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Efficacy of an Asynchronous Tele-Medicine Model in Otorhinolaryngology

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ABSTRACT

Introduction
Access to Otorhinolaryngologists in remote regions is limited in Nepal. The country's rugged topography is one important cause. Telemedicine may help bridge this gap; however, evidence supporting its effectiveness in low-resource settings is sparse. This study evaluates the diagnostic performance of an asynchronous telemedicine model in Otorhinolaryngology at Tribhuvan University Teaching Hospital.

Methods
A hospital-based analytical cross-sectional study was conducted in a tertiary care center. A convenience sampling method was used with a minimum sample of 94. The study included patients of all ages. Trained undergraduate medical students recorded the clinical history and examination findings of the participants. Diagnosis made through asynchronous telemedicine using smartphones, endoscopic imaging, and EMR systems by a consultant Otorhinolaryngologist were compared with standard in-person evaluations in 102 patients by a separate ENT specialist independently. Concordance was assessed using Cohen's Kappa.

Results
Diagnostic agreement analysis showed high diagnostic concordance across Otorhinolaryngology subspecialties; rhinology had the highest concordance ($\kappa = 0.96$) followed by pediatric cases ($\kappa = 0.84$), Otology cases ($\kappa = 0.79$), and then head and neck cases ($\kappa = 0.79$). Diagnostic discrepancies arose mainly due to poor-quality images and the lack of physical examination.

Conclusion
Asynchronous telemedicine is a viable strategy for otolaryngology diagnostics in resource-constrained settings. It holds potential to improve access to specialist care and optimize referral efficiency in Nepal and similar contexts.

Keywords
Asynchronous telemedicine; diagnostic concordance; otorhinolaryngology; low-resource settings; Nepal

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INTRODUCTION

Nepal, a lower-middle-income country, has made notable progress in strengthening healthcare delivery, though advancements still lag behind other developing nations.[1] Persistent barriers include shortages of skilled personnel, poor intergovernmental coordination, delays in funding, and inadequate monitoring .[2,3] Economic deprivation, difficult terrain, and limited transport further delay care-seeking, leading to advanced disease presentations. Common ENT (Ear, Nose, and Throat) conditions such as chronic otitis media (COM), head and neck cancer, and undiagnosed childhood hearing loss highlight the need for early diagnosis to improve outcomes and reduce financial burden.[4]

Telemedicine offers a potential solution, especially in specialties like Otolaryngology that rely on visual assessment. It can be delivered synchronously, through real-time interactions or asynchronously.[5,6] Benefits include expanded access, diagnostic accuracy comparable to in-person care [7], reduced travel and wait times, cost savings, improved follow-up, high patient satisfaction, and optimized use of specialized time. Challenges include confidentiality concerns, limited technological adoption, misdiagnosis risks, and medico-legal issues.[8,9] In Nepal, telemedicine use, accelerated during COVID-19, remains limited, though recent Nepal Medical Council guidelines mark a positive step.[10]

Most studies focus on synchronous telemedicine, which may be impractical in remote settings due to connectivity and scheduling barriers. Asynchronous models, highlighted in a recent multispeciality review, including otology, may overcome these constraints but remain underexplored in otorhinolaryngology.[11] This study addresses this gap by evaluating the diagnostic concordance between an asynchronous telemedicine clinic model and traditional in-person assessments in otorhinolaryngology, thereby exploring its potential role in improving access to ENT care in remote regions of the country.

METHODS

This hospital-based analytical cross-sectional study was conducted in the Department of Otorhinolaryngology–Head and Neck Surgery (ENT–HNS) at Tribhuvan University Teaching Hospital (TUTH), Kathmandu, Nepal, a tertiary referral center serving patients from across the country from May to July 2025 over a period of two months. Ethical approval was taken from the Institutional Review Committee for the study (Ref: 544 (6-11) E2,081/082).

