing a never-before era of advancement. In the area of medical imaging such as that of FEES, continuous advancements in scope design, light sources, and image processing have significantly refined visualization, providing clinicians with increasingly high-definition views of pharyngeal and laryngeal structures. While few dedicated systems are designed as integrated platforms combining imaging, recording, illumination, and suction, most often, these systems are not affordable to clinicians and modest health care systems. This group of professionals uses discrete components, resulting in variability in system configuration and functionality across clinical settings.

Technical specifications of the endoscope further contribute to heterogeneity. Common parameters include a field of view ranging from 80° to 90°, deflection capabilities between 120° and 180°, and scope diameters of approximately 2.4–3.8 mm. Image quality is influenced by scope camera resolution and output formats such as DVI-D (M/s ATMOS Medizin Technik, 2020; Karl Storz-Endoskope, n.d.; Pentax Medical, n.d.). The source of light also vary across endoscopic systems, with the most recent preference being LED due to its superior brightness and efficiency.

The modern FEES systems incorporate features that support comprehensive documentation and analysis. Attractive features are being added to the endoscopic systems, such as the facility for audio recording that facilitates capture of commentary of the procedure, a dataset that is of immense value in offline analysis. Playback functionalities such as slow motion, frame-by-frame review and still-image extraction also facilitate precise study and interpretation. The data recording facility enables longitudinal comparisons of swallowing function, useful for multidisciplinary review, and facilitates patient education through visual biofeedback. However, variability in data storage practices, including differences in internal databases, file formats, and transfer options such as involvement of USB or cloud-based systems, creates additional challenges for data sharing, integration, and reproducibility. Large-scale collaborative research and the development of standardized analytical frameworks are therefore a distant mission.

Standardization of the FEES procedure across the globe necessitates the identification and inclusion of clinically relevant data points across the full spectrum of dysphagia population. However, existing literature indicates a disproportionate representation across the clinical groups. The majority of FEES-based evidence can be retrieved in post-stroke dysphagia (González-Fernández et al., 2013; Labeit et al., 2024; Wang et al., 2025), head and neck carcinoma (Denk et al., 1997; Gitto et al., 2025), and acquired brain injury (Lee et al., 2016; Morgan et al., 2010).

Other etiologies, such as neurocognitive disorders (Peranovic et al., 2025), motor neuron diseases (Briani et al., 1998), vocal fold palsy (Schiedermayer et al., 2020), gastroesophageal conditions (Slovik et al., 2025), metabolic disorders (Santa Maria et al., 2024), and developmental or sensory-motor disorders across pediatric and adult populations (Pazinatto et al., 2024) remain underrepresented in basic as well as applied research. While one possible reasoning could be the differences in disease prevalence, referral patterns, and clinical presentation across etiologies (Azer et al., 2023; Martino et al., 2005; Takizawa et al., 2016), another reason could be the variability in access to the diverse range of clinical populations across health-care set up. Research and clinical training in these underrepresented groups are often constrained by small sample sizes. In the research domain, this increases bias, reducing internal and external validity, limiting generalization and comparability across studies. Addressing this gap requires the development of systematic, multicentric approaches to aggregate endoscopic data from the wide range of dysphagia populations, including the less-studied populations. This would add to the evidence base and allow for more inclusive standardization efforts.

As mentioned previously, standardized schemes of evaluation are needed to correctly interpret the endoscopic evaluation of swallowing, decreasing the subjective component and the variability between professionals. There is a need to develop and implement structured and scalable training programs with pre-defined learning outcomes and competency benchmarks. The existing FEES training models include a combination of didactic instruction, supervised hands-on practice (FEES Competency Resources, 2022; Sanderson & Sanderson, 2023), and simulation-based learning approaches. These programs are designed to facilitate skill acquisition prior to direct patient exposure (Langmore et al., 2022). The involvement of upcoming professionals and clinicians in the design and delivery of such programs is essential for ensuring training quality and clinical relevance (Langmore et al., 2022). However, such traditional in-person training approaches are associated with several limitations. Effectively running these programs is resource-intensive, involving substantial time, infrastructure, and expert availability. Maintaining the long-term reliability and continuous updation of professionals also remain a challenge (Meguerdichian et al., 2019). Competing clinical responsibilities, limited access to onsite expert mentorship, and unequal exposure to diverse dysphagia populations in practice may constrain the effectiveness and scalability of such training models (Burdick et al., 2024; Oliveira et al., 2022; Prikladnicki et al., 2022).

A carefully designed online training program for clinical decision-making based on FEES examinations offers a potential alternative to conventional training methods. Other digital training frameworks in the field of dysphagia have been successfully implemented in similar limes. The online training programs on videofluoroscopic swallow studies (Edwards et al., 2021; Medbridge Inc., 2025), ultrasound (Dietrich et al., 2022; SonoSim, Inc., 2025) and high-resolution manometry (Laborie Medical Technologies Corp., 2024) are increasingly popular and demanded. These programs are characterized by repeated patient examination exposure, formal feedback mechanisms, and access to expert rated video libraries providing for consistent and reliable skill development for clinicians hoping to work in the field of swallowing and its disorders (Wallace et al., 2020).

Advanced teaching strategies, such as multi-rater learning approaches that utilize assessments from a wider range of examiners, foster deeper understanding and calibration of clinical judgment. Frame of Reference (FOR) training involves matching observed clinical features to standardized ratings via guided comparison to expert benchmarks (Northern Speech Services, 2025). These platforms may provide Rater Error Training (RET) focusing on identifying common rating biases to enhance scoring accuracy (Curtis et al., 2022; Wallace et al., 2020). Digital platforms boost the virtual calibration and asynchronous learning, making such training programs scalable, accessible, and affordable without interfering with the quality (Johnson et al., 2016; Langmore et al., 2022). Several systemic barriers impede the development and implementation of such comprehensive training programs in medical imaging. The disease diversity, heterogeneity in treatment and its outcomes, and challenges in data collection, processing, and interpretation make medical data-based training a challenge (Dinov, 2016). Retrieval, organization, and large-scale analysis is affected with traditional data storage approaches in medical records and case-based documentations (Ramez et al., 2010). They lack dynamic, annotated content required for advanced clinical training, machine learning applications, and research development (Date, 2004; Kwak et al., 2025; Molfenter & Steele, 2014).

Advances in data sciences and technologies have been transforming health information systems with large volumes of heterogeneous data varying in type, format, and structure (Lippeveld et al., 2000; Raghupathi & Raghupathi, 2014). The need for structured and high-quality datasets has become more pronounced now with the increasing integration of machine learning (ML) in healthcare. The success of any ML-driven application depends on the availability of high-quality benchmark datasets, which are essential for training, validation, and performance comparison of computational models (Wiens et al., 2019). In this context the creation of organized, centralized repositories providing secure storage, systematic annotation and efficient retrieval of clinical data is critical. These databases enable data interoperability, large-scale analysis, and reproducibility in research (Ramez et al., 2010). A dataset which includes endoscopic examinations across different clinical populations and settings, would be a very useful resource for research and training in the area of dysphagia rehabilitation. This would enable full data integration, population comparisons and the ability to refine clinical protocols. These repositories can help overcome some of the current limitations in infrastructure and thus support both clinical education and technological innovation. But the development of shared databases is not without challenges. It must consider and address data-sharing limitations due to patient privacy, variability in instrumentation and protocols makes standardization and integration efforts difficult (Date, 2004; Molfenter & Steele, 2014). The increasing utilization of artificial intelligence (AI), particularly convolutional neural networks (CNNs), underscores the importance of large well-annotated datasets for FEES assessment of dysphagia (Oliveira et al., 2022; Weng et al., 2022). A comprehensive and standardized database is not only essential for future research and training, but also a basis for the future integration of more automated and objective analytical tools in swallowing assessment .

With this background, the current study was planned to develop a novel swallowing endoscopic database that permits protected data storage of a wide range of clients with dysphagia reporting to the Centre for Swallowing Disorders. An attempt was made to keep the instrumentation and protocol used for data collection uniform by restricting the data to 2024 to 2026, during which these variables were uniform in practice. The database included detailed annotated endoscopic videos that were checked and validated by speech-language pathologists for their annotations. Further, the database was validated for its end-user feedback to list down the scope for refinement.

CHAPTER II

REVIEW OF LITERATURE

The advancements in the development of machine learning (ML) algorithms for accurate analysis of disorders had increased the development of video databases. A database is essentially a computerized record-keeping system to store information and allow the user to retrieve the information on demand. The major advantage of the database is that it will be helpful in data integration and data sharing (Date, 2004). By integration means, the database can be thought of as a unification of several otherwise distinct files, with any redundancy among those files partly or wholly eliminated. For example, consider a PATIENT file with details such as ID, name, age, medical history, and clinician, alongside a FEES_PROCEDURE file tracking video IDs, timestamps, bolus types (e.g., thin liquid, puree), swallow trials, and penetration-aspiration scale (PAS) scores. Without integration, the FEES_PROCEDURE file might redundantly store each patient's name, age, and clinician for every video trial. By linking via patient ID, the department or clinician information stays only in PATIENT, retrievable as needed for reports avoiding updates across multiple records if a clinician changes. Various integration efforts have been made such as approaches to integrate terminologies, ontologies, and schema matching (Brazhnik, 2007). The rapid progress in deep learning, especially convolutional neural networks (CNNs), has led to an increasing demand for high-quality repositories of endoscopic images and videos that can facilitate robust training and validation of algorithms.

In order for a database to be useful for multiple purposes, the content and description of the database should be comprehensive (Liolios et al., 2012; Wiederhold, 1981) . Recent literature has also shown a move away from small single-center datasets to large multi-center repositories with diverse patient populations and imaging conditions (Gliklich et al., 2014) . The swallowing therapist reviews the videos of the PAS scores and provides the patient details such as ID and medical history, the otolaryngologist reviews the procedure notes and the researcher reviews the bolus trial results. None of this is in separate "personal" spreadsheets by user . All get the same non-redundant info at the same time via patient ID links .

Another important trend in recent years has been the emphasis on annotation quality and standardization. Many studies now involve technical experts in the annotation process to ensure accurate localization and classification of videos related to healthcare. A healthcare or medical dataset is a set of health-related data such as patient records, lab results, medical images, or treatment histories (Shaip, 2025). Healthcare datasets are often curated into data collections, curated repositories for research, public health, and clinical use (Johnson et al., 2023). These datasets are used to study disease, improve treatments, and build tools like AI models to better diagnose and care for patients. Many healthcare datasets contain de-identified health-related data, which maintains patients' privacy and still allows valuable research and analysis (U.S. Department of Health and Human Services, 2012). Healthcare datasets provide holistic insights into the health of a patient and help healthcare professionals to make early interventions and develop personalized treatment plans. Most importantly, medical image annotation helps achieve faster and better diagnoses that make medical care better and may improve patient health. They also support advanced medical research, such as genomic and oncological biomarker analysis, treatment plans and recovery patterns in cancer patients and other clinical populations (Tomczak et al., 2015; Weinstein et al., 2013). They can find the best real-world treatments. This data-driven approach aids in revealing trends that lead to better patient outcomes (Jensen et al., 2012). These datasets also provide support for healthcare management through optimizing hospital workflows, predicting patient admission rates, and managing resources (Rajkomar et al., 2018; Shickel et al., 2018). This enhances operational efficiency and delivery of care. And all of these, they also support public health programs. For example, datasets can be used to geographically track the affected areas and use the data to start targeted vaccination drives and health education campaigns. Hence, clinical data is the cornerstone of contemporary healthcare datasets, providing a valuable source of information for the enhancement of patient care and medical research (Johnson et al., 2023). The data are collected from a range of sources, including electronic health records (EHRs), medical imaging, and genomic sequencing (Jensen et al., 2012; Prosperi et al., 2018).

Medical imaging, such as endoscopy databases, also helps reduce diagnostic variability among clinicians. The interpretation of endoscopic images can differ depending on the experience and expertise. Despite substantial progress in healthcare and medical datasets, several challenges remain in endoscopy dataset development. These include privacy and ethical concerns, data imbalance, limited demographic diversity, and insufficient real-world validation across institutions.

The World Health Organization (WHO) has a global health data repository that is open access and collects clinical data from health systems around the globe. The abundance of health data allows researchers to conduct healthcare analytics, providing valuable insights into disease progression, treatment effectiveness, and patient outcomes. Datasets such as the Alzheimer's Disease Neuroimaging Initiative (ADNI; Mueller et al., 2005) and The Cancer Genome Atlas (TCGA; Weinstein et al., 2013) add another layer of richness by providing granular clinical data on disease progression, genetic markers, and therapeutic responses. Such resources are important for developing machine learning models that can predict clinical outcomes, personalize treatments, and ultimately improve patient outcomes while reducing healthcare costs. Utilizing such a comprehensive collection of clinical data, the healthcare sector is better equipped to address global health challenges and drive innovation in medical research.

Medical data have several unique characteristics that differ from data in other disciplines: medical data are often difficult to obtain (Jensen et al., 2012; Raghupathi & Raghupathi, 2014) are usually based on protocols, collected, and relatively structured (Bellazzi & Zupan, 2008; Wang et al., 2018) and, when analyzing data and interpreting results, the role of professional knowledge may be dominant (Bellazzi & Zupan, 2008) and time-dependent mixing. Medical data are large in scale, extremely fast in updates, polymorphic, incomplete, and time sensitive (Raghupathi & Raghupathi, 2014; Shickel et al., 2018). These data should be efficiently gathered, arranged, integrated, and stored in a way that is accessible and shareable. Henceforth, healthcare providers should implement robust data entry and management systems to collect high-quality data. These systems must ensure the accuracy and completeness of the information. In general, considering all these factors together, medical databases are relational databases by data model, secondary or public databases by data source, and research and specialized and Online Analytical Processing (OLAP) enabled by usage and are frequently distributed or cloud-hosted by architecture (Branescu et al., 2014; Herland et al., 2014).

Healthcare datasets are of different types, based on their structure, purpose, and utility. Electronic Health Records (EHR) databases provide a comprehensive record of patient history, including diagnoses, medications, lab results, and provider notes, enabling longitudinal tracking and care coordination (Centers for Medicare & Medicaid Services [CMS], n.d.). They have revolutionized the manner in which healthcare providers handle patient information. For example, Medical Information Mart for Intensive Care (MIMIC-III; Johnson et al., 2016) offers de-identified ICU data for more than 40,000 patients, and Shaip's EHR dataset has 5.1 million records across 31 specialties (KMS Technology, n.d.; Shaip, 2025). The second type are databases of ICU-specific data such as vital signs, ventilators, labs, and severity scores. Includes MIMIC and eICU Collaborative Research Database (eICU-CRD; Pollard et al., 2018), with severity scores and real-time monitoring data, outcome prediction, and sepsis and ventilation research. Clinical trial databases stem from research studies that evaluate medical, surgical, or behavioral treatments in patients; these support outcomes and evidence-based research. Notable instances are the Healthcare Cost and Utilization Project (Agency for Healthcare Research and Quality [AHRQ], 2024) for U.S. hospital stays and emergency visits, alongside the ADNI (Mueller et al., 2005) for dementia biomarkers. Public health and epidemiology databases focus on aggregating population-level statistics; these aid surveillance and policy. A few databases, such as the U.S. Department of Health and Human Services (HHS) datasets available through Data.gov (General Services Administration [GSA], 2025) and WHOs Global Health Observatory (WHO, 2025) for global indicators on mortality, are developed for monitoring general public health trends and to enhance the well-being of individuals. However, the information could also prove beneficial for other training sets in research or additional public health domains. Some other similar databases, such as the Human Mortality Database (WHO, 2025), offer access to data on mortality rates, population figures, and various health and demographic statistics for 35 nations, whereas other databases like The Child Health and Development Studies (CHDS; 2025), Merck Molecular Activity Challenge (Merck & Co., Inc., 2012), and 1000 Genomes Project (The 1000 Genomes Project Consortium, 2015) are also purposed for general public health through researching genomic expression and oncology databases. For example, The Cancer Genome Atlas (TCGA; Weinstein et al., 2013) analyzes over 11,000 tumor samples, complemented by Surveillance, Epidemiology, and End Results (SEER) Program, which provides population-based data on cancer incidence, survival, and mortality (National Cancer Institute [NCI], 2025). For cancer incidence, these genomics and oncology databases capture molecular profiles for precision medicine and also account for the influence of social, environmental, and cultural factors on disease and health. Some of the above-mentioned databases, such as data.gov and WHOs Global Health Observatory (WHO, 2025), are freely available and have open access; some, such as MIMIC and eICU-CRD are restricted in access. Some databases, such as Merck Molecular Activity Challenge, are designed to promote the application of machine learning. Finally, medical databases that are set to advance medical research are the medical imaging databases. Curated for the purpose of visual diagnostics and AI training, these store scans, videos, and annotations. Some of the databases discussed above, such as ADNI and MIMIC-III, are essentially medical imaging databases stored as part of EHRs, they support medical imaging and machine learning too. The ADNI database consists of data collected by scientists around the world whose mission is to characterize the progression of Alzheimer's disease. The dataset includes an extensive collection of Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) images, genetic data, cognitive assessments, and cerebrospinal fluid (CSF) and blood biomarkers, providing a multi-dimensional perspective on this complex condition. MIMIC-III, on the other hand, is a large database of ICU patient data, including imaging reports and clinical information. There is another database called Open Neuro (Markiewicz et al., 2021). It is a free and open platform; it shares a wide range of medical images, including MRI, magnetoencephalography (MEG), electroencephalography (EEG), Intracranial Electroencephalography (iEEG), Electrocorticography (ECoG), Arterial Spin Labeling (ASL) and PET data. It contains 563 medical datasets and 19,187 participants, making it an invaluable resource for researchers and healthcare professionals. Another one the Open Access Series of Imaging Studies (OASIS; Marcus et al., 2007) dataset that provides neuroimaging data for free to the public for the benefit of the scientific community. It is composed of 1098 subjects with 2168 MRI sessions and 1608 PET sessions, representing a rich resource for researchers. CheXpert purposed for automated chest X-ray interpretation; it is a vast dataset of over 224,000 chest X-ray images with uncertainty labels (Irvin et al., 2019). It plays a crucial role in radiology research and disease detection. The below table (Table 1) depicts existing medical imaging databases, their purpose, utility, format, access, and database type, and Table 2 specifies existing speech, hearing, and communication-based and dysphagia rehabilitation-based databases.

Table 1.

Existing medical imaging databases their purpose, utility, format, access, and database type.

Database Name	**Purpose**	**Utilities**	**Unique Features**	**Format**	**Common Software**	**Access Type**	**Database Type**
ADNI (Alzheimer's Disease Neuroimaging Initiative)	Track Alzheimer's progression via multimodal data	Disease modeling, biomarker discovery, ML for neurodegeneration	MRI/PET, genetics, cognitive/CSF biomarkers; longitudinal	NIfTI, DICOM	FSL, FreeSurfer, SPM	Restricted (application/review)	Multimodal Clinical
MIMIC-III/IV (Medical Information Mart for Intensive Care)	ICU patient management /outcomes analysis	Aspiration pneumonia prediction, ventilator weaning	Time-series vitals/labs, de-identified EHR; >60K admissions	CSV, waveform (WFDB)	PostgreSQL, Python (pandas)	Restricted (CITI training/PhysioNet)	Relational Critical Care EHR

OpenNeuro	Share neuroimaging data openly	AI training, reproducibility in brain research	MRI/MEG/EEG/PET; 563 datasets, 19K subjects	BIDS, NIfTI	FSL, MRIcron, EEGLAB	Open	NoSQL/Object (BIDS standard)
OASIS (Open Access Series of Imaging Studies)	Provide free neuroimaging for science	Aging/dementia studies, ML benchmarks	1,098 subjects; 2,168 MR/1,608 PET sessions	NIfTI	SPM, FSL	Open	Relational/Hierarchical
CheXpert	Automated chest X-ray interpretation	Radiology AI, disease detection	224K images with uncertainty labels	DICOM, PNG	PyTorch, MONAI	Open	Key-Value/Image Repository
KID Project (Capsule Endoscopy Atlas)	MDSS research in SB pathology	AI for CE lesion detection	Annotated images/videos; MySQL backend	JPG/MP4, semantic annotations	Coppermine, MySQL	Open	Relational

Table 2.

Existing speech, hearing, and communication-based and dysphagia rehabilitation-based databases: their purpose, utility, format, access, and database type.

Speech, hearing, and communication-based databases

Database Name	Purpose	Utilities	Unique Features	Format	Common Software	Access Type	Database Type
AVFAD (Advanced Voice Function Assessment Databases)	Voice pathology diagnosis/research	Non-invasive voice analysis	8,648 audio files + Praat parameters/ clinical data	WAV, Praat .TextGrid	Praat, Python (librosa)	Restricted (email request)	Relational (CSV + audio)
Arabic Voice Pathology Database (AVPD)	Voice disorder detection in Arabic speakers	Cross-lingual pathology classification	366 samples (normal/pathological: sulcus/nodules/etc.)	WAV	Praat, ML toolboxes	Open (paper-linked)	Relational
VOICED Database (Healthy/Pathological Voices)	Voice pathology studies	Automatic detection/classification	208 samples (/a/ vowels); PhysioBank format	WAV, .dat/.hea	Physio Toolkit, WFDB	Open	Relational Time-Series
FEIS (EEG Imagined Speech)	Imagined speech BCI research	Phoneme decoding from EEG	21 English/2 Chinese speakers (listening/imagining/speaking phonemes); 5 CSV/participants	CSV	MATLAB/Python	Open (GitHub/Zendesk)	Relational Time-Series
Dysphagia rehabilitation-based databases							
Database Name	**Purpose**	**Utilities**	**Unique Features**	**Format**	**Common Software**	**Access Type**	**Database Type**

VFSS2022 Dataset	VFSS analysis for swallowing disorders	AI in videofluoroscopy	Annotated VFSS videos (swallowing dynamics)	Video (MP4)	Custom viewers	Open	NoSQL Video Repo
FEES-IS (Real-time Instance Segmentation of FEES)	AI segmentation of swallowing structures	Residue/penetration detection in FEES videos	Real-time instance segmentation; endoscopic frames	Video frames (MP4/JPG)	PyTorch, Detectron2	Restricted (ResearchGate/authors)	NoSQL Document (annotations)
FEES-CAD (Fukushima Med Univ)	CNN training for aspiration/residue detection	CADx in dysphagia assessment	199 train/40 test annotated videos; de-identified	Video (AVI/MP4), annotations (JSON)	TensorFlow, MATLAB	Restricted (contact authors)	Relational NoSQL Hybrid

As per this review, it is evident that extensive imaging databases exist in medicine especially video-based databases such as KID Project database in gastrointestinal endoscopy (Koulaouzidis et al., 2017) and radiology; these generally focus on anatomical or pathological structures without functional swallowing dynamics (Kwak et al., 2025). FEES databases are scarce, with only one currently available FEES-CAD, an AI-assisted computer-aided detection (CAD) system for real-time aspiration and penetration identification during FEES procedures. Weng et al. from Fukushima Medical University compiled a FEES video dataset compiling 199 training and, additionally, 40 testing videos, which were de-identified and annotated by three otolaryngologists using the Penetration-Aspiration Scale (PAS). Preprocessing included segmentation of videos into swallow trails, and then they were subject to a custom convolutional neural network for binary classification of the presence of aspiration or penetration vs. normal swallows. Training involved 5-fold cross-validation and focal loss for class imbalance along with data augmentation using rotation or flip. Evaluation revealed Area Under the Curve (AUC) measures of 0.92 on the test set, and frame-level sensitivity of 85% and a specificity of 90% revealed favorable results when compared to novice endoscopists. Clinical validation included testing on 50 prospective FEES exams demonstrates real-time utility for reducing oversight in dysphagia assessment. Although it is a decent attempt at advancing medical care, it is limited to AI training purposes with no broad clinical or training access (Weng et al., 2022). Alternatively, a video-based database of VFSS exists (Martin-Harris et al., 2008), but this does not fully address the unique endoscopic perspective of FEES (Molfenter & Steele, 2014). The benchmark requirements for machine learning are high-quality and sufficient clinical datasets in healthcare as well. However, such a validated dataset is difficult to obtain due to lack of standardization, data quality issues, diverse clinical populations, and other technical barriers. This underscores the critical need for the development of an accessible, comprehensive, and functional FEES video database to support multipurpose clinical training, research, and technology development (Burdick et al., 2024; Oliveira et al., 2022).

