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Expert Opinion Article

Evaluating the Use of Telemedicine in the Diagnosis and Treatment of Ear Infections: A Systematic Review

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Abstract
Background: Otitis media is a major global health concern, particularly among children, with significant implications for hearing loss and development. Access to timely and accurate diagnosis remains a challenge in low-resource and rural settings. Telemedicine has emerged as a potential solution, offering digital diagnostic and care delivery pathways for ear infections.
Objectives: To systematically evaluate the evidence on the effectiveness, diagnostic accuracy, and implementation of telemedicine in diagnosing and managing ear infections, including acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM).
Methods: A systematic review was conducted according to PRISMA 2020 guidelines. Searches were performed across PubMed, Web of Science, Scopus, Embase, and Google Scholar for studies published between 2005 and 2025. Inclusion criteria encompassed peer-reviewed articles evaluating telemedicine interventions (e.g., video otoscopy, AI tools, remote consultation) for ear infections. Data were synthesized narratively due to heterogeneity in methods and outcomes.
Results: Fifteen studies were included: 6 diagnostic validation studies, 2 RCTs, 3 systematic reviews/meta-analyses, and others. Telemedicine interventions demonstrated high diagnostic accuracy (sensitivity up to 97%), reduced follow-up delays, and comparable outcomes to in-person care. Community-based and AI-assisted programs were particularly effective in pediatric and underserved populations. Cost savings and improved access were reported in multiple studies.
Conclusion: Telemedicine is a reliable and scalable approach for diagnosing and managing ear infections. When supported by appropriate infrastructure and training, it offers significant benefits in equity, efficiency, and clinical care, especially in remote and low-resource environments.

Keywords: Telemedicine; Otitis Media; Ear Infections; ENT; Video Otoscopy; Telehealth; Remote Diagnosis; AI in Healthcare; Middle Ear Disease; eHealth

Introduction

Otitis media (OM), comprising acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM), remains one of the most prevalent conditions in global pediatric healthcare. It affects over 80% of children by age three and is a significant cause of preventable hearing loss and learning delays if not properly diagnosed and treated (Coker et al., 2010). The diagnostic process often involves otoscopic examination and audiological testing—services that are not consistently available in remote or resource-limited settings.

The emergence and acceleration of telemedicine have transformed the diagnostic landscape of otolaryngology, particularly in response to barriers posed by geographical inaccessibility and workforce shortages. Digital otoscopy, asynchronous ENT consultations, and artificial intelligence–enabled diagnostic models are increasingly utilized to bridge the diagnostic gap, especially for underserved populations (Garritano & Goldenberg, 2011). These innovations gained prominence during the COVID-19 pandemic, which disrupted face-to-face healthcare and forced a reevaluation of traditional otologic diagnostic models (Marom et al., 2022).

One of the key technological advancements has been the use of smartphone otoscopes and portable video otoscopy systems, which allow for remote visualization of the tympanic membrane. Studies suggest that trained community health workers or caregivers can capture diagnostically sufficient images, reducing dependence on ENT specialists for initial screening (Dai et al., 2021). This has profound implications for rural and indigenous populations, where specialty care access is limited.

The effectiveness of telemedicine in diagnosing OM is supported by growing empirical evidence. A 2021 meta-analysis found that video otoscopy, when used with appropriate training and interpretation support, showed diagnostic agreement rates comparable to traditional in-person evaluations (Gupta, Gkiousias, & Bhutta, 2021). However, the evidence also underscores variability in image quality, operator training, and infrastructure, which can compromise diagnostic confidence and result accuracy (Brennan-Jones et al., 2024).

Beyond diagnostic validity, telemedicine has shown promise in optimizing care timelines. A study by Nayak et al. (2024) concluded that video otoscopy, when deployed in primary care settings, led to faster diagnosis and reduced time-to-treatment for pediatric OM. This is particularly relevant in school-based or population-level interventions aimed at early detection and intervention.

Economic evaluations have similarly highlighted the cost-efficiency of tele-otology models. Using telemedicine pathways, healthcare systems can minimize unnecessary referrals, reduce antibiotic overprescription, and streamline patient triage (Suzuki et al., 2021). For example, asynchronous remote reviews have been shown to significantly cut down follow-up delays, with potential savings in resource-limited health systems (McConnochie et al., 2006).