Patients of all ages and genders admitted during the study period were enrolled using a convenience sampling method, with a minimum sample size of 94 calculated for Cohen's Kappa agreement analysis, based on an expected overall agreement of 0.86, a 95% confidence level (Z = 1.96), and a precision of 0.07. Written informed consent was obtained from all participants or guardians. Postoperative cases with altered anatomy and patients declining consent were excluded.

Clinical history, examination findings, and diagnostic media were recorded by trained undergraduate medical students using a structured digital questionnaire (Google Form-based EMR), smartphone photography and videography, a portable otoendoscope (Teslong, China), and a flexible nasopharyngoscope (Machida, Japan). Hearing assessment was performed using the Mimi Hearing Test application (version 6.8.1), developed by Mimi Hearing Technologies GmbH, a Berlin-based company. All data were uploaded to a Google form and reviewed asynchronously by a consultant ENT specialist or Otolaryngologist, blinded to the in-person findings, who provided a primary diagnosis, differential diagnoses, and a management plan. A separate ENT specialist independently performed a standard in-person clinical evaluation for each patient.

Diagnostic concordance was defined as complete agreement between remote and in-person primary diagnoses, or inclusion of the in-person diagnosis within the remote differential list, with alignment of management plans. Data were analyzed using SPSS version 26 (IBM Corp., USA). Categorical variables were expressed as frequencies and percentages, continuous variables as mean ± standard deviation, and agreement between diagnostic modalities was assessed using Cohen's Kappa with 95% confidence intervals.

RESULTS

A total of 117 patients were initially enrolled, of which 15 were excluded, leaving 102 for final analysis. The cohort comprised 62 females (60.8%) and 40 males (39.2%), aged between 2 months and 65 years; 32 (31.4%) were pediatric patients.

Otological cases (n=21) were most frequently diagnosed as chronic otitis media (COM) mucosal (28.6%) and COM squamous (23.8%), with other conditions including otosclerosis, sudden sensorineural hearing loss, and vestibular neuronitis (Table 1).

Rhinological cases (n=20) were dominated by symptomatic deviated nasal septum (35%) and CRS with polyposis (20%), followed by less frequent conditions such as CRS with complications, nasal deformity, and inverted papilloma (Table 2).

Head and neck cases (n=29) most commonly presented as benign neck swellings (34.5%) and

Table 1. *Clinical distribution of otological cases*

Diagnosis	Frequency
Chronic Otitis Media-Mucosal	6
Chronic Otitis Media-Squamous	5
Otosclerosis	3
Sudden Sensory Neural Hearing Loss	2
Chronic Otitis Media Squamous with complications Intracranial complication (2) Intratemporal Complication (1)	3
Sequelae of Otitis Media with Effusion	1
Vestibular neuronitis	1

Table 2. *Clinical distribution of rhinological cases*

Diagnosis	Frequency
Symptomatic Deviated Nasal Septum	7
Chronic Rhinosinusitis with polyposis	4
Chronic Rhinosinusitis with complications	2
Nasal deformity	2
Nasal tumor (Inverted papilloma)	1
Chronic Rhinosinusitis without polyposis	1
Antrochoanal polyp	1
Cerebro Spinal Fluid rhinorrhoea	1
Epistaxis	1

Table 3. *Clinical distribution of head and neck cases*

Diagnosis	Frequency
Benign neck swellings (non-tumorous)	10
Benign tumor	7
Thyroid carcinoma	3
Tonsillitis	3
Oral cancer	3
Recurrent acute tonsillitis	2
Deep Neck Space Infections	1

Table 4. *Clinical distribution of pediatric cases*

Diagnosis	Frequency
Adenotonsillar hypertrophy	9
Chronic Otitis Media- mucosal	5
Laryngomalacia	4
Congenital head and neck anomalies	3
Deep Neck Space Infections	2
Chronic Otitis Media - Squamous	2
Chronic Otitis Media with complication	1
Benign nasal tumor (JNA)	1
Benign neck tumor	1
Antrochoanal polyp	1
Asymmetric tonsils	1
Acute Otitis Media	1

benign tumors (24.1%), with thyroid carcinoma, oral cancer, and tonsillitis also observed (Table 3).