Meeting these challenges requires the establishment of a centralized, curated FEES video database that supports dynamic video content annotated with swallowing events and full metadata. Unlike static image repositories, video-based databases contain the temporal swallowing biomechanics and sequence of events critical for accurate interpretation, enhancing both clinical training and research accuracy (Kwak et al., 2025; Molfenter & Steele, 2014; Ramez et al., 2010). These databases enable consistent learning and calibration across all levels of clinicians and provide invaluable datasets for artificial intelligence or augmented reality training, allowing automated recognition of swallowing events and improved diagnostic tools in the future (Burdick et al., 2024; Weng et al., 2022)

Given that FEES is an instrumental evaluation, these repositories must be designed not just to store video or image records but to integrate rich, validated interpretations that account for inter-rater variability and encompass detailed physiological, anatomical, and clinical metadata (Burdick et al., 2024; Kwak et al., 2025). A common platform with standardized FEES data may be a major leap towards uniformity in professional practice across the globe. A centralized FEES video database that offers features to standardize the data quality across variables of bolus, population, dysphagia type and etiologies, assessment methods, etc. could form a source of immense information for clinical, research, and academic purposes (Kwak et al., 2025; Molfenter & Steele, 2014). The proposed study is aimed at developing the basic outline and digital layout of one such endoscopic database titled “A Novel Swallowing Endoscopy Record Database (ANSwEReD™[1])”. The study is planned to initiate a systematic annotated FEES video image database that provides classified information on the client demographics, medical history, symptoms, safety scores, efficiency scores, and therapy progress. The study will include identification of the FEES examinations conducted over a fixed period of time and integrate them into the ANSWERed database. The below table (Table 3) compares the recommended features of an image database and the features proposed for the ANSwEReD database.

Aim of the study:

The current study aimed to develop a medical imaging database for flexible endoscopic examination (FEES) of typical and atypical swallowing functions. The study aimed to result in a

[1]ANSwEReD is in the process of registration under Trademark Act, 1999

classified, de-identified, annotated, video database on FEES examinations that could serve as a secondary database for clinical training and research in the procedure.

Table 3.

A comparison between features of an image database and that of the proposed ANSwEReD database.

Feature	**Existing FEES Database**	**ANSwEReD Database**
Publicly accessible	No	Yes, for contributors, for limited time
Comprehensive video annotation	Limited	Extensive, standardized, multi-parameter
Validated inter-rater reliability	Limited	Included as core component
Quantitative swallowing measures	Rare	Integral part of database
Covers broad patient demographics	Limited	Wide age and clinical range
Designed for clinician training	No	Primary goal
Supports AI training & research	Limited	Supported
Multimedia indexing (video + meta)	No	Yes
Client, protocol and technical variables	No	Incorporated systematically

Objectives of the study:

Specific objectives of the study were to

1. Categorize and annotate high-quality FEES recordings of typical and atypical swallows.
2. Integrate the classified data into a structured, de-identified imaging database
3. Evaluate inter-rater reliability of classification and annotation
4. Evaluate user feedback on the database for appeal and utility.

CHAPTER- III

METHOD

The current study was a retrospective, observational analysis of the archived clinical evaluation records in the Centre for Swallowing Disorders from 2024 to 2026. The data from this period was specifically targeted as the updated endoscopic infrastructure (M/s ATMOS Flexible Endoscope, Germany) and uniform data collection protocols were implemented for routine evaluation during this period. This controlled the variables related to equipment quality and data collection process in the quality of data included in the database. The methodology followed for the current study was reviewed and accepted by Institutional Review Board vide SH/IRB/M.5/SLP.30/2025-26.

The development of this database (AnSwERed^{TM}, from this point onwards) required retrieval, categorization of data, tabulation of relevant annotations related to client demographics, FEES task and procedure such as phonation and swallow bolus characteristics etc, and integration of these into a structured digital database designed specifically for the purpose. The developed database is an institute product with potential registration for multiple Intellectual Property Rights for database nomenclature (in process), organization, annotation, and algorithms. The methodology followed for the development of AnSwERed™ is described under various stages below:

Retrieval and classification of FEES data

The database aimed at inclusion of typical and atypical FEES data for providing a comprehensive dataset for clinical training. The data was selected systematically with careful review of the archived data within the ATMOS repository available at the institute (on-site database) for appropriate FEES recordings, as described below:

Typical Data: The archived FEES recordings in the dedicated endoscopic system (ATMOS Medizin Technik, 2020) was reviewed for recordings from typical individuals that were systematically obtained for other research purposes. These recordings were collected for another simultaneous research work aimed at quantification of specific data from FEES studies and were hence uniformly collected from a group of typical adults using strict screening and inclusion criteria.

Atypical data: The medical record database from January 2024 to March 2026 in the Centre for Swallowing Disorders, All India Institute of Speech and Hearing was reviewed for identification of clients who were recommended for FEES evaluation after detailed clinical subjective evaluation by expert SLPs. The list of clients from the medical records was the basis for review of the archived FEES recordings in the dedicated endoscopic system (ATMOS Medizin Technik, 2020)

All the FEES recordings were retrieved in .MP4 format for further analysis. The video records of FEES examinations conducted in the Centre for Swallowing Disorders from January 2024 to 2026 were categorized into two mutually exclusive datasets:

Annotation of Retrieved FEES recordings

Each retrieved recording (referred to as 'data' from this point forward) went through further categorization and annotation in the following steps:

Step 1: Each FEES examination in the .mp4 format was reviewed for visualization of the following:

1. Velar movement while prolonging the vowel /i/
2. Velar movement during swallows using a bolus (liquid- IDDSI 1/2; honey-thick liquid- IDDSI 3/4; puree-IDDSI 5; solids- IDDSI 6-8).

3. Glottal function while prolonging the vowel /i/
4. Glottal function during breath-hold maneuvers (light, and tight)
5. Pharyngeal function during swallows using a bolus (liquid- IDDSI 1/2; honey-thick liquid- IDDSI 3/4; puree-IDDSI 5; solids- IDDSI 6-8)

This review was based on the simultaneous audio data of instructions and procedure with the FEES examinations. The endoscopist narrated the events and observations during the procedure that facilitated reliable categorization of the data for this step. Also, the client evaluation records were used to verify the boluses provided during evaluation for annotation of swallowing functions.

Step 2: Each data point was tabulated for the following annotations related to data demographics, tasks, medical history, using Microsoft Excel® (Microsoft Corporation, Redmond, WA, USA). Table 4 provides the annotations tabulated for a sample of actual data. The data with visualization of at least two among the five functions (velar movement during phonation and swallow, glottic function for phonation and swallow, and breath hold) was selected for further inclusion.

Step 3: Each selected datum was reviewed again for the clarity of visuals before and after the target function (phonation, swallow, and breath hold). The judgment on clarity was based on instances of fogging, loss or disturbed endoscopic view, movement artifacts, and residue sticking on the scope lens restricting clear visualization. The review remarks were tabulated for each datum. Specifically, the following frames were targeted for clear visualization under each of the five functions:

a) Velar movement while prolonging the vowel: initiation of velar closure, Maximum velar closure, Return of velum to its baseline position

b) Velar movement during bolus swallows: Initiation of velar closure, Maximum velar closure, Return of velum to its baseline position

c) Glottal function while prolonging the vowel /i/: Initiation of arytenoid closure, Maximum medial movement of arytenoids, Return of arytenoid to its baseline position

d) Glottal function during breath-hold maneuvers (light, and tight): Change in area of laryngeal vestibule during light breath hold, Change in area of laryngeal vestibule during tight breath hold

e) Pharyngeal function during bolus swallows: Entry of bolus into the pharynx, Onset of whiteout, Offset of whiteout, Frame after offset of whiteout

Step 4: The data judged as 'clear' in the previous step were clipped into separate video clips for each target function using *Kinovea* (Version 2023.1.2; Charmant & Contributors, 2024). The playhead for each clip was positioned 2 frames prior to the initiation of the target movement, and the offset was defined as 2 frames following completion of the target function. The following frames were considered for preparing the video segments relevant for the function.

a) Velar movement while prolonging the vowel:

- Onset of Velar closure: The first frame where a posterior-superior movement of the velum was evident.
- Offset of velar closure: The final frame showing velum in baseline position after maximum velar movement

b) Velar movement during bolus swallows:

- Onset of velar closure: The first frame showing posterior movement of velum after the clinician says "swallow now" .

- Offset of velar closure: The final frame showing velum in baseline position after maximum velar movement

c) Glottal function while prolonging the vowel /i/:

- Initiation of arytenoid closure: The first frame showing movement of arytenoids toward each other.
- Return of arytenoid to its baseline position: The duration between the last frame of complete contact of arytenoids to the first frame of most lateral movement of aretenoid

d) Glottal function during breath-hold maneuvers

- Initiation of arytenoid closure: The first frame showing movement of arytenoids toward each other for breath hold
- Return of arytenoid to its baseline position: The duration between the last frame of complete contact of aretenoids to the first frame of most lateral position of aretenoid.

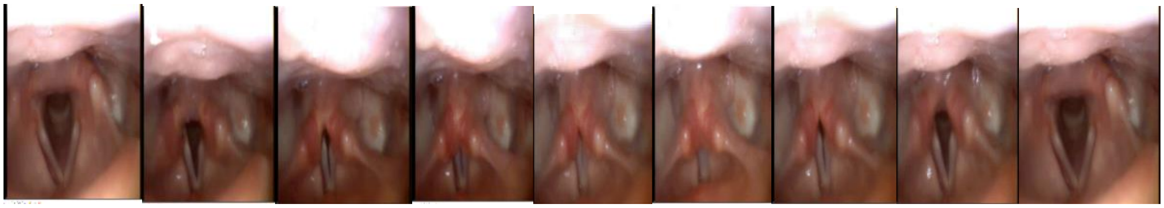
e) Pharyngeal function during bolus swallows:

- Entry of bolus into the pharynx: The time of first frame with bolus head visible in the pharynx/onset of white out, whichever is first.
- Frame after offset of whiteout: The first frame where minimum residue post white out is seen.

In case multiple visualizations of the same function were available, the most ‘clear’ performance was selected (for example, multiple trials of the same bolus or multiple iterations of vowel prolongation, etc.). Figures 1-4 are depictions of a series of sample frames identified for velar and glottal function for phonation, swallowing, and breath-holding.

Figure 1

Sample frames that represent 2 sec before the onset of medial arytenoid movement to 2 sec after the offset of lateral arytenoid movement for the phonation task.



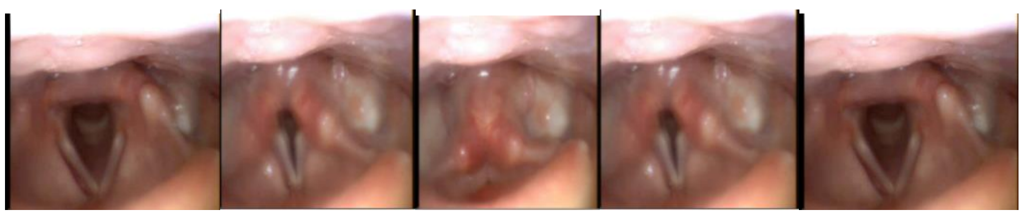
0.00 (initiation of arytenoid closure)

0.90 (Max. medial movement of arytenoids)

5.47 sec Return of arytenoid to baseline)

Figure 2.

Sample frames that represent 2 sec before onset of medial arytenoid movement for breath hold to 2 seconds after the offset of lateral arytenoid movement for breath holding task



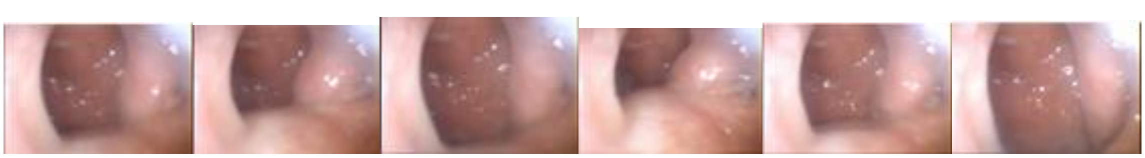
0.00 (initiation of arytenoid closure)

0.73 (Max. medial and sphincteric closure of airway)

1.97sec Return of arytenoid to baseline)

Figure 3.

Sample frames that represent 2 sec before onset of posterior movement of velunm to 2 sec after offset of relaxation of velum to baseline for phonation task.



0.00 (Onset of velar closure)

0.57 (Maximum velar closure)

1.18 (Offset of velar closure)

Figure 4.

Sample frames that represent 2 sec before entry of an IDDSI 1-2 bolus into the pharynx to 2 sec after offset of whiteout event after a swallow task.

0.00	1.40	1.44	2.16	2.23
(2 secs before entry of Bolus into the pharynx)	(entry of bolus into the pharynx)	(onset of whiteout)	(Offset of whiteout)	(frame after offset of white out)

Step 5: Each clipped video segment was then subjected to annotations using specific labels under the following heads.

- Demographic characteristics
- Medical background
- Task parameters
- Clinical outcomes.

Specific subcategories under these headings and their definitions are detailed below

Table 4.

Definitions for categorization, filters, and their annotations in the database.

Category	Filter	Definitions of each filter
Demographics characteristics	1. **Age:** Categorizes individuals based on chronological age at the time of assessment.	➢ **18–39**: Young adults between 18 and 39 years ➢ **40–59**: Middle-aged adults between 40 and 59 years ➢ **>60**: Older adults aged above 60 years
	2. **Gender:** Indicates the gender identity of the individual	➢ **Male**: Individuals identified as male ➢ **Female**: Individuals identified as female ➢ **Rather not specify**: Gender not specified or undisclosed
	3. **Type of data:** Describes the presence or absence of swallowing complaints	➢ **No dysphagia**: Individuals without reported swallowing difficulties ➢ **Dysphagia**: Individuals with reported swallowing impairment
Medical background	**1. Medical diagnosis:** Represents the primary medical condition associated with dysphagia	➢ **CVA**: Cerebrovascular accident confirmed through neurological evaluation and neuroimaging

	➢ **HNC**: Head and neck cancer diagnosed through oncological assessment ➢ **Vocal fold palsy**: Diagnosed via endoscopic evaluation by an otolaryngologist ➢ **Neurocognitive degenerative**: Includes conditions such as Parkinson's disease, Alzheimer's disease, and other dementias as per neurologist report ➢ **Motor neuron disease**: Diagnosed by a neurologist ➢ **Traumatic brain injury**: Neurological injury due to trauma (e.g., road traffic accidents) ➢ **No diagnosis**: No confirmed medical diagnosis available
2. Symptoms: Indicates patient-reported or clinically observed swallowing-related symptoms	➢ **Choking**: Sensation of food obstruction in the throat with associated breathing difficulty ➢ **Effortful**: Increased effort required during swallowing

		➢ **Cough:** Reflexive response to swallowing difficulty with forceful expelling in the form of a cough observed before, during or after food intake ➢ **Nasal regurgitation**: Passage of food or liquid through the nasal cavity during swallowing ➢ **No swallow**: Absence of observable swallow reflex following bolus entry ➢ **NPO**: Nil per oral status; individual is on enteral or tube feeding as per previous recommendation
Task and Swallow Parameters	1. **Task:** Specifies the task performed during FEES	➢ **Phonation**: Sustained production of /i/ following clinician instruction ➢ **Breath hold**: Voluntary breath-holding maneuver on instruction ➢ **Swallow**: Swallow initiated after bolus administration, typically on cue

	2. Number of swallows: Indicates the number of swallows observed per bolus	➢ **1**: Single swallow ➢ **2**: Two swallows, either sequential or compensatory ➢ **3**: Three swallows ➢ **>3**: More than three swallows
	3. Bolus: Classifies bolus consistency based on IDDSI levels	➢ **IDDSI 1–2**: Thin liquids (e.g., coloured water or milk) ➢ **IDDSI 3–4**: Thick liquids or semi-solids (e.g., coloured curd) ➢ **IDDSI 5–6**: Soft solids (e.g., mashed banana) ➢ **IDDSI 7**: Regular solids (e.g., cookies)
Functional and Clinical Scores	**1. Function visualized:** Indicates the anatomical function assessed	➢ **Velar**: Velopharyngeal function during phonation or swallowing ➢ **Vocal fold movement**: Glottal function observed during phonation, breath hold, or swallowing
	2. Intervention status: Specifies the timing of assessment relative to therapy	➢ **Pretherapy**: Assessment conducted prior to swallowing intervention ➢ **Posttherapy**: Assessment conducted following completion of therapy

3. PAS score: The Penetration–Aspiration Scale (PAS) (Rosenbek et al., 1996) evaluates the severity of airway invasion and the individual's response. It is an 8-point ordinal scale. For the database, the PAS scores were independently provided by two SLPs, and consensus on the score was obtained for every data included in this database. Each score is described as below

Score	**Description**	**Safety Status**
1	No airway entry	Safe
2	Entry above vocal folds, ejected	Flash penetration
3	Entry above vocal folds, not ejected	Penetration
4	Contacts vocal folds, ejected	Penetration
5	Contacts vocal folds, not ejected	Penetration
6	Passes below vocal folds, ejected	Aspiration
7	Passes below vocal folds, not ejected despite effort	Aspiration
8	Passes below vocal folds, no attempt to eject	Aspiration

4. Yale residue: The Yale Pharyngeal Residue Severity Rating Scale (Neubauer et al., 2015) provides location-

Vallecular Residue

Grade	**Severity**	**Percentage**	**Description**
I	None	0%	No residue

specific grading of residue severity. The scale is provided below

II	Trace	1–5%	Minimal coating
III	Mild	5–25%	Epiglottic ligament visible
IV	Moderate	25–50%	Epiglottic ligament covered
V	Severe	>50%	Filled to epiglottic rim

Pyriform Sinus Residue

Grade	**Severity**	**Percentage**	**Description**
I	None	0%	No residue
II	Trace	1–5%	Minimal coating
III	Mild	5–25%	Up wall to quarter full
IV	Moderate	25–50%	Up wall to half full
V	Severe	>50%	Filled to aryepiglottic fold

5. Residue location: Identifies the anatomical site of post-swallow residue

- ➢ **Valleculae**: Residue in vallecular space, between the tongue base and lingual side of epiglottis.
- ➢ **Posterior pharyngeal wall**: Residue along the superior, middle or inferior posterior pharyngeal wall

	➢ **Epiglottis**: Residue coating the rim or laryngeal side of epiglottis ➢ **Pyriform sinus**: Residue in one or both pyriform sinuses and/or posterior commissure ➢ **Laryngeal vestibule**: Residue within the laryngeal vestibule defined as the area surrounded by epiglottic petiole, ary-epiglottic folds, inter aretenoid region in the hypopharynx.
6. Response to residue: Describes the immediate physiological or behavioral response to the presence of residue in the oro-pharyngeal area	➢ **Cough**: Expulsive response with visible airflow or bolus movement ➢ **Throat clearing**: Brief glottal clearing attempt with visible closure of vocal folds ➢ **Multiple swallows**: Additional swallows with no entry of another bolus into the pharynx. ➢ **No response**: No observable or reported response within 10 seconds

Step 6: Each video was systematically encoded following the customized pattern for the current study (Table 5). This was done to enable back-end tracing of source of data for future modifications in the database.

Table 5.

Scheme for coding the videos for its annotation

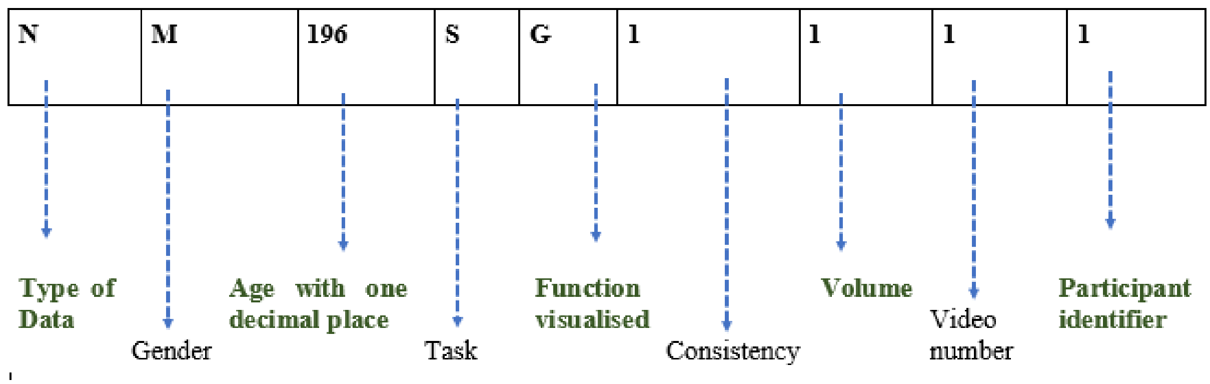
Variable	Description And Codes
Medical Diagnosis	CV (Cerebrovascular Accident)
	HN (Head & Neck Cancer)
	VF (Vocal Fold Paralysis)
	ND (Neurocognitive Degenerative)
	MN (Motor Neuron Disease)
	TB (Traumatic Brain Injury)
	N (Normal)
Gender	M = Male
	F = Female
Age	Two Digits + One Decimal (E.g., 19.6 encoded as 196)
Task	S = Swallow
	P = Phonation
	B = Breath Hold
Function Visualised	G = Glottal (Vocal Fold Movement)
	V = Velar Movement

Bolus Consistency	0 = No Bolus
	1 = IDDSI 1–2
	2 = IDDSI 3–4
	3 = IDDSI 5–6
	4 = IDDSI 7–8
Bolus Volume	0 = Not Measured
	1 = 5 ml
	2 = 10 ml
	3 = 15 ml
	4 = 20 ml
Video Number	Sequential numbering (E.g., 1 = First Video, 2 = Second Video)
Participant Identifier	Sequential numbering for participants with identical profiles

Based on the coding scheme in Table 5, the code NM196SG1111 corresponds to the first video of glottal function during swallow of ml IDDSI 1–2 consistency obtained from a healthy male of 19.6 years. This is the first video of this participant in the current task. The code NM196SG11112 refers to the second video in this series in the same condition. Similarly, in the clinical data, code CVM820SG3111 refers to the first swallow in the series of glottic function visualization for a swallow of a 5 ml bolus with IDDSI 5–6 consistency obtained from an 82.0-year-old male with dysphagia post-CVA. Figure 5 depicts the pattern and nomenclature of sample data.

Figure 5.