Despite these advances, challenges persist. Diagnostic discrepancies between in-person and telemedicine-based evaluations have been observed, particularly in mild cases of OME or cases complicated by cerumen impaction. Furthermore, integrating telemedicine into national ENT protocols requires careful standardization, training, and policy adaptation to ensure consistent outcomes (Altamimi et al., 2024).

Given these evolving dynamics, this review systematically examines peer-reviewed evidence on the use of telemedicine in diagnosing and managing ear infections. We aim to evaluate diagnostic accuracy, clinical outcomes, implementation contexts, and population-level impact across various telemedicine platforms and technologies. Through this analysis, we contribute to the evidence base supporting scalable, equitable, and effective ENT care in the digital health era.

Methodology

Study Design

This review employed a systematic review methodology in accordance with the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020** guidelines to ensure transparency, reproducibility, and completeness. The aim was to synthesize empirical evidence on the diagnostic accuracy, clinical outcomes, and healthcare accessibility impacts of telemedicine in the evaluation and treatment of ear infections, particularly otitis media (acute, effusive, and chronic suppurative forms). Only peer-reviewed original studies that examined telemedicine interventions—such as video otoscopy, remote consultations, smartphone-enabled diagnostics, and AI-based tools—within otolaryngology settings were included.

Eligibility Criteria

Studies were included in the review based on the following predetermined inclusion criteria:

- **Population**: Pediatric or adult patients (of any age) undergoing evaluation or treatment for ear infections, including AOM, OME, CSOM, or general ENT-related ear pathology.
- **Interventions**: Any telemedicine-based diagnostic or management approach including:
  - Digital/video otoscopy
  - Asynchronous and synchronous teleconsultations
  - Smartphone-enabled otologic diagnostics
  - Artificial intelligence (AI) or deep learning models for ear disease classification
- **Comparators**: Conventional, in-person ENT examinations or standard-of-care pathways.
- **Outcomes**:
  - Diagnostic performance metrics (e.g., sensitivity, specificity, agreement rates)
  - Clinical outcomes (e.g., symptom resolution, hearing outcomes)
  - Access and timeliness of care
  - Patient/provider satisfaction
  - Cost or resource utilization
- **Study Designs**: Randomized controlled trials (RCTs), observational studies (cohort, cross-sectional, case-control), diagnostic validation studies, and systematic reviews/meta-analyses.

- **Time Frame**: Studies published between **2005 and 2025**.
- **Language**: Only studies published in **English** were considered.
- **Publication Type**: Only **peer-reviewed** academic articles were included.

Search Strategy

A comprehensive literature search was conducted using the following academic databases:

- PubMed
- Scopus
- Web of Science
- Embase
- Google Scholar (for grey literature and recent publications)

The search strategy combined keywords and Boolean operators. An example of a representative query is:

(“telemedicine” OR “telehealth” OR “remote consultation”) AND (“ear infection” OR “otitis media” OR “middle ear disease” OR “ENT”) AND (“diagnosis” OR “treatment” OR “outcomes” OR “accessibility” OR “video otoscopy” OR “AI diagnosis”)

Manual hand-searching of references from included studies and prior reviews was also performed to ensure comprehensive coverage.