Pediatric cases (n=32) were primarily adenotonsillar hypertrophy (28.1%), followed by COM mucosal (15.6%) and laryngomalacia (12.5%) (Table 4).

Diagnostic agreement analysis (Table 5) showed the highest concordance for nasal and PNS pathologies ($\kappa = 0.960$), followed by pediatric cases ($\kappa = 0.837$), otological cases ($\kappa = 0.795$), and head and neck cases ($\kappa = 0.791$), indicating substantial to almost perfect agreement.

Misdiagnoses were mainly due to poor image quality and the absence of tactile assessment.

DISCUSSION

This study evaluated a low-cost asynchronous telemedicine clinic model comprising a Portable otoendoscope (Teslong, China), a smartphone with an adapter, an Android-based Mimi Hearing Test Application, a portable flexible endoscope, and a custom Google Form-based EMR. Telemedicine broadly encompasses remote monitoring, store-and-forward (asynchronous), and real-time (synchronous) approaches.[12] We chose the asynchronous model for its time efficiency and flexibility, as synchronous telemedicine requires constant physician presence and can detract from in-person care.

A total of 102 patients were assessed, with pediatric cases forming the largest subgroup due to the inclusion of all children presenting with ENT disorders, whereas adult cases were selectively categorized by subspecialty. Chronic otitis media (COM) was the most common diagnosis, encompassing both mucosal and squamous types, including complications. This model facilitated early diagnosis and timely referral, critical for conditions like COM, which are both prevalent and potentially serious. However, our findings are not generalizable

Table 5. Diagnostic agreement between asynchronous telemedicine and in-person evaluations

Parameters	Ear (n=21)	Nose & PNS (n=20)	Head & Neck (n=29)	Pediatric (n=32)
Correct Primary Diagnosis	19	17	7	12
Correct Management plan leading to diagnosis	0	2	17	16
Diagnosis Discrepancy	2	1	5	4
Cohen's kappa value	0.795	0.960	0.791	0.837
Degree of agreement	Substantial	Almost perfect	Substantial	Almost perfect

to the broader Nepalese population as the sample was drawn from a tertiary referral center. National-level prevalence data on ENT disorders remain sparse; a Himalayan region study found ENT disease in 10.83% of 3,174 students, including mucosal, squamous, and healed COM.[13]

Although fewer in number, head and neck cancers deserve emphasis due to the survival benefits of early detection. A five-year cancer hospital review in Nepal reported over 4,000 admissions, with oral cancers most frequent, followed by other head and neck malignancies, and an upward trend in incidence.[14] More broadly, many ENT disorders, if diagnosed late, contribute significantly to morbidity, mortality, and economic burden, particularly in settings like Nepal, where specialist services are centralized, terrain limits access, and travel costs deter timely care. Telemedicine offers an avenue to address these barriers, reducing both patient and system costs.

In otology, the model showed substantial agreement with in-person diagnosis ($\kappa > 0.7$), with COM most frequent. Endoscopic visualization proved essential for assessing the middle ear, while diseases like sudden sensorineural hearing loss and vestibular neuronitis were diagnosed clinically. Structured history-taking and examination protocols minimized omissions, though two COM squamous cases were missed due to cerumen or poor image angles. Training field workers in aural toileting and comprehensive image capture could improve accuracy. Biagio et al. reported moderate agreement ($\kappa = 0.59$) between non-specialist and specialist otoscopic images, supporting the importance of operator skill.[15] Tele-otoscopy meta-analyses have reported >80% sensitivity and >95% specificity [16], while Mbao et al. found otoendoscopes capable of high-quality images but cautioned against unskilled use due to injury risk.[17]