A hypothetical video number and its decoding



Design and integration of data into digital database

The graphical user interface (GUI) of the developed endoscopy database system was designed to provide a simple, efficient, and user-friendly platform for accessing and managing endoscopic video data. The complete system was divided into three major components: the front-end interface, the admin portal, and the back-end database.

The front-end and admin portal were developed using Microsoft Visual Studio 2022 (Licensed Version), while the back-end database was implemented using MySQL, focusing on a user-friendly interface. The front-end GUI consists of a home page with a self-explanatory video. The introductory welcome page of the database was developed and included a video demonstration on 'How to use ANSwEReD'. This serves as a video manual for future and new users. The specific visual content and the audio script of the instructional video are provided in Appendix A. Users can access the front end and admin portal by entering their name and mobile number for authentication. This maintains traceability and simplicity. Upon login, the interface will allow navigation through patient records (unique ID) and video clips. Standard scoring guidelines are also provided in drop-down menus, radio buttons, and links to reduce user errors and ensure consistent annotation. Importantly, all video files are allowed to be streamed but not downloadable to ensure privacy and ethical standards are maintained.

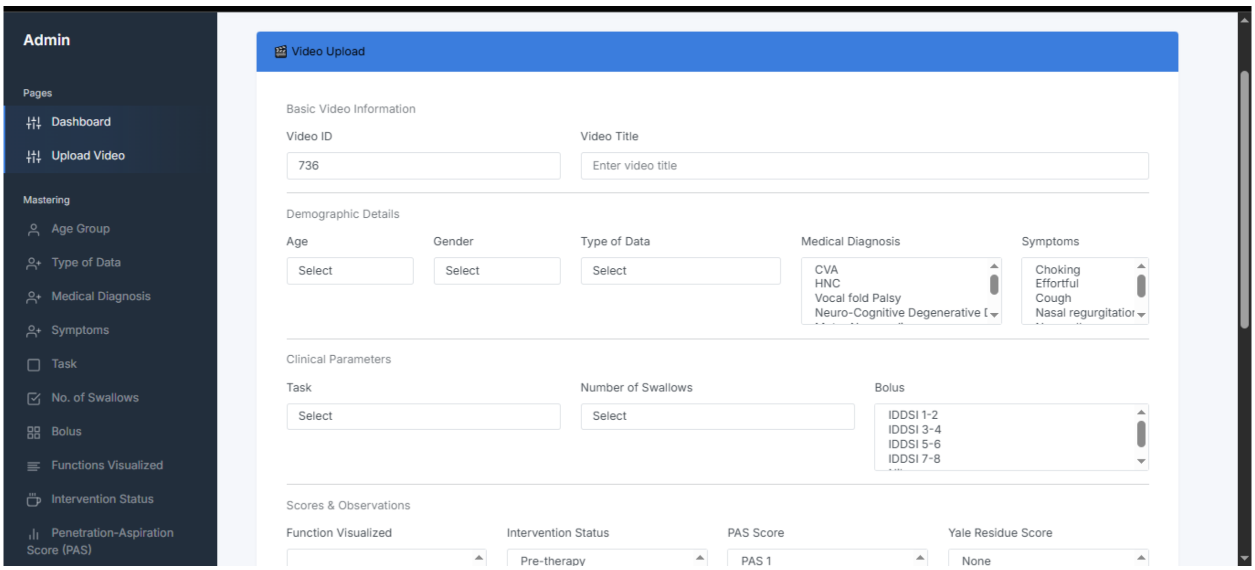
The design and development of endoscopic swallowing video databases was based on a model where recordings were systematically organized with subject metadata and standardized tasks to ensure consistency. Demographic characteristics, diagnostic data, treatment stage, swallow tasks, bolus consistency (IDDSI levels), penetration-aspiration scores, pharyngeal residue ratings, and compensatory responses were annotated for each video clip. This framework facilitates clinical practice and scientific advancement by converting raw recordings into research-ready datasets.

The admin portal was developed as a centralized management system to maintain the database content. This portal allows administrators to insert, update, and delete videos with minimum effort. The goal of the portal's design was to organize the front end, with easy operation and efficient database management. The admin portal has a secure login authentication system, which allows access to authorized administrators only. Back-end MySQL database to check IDs and passwords for secure access and data protection.

The admin portal has been designed with structured navigation menus, search options and filtering mechanisms to improve usability and help administrators quickly find and manage specific records. The interface helps to manage large amounts of endoscopic data efficiently and cuts down the time for database maintenance activities. The admin portal connects directly to the back-end MySQL database so that the data stored in the database and the front-end application are synchronized in real-time. Changes made through the admin portal, such as adding, editing or deleting videos, are immediately reflected in the front-end interface. This integration ensures data consistency and the smooth running of the entire system. (Figure 6) is screenshot of Admin portal where videos and annotations are uploaded which are immediately reflected on the front end of the database

Figure 6.

Screenshot of the Admin portal of the database where videos and annotations can be uploaded.



The back end was a MySQL relational database that stored patient information, session metadata and annotation records in normalized tables . Each patient was associated with records and each record with multiple annotated clips. The database contains tables for user authentication (usernames and passwords) and detailed information for endoscopic videos along with its metadata. This structure was believed to allow flexible querying such as obtaining all instances of stroke patients with moderate severity on thin liquids or comparing pre- and post-therapy swallow efficiency between diagnostic groups. The video files themselves were stored on a secure server with database entries pointing to file locations for performance and security optimization . The application is available at the web page https://answered.aiishtools.co.in.

User-friendliness was achieved through a clear graphical interface that reflected clinical workflow from patient selection; to task identification . The rating criteria (e.g., trace vs. mild vs. severe) were specified in clear annotation manuals to ensure inter-rater reliability. The clinical annotation of swallowing video databases was a systematic process of labeling and scoring clinically relevant events from endoscopic recordings to produce structured, research-ready data. Clinicians adhere to guidelines such as penetration-aspiration scores, severity of residue, bolus type, and compensatory responses. Videos were carefully reviewed, segmented into discrete swallow events, and annotated using rating scales that were used manually. Consistency checks and software rules were applied to ensure accuracy. Annotations were stored as metadata linked to videos in a Microsoft Excel file (Microsoft Corporation, Redmond, WA, USA), where the corresponding video clip was mentioned in the duration of the event.

In addition to clinical utility, the database could be a resource for research. The annotated video clips provide a standard dataset for training AI and machine learning models to automatically detect dysphagia, classify severity, and predict outcomes. The database can support the development of computer vision algorithms for anatomical segmentation, bolus tracking, residue quantification, and real-time aspiration detection in image and video processing. From a clinical informatics perspective, the structured data facilitates large-scale analysis of patient demographics, disease patterns, and therapeutic outcomes, contributing to predictive models and precision rehabilitation.

The details of the annotations along with video clips were integrated into the customized, user-friendly digital database. The database is hosted on the on-campus AIISH server.

Inter-rater reliability of annotations:

Reliability and accuracy of the annotation and retrieval system were evaluated within the ANSwEReD™ database. An inter-rater reliability verification procedure was conducted using a random subset of 10 FEES video recordings. The verification process involved a speech-language pathologist applying the investigator-tabulated annotation variables as search filters within the database interface. The FEES recording that filtered-in was matched with the coded FEES data, as per the nomenclature. Accuracy of the retrieval and nomenclature was assessed. The annotation variables included demographic details, clinical diagnosis, swallow task, bolus consistency, endoscopic findings, and perceptual rating outcomes.

User Feedback

Temporary access to the final database was provided to ten speech-language pathologists (SLPs) in the country. These SLPs were selected from nationally accredited speech and hearing institutes and private clinics after obtaining their written consent for participation. Each SLP was given access to the database from their convenient environment. They were requested to navigate through the database in detail and provide their feedback and input. A questionnaire that probes into the following parameters was integrated into Google Forms®:

A. ***Appeal:*** the overall appearance, organization, layout, colour schemes

B. ***Accessibility:*** access to all features, view of data, annotations etc

C. ***User-friendliness:*** ease of understanding on how to navigate the database.

The questionnaire used for validation by the end-users under the appeal, accessibility, and user-friendliness category is provided below.

Table 6.

Components of the questionnaire for obtaining user feedback on ANSwEReD™ database

Section 1	Appeal
1.	The layout of the database was well organized.
2.	The color scheme used in the application is appropriate and comfortable to view.
3.	The font style and size were clear and easy to read.
4.	The visuals (images/graphics) were clear and appropriate.
5.	The overall appearance of the database is visually appealing.
6.	Any other suggestions that could enhance the user appeal of the database?
Section 2	**Accessibility**
7.	All features of the database were easily accessible.
8.	The data/content within the database could be viewed clearly.
9.	The annotations provided were clear and helpful.
10.	Different sections of the database could be accessed without technical difficulties.
Section 3	**User-friendliness**
11.	The database was easy to navigate.
12.	The technical instructions provided were clear and helpful.
13.	The audio quality was clear and understandable.

14.	The video quality was satisfactory.
15.	The filters within the tasks functioned properly.
16.	The loading time of the application was reasonable.
17.	There were no technical issues while using the application.
	Overall Satisfaction
18.	How satisfied were you with the overall user experience?
	Open-Ended Feedback
19.	Please provide any suggestions or feedback to improve the design, accessibility, or technical aspects of the database.

Responses for questions 1-18 were obtained using a 5-point Likert scale, with the lowest rating being 1-strongly disagree and 5-strongly agree. At the end of the questionnaire every participant was also provided with an open suggestion box for their constructive feedback. An 80% satisfaction rate in each item of the questionnaire was targeted. All the feasible suggestions provided by reviewers were incorporated into the database before the closure of this project. Justification for non-compliance was also provided to the reviewers (details in the results section).

Analysis

Item-wise descriptive statistical analysis for the average rating of the questionnaire by the reviewers was done and is detailed in the results section.

CHAPTER- IV

RESULTS AND DISCUSSION

The current study aimed to develop a novel swallowing endoscopy record database named "ANSwEReD™", a systematically planned, reliable, and structured medical imaging database for flexible endoscopic examination (FEES) aimed to support clinical training and future advanced technological and computing applications. The database included both typical and atypical FEES recordings, which were selected through rigorous evaluation of reliability and visual clarity. This work was based on the understanding of the ever-growing demand for unified data for global practice and improved clinical effectiveness. ANSwEReD™ is a user-oriented platform suitable for multidisciplinary utility. For this study, the archived database of the Centre for Swallowing Disorders was screened, categorized, and annotated before integrating it into a structured database with searchable filters, terminology, and instructions to facilitate efficient navigation through the database. In the long run, this database is expected to form a central repository for training on machine-assisted dysphagia analysis. The results of the methodological phases implemented are detailed below:

Retrieval and classification of FEES data

A total of 527 recordings from the year 2025-26 were screened for inclusion based on strict criteria. Among these, 396 videos belonged to healthy individuals, and 131 videos were from individuals with dysphagia. After the systematic, multi-level screening for the presence of oral trials and clarity of visuals, 35 recordings from typical and 44 recordings from individuals with dysphagia were screened out because of the following reasons:

- ➔ Only structural evaluation done

➔ Severe pooling of saliva with no swallow tasks

➔ Inability to follow instructions due to cognitive language or apraxic conditions

➔ Too many fogging incidences, or movement artifacts.

The remaining 361 recordings from typical individuals, and 87 recordings from individuals with dysphagia were included in the database. Therefore, at this point of time, ANSwEReD™ contains a total of 448 videos. The origins of these videos were from 20 typical individuals and 23 individuals with dysphagia. All data were collected using uniform clinical protocols and technical quality. The details of the screened-in data under each annotated filter incorporated into the ANSwEReD™ is provided in table 7.

Table 7.

Characteristics of the FEES data included in the ANSwEReD™ database at this stage

No dysphagia dataset			
Demographic variables	**Categories**	**Number**	**%**
Age (N=20)	18-39	19	95
	40-59 years	0	0
	>60 years	1	5
Gender (N=20)	Male	8	40
	Female	12	60
	Rather not say	0	0
Task (N = 361)	Phonation	38	10.52
	Breath-hold	1	0.27
	Swallow	322	89.19

Function visualised (N = 361)	Velar movement	178	49.30
	Vocal fold movement (Phonation task)/ Swallow (Swallow task)	183	50.69
Number of swallows (N=158)	1	58	36.70
	2	77	48.73
	3	14	8.86
	>3	9	5.69
Bolus consistency (N= 322)	IDDSI 1-2	103	31.98
	IDDSI 3-4	107	33.22
	IDDSI 5-6	101	31.36
	IDDSI 7-8	11	3.41

Dysphagia dataset

Demographic variables	**Categories**	**Number**	**%**
Age (N=23)	18-39	1	4.34
	40-59 years	4	17.39
	>60 years	18	78.26
Gender (N=23)	Male	20	86.95
	Female	3	13.04
	Rather not say	0	0
Medical Diagnosis (N=23)	CVA	11	47.82
	HNC	3	13.04
	Vocal Fold Paralysis	2	8.69

	Neurocognitive Degenerative	3	13.04
	Motor Neuron Disease	2	8.69
	TBI	1	4.34
	NA	1	4.34
Task (N=87)	Phonation	38	43.67
	Breath hold	3	3.44
	Swallow	46	52.87
Function visualised (N=87)	Velar movement	19	21.83
	Vocal fold movement (for phonation task)/ swallow (for swallow task)	68	78.16
Intervention status (N=87)	Pretherapy	87	100
	Post therapy	0	0
Number of swallows (N = 46)	1	5	10.86
	2	8	17.39
	3	6	13.04
	>3	27	58.69
Bolus consistency (N = 46)	IDDSI 1-2	14	30.43
	IDDSI 3-4	14	30.43
	IDDSI 5-6	9	19.56
	IDDSI 7-8	9	19.56
PAS Score (N = 46)	1	33	71.73
	2	8	17.39

	3	3	6.52
	4	0	0
	5	2	4.34
	6	0	0
	7	0	0
	8	0	0
Yale residue score (N = 46)	None	9	19.56
	Trace	18	39.13
	Mild	14	30.43
	Moderate	5	10.86
	Severe	0	0
Residue location (N = 46)	Valleculae	34	73.91
	Posterior pharyngeal wall	4	8.69
	Epiglottis	5	10.86
	Pyriform sinus	21	45.65
	Laryngeal vestibule	6	13.04
Response to residue (N = 46)	Cough	2	4.34
	Throat clearing	2	4.34
	Multiple swallows	37	80.43
	No response	8	17.39

The typical group had complete data with every participant providing clearly visualized pharyngeal events for phonation and swallow. In the data from the dysphagia group, certain events had to be screened out due to non-visualization, fogging, or not tested due to safety concerns. During a typical FEES evaluation of an individual with dysphagia, the bolus trials and sequences are decided in real time with utmost priority to swallow safety. Therefore, at any point, when significant swallowing concerns were revealed at any bolus volume of consistency, the evaluation may be discontinued. This leads to incomplete data sets from the clinical population, which is inherent to the FEES evaluation studies. In individuals with significant dysphagia and/or severe saliva pooling, FEES evaluation was restricted to non-swallow events (phonation, respiratory function and/or sensory testing) Also, in individuals with cognitive-language deficits or apraxic conditions data was incomplete with many movement artifacts and fogging incidences.

In the typical cohort, the majority of the data belonged to 18–39 years age range while in dysphagic cohort data predominantly comprised individuals older than 60 years. This is consistent with the increased prevalence of dysphagia among older adults (Baijens et al., 2016; Doan et al., 2022) . The database included more samples from healthy females and dysphagic male participants. The source of data with no dysphagia was from a research study that followed convenience sampling. However, the clinical data was sourced from the archive. Distribution of more male data in the clinical group may be related to the gender difference in prevalence of dysphagia (Cho et al., 2015; Wakabayashi et al., 2024) .

In a typical FEES evaluation, the number of swallow trials are more compared to phonation trials. Varied bolus volumes and consistencies are attempted in swallow evaluation. Therefore, it is only logical that the data related to swallow function was more in number, compared to phonation. However, presence of dysphagia may have further restricted the number of bolus trials for swallow evaluation in this group.

The distribution of swallowing frequency also differed between groups. In the typical group, most boluses were cleared within three swallows, restricting the number of annotations in this group. However, in the individuals with dysphagia, a greater proportion of swallowing events required more than three swallows for bolus clearance probably due to swallowing inefficiency or as compensatory behaviour (Kahrilas & Logemann, 1993; Omari et al., 2022). Consistent with this observation, dysphagic recordings were generally longer in duration from bolus introduction to pharyngeal clearance.

The distribution of data across bolus consistencies was broadly comparable between the typical and dysphagic groups with four different levels of consistencies represented in the database for both healthy and clinical swallow behaviours. However, the number of data available under each category varied due to differences in the overall source of data. Also, observation of velar movements for swallow task across bolus characteristics was not commonly practiced (Langmore et al., 1988; Warnecke et al., 2009). Retrospective data for the clinical group hence had minimal data on velar movement specifically for swallow of bolus. But, the same was available for typical group, as it was recorded for the purpose of another research study that aimed at studying velar movements for swallowing purposes.

The database did not aim at restricting the dataset to any specific medical condition, and was open to inclusion of neurogenic and non-neurogenic datasets. However, as the source of data was retrospective archived data, also due to increased prevalence of dysphagia in post-stroke (Cohen et al., 2016; Martino et al., 2005) there were more dataset for CVA medical diagnosis.

The proportion of data with PAS scoring 1-3 (normal or flash penetration) was more than the data that showed deeper penetration/aspiration (PAS4-8). This could be because of 2 reasons. Firstly, it might depict the functional status of clients who sought FEES evaluation in the centre for swallowing disorders. Or secondly, higher PAS scores resulted in movement artifacts or obscured visualization of swallow. Most data in the database had trace to moderate residue in the valleculae and pyriform sinus, correlating with the distribution of PAS data. There were more data on spontaneous multiple swallows as the response to residue correlating with greater swallow frequency among the clinical dataset. A total dataset of of 448 videos are currently included in the ANSwEReD^{TM} to support training and capacity building among SLPs in the procedure of FEES.

Integrate the classified data into a structured, de-identified imaging database

The annotated FEES video clips and associated clinical metadata were successfully integrated into a personalized and user-oriented digital database developed for the study. The database is currently hosted on the in-campus server at the All India Institute of Speech and Hearing (AIISH) . The database is temporarily accessible through cloud-based storage for controlled user access and data management. The interface was systematically organized to facilitate easy navigation and efficient retrieval of information. The primary navigation panel comprised four major sections: *Definitions*, *Instructions*, *Database*, and *Contact Us*.

The home page included information on the title, developer, IPR information, and year of development. A brief write up on the platform for the end users, and navigation options were also provided in the home page (Figure 7).

The 'Definitions' section was specifically designed for the support of the first-time users of this database and the multidisciplinary learners. This section summarized the standardized explanations of key FEES terminologies, annotation variables, and database filters used throughout the platform (Figure 8).

Figure 7.

The home page of the database on entry.

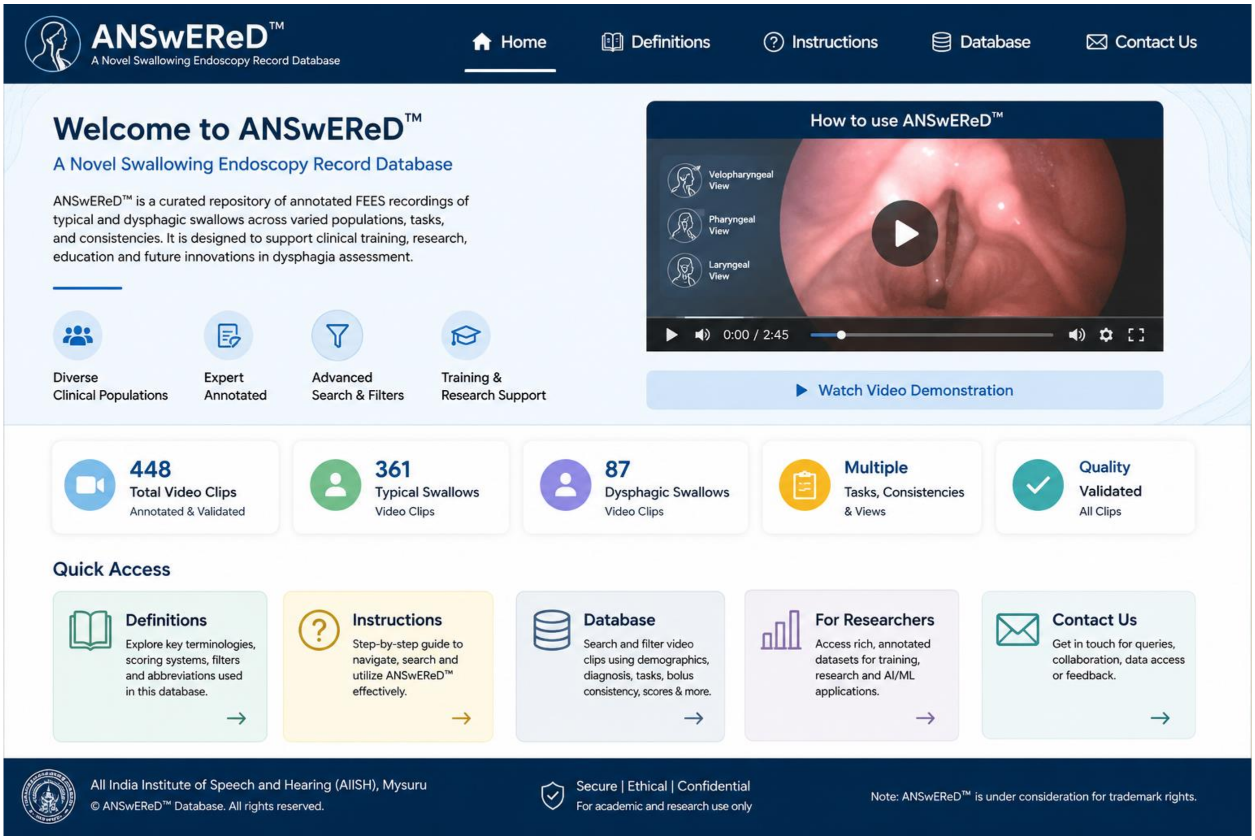
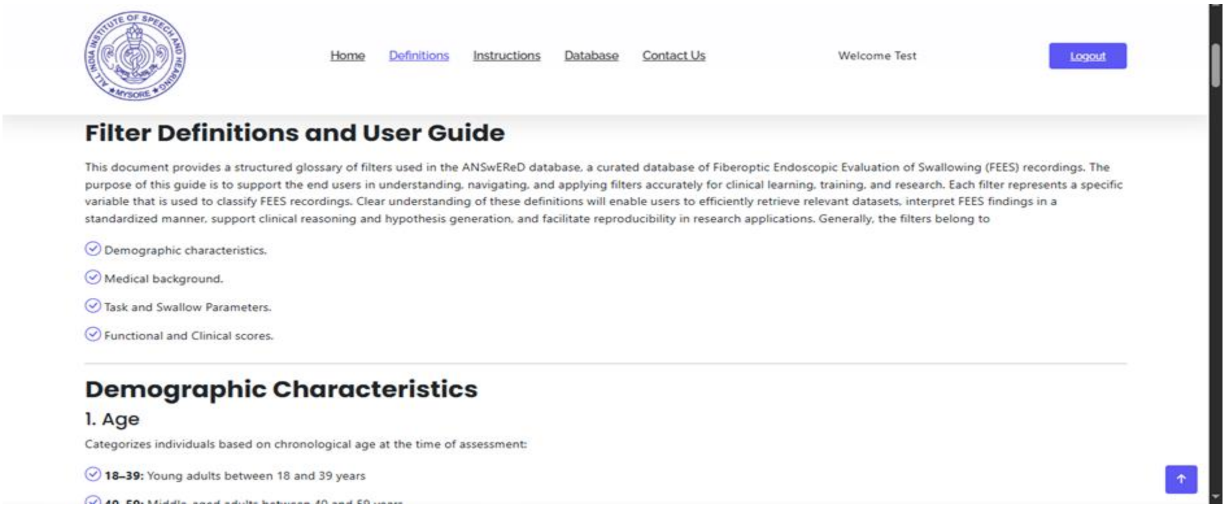


Figure 8.

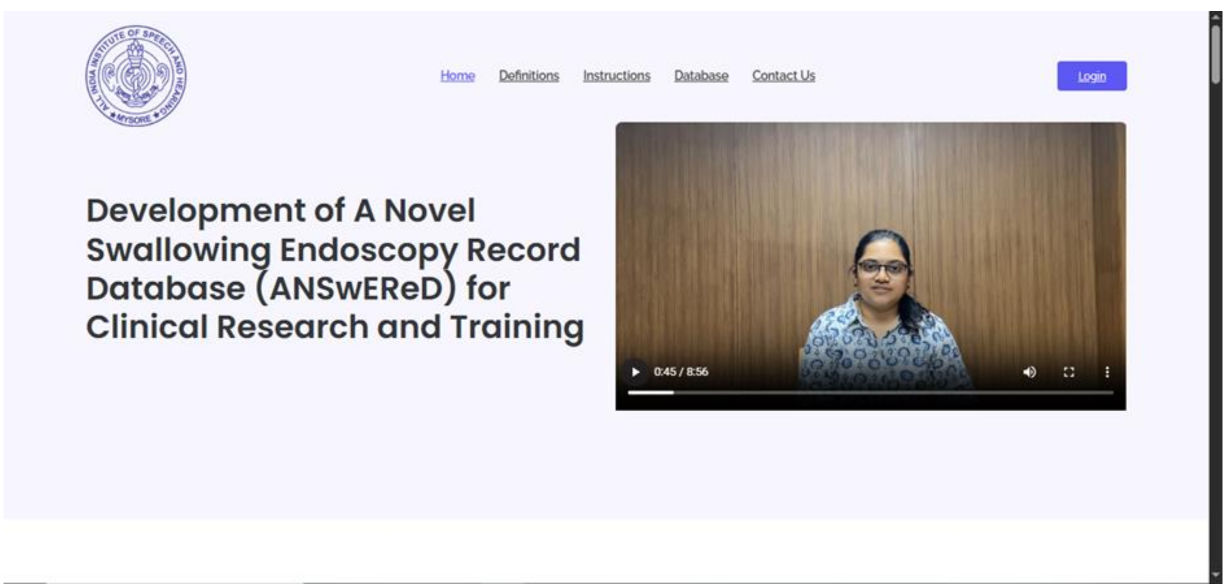
Screenshot of the 'Definitions' section of ANSwEReD^{TM}



An instructional video on how to use the database was also developed and incorporated under ‘Instructions’. This video included a short introductory segment by the author, which welcomed the users and introduced the purpose of the database and the purpose of the video (Figure 9).

Figure 9.

Screenshot of the Introductory home page



The second segment of the video included a screen demonstration of the procedure that the user needs to follow for effective use of the database (Figure 10). This instructional segment provided step-by-step guidance on database navigation, application of filters, and utilization of the platform for both educational and research purposes (Appendix A).

Currently, the login page requires the individual to provide the username and password obtained from the host. In future, this procedure is expected to get simplified with self registration and data validation with One Time Passwords. (Figure 11).

Figure 10.

Screenshot on step-by-step demonstration on using the database

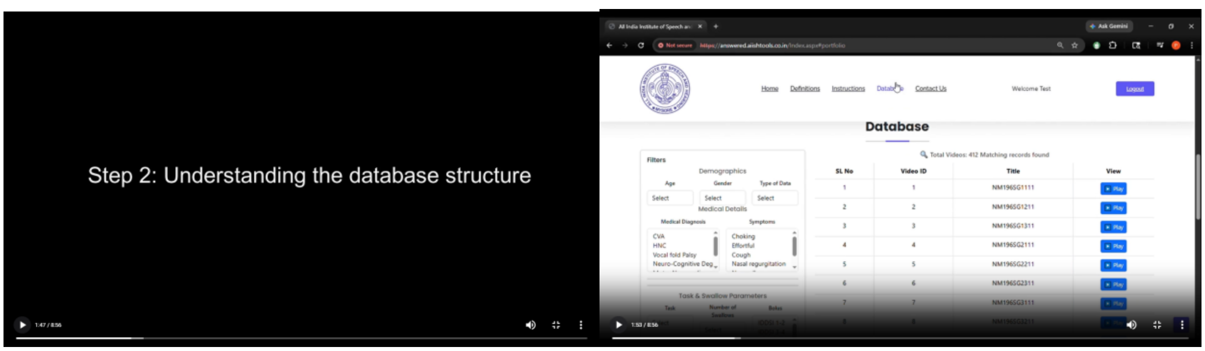
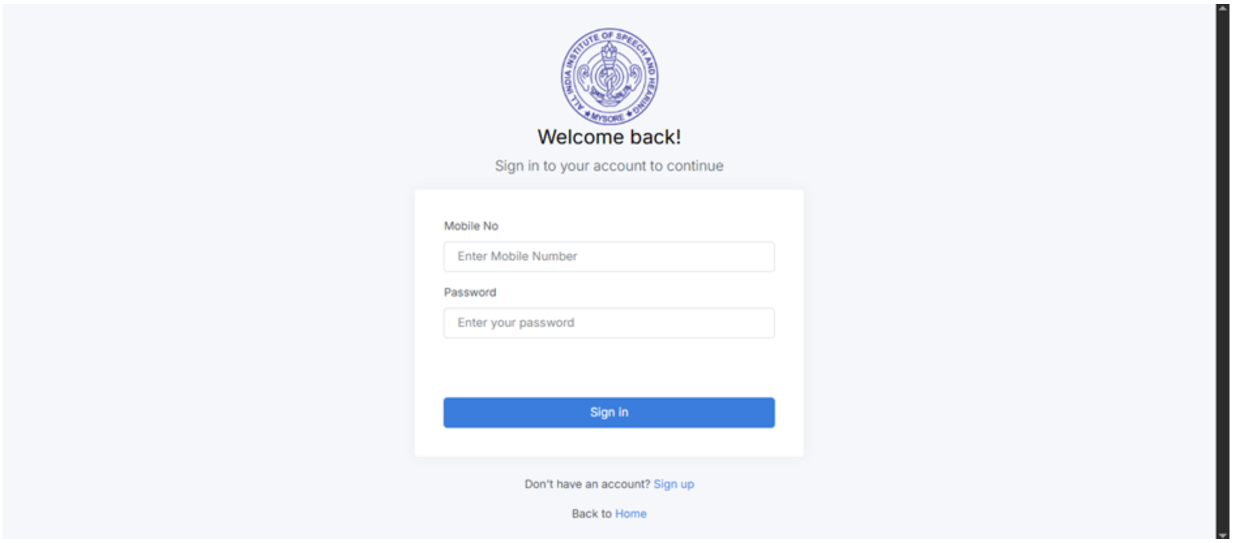


Figure 11.

Screenshot of the demonstration focusing on login page

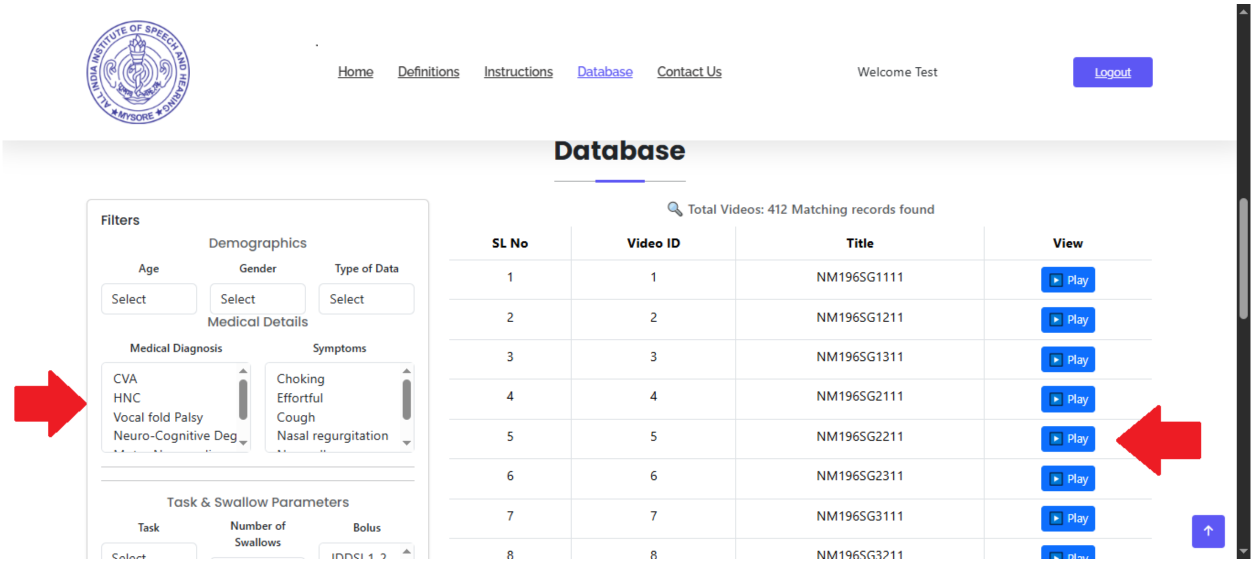


On successful login, the participants enter the structured ANSwEReD^{TM} Database. From this point forward, the users will be able to access all the sections of the main navigation panel at the top of the screen. The access to the page of definitions continued after login as well, and the users were strongly recommended to review the definitions section. The definitions were a structured glossary of filters used in the ANSwEReD^{TM} database. This section was purposed to support the end users in understanding, navigating, and applying filters accurately for clinical learning, training, and research.

The database was organized into four main sections: Demographics, Medical Details, Task and Swallow Parameters, and Functional and Clinical Scores. The users use these filters to narrow down and retrieve specific FEES recordings based on their requirements. This framework was made to make navigation through this database quick, easy, and more focused on particular requirements (Figure 12).

Figure 12.

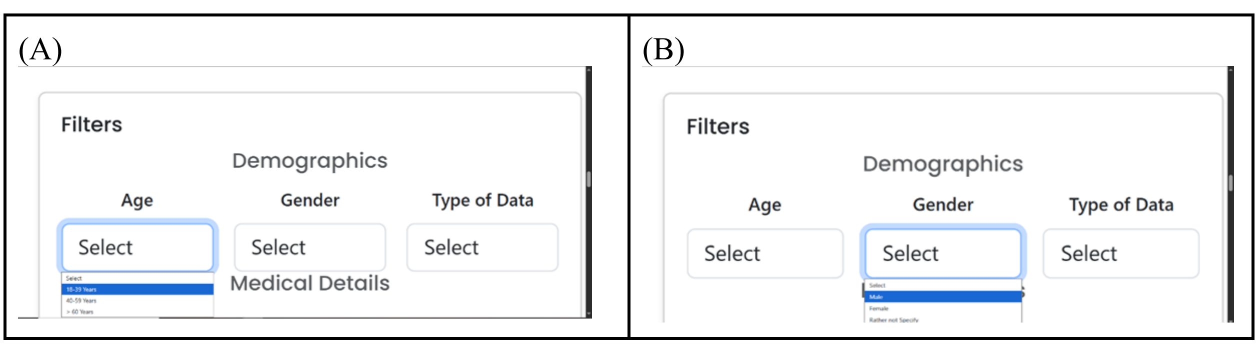
Screenshot of the database with structured filters on the left side and list of FEES recordings that suit their selection on the right side of the display.

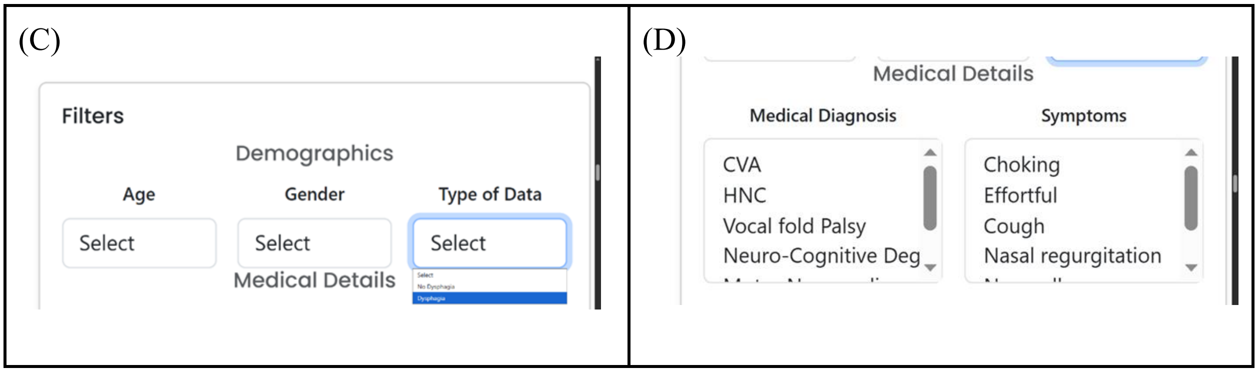


Users may apply different subcategories of filters as detailed in Table 4. The first filter “Demographics” narrowed the available FEES recordings according to age categories of 18–39 years, 40–59 years, and >60 years. The second demographic filter “Gender” further narrowed the recordings within the selected age group according to the selection. Similarly, the user was required to indicate their requirements on the type of data, i.e typical or clinical data (Figure 12). If the ‘dysphagia’ filter was activated, further filtering based on medical details and the specific task (phonation or swallow) and other related filters were enabled (Figure 13). At the time of this report, the database included phonation, breath-hold, and swallowing tasks for visualization.

Figure 13.

Screenshot of the database specifying filters for demographics and medical details section



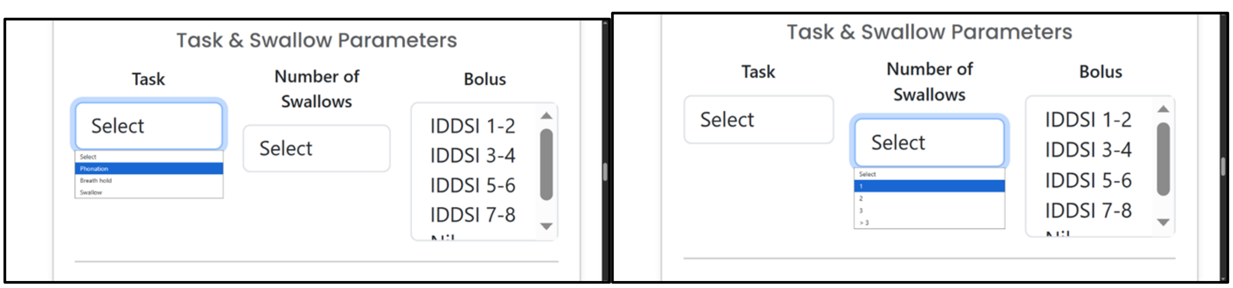


Note. The figure involves screenshots of demographic filters for specifying (A) the age, (B) gender, (C) type of data (typical or dysphagia data). On selection of 'Dysphagia' type of data the (D) Medical details filter is enabled.

If the swallowing task was chosen, further options on the number of swallows, bolus consistency based on IDDSI levels, and other variables were made available to filter down to specific data of user's interest (Figure 14).

Figure 14.

Screenshot of filters under task and swallow parameters

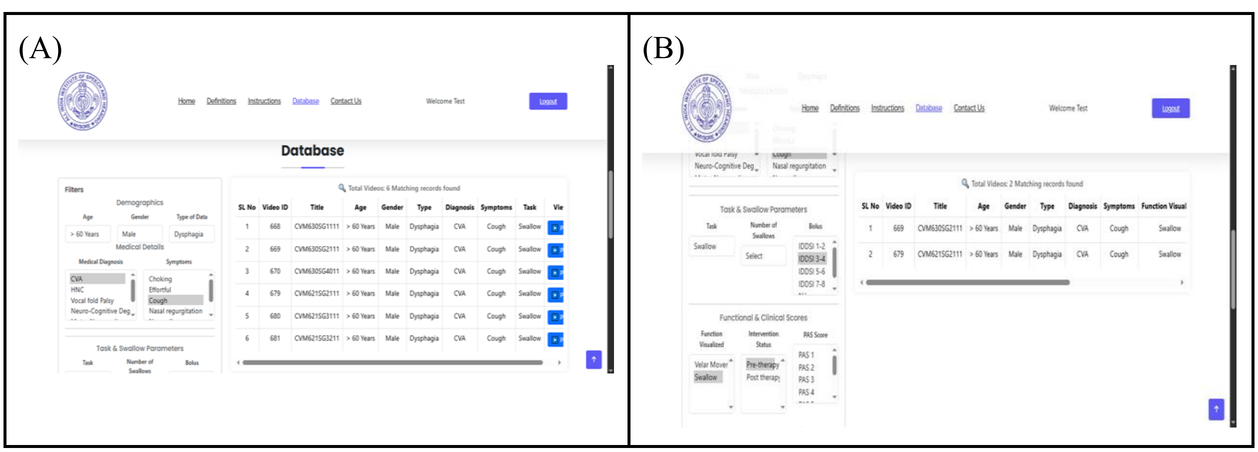


Detailed filtering of swallow related data was possible with the options of specific function visualized, Time point in recovery while the data was recorded (pre or post therapy), Penetration–Aspiration Scale scores (PAS), Yale Pharyngeal Residue Scores could also be selected according to the requirements. In case the user wishes to observe specific responses to swallow inefficiencies, such as cough or throat clearing, the same could be filtered using the patient response filter. These filters are aimed to help the end users navigate through the variety of FEES findings for safety and efficiency concerns in persons with dysphagia.

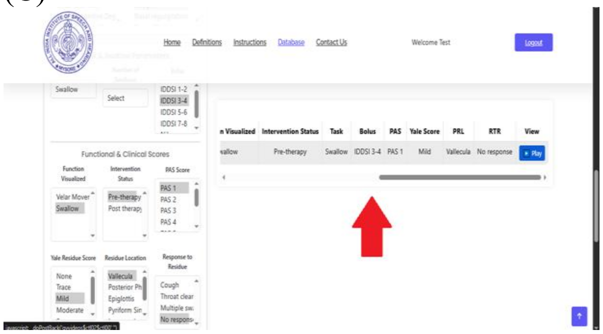
Once desired filters have been applied, the database would narrow down and display only the FEES videos that matched the user's selection. The selected video recordings may then be viewed to visualize swallowing physiology and allow comparison across cases in the selected dataset. For example, the application of filters for a male patient aged above 60 years with cerebrovascular accident (CVA), performing a swallowing task with a semi-solid bolus (IDDSI 3–4), demonstrating mild vallecular residue and no observable compensatory response, allowed retrieval of specific clinically relevant FEES recordings for focused observation and comparative analysis. Figure 15 demonstrates the application of these filters and the corresponding filtered output displayed within the database. After the selection of all required filters, the available recordings that satisfy all requirements of the end user will be displayed on the right side of the display.

Figure 15.

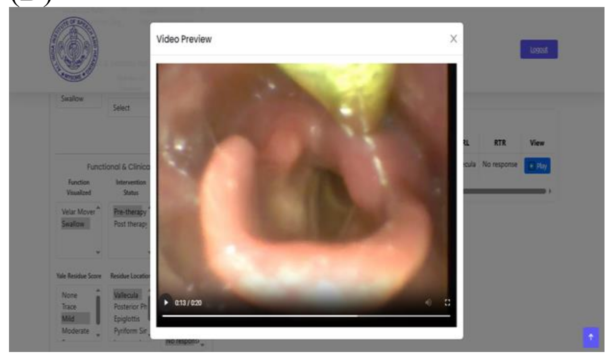
Screenshot of filter selections elected FEES Samples within the Database



(C)



(D)

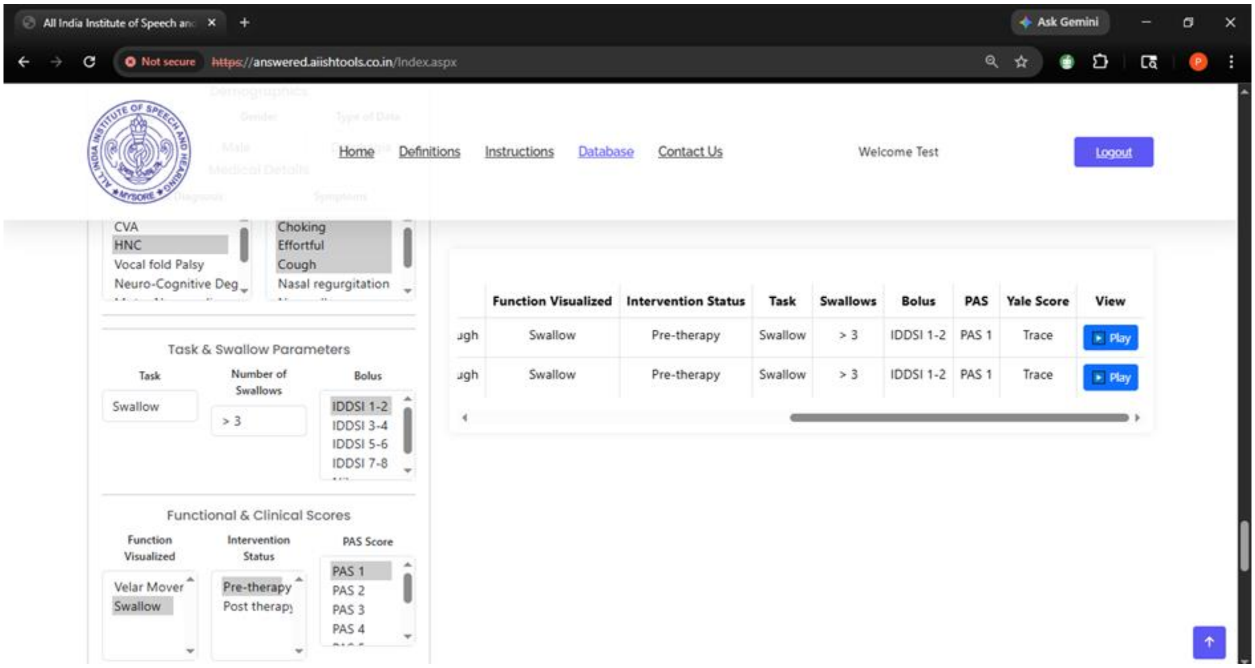


Note: (A) Applying demographics and medical filters. (B) Applying task and swallow filters. (C) Applying functional and clinical score filters. (D) Viewing results

For beginning learners in FEES evaluation, the database provides a range of video samples that facilitate observation and visualization of structural and functional aspects of the pharyngeal phase of swallowing. During video review, learners may focus on airway protection by identifying the presence of penetration or aspiration and determining the most appropriate Penetration–Aspiration Scale (PAS) score. Similarly, application of pharyngeal residue scales, learning to identify the anatomical landmarks, severity of swallowing impairment and learning to identify the integrity of specific physiological events during swallow is facilitated with the current data. Further, comparison across selected samples is enabled, for comparative observation and learning (Figure 16).