Rhinology achieved the highest agreement ($\kappa = 0.96$). Most conditions were diagnosable from history, consistent with EPOS 2020 guidelines [18], which state early rhinosinusitis diagnosis may not require endoscopy or imaging. We documented nasal findings with a pen-endoscope but did not use portable flexible scopes for rhinology; facilitator training in their use could further improve accuracy. One CRS case was misdiagnosed as migraine-associated vertigo due to subjective interpretation. Literature on tele-rhinology is limited, though a Canadian survey of rhinologists found virtual visits nearly as effective as in-person for history and report review, with direct visualization remaining a key limitation.[19]

Head and neck cases showed substantial agreement ($\kappa = 0.79$). While benign neck swellings predominated, some malignant and infectious cases were also seen. History and lesion site often guided appropriate management, but the absence of palpation limited diagnostic certainty, especially for non-visible swellings and incidental cancers like micropapillary thyroid carcinoma. Our findings align with Stalfors et al., who reported 91% concordance in head and neck cancer assessments, with discrepancies due to absent tactile input.[20] Literature mainly covers postoperative and follow-up contexts; Rimmer et al. and Head et al. documented shorter wait times, reduced travel, and high patient satisfaction in head and neck cancer teleconsultations.[21,22]

Pediatric ENT evaluation showed almost perfect agreement ($\kappa = 0.837$), with adenotonsillar hypertrophy, COM mucosal, laryngomalacia, and congenital anomalies being most common. Endoscopic video was particularly valuable for adenoid and airway assessment. Misdiagnoses were mainly otological, linked to poor image quality. Prior studies confirm higher diagnostic agreement when trained caregivers capture images.[23] For pediatric sleep apnea, McLean et al. found smartphone video scoring ≥3 had 92–96% sensitivity versus polysomnography.[24] Our inclusion of flexible laryngoscopy enabled accurate diagnosis of laryngomalacia in all cases, performed by senior clinicians; training remote providers could enable earlier detection and referral.

This study has limitations. Diagnostic accuracy depended on the quality of images, videos, and histories obtained by non-specialist examiners. Inadequate lighting, incomplete visualization, or obstruction sometimes compromised assessments. The lack of tactile examination constrained head and neck diagnoses, and the single-center design with a modest sample size limits generalizability.

Nonetheless, the findings support asynchronous telemedicine as a viable, cost-effective tool for expanding ENT services in underserved areas. Policy adoption could include national integration of such models, investment in telemedicine infrastructure, and standardized training programs for healthcare workers in high-quality image capture and endoscopic techniques. Deploying portable diagnostic devices such as point-of-care endoscopes and validated mobile audiometry would further strengthen diagnostic capacity. Embedding telemedicine into referral pathways could optimize specialist time, reduce unnecessary hospital visits, and improve access while reducing costs for both patients and the health system.

Future research should validate this model through larger multicenter studies across diverse geographic and clinical contexts, incorporating cost-effectiveness analyses, patient satisfaction surveys, and workflow impact assessments. AI-based image enhancement and automated diagnostic support could improve reliability, especially for ear and airway conditions. Additionally, targeted evaluation of telemedicine's role in early detection and triage of malignant ENT lesions, particularly head and neck cancers, would inform its integration into community-level oncology screening programs.

CONCLUSION

Our asynchronous telemedicine clinic model in otorhinolaryngology demonstrated a strong diagnostic concordance with in-person evaluation and thus may serve as a viable strategy for managing ENT disorders in resource-constrained settings such as Nepal

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHOR CONTRIBUTIONS

Concept of research and Design of research: BRG; literature search: BRG, GBC, OO, SG, AK; Data collection:BRG, GBC, OO, SG, AK ; Data analysis: BRG, GBC, OO, SG, AK; Data Interpretation: BRG, GBC, OO, SG, AK; Drafting and Reviewing of the manuscript for important intellectual content: BRG, GBC; Final approval of the version ready for submission: BRG, GBC ; Agreement to be accountable for all aspects of the work: BRG, GBC, OO, SG, AK.

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