Figure 16.

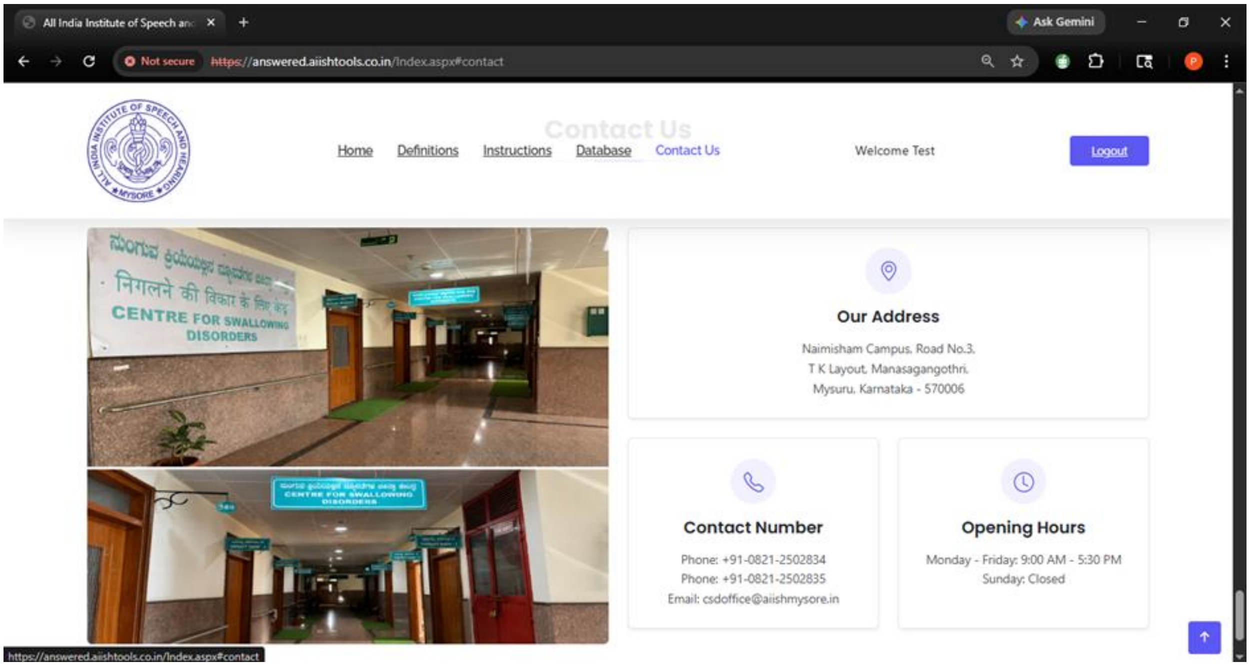
Screenshot of database enabling comparison across selected samples



The database aims to assist clinicians, researchers, and students in research, academic, and clinical learning activities involving dysphagia and FEES. The platform not only provides access to data for research purposes but also encourages contribution of validated, high-quality datasets and promotes collaboration in FEES and dysphagia-related research. The resource was also an educational tool for developing knowledge and skills in FEES procedures and interpretation and thereby improved the clinical application of FEES. For partnering, collaboration, queries, and other database related enquiries, the address of the host was provided in the 'contact us' section (Figure 17).

Figure 17.

Screenshot of the 'Contact Us' page section in the database for user communication, collaboration, and support.



At the time of development, the ANSwEReD™ database comprised approximately 448 annotated and quality-validated video clips, including approximately 361 typical and 87 clinically diagnosed dysphagia swallowing studies.

Inter-rater reliability of classification and annotation

The inter-rater reliability of the filtering process demonstrated a high level of consistency and accuracy in database indexing and retrieval. The annotation data of a random set of 10 FEES recordings was evaluated by a speech-language pathologist. Out of the 10 randomly selected recordings evaluated, 9 video files (90%) were retrieved accurately without discrepancies when the corresponding annotation filters were applied. One file showed discrepancy (10%), which was traced to an error in file nomenclature generated during the annotation-based indexing procedure. The error identified was subsequently corrected within the database structure. No other inaccuracies were identified in the annotation variables in the database.

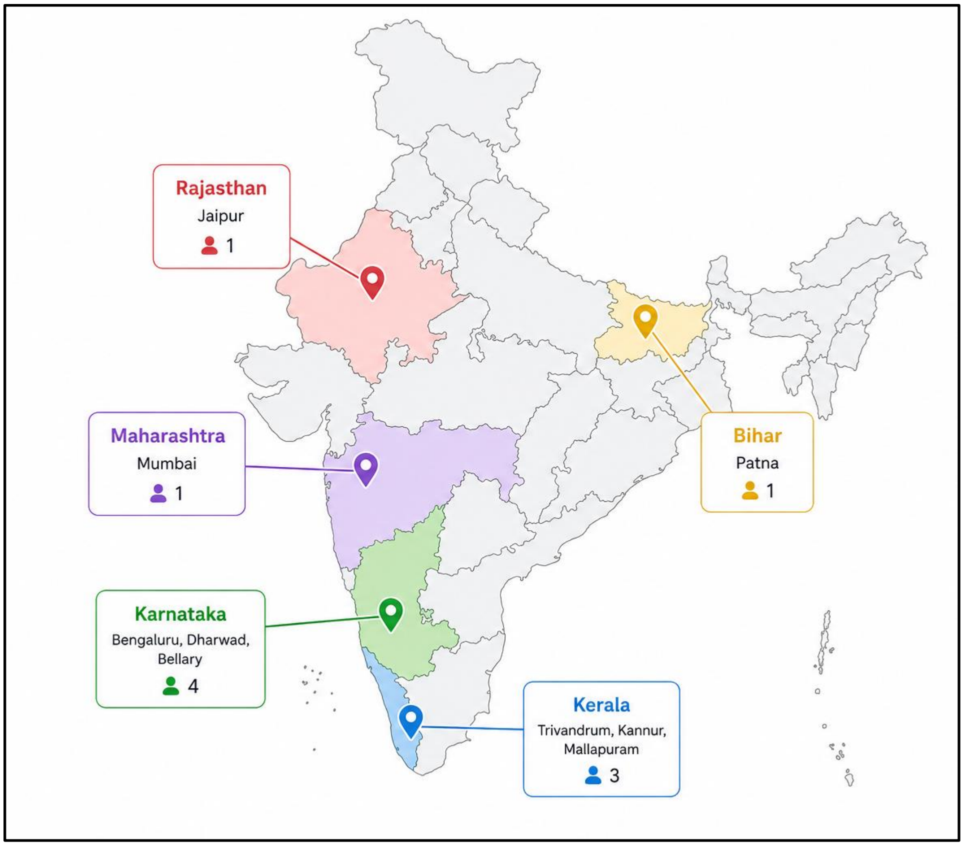
Additionally, it was observed that two separate FEES recordings shared identical annotation profiles across all selected filter variables. Consequently, application of the same filter combination retrieved both video recordings simultaneously. This meant, two FEES recordings with exact same filter settings/annotations from two different individuals were present. This outcome was determined to reflect true overlap in clinical and procedural characteristics rather than an indexing or annotation error. The expansion of database into true clinical and research database should include such homogenous data made available through collaboration. No additional issues related to annotation consistency, database filtering, retrieval accuracy, or video mapping were identified during the verification process. This suggested that the reliability verification procedure demonstrated that the ANSwEReD™ database possesses a high degree of annotation consistency and retrieval accuracy, supporting its potential utility for structured learning, clinical training, and research applications in FEES.

User feedback on the database for appeal and utility

User feedback was obtained by giving temporary access to ANSwEReD™ to ten Speech-Language Pathologists across India. Figure 18 represents the distribution of end-users who used the database, reviewed and provided the feedback through an online method. The participants were distributed across different places within India: 4 from Karnataka, 3 from Kerala, 1 each from Maharashtra, Rajasthan, and Bihar.

Figure 18.

Distribution of tentative users across India



The ten users provided feedback on 19 questions categorized under the four major sections: Appeal of the platform (number of questions = 5), Accessibility (number of questions = 4), User friendliness (number of questions = 7) open-ended feedback (number of questions = 2). Any suggestions or feedback to improve the design, accessibility, or technical aspects of the database was welcomed through open ended questions. A total of 16 questions included the user rating of specific features of the database on a 5- point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The overall satisfaction was rated as a different item in the questionnaire, in a similar likert scale between 1 (very dissatisfied) and 5 (very satisfied). The percentage ratings obtained for each of the components of user satisfaction from the ten judges are presented in Table 8.

Table 8.

Result of user rating obtained from ten judges.

Parameters	Ratings				
	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
Layout	-	-	-	5 (50%)	5 (50%)
Colour Scheme	-	-	1 (10%)	4 (40%)	5 (50%)
Font style and size	-	-	2 (20%)	1 (10%)	7 (70%)
Visuals	-	-	3 (30%)	3 (30%)	4 (40%)
Overall appearance	-	-	1 (10%)	5 (50%)	4 (40%)
Features accessibility	-	-	1 (10%)	4 (40%)	5 (50%)
Display clarity	-	-	-	3 (30%)	7 (70%)
Clarity of annotations	-	-	-	5 (50%)	5 (50%)
Section accessibility	-	-	3 (30%)	3 (30%)	4 (40%)
Ease of navigation	-	-	1 (10%)	5 (50%)	4 (40%)
Technical Instruction	-	-	-	4 (40%)	6 (60%)
Audio quality	-	-	2 (20%)	2 (20%)	6 (60%)
Video quality	-	-	1 (10%)	6 (60%)	3 (30%)
Filter functionality	-	-	-	5 (50%)	5 (50%)
Loading time	-	-	2 (20%)	1 (10%)	7 (70%)
No technical issues	-	-	2 (20%)	2 (20%)	6 (60%)

The weighted satisfaction percentage was calculated for each parameter using the formula:

$$\text{Satisfaction Percentage} = \frac{\sum(\text{Rating} \times \text{Frequency})}{\text{Maximum Possible Score}} \times 100$$

Where maximum possible score= (Total Respondents × 5)

The same was plotted in a spider plot for better visualization (Figure 19). From this figure, it was clear that all the 16 parameters included to understand the end-user experience had 80% satisfaction rating from the judges. This suggested that ANSwEReD™ had very good end-user satisfaction on the quality, accessibility, appeal, and ease of navigation through the database. In addition, open suggestions on improvement from the judges were tabulated.

In addition to the Likert ratings, open-ended feedback was collected from the participants on any other components that were not included in the Likert scale. The same was tabulated and discussed with the technical team for implementation. Table 9 provides the compliance for the additional suggestions for improvement.

Figure 19.

Weighted satisfaction percentage rating for each parameter by the participants

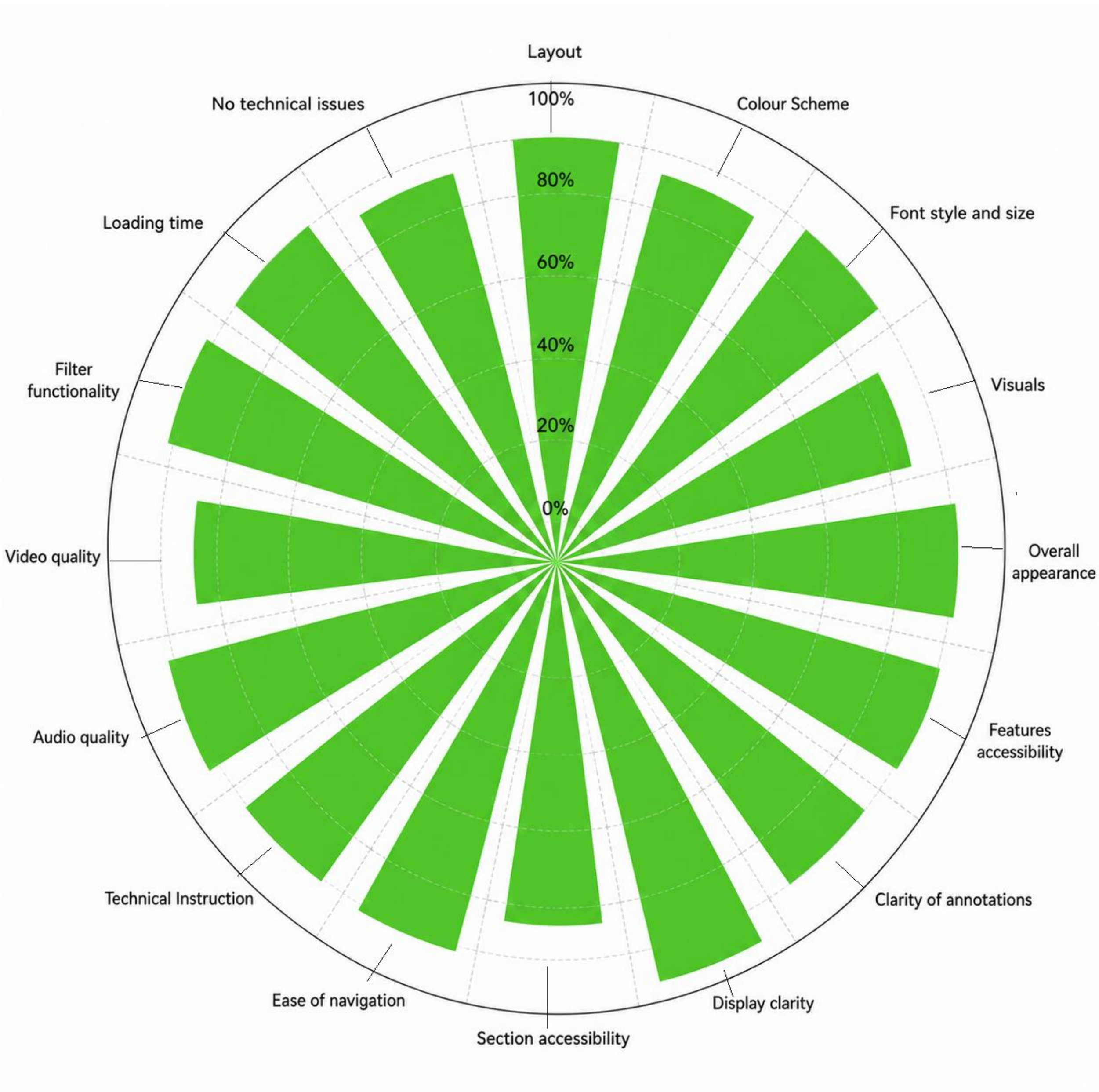


Table 9.

Compliance report of the open-ended suggestions obtained from users.

Suggestion	Response to reviewer	Details of incorporation
The font size of the filter section could be increased by a little.	Suggestion taken	Incorporated throughout the database
The filters work well, though adjusting their order could help it feel less crowded and more streamlined	Suggestion taken. Filters have been ordered systematically considering the demographics and medical histories first followed by task parameters and finally clinical scores which gives a scientific and systematic way of categorizing.	Incorporated into the filter section of the database
Removing of filters or unselecting of filters can be improved	The remarks of the reviewer were discussed, but the suggestion could not be taken due to the requirement of change in the underlying development platform. This is a time taking process and will be attempted in future.	-

Adding a primary colour to the selected option while navigating the filters would be helpful	Suggestion taken. The selected filters will be highlighted for visibility	Incorporated into the filter section of the database
Once again, the effort is appreciable. In the filters, it would be nice if you can provide a select option for all the filters. At present, you have given for only demographics. If you could provide the same option in all filters, users can come back easily and navigate other filters as well.	The remarks of the judge are appreciated. However, the mandatory filters options are to be provided. Under the mandatory filter like ‘demographics’, optional filters are included. This is required for easy navigation. Hence, the suggestion was not incorporated.	-
Make the database accessible through the phone too, sometimes the videos would not get selected with repeated selection (that would need to	The remarks of the judge is appreciated However, as the database was intended for clinical learning and research, the same is better visualized	-

be looked into - don't know if it was a network issue).	through bigger screens like that of personal computers.	
Can be provided more database on age group of <25	The remarks of the judge are appreciated. This was a retrospective project from archived data. In future, with further data made available through collaboration and updation, this suggestion will gradually get implemented.	-

The evaluation method of Flexible Endoscopic Evaluation of Swallowing (FEES) is one of the most widely used technology in the assessment of swallowing disorders. Clinical skill to perform and interpret FEES has become an integral component of dysphagia rehabilitation practice Despite its popularity and practice, considerable variability exists in FEES protocols, procedures, interpretation methods, and reporting practices. This contributes to inconsistencies in decision-making, limits reproducibility of clinical findings, and reduces the generalizability and comparability of research outcomes across studies. The investigators felt a growing need for standardized FEES resources that can support uniform clinical training, research, and evidence-based practice in this field of dysphagia practice.

The present study addressed this need through the development of ANSwEReD™, a digital, structured, and annotated FEES imaging database. To the best of our knowledge, there are no other dedicated repositories for FEES video recordings with the extent of detailed demographic, clinical, physiological, and instrumental annotations like that in the current study. ANSwEReD™ was intended to be a centralized platform that systematically organized FEES data across both typical and dysphagic populations with the purpose of supporting clinical education, research, and future technological developments in dysphagia rehabilitation.

One of the major challenges associated with FEES is its perceptual interpretation. Advanced clinical expertise and experience in the procedure is required for identifying physiological events and for differentiating normal from deviated swallowing patterns. Previous literature has reported significant variability in inter-rater agreement of FEES rating scores, particularly among less experienced clinicians (Butler et al., 2015; Colodny, 2002; Pisegna et al., 2018). There is a need for developing structured training and professional calibration methods to benefit the clinical dysphagia practice. Contemporary educational approaches repeatedly emphasize establishing frame-of-reference training, including expert-guided benchmarking, and multi-rater learning methods for improved reliability (Pisegna et al., 2018; Zarkada & Regan, 2018). Digital learning platforms facilitate these methods of learning by enabling asynchronous access to training materials (Romano et al., 2025; Zarkada & Regan, 2018). In this direction, the current database initiated a repository of validated FEES recordings that could serve as a reference source for clinician training, professional calibration exercises, and competency development initiatives. The inclusion of both typical and dysphagic recordings enables the users to compare normal and pathological swallowing physiology, strengthening clinical reasoning and observational skills.

The database also attempted to address the challenge of limited access to validated typical FEES videos. Obtaining and organizing recordings from healthy individuals is often difficult for typical clinical or educational datasets, because typically healthy individuals do not require a FEES evaluation. As a result, learners may have fewer opportunities to appreciate the range of physiological variability present in typical swallowing. ANSwEReD™ includes recordings of multiple pharyngo-laryngeal functions, including swallowing, phonation, and breath-holding function. Therefore, ANSwEReD provides a comprehensive representation of both endoscopic anatomy and function in healthy as well as deviant body systems. The availability of both groups of data may facilitate comparative learning and support the stronger understanding of healthy swallowing physiology as a prerequisite for identifying pathological functions.

Traditional FEES competency-building training programs rely on direct clinical exposure under expert mentorship. These approaches are often constrained by limited availability of expert supervisors, competing clinical responsibilities, and unequal exposure to diverse clinical populations. Learners in such training programs may have unequal exposure to the range of conditions resulting in swallowing disorders during their training period. Digital repositories can partially address these limitations by providing access to a broader spectrum of clinical presentations. The present database incorporates recordings from individuals with cerebrovascular accidents, head and neck cancer, traumatic brain injury, vocal fold paralysis, neurocognitive disorders, and motor neuron diseases. This diversity enables the learners to observe, appreciate, and learn the condition-specific swallowing characteristics. With further expansion and collaboration with ANSwEReD™ it is expected that additional etiologies such as gastroesophageal disorders, metabolic conditions, developmental disorders, and sensory-motor impairments across pediatric and adult populations will be incorporated into the database.

Dysphagia management requires interpretation of instrumental findings within the context of subjective clinical evaluation findings. ANSwEReD™ included both these categories of information in a single platform, thereby supporting a comprehensive learning of clinical reasoning and evidence-based decision-making.

The dynamic nature of FEES data demands large data storage, fast retrieval, and detailed analysis. Unlike static image repositories, FEES recordings capture temporal swallowing biomechanics and sequential physiological events critical for clinical interpretation. ANSwEReD™ addresses this requirement through systematic organization of annotated video recordings with its relevant metadata and physiological descriptors. This improves accessibility and retrieval and enables detailed analyses of dynamic swallowing function, rather than isolated image-based data.

From a research perspective, organized databases such as the one developed in the current study facilitate large-scale data analysis, improving reproducibility of findings, generalizability, and support for data sharing across institutions. Standardized repositories also create opportunities for cross-study comparisons and multicenter collaborations.

At present, ANSwEReD™ contains approximately 448 validated video clips from both typical and dysphagic populations. There are data related to velar movements, glottic functions, and pharyngeal function during phonation and swallowing across variables. The range of The information included in the database provides a solid foundation for future clinical and research investigations.

Although the current project was not aimed at developing automated analytical systems, the structured, validated range of relevant data incorporated in the ANSwEReD™ establishes a baseline for future artificial intelligence and machine learning applications. The development of computational models requires large-scale availability of high-quality, well-annotated datasets to be benchmarks for training and validation. As artificial intelligence is becoming increasingly integrated into healthcare, ANSwEReD™ may contribute to future development of automated tools for event detection, quantitative swallowing analysis, and clinical decision support in dysphagia practice. Thus, the database represents not only an educational and research resource but also may evolve as a reference for future technological innovations in dysphagia assessment.

The current study involved evaluation of user experience of using the database from different SLPs across the country. Excellent ratings of user satisfaction across domains related to accessibility, usability, technical performance, and overall appeal was obtained. Feedback obtained through open-ended responses suggested minor technical refinements that were incorporated successfully.

In conclusion, the present study successfully developed a structured, annotated, and clinically relevant FEES imaging database—ANSwEReD™. It addresses important gaps in FEES training and research by providing access to validated recordings across typical and dysphagic populations. Beyond its immediate utility, the database establishes a foundation for future multicenter collaborations aimed at standardization initiatives and artificial intelligence–driven innovations in dysphagia assessment and management.

CHAPTER- V

SUMMARY AND CONCLUSION

Flexible Endoscopic Evaluation of Swallowing (FEES) is a widely used method in dysphagia assessment. The variability in protocols, bolus parameters, and scoring approaches in conducting and interpreting the procedure has led to variabilities and inconsistencies in clinical practice and research reporting. The variability leads to non-standardized FEES-based judgments, limiting reproducibility and non-meaningful cross-study comparability. With the growing integration of artificial intelligence (AI) in health care, FEES based dysphagia practice requires a large, standardized, and well-annotated datasets for standardization and automatization. A standardized, annotated FEES database could enable consistent interpretation through scalable training, and prepare the field for AI-driven clinical decision-making. This study aimed to develop and preliminarily validate a novel swallowing endoscopy record database (ANSwEReD)™ to support clinical research, training, and future AI applications.

The study utilized the archived FEES recordings from the Centre for Swallowing Disorders during the period 2024–2026. The retrieved data was classified into two datasets:

- Dataset 1 included FEES of individuals without dysphagia complaints (typical), 396 videos and
- Dataset 2 included FEES of individuals with dysphagia complaints (atypical), included 131 videos

Each FEES evaluation was clipped for specific endoscopic events including velar elevation, pharyngeal, glottic function for phonation and swallow and breath hold tasks. The data was prepared for inclusion by segmenting the videos at two frames prior and after the target event to preserve temporal context. Each clip was screened for optimal visualization by two investigators independently. Video clips that were agreed as “clear and physiology visible” were selected. The data was then annotated using a structured framework encompassing client demographics including information regarding age, gender and type of data, medical details including diagnosis and symptoms, physiological parameters including task and bolus related information, functional and clinical scores included information regarding function visualised, intervention status, clinical scores including PAS rating, Yale residue rating, residue location and response to airway intrusion and residue were integrated into the purpose-built digital database. Further these were systematically encoded following the customized pattern coded to enable back-end tracing of source of data for future modifications in the database.

The annotated FEES video clips and associated clinical metadata were successfully incorporated into a personalized and user-centered digital database developed for the study. The introductory home page included an instructional video on ‘How to use ANSwEReD™’ and the primary navigation panel comprised of four major sections: Definitions, Instructions, Database, and Contact Us. The ‘Definition’ section included explanations of key FEES terminologies, annotation variables, and database filters used throughout the platform. The ‘Contact Us’ page section integrated within the database interface included details of point of contact for user communication, collaboration, and support. The ‘Database’ section included structured filters on the left side and list of FEES recordings that suit their selection on the right side of the display. Users could apply different subcategories of filters, as desired. The database would narrow down to the specific data matching the filter selection and display the relevant data on the right side of the database screen. The FEES data can then be viewed to visualize swallowing physiology and allow comparison across cases in the selected dataset. Currently, a total of 448 videos are included in the ANSwEReD™ comprising 361 typical and 87 dysphagic videos to support training and capacity building among SLPs in the procedure of FEES.

Inter-rater reliability of annotations, visual quality, and user experience feedback on the database was evaluated by clinicians across India. The inter-rater reliability of the filtering process demonstrated a high level of consistency and accuracy in database indexing and retrieval, supporting its potential utility for structured learning, clinical training, and research applications in FEES. All the components of feedback attained more than 80% satisfaction from the end-users, suggesting excellent quality, accessibility, appeal, and ease of navigation through the database. Attempts were made to incorporate certain technical improvements that were suggested by the users.

ANSwEReD™ represents, to our knowledge, the first structured and annotated FEES video database specifically for dysphagia research and training. It addresses the significant shortcomings of FEES data interpretation variability and lack of reproducible datasets by means of standardized video segmentation and annotation. The database offers a platform for ethical, de-identified data sharing that can facilitate large-scale clinical training and cross-study comparisons. In the future, the platform could serve as a basic resource for the development and validation of AI-based tools for FEES assessment. This initiative has the potential to greatly promote the standardization, reproducibility and innovation in dysphagia evaluation. Further validation and user-based evaluation data will improve its applicability in clinical and research settings.

Limitations

The systematic methodology aimed to develop a curated FEES video database addressing variability and reliability of FEES procedure and scoring. However, the current study had some limitations. At present, the database includes data from a single clinical center. Typical and atypical FEES recordings were included which improves the utility of the database. However, the distribution of data across the filters is currently not uniform. While this is not a mandate for any database, expansion of the current version is required to evolve into a full-fledged clinical database that can meet the demands for future research. .

Future Directions

Several opportunities exist for further expansion and refinement of the ANSwEReD^{TM} platform

Clinical Development

- Expansion through multicenter collaborations to improve representation of the clinical diversity across healthcare settings..
- Integration of the database with electronic medical record (EMR) systems of collaborators could facilitate systematic extraction and linkage of data.
- Inclusion of further annotations such as dysphagia severity indicators, and disease progression may improve clinical utility.

Educational Development

- Development of FEES training modules utilizing curated FEES data for capacity building and professional updates.
- Deriving quantitative FEES measures thorough machine learning and AI-Mediated processes for clinical decision making..

Research Development

- Initiating multicenter research networks to support large-scale studies, normative data development, and cross-institutional collaborations.
- Development of longitudinal data collection protocols to monitor disease progression, treatment outcomes, and swallowing recovery.

Technological Development

- Integration of artificial intelligence and machine-learning approaches for automated analysis of swallowing function and its correlation with perceptual measures.
- Exploration of advanced image-processing and video-segmentation techniques to enhance objective interpretation.

Infrastructure and Data Security

- Strengthening of data governance through advanced encryption, and secure authentication systems.
- Implementation of OTP-based authentication and streamlined user-access mechanisms.
- Adoption of scalable storage infrastructure, including dedicated servers and secure cloud-based solutions to support long-term sustainability and accountability of the database.

REFERENCES

Agency for Healthcare Research and Quality. (2024). *Healthcare Cost and Utilization Project (HCUP)*. https://www.hcup-us.ahrq.gov/

Altman, K. W., Yu, G.-P., & Schaefer, S. D. (2010). Consequence of Dysphagia in the Hospitalized Patient: Impact on Prognosis and Hospital Resources. *Archives of Otolaryngology–Head & Neck Surgery*, *136*(8), 784. https://doi.org/10.1001/archoto.2010.129

American Speech-Language-Hearing Association (ASHA). (2024). *Flexible Endoscopic Evaluation of Swallowing*. Asha.org. https://www.asha.org/practice-portal/resources/flexible-endoscopic-evaluation-of-swallowing/

ATMOS MedizinTechnik GmbH & Co. KG. (2015). *ATMOS mobile swallowing diagnostics*. https://atmosmed.com/en/products-solutions/schluckdiagnostik/mobile-schluckdiagnostik#technical-data

Azer, S. A., Kanugula, A. K., & Kshirsagar, R. K. (2025). Dysphagia. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK559174/

Baijens, L. W. J., Pilz, W., Kremer, B., & Passos, V. L. (2015). Identifying Patterns of FEES-Derived Swallowing Trajectories Using Group-Based Trajectory Model. *Dysphagia*, *30*(5), 529–539. https://doi.org/10.1007/s00455-015-9632-3

Baijens, L. W. J., Speyer, R., Pilz, W., & Roodenburg, N. (2014). FEES Protocol Derived Estimates of Sensitivity: Aspiration in Dysphagic Patients. *Dysphagia*, *29*(5), 583–590. https://doi.org/10.1007/s00455-014-9549-2

Beam, A. L., Manrai, A. K., & Ghassemi, M. (2020). Challenges to the Reproducibility of Machine Learning Models in Health Care. *JAMA*, *323*(4), 305. https://doi.org/10.1001/jama.2019.20866

Benadom, E. M., & Potter, N. L. (2011). The Use of Simulation in Training Graduate Students to Perform Transnasal Endoscopy. *Dysphagia*, *26*(4), 352–360. https://doi.org/10.1007/s00455-010-9316-y

Boaden, E., Nightingale, J., Bradbury, C., Hives, L., & Georgiou, R. (2020). Clinical practice guidelines for videofluoroscopic swallowing studies: A systematic review. *Radiography*, *26*(2), 154–162. https://doi.org/10.1016/j.radi.2019.10.011

Branescu, I., Purcarea, V. L., & Dobrescu, R. (2014). Solutions for medical databases optimal exploitation. *Journal of Medicine and Life*, *7*(1), 109–118. https://pubmed.ncbi.nlm.nih.gov/24653769/

Briani, C., Marcon, M., Ermani, M., Costantini, M., Bottin, R., Iurilli, V., Zaninotto, G., Primon, D., Feltrin, G., & Angelini, C. (1998). Radiological evidence of subclinical dysphagia in motor neuron disease. *Journal of Neurology*, *245*(4), 211–216. https://doi.org/10.1007/s004150050207

Burdick, R. J., Dallal-York, J., & Shapira-Galitz, Y. (2024). Flexible Endoscopic Evaluation of Swallowing: A Proposed Checklist. *American Journal of Speech-Language Pathology*, *33*(5), 2220–2229. https://doi.org/10.1044/2023_AJSLP-22-00182

Butler, S. G., Markley, L., Sanders, B., & Stuart, A. (2015). Reliability of the Penetration Aspiration Scale With Flexible Endoscopic Evaluation of Swallowing. *Annals of Otology, Rhinology & Laryngology*, *124*(6), 480–483. https://doi.org/10.1177/0003489414566267

Centers for Medicare & Medicaid Services. (n.d.). *Electronic health records*. U.S. Department of Health and Human Services. https://www.cms.gov/priorities/key-initiatives/e-health/records

Child Health and Development Studies. (2025). *Child Health and Development Studies*. Public Health Institute. https://www.chdstudies.org

Cho, S. Y., Choung, R. S., Saito, Y. A., Schleck, C. D., Zinsmeister, A. R., Locke, G. R., & Talley, N. J. (2015). Prevalence and risk factors for dysphagia: A USA community study. *Neurogastroenterology & Motility*, *27*(2), 212–219. https://doi.org/10.1111/nmo.12467

Clayton, N. A., Freeman-Sanderson, A., & Walker, E. (2024). Dysphagia Prevalence and Outcomes Associated with the Evolution of COVID-19 and Its Variants in Critically Ill Patients. *Dysphagia*, *39*(1), 109–118. https://doi.org/10.1007/s00455-023-10598-7

Cohen, D. L., Roffe, C., Beavan, J., Blackett, B., Fairfield, C. A., Hamdy, S., Havard, D., McFarlane, M., McLauglin, C., Randall, M., Robson, K., Scutt, P., Smith, C., Smithard, D., Sprigg, N., Warusevitane, A., Watkins, C., Woodhouse, L., & Bath, P. M. (2016). Post-stroke dysphagia: A review and design considerations for future trials. *International Journal of Stroke*, *11*(4), 399–411. https://doi.org/10.1177/1747493016639057

Colodny, N. (2002). Interjudge and Intrajudge Reliabilities in Fiberoptic Endoscopic Evaluation of Swallowing (FEES). Using the Penetration-Aspiration Scale: A Replication Study. *Dysphagia*, *17*(4), 308–315. https://doi.org/10.1007/s00455-002-0073-4

Curtis, J. A., Borders, J. C., & Troche, M. S. (2022). Visual Analysis of Swallowing Efficiency and Safety (VASES): Establishing Criterion-Referenced Validity and Concurrent Validity. *American Journal of Speech-Language Pathology*, *31*(2), 808–818. https://doi.org/10.1044/2021_AJSLP-21-00116

Date, C. J. (2004). *An Introduction to Database Systems*. Addison Wesley.

Denk, D.-M., & Kaider, A. (1997). Videoendoscopic Biofeedback: A Simple Method to Improve the Efficacy of Swallowing Rehabilitation of Patients after Head and Neck Surgery. *ORL*, *59*(2), 100–105. https://doi.org/10.1159/000276918

Dietrich, C. F., Lucius, C., Nielsen, M. B., Burmester, E., Westerway, S. C., Chu, C. Y., Condous, G., Cui, X.-W., Dong, Y., Harrison, G., Koch, J., Kraus, B., Nolsøe, C. P., Nayahangan, L. J., Pedersen, M. R. V., Saftoiu, A., Savitsky, E., & Blaivas, M. (2023). The ultrasound use of simulators, current view, and perspectives: Requirements and technical aspects (WFUMB state of the art paper). *Endoscopic Ultrasound*, *12*(1), 38–49. https://doi.org/10.4103/EUS-D-22-00197

Dinov, I. D. (2023). *Data Science and Predictive Analytics: Biomedical and Health Applications using R*. Springer International Publishing. https://doi.org/10.1007/978-3-031-17483-4

Edwards, A., Froude, E., Sharpe, G., & Carding, P. (2021). Training for videofluoroscopic swallowing analysis: A systematic review. *International Journal of Speech-Language Pathology*, *23*(5), 529–539. https://doi.org/10.1080/17549507.2020.1861327

Edwards, A., Holm, A., Carding, P., Steele, M., Froude, E., Burns, C., & Cardell, E. (2024). Developing novice analysts' videofluoroscopic swallowing study skills in speech-language pathology: A randomised control trial comparing blended and online training approaches. *International Journal of Speech-Language Pathology*, *26*(2), 212–224. https://doi.org/10.1080/17549507.2023.2212142

Ekberg, O., Hamdy, S., Woisard, V., Wuttge-Hannig, A., & Ortega, P. (2002). Social and Psychological Burden of Dysphagia: Its Impact on Diagnosis and Treatment. *Dysphagia*, *17*(2), 139–146. https://doi.org/10.1007/s00455-001-0113-5

Eller, R., Ginsburg, M., Lurie, D., Heman-Ackah, Y., Lyons, K., & Sataloff, R. (2008). Flexible Laryngoscopy: A Comparison of Fiber Optic and Distal Chip Technologies. Part 1: Vocal Fold Masses. *Journal of Voice*, *22*(6), 746–750. https://doi.org/10.1016/j.jvoice.2007.04.003

Eller, R., Ginsburg, M., Lurie, D., Heman-Ackah, Y., Lyons, K., & Sataloff, R. (2009). Flexible Laryngoscopy: A Comparison of Fiber Optic and Distal Chip Technologies—Part 2: Laryngopharyngeal Reflux. *Journal of Voice*, *23*(3), 389–395. https://doi.org/10.1016/j.jvoice.2007.10.007

Eskildsen, S. J., Poulsen, I., Jakobsen, D., Riberholt, C. G., & Curtis, D. J. (2021). Scoping review to identify and map non-pharmacological, non-surgical treatments for dysphagia following moderate-to-severe acquired brain injury. *BMJ Open*, *11*(12), e053244. https://doi.org/10.1136/bmjopen-2021-053244

FEES Competency Resources. (2022). *TIMS Medical*. TIMS Medical. https://www.tims.com/fees-training

Ferrari De Castro, M. A., Dedivitis, R. A., Luongo De Matos, L., Baraúna, J. C., Kowalski, L. P., De Carvalho Moura, K., & Herman Partezani, D. (2025). Endoscopic and videofluoroscopic evaluations of swallowing for dysphagia: A systematic review. *Brazilian Journal of Otorhinolaryngology*, *91*, 101598. https://doi.org/10.1016/j.bjorl.2025.101598

General Services Administration. (2025). *Data.gov*. U.S. Government. https://data.gov/

Gitto, M., Mozzanica, F., Porpiglia, V., Morelli, L., Ninfa, A., Selvagio, A., Rocca, S., Pizzorni, N., & Schindler, A. (2025). Fiberoptic Endoscopic Evaluation of Swallowing (FEES) in Head and Neck Cancer Patients with Late Radiation-Associated Dysphagia: Swallowing

Safety, Efficacy, and Dysphagia Phenotype. *Current Oncology*, *32*(4), 233. https://doi.org/10.3390/curroncol32040233

Gliklich, R. E., Dreyer, N. A., & Leavy, M. B. (Eds.). (2014). *Registries for evaluating patient outcomes: A user's guide* (3rd ed.). Agency for Healthcare Research and Quality. https://www.ncbi.nlm.nih.gov/books/NBK208618/

González-Fernández, M., Ottenstein, L., Atanelov, L., & Christian, A. B. (2013). Dysphagia after stroke: An overview. *Current Physical Medicine and Rehabilitation Reports*, *1*(3), 187–196. https://doi.org/10.1007/s40141-013-0017-y

Gu, H., & Ren, D. (2024). Prevalence and Risk Factors of Poststroke Dysphagia: A Meta-Analysis. *Cerebrovascular Diseases*, 1–24. https://doi.org/10.1159/000538218

Haas, R., & Bailey, S. (2024). Clinical and Instrumental Swallowing Assessments for Dysphagia: Rapid Review. In *PubMed*. Canadian Agency for Drugs and Technologies in Health. https://www.ncbi.nlm.nih.gov/books/NBK602505/

Hashimoto, H., Hirata, M., Takahashi, K., Kameda, S., Katsuta, Y., Yoshida, F., Hattori, N., Yanagisawa, T., Palmer, J., Oshino, S., Yoshimine, T., & Kishima, H. (2018). Non-invasive quantification of human swallowing using a simple motion tracking system. *Scientific Reports*, *8*(1), 5095. https://doi.org/10.1038/s41598-018-23486-0

Herland, M., Khoshgoftaar, T. M., & Wald, R. (2014). A review of data mining using big data in health informatics. *Journal Of Big Data*, *1*(1), 2. https://doi.org/10.1186/2196-1115-1-2

Hsiao, M.-Y., Wu, C.-H., & Wang, T.-G. (2021). Emerging Role of Ultrasound in Dysphagia Assessment and Intervention: A Narrative Review. *Frontiers in Rehabilitation Sciences*, *2*, 708102. https://doi.org/10.3389/fresc.2021.708102

Huckabee, M. L., & Cannito, M. P. (1999). Outcomes of Swallowing Rehabilitation in Chronic Brainstem Dysphagia: A Retrospective Evaluation. *Dysphagia*, *14*(2), 93–109. https://doi.org/10.1007/PL00009593

Huckabee, M. L., & Pelletier, C. A. (1999). *Management of Adult Neurogenic Dysphagia*. Singular.

Imada, M., Kagaya, H., Ishiguro, Y., Kato, M., Inamoto, Y., Tanaka, T., Shibata, S., & Saitoh, E. (2016). Effect of visual biofeedback to acquire supraglottic swallow in healthy individuals: A randomized-controlled trial. *International Journal of Rehabilitation Research*, *39*(2), 181–184. https://doi.org/10.1097/MRR.0000000000000154

Irvin, J., Rajpurkar, P., Ko, M., Yu, Y., Ciurea-Ilcus, S., Chute, C., Marklund, H., Haghgoo, B., Ball, R., Shpanskaya, K., Seekins, J., Mong, D. A., Halabi, S. S., Sandberg, J. K., Jones, R., Larson, D. B., Langlotz, C. P., Patel, B. N., Lungren, M. P., & Ng, A. Y. (2019). CheXpert: A Large Chest Radiograph Dataset with Uncertainty Labels and Expert Comparison. *Proceedings of the AAAI Conference on Artificial Intelligence*, *33*(01), 590–597. https://doi.org/10.1609/aaai.v33i01.3301590

Jamróz, B., Sielska-Badurek, E., & Niemczyk, K. (2015). Use of flexible endoscope for evaluation of swallowing. *Polski Przegląd Otorynolaryngologiczny*, *4*(2), 1–5. https://doi.org/10.5604/20845308.1150791

Jensen, P. B., Jensen, L. J., & Brunak, S. (2012). Mining electronic health records: Towards better research applications and clinical care. *Nature Reviews Genetics*, *13*(6), 395–405. https://doi.org/10.1038/nrg3208

Jeong, S. Y., Kim, J. M., Park, J. E., Baek, S. J., & Yang, S. N. (2023). Application of deep learning technology for temporal analysis of videofluoroscopic swallowing studies. *Scientific Reports*, *13*(1), 17522. https://doi.org/10.1038/s41598-023-44802-3

Johnson, A. E. W., Bulgarelli, L., Shen, L., Gayles, A., Shammout, A., Horng, S., Pollard, T. J., Hao, S., Moody, B., Gow, B., Lehman, L. H., Celi, L. A., & Mark, R. G. (2023). MIMIC-IV, a freely accessible electronic health record dataset. *Scientific Data*, *10*(1), 1. https://doi.org/10.1038/s41597-022-01899-x

Johnson, A. E. W., Pollard, T. J., Shen, L., Lehman, L. H., Feng, M., Ghassemi, M., Moody, B., Szolovits, P., Anthony Celi, L., & Mark, R. G. (2016). MIMIC-III, a freely accessible critical care database. *Scientific Data*, *3*(1), 160035. https://doi.org/10.1038/sdata.2016.35

Jones, C. A., Meisner, E. L., Broadfoot, C. K., Rosen, S. P., Samuelsen, C. R., & McCulloch, T. M. (2018). Methods for Measuring Swallowing Pressure Variability Using High-Resolution Manometry. *Frontiers in Applied Mathematics and Statistics*, *4*, 23. https://doi.org/10.3389/fams.2018.00023

Kahrilas, P. J., & Logemann, J. A. (1993). Volume accommodation during swallowing. *Dysphagia*, *8*(3), 259–265. https://doi.org/10.1007/BF01354548

Kaneoka, A., Inokuchi, H., Ueha, R., Sato, T., Goto, T., Yamauchi, A., Seto, Y., & Haga, N. (2024). Longitudinal Analysis of Dysphagia and Factors Related to Postoperative Pneumonia in Patients Undergoing Esophagectomy for Esophageal Cancer. *Dysphagia*, *39*(3), 376–386. https://doi.org/10.1007/s00455-023-10618-6

Kantczak, A., Bielecki, I., Gierlotka, A., Dawiec, G., Górny, D., & Kruczek, W. (2025). The use of flexible endoscopic evaluation of swallow in the paediatric population. *Pediatria i Medycyna Rodzinna*, *21*(2), 90–96. https://doi.org/10.15557/PiMR.2025.0013

KARL STORZ Endoskope. (n.d.). *Welcome to the world of endoscopy*. https://www.karlstorz.com/us/en/

Kelly, A. M., Drinnan, M. J., & Leslie, P. (2007). Assessing Penetration and Aspiration: How Do Videofluoroscopy and Fiberoptic Endoscopic Evaluation of Swallowing Compare? *The Laryngoscope*, *117*(10), 1723–1727. https://doi.org/10.1097/MLG.0b013e318123ee6a

KMS Technology. (2025). *Top 10 healthcare data sets and sources*. https://kms-technology.com/blog/healthcare-data-sets/

Kou, W., Carlson, D. A., Baumann, A. J., Donnan, E., Luo, Y., Pandolfino, J. E., & Etemadi, M. (2021). A deep-learning-based unsupervised model on esophageal manometry using variational autoencoder. *Artificial Intelligence in Medicine*, *112*, 102006. https://doi.org/10.1016/j.artmed.2020.102006

Koulaouzidis, A., Iakovidis, D., Yung, D., Rondonotti, E., Kopylov, U., Plevris, J., Toth, E., Eliakim, A., Wurm Johansson, G., Marlicz, W., Mavrogenis, G., Nemeth, A., Thorlacius, H., & Tontini, G. (2017). KID Project: An internet-based digital video atlas of capsule endoscopy for research purposes. *Endoscopy International Open*, *05*(06), E477–E483. https://doi.org/10.1055/s-0043-105488

Krishnamurthy, R., Balasubramanium, R. K., & Premkumar, P. K. (2022). Systematic Review and Meta-Analysis of Dysphagia and Associated Pneumonia in Patients With Stroke From India: A Call to Arms. *American Journal of Speech-Language Pathology*, *31*(1), 502–514. https://doi.org/10.1044/2021_AJSLP-21-00175

Kwak, S., Kim, J. K., Moon, J. S., Lee, G. W., Kim, S., & Chang, M. C. (2025). Deep learning-based video analysis for automatically detecting penetration and aspiration in videofluoroscopic swallowing study. *Scientific Reports*, *15*(1), 24296. https://doi.org/10.1038/s41598-025-10397-0

Labeit, B., Michou, E., Trapl-Grundschober, M., Suntrup-Krueger, S., Muhle, P., Bath, P. M., & Dziewas, R. (2024). Dysphagia after stroke: Research advances in treatment interventions. *The Lancet Neurology*, *23*(4), 418–428. https://doi.org/10.1016/S1474-4422(24)00053-X

Laborie Medical Technologies Corp. (2024, March 20). *Online Courses for Healthcare Professionals | Laborie*. Laborie. https://www.laborie.com/online-courses/

Langmore, S. (2001). *Endoscopic Evaluation and Treatment of Swallowing Disorders*. Thieme.

Langmore, S. E., Kenneth, S. M. A., & Olsen, N. (1988). Fiberoptic endoscopic examination of swallowing safety: A new procedure. *Dysphagia*, *2*(4), 216–219. https://doi.org/10.1007/BF02414429

Langmore, S. E., Krisciunas, G. P., Warner, H., White, S. D., Dvorkin, D., Fink, D., McNally, E., Scheel, R., Higgins, C., Levitt, J. E., McKeehan, J., Deane, S., Siner, J. M., Vojnik, R., & Moss, M. (2021). Abnormalities of Aspiration and Swallowing Function in Survivors of Acute Respiratory Failure. *Dysphagia*, *36*(5), 831–841. https://doi.org/10.1007/s00455-020-10199-8

Langmore, S. E., Scarborough, D. R., Kelchner, L. N., Swigert, N. B., Murray, J., Reece, S., Cavanagh, T., Harrigan, L. C., Scheel, R., Gosa, M. M., & Rule, D. K. (2022). Tutorial on Clinical Practice for Use of the Fiberoptic Endoscopic Evaluation of Swallowing Procedure With Adult Populations: Part 1. *American Journal of Speech-Language Pathology*, *31*(1), 163–187. https://doi.org/10.1044/2021_AJSLP-20-00348

Langmore, S. E., Terpenning, M. S., Schork, A., Chen, Y., Murray, J. T., Lopatin, D., & Loesche, W. J. (1998). Predictors of Aspiration Pneumonia: How Important Is Dysphagia? *Dysphagia*, *13*(2), 69–81. https://doi.org/10.1007/PL00009559

Leder, S. B., Sasaki, C. T., & Burrell, M. I. (1998). Fiberoptic Endoscopic Evaluation of Dysphagia to Identify Silent Aspiration. *Dysphagia*, *13*(1), 19–21. https://doi.org/10.1007/PL00009544

Leder, S. B., & Espinosa, J. F. (2002). Aspiration Risk After Acute Stroke: Comparison of Clinical Examination and Fiberoptic Endoscopic Evaluation of Swallowing. *Dysphagia*, *17*(3), 214–218. https://doi.org/10.1007/s00455-002-0054-7

Lee, B. H., Lee, J. C., Lee, S. M., Park, Y., & Ryu, J. S. (2019). Application of Automatic Kinematic Analysis Program for the Evaluation of Dysphagia in ALS patients. *Scientific Reports*, *9*(1), 15644. https://doi.org/10.1038/s41598-019-52246-x

Lee, J. T., Park, E., Hwang, J.-M., Jung, T.-D., & Park, D. (2020). Machine learning analysis to automatically measure response time of pharyngeal swallowing reflex in videofluoroscopic swallowing study. *Scientific Reports*, *10*(1), 14735. https://doi.org/10.1038/s41598-020-71713-4

Lee, W. K., Yeom, J., Lee, W. H., Seo, H. G., Oh, B.-M., & Han, T. R. (2016). Characteristics of Dysphagia in Severe Traumatic Brain Injury Patients: A Comparison with Stroke Patients. *Annals of Rehabilitation Medicine*, *40*(3), 432–439. https://doi.org/10.5535/arm.2016.40.3.432

Likar, R., Aroyo, I., Bangert, K., Degen, B., Dziewas, R., Galvan, O., Grundschober, M. T., Köstenberger, M., Muhle, P., Schefold, J. C., & Zuercher, P. (2024). Management of swallowing disorders in ICU patients—A multinational expert opinion. *Journal of Critical Care*, *79*, 154447. https://doi.org/10.1016/j.jcrc.2023.154447

Liolios, K., Schriml, L., Hirschman, L., Pagani, I., Nosrat, B., Sterk, P., White, O., Rocca-Serra, P., Sansone, S.-A., Taylor, C., Kyrpides, N. C., & Field, D. (2012). The Metadata Coverage Index (MCI): A standardized metric for quantifying database metadata richness. *Standards in Genomic Sciences*, *6*(3), 444–453. https://doi.org/10.4056/sigs.2675953

Lippeveld, T., Sauerborn, R., & Bodart, C. (Eds.). (2000). *Design and implementation of health information systems*. World Health Organization. https://iris.who.int/handle/10665/42289

Logemann, J. (1997). Role of the modified barium swallow in management of patients with dysphagia. *Otolaryngology - Head and Neck Surgery*, *116*(3), 335–338. https://doi.org/10.1016/S0194-5998(97)70269-9

Logemann, J. A. (1998). *Evaluation and Treatment of Swallowing Disorders*. Pro-Ed.

Maeda, K., Nagasaka, M., Nagano, A., Nagami, S., Hashimoto, K., Kamiya, M., Masuda, Y., Ozaki, K., & Kawamura, K. (2023). Ultrasonography for Eating and Swallowing Assessment: A Narrative Review of Integrated Insights for Noninvasive Clinical Practice. *Nutrients*, *15*(16), 3560. https://doi.org/10.3390/nu15163560

Marcus, D. S., Wang, T. H., Parker, J., Csernansky, J. G., Morris, J. C., & Buckner, R. L. (2007). Open Access Series of Imaging Studies (OASIS): Cross-sectional MRI Data in Young, Middle Aged, Nondemented, and Demented Older Adults. *Journal of Cognitive Neuroscience*, *19*(9), 1498–1507. https://doi.org/10.1162/jocn.2007.19.9.1498

Markiewicz, C. J., Gorgolewski, K. J., Feingold, F., Blair, R., Halchenko, Y. O., Miller, E., Hardcastle, N., Wexler, J., Esteban, O., Goncavles, M., Jwa, A., & Poldrack, R. (2021).

The OpenNeuro resource for sharing of neuroscience data. *eLife*, *10*, e71774. https://doi.org/10.7554/eLife.71774

Martino, R., Foley, N., Bhogal, S., Diamant, N., Speechley, M., & Teasell, R. (2005). Dysphagia After Stroke: Incidence, Diagnosis, and Pulmonary Complications. *Stroke*, *36*(12), 2756–2763. https://doi.org/10.1161/01.STR.0000190056.76543.eb

McCullough, G. H., Wertz, R. T., Rosenbek, J. C., Mills, R. H., Webb, W. G., & Ross, K. B. (2001). Inter- and Intrajudge Reliability for Videofluoroscopic Swallowing Evaluation Measures. *Dysphagia*, *16*(2), 110–118. https://doi.org/10.1007/PL00021291

Medbridge. (2025). *Foundations of best practice in videofluoroscopy (VFSS)*. https://www.medbridge.com/educate/certificate-programs/52381-foundations-of-best-practice-in-videofluoroscopy-vfss

Meguerdichian, M., Bajaj, K., Wong, N., Bentley, S., Walker, K., Cheng, A., & Ahmed, R. A. (2019). Simulation Fellowships: Survey of Current Summative Assessment Practices. *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare*, *14*(5), 300–306. https://doi.org/10.1097/SIH.0000000000000384

Meng, Q.-N., Zhu, Y., Liu, S.-W., Hu, B., Chai, D.-J., & Dong, C.-X. (2024). Study on the treatment of dysphagia after stroke with electromyographic biofeedback intensive training. *World Journal of Clinical Cases*, *12*(19), 3725–3733. https://doi.org/10.12998/wjcc.v12.i19.3725

Merck & Co., Inc. (2012). *Merck Molecular Activity Challenge*. Kaggle. https://www.kaggle.com/c/MerckActivity

Molfenter, S. M., & Steele, C. M. (2012). Temporal Variability in the Deglutition Literature. *Dysphagia*, *27*(2), 162–177. https://doi.org/10.1007/s00455-012-9397-x

Molfenter, S. M., & Steele, C. M. (2014). Kinematic and Temporal Factors Associated with Penetration–Aspiration in Swallowing Liquids. *Dysphagia*, *29*(2), 269–276. https://doi.org/10.1007/s00455-013-9506-5

Morgan, A. T. (2010). Dysphagia in childhood traumatic brain injury: A reflection on the evidence and its implications for practice. *Developmental Neurorehabilitation*, *13*(3), 192–203. https://doi.org/10.3109/17518420903289535

Mueller, S. G., Weiner, M. W., Thal, L. J., Petersen, R. C., Jack, C. R., Jagust, W., Trojanowski, J. Q., Toga, A. W., & Beckett, L. (2005). Ways toward an early diagnosis in Alzheimer's disease: The Alzheimer's Disease Neuroimaging Initiative (ADNI). *Alzheimer's & Dementia*, *1*(1), 55–66. https://doi.org/10.1016/j.jalz.2005.06.003

Mulder, T., & Hulstyn, W. (1984). Sensory feedback therapy and theoretical knowledge of motor control and learning. *American Journal of Physical Medicine*, *63*(5), 226–244

Murray, J., Langmore, S. E., Ginsberg, S., & Dostie, A. (1996). The significance of accumulated oropharyngeal secretions and swallowing frequency in predicting aspiration. *Dysphagia*, *11*(2), 99–103. https://doi.org/10.1007/BF00417898

Namasivayam-MacDonald, A. M., & Shune, S. E. (2018). The Burden of Dysphagia on Family Caregivers of the Elderly: A Systematic Review. *Geriatrics*, *3*(2), 30. https://doi.org/10.3390/geriatrics3020030

National Cancer Institute. (2025). *Surveillance, Epidemiology, and End Results (SEER) Program*. https://seer.cancer.gov/

Neubauer, P. D., Rademaker, A. W., & Leder, S. B. (2015). The Yale Pharyngeal Residue Severity Rating Scale: An Anatomically Defined and Image-Based Tool. *Dysphagia*, *30*(5), 521–528. https://doi.org/10.1007/s00455-015-9631-4

Northern Speech Services. (n.d.). *MBSImP training: Standardized dysphagia assessment*. https://www.northernspeech.com/dysphagia-assessment-adult/the-modified-barium-swallow-impairment-profile-mbsimp-standardized-training-and-reliability-testing/

Office for Civil Rights (OCR). (2022, October 25). *Methods for de-identification of PHI*. HHS.gov. https://www.hhs.gov/hipaa/for-professionals/privacy/special-topics/de-identification/index.html

O'Horo, J. C., Rogus-Pulia, N., Garcia-Arguello, L., Robbins, J., & Safdar, N. (2015). Bedside diagnosis of dysphagia: A systematic review. *Journal of Hospital Medicine*, *10*(4), 256–265. https://doi.org/10.1002/jhm.2313

Obata, H., Izumi, T., Ishizuka, M., Yamaguchi, K., Hao, N., Yagihara, N., Abe, S., Watanabe, H., Inomata, T., Makita, S., & Fujimoto, S. (2024). Impact and management of integrated dysphagia rehabilitation within cardiac care programs for older patients with cardiovascular disease. *European Geriatric Medicine*, *15*(6), 1657–1668. https://doi.org/10.1007/s41999-024-01031-9

Oliveira, I. de J., Couto, G. R., Santos, R. V., Campolargo, A. M., Lima, C., & Ferreira, P. L. (2022). Best Practice Recommendations for Dysphagia Management in Stroke Patients: A Consensus from a Portuguese Expert Panel. *Portuguese Journal of Public Health*, *39*(3), 145–162. https://doi.org/10.1159/000520505

Omari, T. I., Ferris, L., Schar, M., Cock, C., & Doeltgen, S. (2022). Multiple swallow behaviour during high resolution pharyngeal manometry: Prevalence and sub-typing in healthy adults. *Speech, Language and Hearing*, *25*(1), 1–7. https://doi.org/10.1080/2050571X.2020.1826109

Ortega, O., Martín, A., & Clavé, P. (2017). Diagnosis and Management of Oropharyngeal Dysphagia Among Older Persons, State of the Art. *Journal of the American Medical Directors Association*, *18*(7), 576–582. https://doi.org/10.1016/j.jamda.2017.02.015

Ortiz Pérez, P., Valero-Arredondo, I., Torcuato-Rubio, E., Herrador-López, M., Martín-Masot, R., & Navas-López, V. M. (2024). Nutritional Issues in Children with Dysphagia. *Nutrients*, *16*(11), 1590. https://doi.org/10.3390/nu16111590

Patel, D. A., Krishnaswami, S., Steger, E., Conover, E., Vaezi, M. F., Ciucci, M. R., & Francis, D. O. (2018). Economic and survival burden of dysphagia among inpatients in the United States. *Diseases of the Esophagus*, *31*(1). https://doi.org/10.1093/dote/dox131

Pazinatto, D. B., Brandão, M. A. B., Costa, F. L. P., Favaro, M. M. A., & Maunsell, R. (2024). Role of fiberoptic endoscopic evaluation of swallowing (FEES) in children with suspected dysphagia. *Jornal De Pediatria*, *100*(5), 476–482. https://doi.org/10.1016/j.jped.2024.03.008

PENTAX Medical. (n.d.). *FEES*. https://www.pentaxmedical.com/pentax/en/99/1/FEES

Peranovic, S., Pourhassan, M., Labeit, B., Muhle, P., Suntrup-Krueger, S., Warnecke, T., Dziewas, R., Trampisch, U., Wirth, R., & Lueg, G. (2025). Endoscopic characterization of oropharyngeal dysphagia in patients with dementia. *Frontiers in Aging*, *6*, 1535137. https://doi.org/10.3389/fragi.2025.1535137

Pikus, L., Levine, M. S., Yang, Y.-X., Rubesin, S. E., Katzka, D. A., Laufer, I., & Gefter, W. B. (2003). Videofluoroscopic Studies of Swallowing Dysfunction and the Relative Risk of Pneumonia. *American Journal of Roentgenology*, *180*(6), 1613–1616. https://doi.org/10.2214/ajr.180.6.1801613

Pisegna, J. M., Borders, J. C., Kaneoka, A., Coster, W. J., Leonard, R., & Langmore, S. E. (2018). Reliability of Untrained and Experienced Raters on FEES: Rating Overall Residue is a Simple Task. *Dysphagia*, *33*(5), 645–654. https://doi.org/10.1007/s00455-018-9883-x

Pollard, T. J., Johnson, A. E. W., Raffa, J. D., Celi, L. A., Mark, R. G., & Badawi, O. (2018). The eICU Collaborative Research Database, a freely available multi-center database for critical care research. *Scientific Data*, *5*(1), 180178. https://doi.org/10.1038/sdata.2018.178

Prikladnicki, A., Santana, M. G., & Cardoso, M. C. (2022). Protocols and assessment procedures in fiberoptic endoscopic evaluation of swallowing: An updated systematic review. *Brazilian Journal of Otorhinolaryngology*, *88*(3), 445–470. https://doi.org/10.1016/j.bjorl.2021.03.002

Printza, A., Sdravou, K., & Triaridis, S. (2022). Dysphagia Management in Children: Implementation and Perspectives of Flexible Endoscopic Evaluation of Swallowing (FEES). *Children*, *9*(12), 1857. https://doi.org/10.3390/children9121857

Prosperi, M., Min, J. S., Bian, J., & Modave, F. (2018). Big data hurdles in precision medicine and precision public health. *BMC Medical Informatics and Decision Making*, *18*(1), 139. https://doi.org/10.1186/s12911-018-0719-2

Raghupathi, W., & Raghupathi, V. (2014). Big data analytics in healthcare: Promise and potential. *Health Information Science and Systems*, *2*(1), 3. https://doi.org/10.1186/2047-2501-2-3

Rajkomar, A., Dean, J., & Kohane, I. (2019). Machine Learning in Medicine. *New England Journal of Medicine*, *380*(14), 1347–1358. https://doi.org/10.1056/NEJMra1814259

Ramez, Elmasri, Shamkant, & Navathe. (2010). *Fundamentals of Database System*. Pearson Education India.

Ramsey, D., Smithard, D., & Kalra, L. (2005). Silent Aspiration: What Do We Know? *Dysphagia*, *20*(3), 218–225. https://doi.org/10.1007/s00455-005-0018-9

Reddy, N. P., Simcox, D. L., Gupta, V., Motta, G. E., Coppenger, J., Das, A., & Buch, O. (2000). Biofeedback therapy using accelerometry for treating dysphagic patients with poor laryngeal elevation: Case studies. *Journal of Rehabilitation Research and Development*, *37*(3), 361–372.

Robinson, H. F., & Dennick, R. (2015). Teaching laryngeal endoscopy skills to speech and language therapists: Applying learning theory to optimize practical skills mastery. *Current Opinion in Otolaryngology & Head and Neck Surgery*, *23*(3), 197–201. https://doi.org/10.1097/MOO.0000000000000163

Rocca, S., Negri, L., Valenza, N., Schindler, A., & Pizzorni, N. (2025). Pharyngeal Residues Scoring through the Yale Pharyngeal Residue Severity Rating Scale (YPRSRS): Efficacy of Training. *Dysphagia*, *40*(1), 271–281. https://doi.org/10.1007/s00455-024-10725-y

Rosenbek, J. C., Robbins, J. A., Roecker, E. B., Coyle, J. L., & Wood, J. L. (1996). A penetration-aspiration scale. *Dysphagia*, *11*(2), 93–98. https://doi.org/10.1007/BF00417897

Sanderson, L., & Sanderson, L. (2023, April 10). *FEES training*. Carolina Speech Pathology. https://carolinafees.com/why-does-hands-on-fees-training-matter/

Santa Maria, C., & O'Dell, K. (2024). Dysphagia as a Manifestation of Endocrine and Metabolic Disorders. *Otolaryngologic Clinics of North America*, *57*(4), 657–668. https://doi.org/10.1016/j.otc.2024.02.024

Schiedermayer, B., Kendall, K. A., Stevens, M., Ou, Z., Presson, A. P., & Barkmeier-Kraemer, J. M. (2020). Prevalence, incidence, and characteristics of dysphagia in those with unilateral vocal fold paralysis. *The Laryngoscope*, *130*(10), 2397–2404. https://doi.org/10.1002/lary.28401

Schmidt, J., Holas, M., Halvorson, K., & Reding, M. (1994). Videofluoroscopic evidence of aspiration predicts pneumonia and death but not dehydration following stroke. *Dysphagia*, *9*(1). https://doi.org/10.1007/BF00262752

Shaip. (2025). *Healthcare datasets: Types, uses, benefits, and challenges*. https://www.shaip.com/blog/healthcare-datasets/

Shickel, B., Tighe, P. J., Bihorac, A., & Rashidi, P. (2018). Deep EHR: A Survey of Recent Advances in Deep Learning Techniques for Electronic Health Record (EHR) Analysis. *IEEE Journal of Biomedical and Health Informatics*, *22*(5), 1589–1604. https://doi.org/10.1109/JBHI.2017.2767063

Simon, S. R., Wieland, M. W. M., Hendriks, C., Pilz, W., Schindler, A., Winkens, B., & Baijens, L. W. J. (2023). Intra and interobserver agreement of the Dynamic Imaging Grade of Swallowing Toxicity Scale (DIGEST) in fiberoptic endoscopic evaluation of swallowing (FEES): The importance of observer-tailored training. *European Archives of Oto-Rhino-Laryngology*, *280*(6), 2865–2876. https://doi.org/10.1007/s00405-023-07840-1

Slovik, Y., Kaminer, B. M., Revital, G., Ron, A., Harris, M., Ziv, O., Loutati, A., & Cohen, O. (2025). A Modified Fiberoptic Endoscopic Evaluation of Swallowing Evaluating Esophageal Dysphagia by a Capsule: A Pilot Study. *Dysphagia*, *40*(1), 263–270. https://doi.org/10.1007/s00455-024-10724-z

Smithard, D. G., O'Neill, P. A., Park, C., Morris, J., Wyatt, R., England, R., & Martin, D. F. (1996). Complications and Outcome After Acute Stroke: Does Dysphagia Matter? *Stroke*, *27*(7), 1200–1204. https://doi.org/10.1161/01.STR.27.7.1200

Song, W., Wu, M., Wang, H., Pang, R., & Zhu, L. (2024). Prevalence, risk factors, and outcomes of dysphagia after stroke: A systematic review and meta-analysis. *Frontiers in Neurology*, *15*, 1403610. https://doi.org/10.3389/fneur.2024.1403610

SonoSim. (n.d.). *The easiest way to learn ultrasonography* https://sonosim.com/

Starmer, H. M., Arrese, L., Langmore, S., Ma, Y., Murray, J., Patterson, J., Pisegna, J., Roe, J., Tabor-Gray, L., & Hutcheson, K. (2021). Adaptation and Validation of the Dynamic Imaging Grade of Swallowing Toxicity for Flexible Endoscopic Evaluation of Swallowing: DIGEST-FEES. *Journal of Speech, Language, and Hearing Research*, *64*(6), 1802–1810. https://doi.org/10.1044/2021_JSLHR-21-00014

Stokely, S. L., Molfenter, S. M., & Steele, C. M. (2014). Effects of barium concentration on oropharyngeal swallow timing measures. *Dysphagia*, *29*(1), 78–82. https://doi.org/10.1007/s00455-013-9485-6

Stokely, S. L., Peladeau-Pigeon, M., Leigh, C., Molfenter, S. M., & Steele, C. M. (2015). The Relationship Between Pharyngeal Constriction and Post-swallow Residue. *Dysphagia*, *30*(3), 349–356. https://doi.org/10.1007/s00455-015-9606-5

Swan, K., Cordier, R., Brown, T., & Speyer, R. (2019). Psychometric Properties of Visuoperceptual Measures of Videofluoroscopic and Fibre-Endoscopic Evaluations of Swallowing: A Systematic Review. *Dysphagia*, *34*(1), 2–33. https://doi.org/10.1007/s00455-018-9918-3

Takizawa, C., Gemmell, E., Kenworthy, J., & Speyer, R. (2016). A Systematic Review of the Prevalence of Oropharyngeal Dysphagia in Stroke, Parkinson's Disease, Alzheimer's Disease, Head Injury, and Pneumonia. *Dysphagia*, *31*(3), 434–441. https://doi.org/10.1007/s00455-016-9695-9

Terré, R., & Mearin, F. (2006). Oropharyngeal dysphagia after the acute phase of stroke: Predictors of aspiration. *Neurogastroenterology & Motility*, *18*(3), 200–205. https://doi.org/10.1111/j.1365-2982.2005.00729.x

The Cancer Genome Atlas Research Network, Weinstein, J. N., Collisson, E. A., Mills, G. B., Shaw, K. R. M., Ozenberger, B. A., Ellrott, K., Shmulevich, I., Sander, C., & Stuart, J. M. (2013). The Cancer Genome Atlas Pan-Cancer analysis project. *Nature Genetics*, *45*(10), 1113–1120. https://doi.org/10.1038/ng.2764

The 1000 Genomes Project Consortium. (2015). A Global Reference for Human Genetic Variation. *Nature*, *526*(7571), 68–74. https://doi.org/10.1038/nature15393

Thommessen, M., Kase, B. F., Riis, G., & Heiberg, A. (1991). The impact of feeding problems on growth and energy intake in children with cerebral palsy. *European Journal of Clinical Nutrition*, *45*(10), 479–487.

Tomczak, K., Czerwińska, P., & Wiznerowicz, M. (2015). Review The Cancer Genome Atlas (TCGA): An immeasurable source of knowledge. *Współczesna Onkologia*, *1A*, 68–77. https://doi.org/10.5114/wo.2014.47136

Wallace, S., McLaughlin, C., Clayton, J., Coffey, M., Ellis, J., Haag, R., Howard, A., Marks, H., & Zorko, R. (2020). *Fibreoptic endoscopic evaluation of swallowing (FEES): The role of speech and language therapy* [Position paper]. Royal College of Speech and Language Therapists.

Wang, Y., Kung, L., Wang, W. Y. C., & Cegielski, C. G. (2018). An integrated big data analytics-enabled transformation model: Application to health care. *Information & Management*, *55*(1), 64–79. https://doi.org/10.1016/j.im.2017.04.001

Wang, Z., Shi, R., & Moreira, P. (2025). Post-stroke dysphagia: Identifying the evidence missing. *Frontiers in Medicine*, *12*, 1494645. https://doi.org/10.3389/fmed.2025.1494645

Warnecke, T., Ritter, M. A., Kröger, B., Oelenberg, S., Teismann, I., Heuschmann, P. U., Ringelstein, E. B., Nabavi, D. G., & Dziewas, R. (2009). Fiberoptic Endoscopic Dysphagia Severity Scale Predicts Outcome after Acute Stroke. *Cerebrovascular Diseases*, *28*(3), 283–289. https://doi.org/10.1159/000228711

Warnecke, T., Suttrup, I., Schröder, J. B., Osada, N., Oelenberg, S., Hamacher, C., Suntrup, S., & Dziewas, R. (2016). Levodopa responsiveness of dysphagia in advanced Parkinson's disease and reliability testing of the FEES-Levodopa-test. *Parkinsonism & Related Disorders*, *28*, 100–106. https://doi.org/10.1016/j.parkreldis.2016.04.034

Warnecke, T., Teismann, I., Oelenberg, S., Hamacher, C., Ringelstein, E. B., Schäbitz, W. R., & Dziewas, R. (2009). Towards a basic endoscopic evaluation of swallowing in acute stroke – identification of salient findings by the inexperienced examiner. *BMC Medical Education*, *9*(1), 13. https://doi.org/10.1186/1472-6920-9-13

Wiens, J., Saria, S., Sendak, M., Ghassemi, M., Liu, V. X., Doshi-Velez, F., Jung, K., Heller, K., Kale, D., Saeed, M., Ossorio, P. N., Thadaney-Israni, S., & Goldenberg, A. (2019). Do no harm: A roadmap for responsible machine learning for health care. *Nature Medicine*, *25*(9), 1337–1340. https://doi.org/10.1038/s41591-019-0548-6

Wiederhold, G. (1981). Database technology in health care. *Journal of Medical Systems*, *5*(3), 175–196. https://doi.org/10.1007/BF02221994

Weng, W., Imaizumi, M., Murono, S., & Zhu, X. (2022). Expert-level aspiration and penetration detection during flexible endoscopic evaluation of swallowing with artificial intelligenceassisted diagnosis. *Scientific Reports*, *12*(1), 21689. https://doi.org/10.1038/s41598-022-25618-z

Wakabayashi, H., Kakehi, S., Nagano, A., Kishima, M., Itoda, M., Nishioka, S., & Momosaki, R. (2024). Age and sex differences in sarcopenic dysphagia: A secondary data analysis. *Journal of General and Family Medicine*, *25*(6), 343–350. https://doi.org/10.1002/jgf2.722

Wooi, M., Scott, A., & Perry, A. (2001). Teaching Speech Pathology Students the Interpretation of Videofluoroscopic Swallowing Studies. *Dysphagia*, *16*(1), 32–39.

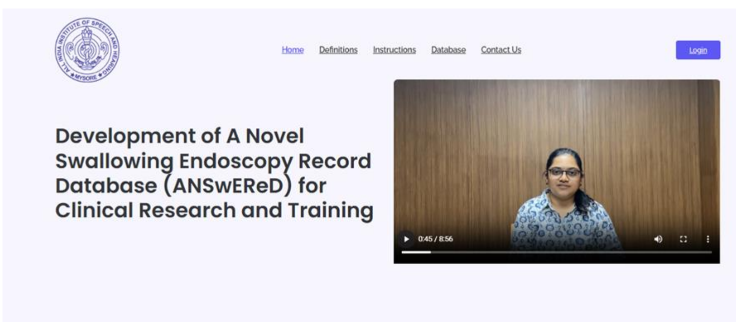
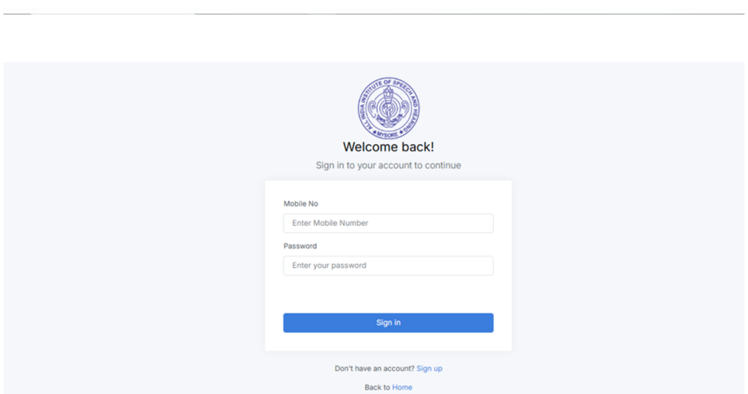
World Health Organization. (2025). *Global Health Observatory: Mortality and burden of disease*. https://www.who.int/data/gho

World Health Organization. (2011). *Global status report on noncommunicable diseases 2010*. https://iris.who.int/handle/10665/44579

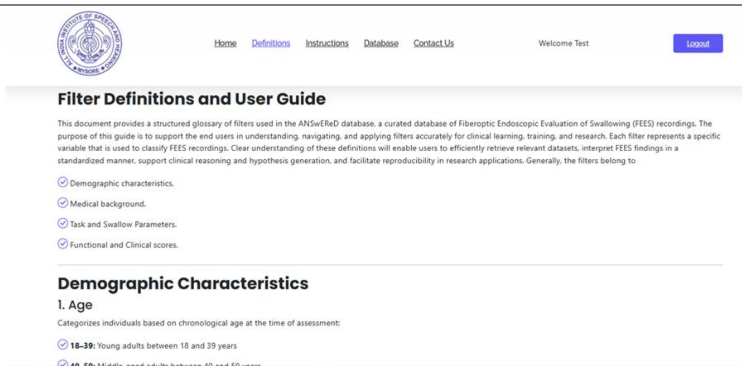
Zarkada, A., & Regan, J. (2018). Inter-rater Reliability of the Dysphagia Outcome and Severity Scale (DOSS): Effects of Clinical Experience, Audio-Recording and Training. *Dysphagia*, *33*(3), 329–336. https://doi.org/10.1007/s00455-017-9857-4

Appendix A

Visual content and the audio script of the instructional video 'How to use ANSwEReD™' present on the homepage of ANSwEReD™

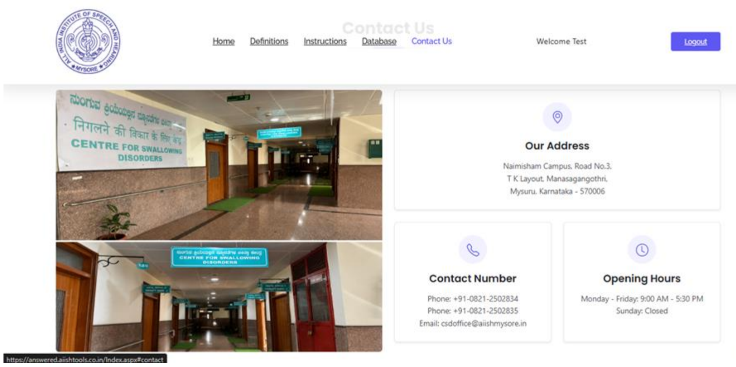
Page	Preview	Description
Home	 	A Novel Swallowing Endoscopy Record Database. ANSwEReD is a curated database of Fiberoptic Endoscopic Evaluation of Swallowing (FEES) recordings, developed to support clinical learning, training, and research in dysphagia. The database includes validated FEES videos of both typical and disordered swallowing, systematically organized using demographic, medical, physiological, and clinical parameters.
How to use ANSwERe D	 	In this video, we will guide you step-by-step on how to navigate this database, apply the available filters, and effectively use it for both learning and research purposes.
Login	 	To begin, one should click on the Login icon at the top right corner of the homepage. Enter their User ID and Password to access the database.

Definitions



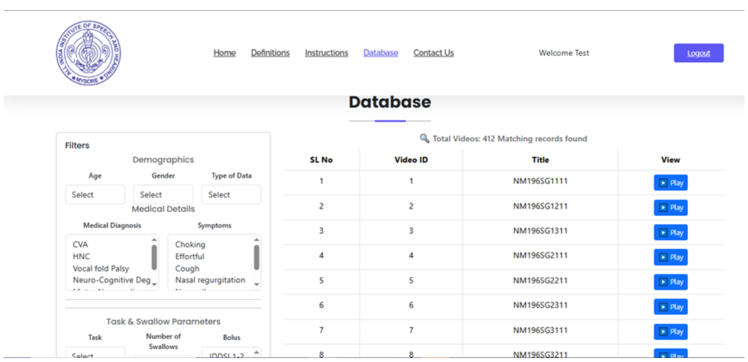
Once you have successfully logged in, you will see the main navigation panel, which includes Definitions, Instructions, Database, and Contact Us sections. If you are new to this database, we strongly recommend you review the Definitions section. Here we have listed and explained the definitions of the key terminologies and the filters used in creation of this database.

Contact Us



We welcome clinicians, researchers, and students who are interested in Using the database for research, contributing validated high-quality data to this database, or those who are interested in collaborating on dysphagia and FEES-based studies and those who are interesting in learning FEES procedure and its interpretation and clinical applications. If you would like to collaborate or learn more, please reach out to us through the Contact Us section.

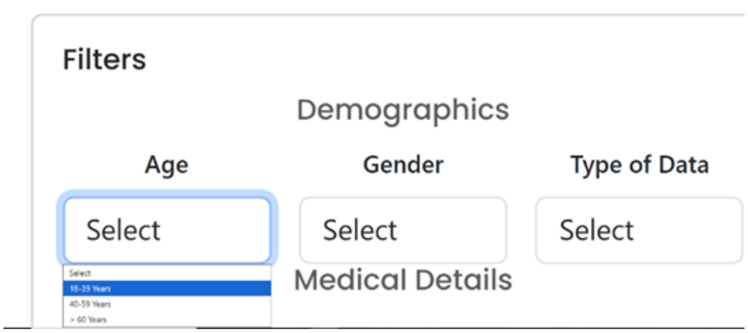
Database



As you can see on the screen, the database is organized into four main sections: Demographics, Medical Details, Task and Swallow Parameters, and Functional and Clinical Scores. You can use these filters to narrow down and retrieve specific FEES recordings based on your requirement. This framework was made to make your navigation through this database quick, easy, and more focused to your requirements.

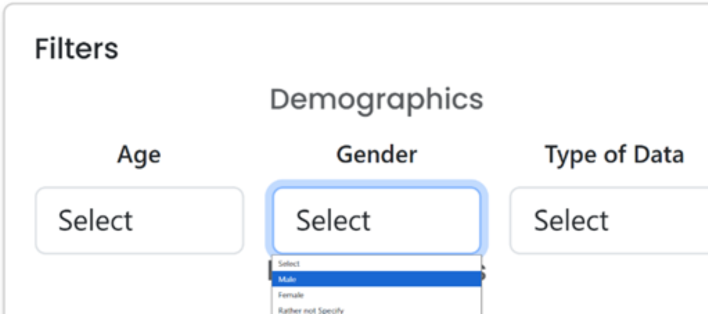
Demographics

1. Age



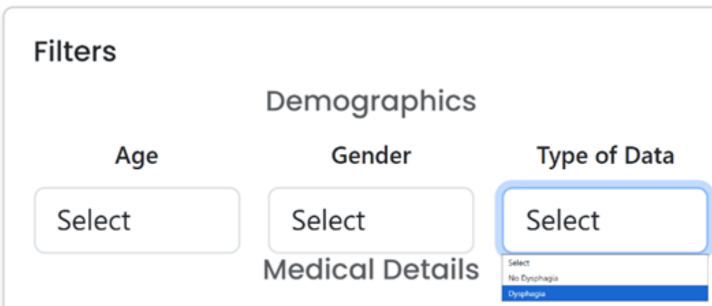
The first filter used here is the "Demographics". Under this, you can choose the age group that you are interested in. We have categorised the FEES videos into three categories here: 18–39 years, 40–59 years, and >60 years.

2. Gender



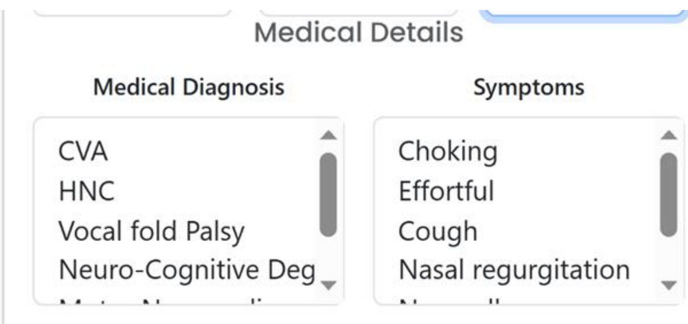
The next demographic filter is of the "Gender" which is classified as male, female, or prefer not to specify.

3. Type of Data



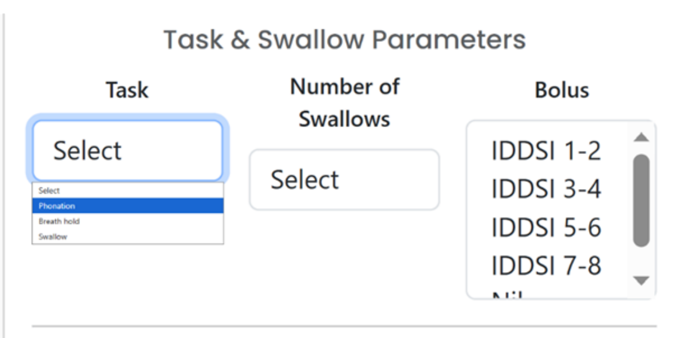
The third filter to be selected is for the type of data. The database contains FEES videos of individuals with no complaints of dysphagia, categorized under "non-dysphagic" and from individuals who reported dysphagia, categorized under "dysphagic". For clinical learning purposes, you can compare the data across these two groups to learn to identify normal and disordered swallowing performances.

Medical details

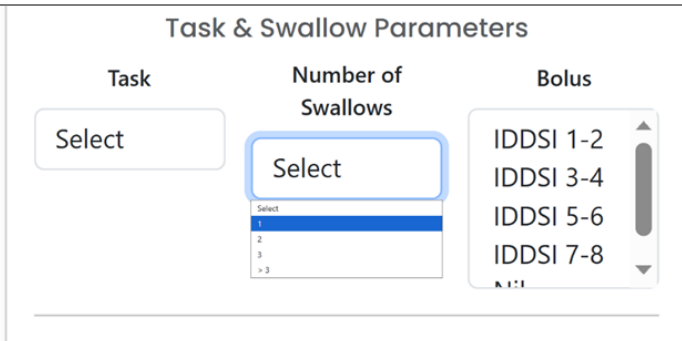
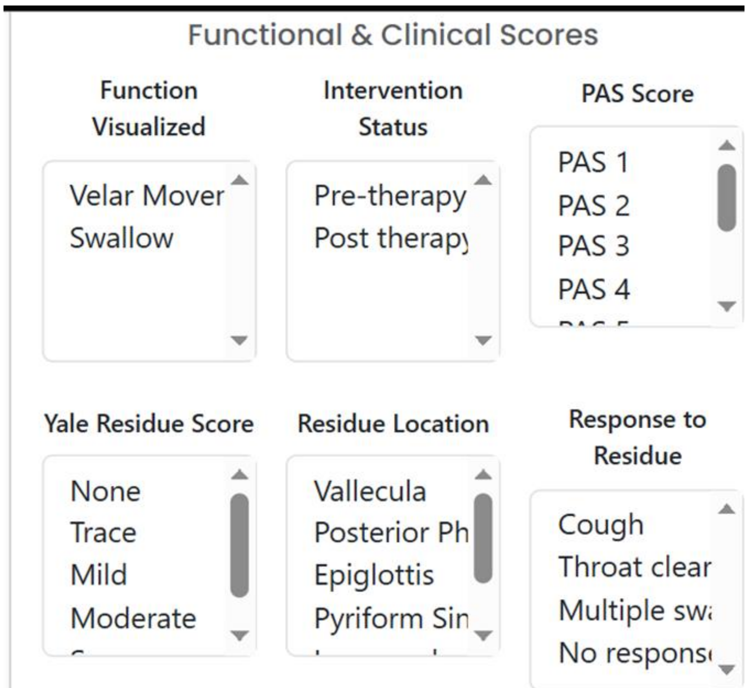
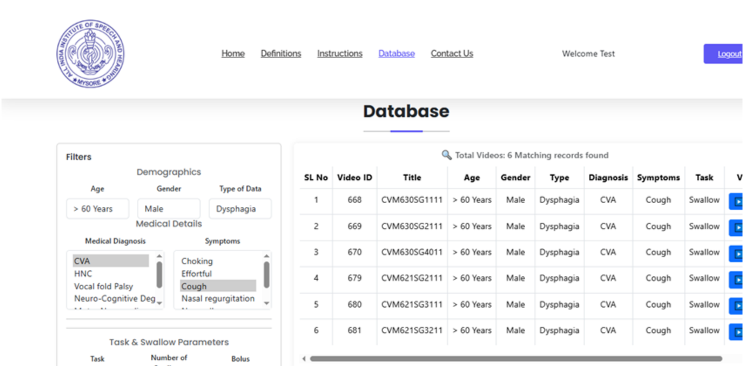


If you choose to visualise "dysphagic" category of FEES videos, you will be guided to the second filter section on Medical Details. Here you can choose the primary medical condition that resulted in dysphagia. The database includes videos on Stroke, Head and neck cancer, Other neurological conditions. Using this filter will help the user study condition-*specific swallowing patterns.*

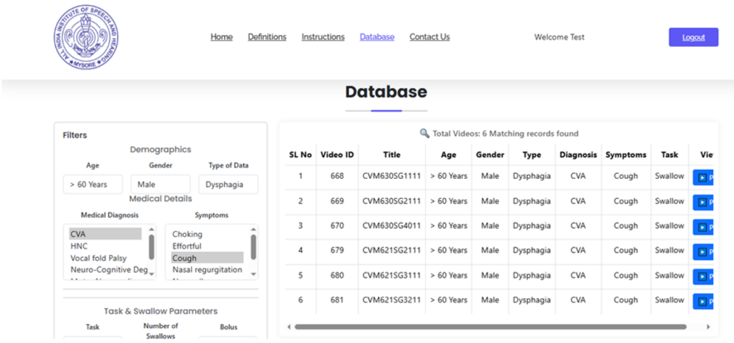
Task and swallow parameters



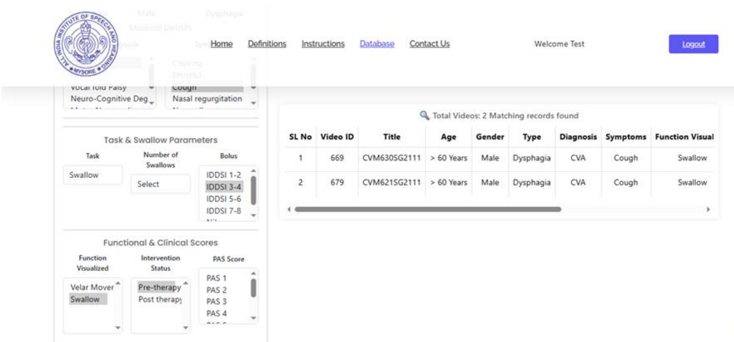
The third category of filter is the Task and Swallow Parameters where you can now choose the task that you want to visualize during the FEES examination. Currently, we have data on Phonation, Breath-hold, and swallowing.

<table>
<tr>
<td>Bolus characteristics</td>
<td>
</td>
<td>If you choose swallowing as your filter, you can further refine your choices in terms of the number of swallows, bolus consistency used in the examination according to the IDDSI levels. For if you select IDDSI level 3–4, you will be observing swallowing of semi-solids.</td>
</tr>
<tr>
<td>Functional and clinical scores</td>
<td>
</td>
<td>Further, you can refine the swallowing task in terms of the function visualized, i.e. do you want to see the velar movement or the glottic function. The other filters on intervention status helps you compare pre and post therapy videos. If you have a specific requirement on the penetration-aspiration scores as per PAS scale, the same can be applied as filter here. Similarly, you can specify any pharyngeal residue requirements that you wish to observe here. In case the user wishes to observe specific responses to swallow inefficiencies, such as cough or throat clearing, the same can be filtered out using the patient response filter. These filters are aimed to help the end users navigate through the variety of FEES findings for safety and efficiency concerns in persons with dysphagia.</td>
</tr>
<tr>
<td>Viewing Results</td>
<td>
</td>
<td>Once you have applied the desired filters, the database will narrow down and display ONLY the FEES videos that match your selection criteria. You can now watch the video recordings, observe swallowing physiology and compare across cases within your selection.</td>
</tr>
</table>

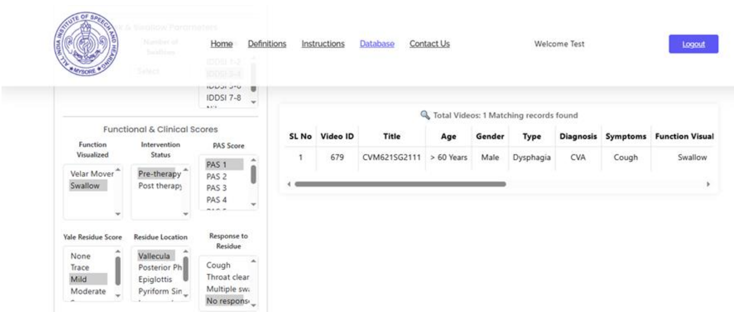
An Example



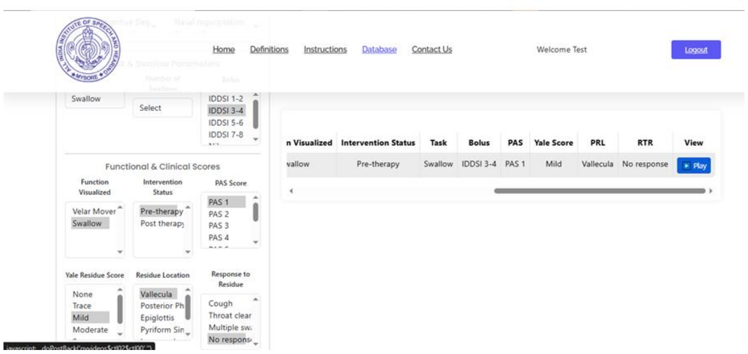
For instance, you may search for a male patient above 60 years, With stroke (CVA),



Performing a swallowing task with semi-solid bolus (IDDSI 3–4)



With mild vallecular residue and no response.



This will help you retrieve specific, clinically meaningful cases for focused observation or analysis.

How to Use This Database for Learning and Research		For beginner learners of FEES evaluation, this database will provide you with a range of videos that can help you observe and visualize the structural and functional pharyngeal evaluation for swallow. While viewing videos, focus on Airway protection: Is there penetration or aspiration? If yes, what is the most appropriate scoring that can be given. Focus on the Residue: Where is it located? How much remains? When is the swallow initiated? How is the person responding to the consequence of swallowing concerns? Is there a protective reaction? Etc. you can compare the different samples of your selection, or you can also vary the filters to compare the variability across conditions.