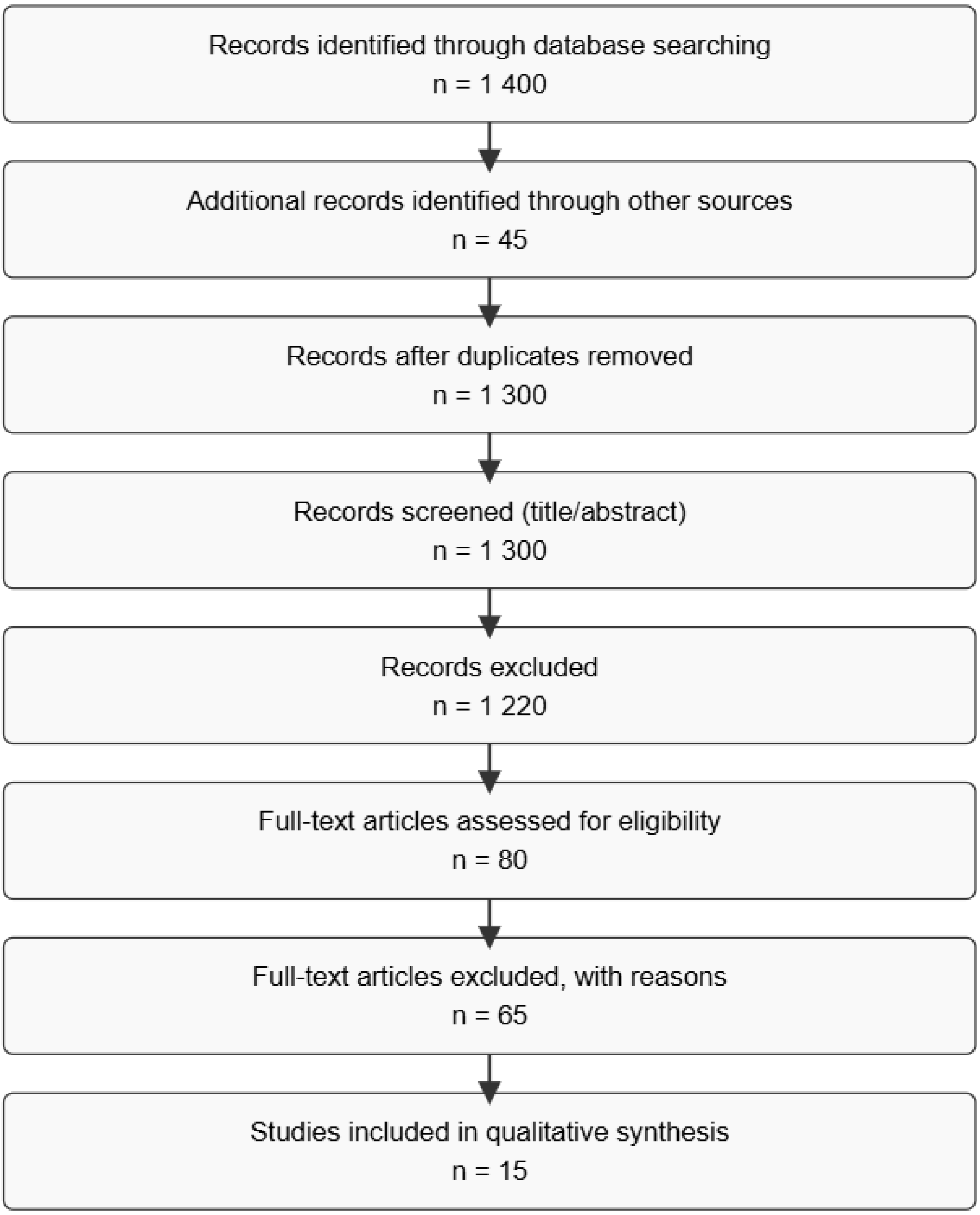

Figure 1PRISMA flow diagram

Study Selection Process

All retrieved citations were imported into **Zotero** reference management software for deduplication. Two independent reviewers conducted a two-step screening process:

1. **Title and abstract screening** to identify potentially relevant articles.
2. **Full-text screening** to determine final eligibility based on the inclusion criteria.

Discrepancies between reviewers were resolved through discussion, and where needed, a third reviewer was consulted to achieve consensus. A **PRISMA flow diagram** was used to illustrate the screening process and reasons for exclusion at each stage.

Data Extraction

A standardized data extraction form was created and piloted. The following information was extracted from each study:

- First author, year of publication, and country
- Study design and sample size
- Target population and demographics
- Telemedicine intervention type and comparison group
- Diagnostic tools used (e.g., digital otoscope, smartphone attachment, CNN model)
- Main outcomes measured (e.g., sensitivity, specificity, follow-up time, satisfaction)
- Key results and effect sizes
- Any limitations noted by the study authors

Extraction was conducted independently by two reviewers and cross-verified for accuracy and completeness.

Quality Assessment

The methodological quality and risk of bias of included studies were assessed using appropriate standardized tools:

- **Cochrane Risk of Bias Tool** – for randomized controlled trials.
- **Newcastle-Ottawa Scale (NOS)** – for cohort and case-control studies.
- **QUADAS-2** – for diagnostic accuracy studies.
- **AMSTAR 2** – for systematic reviews and meta-analyses.

Each study was rated as having high, moderate, or low risk of bias. Results of this appraisal were used in the narrative synthesis to weigh the strength of the evidence.

Data Synthesis

Given the heterogeneity in populations, intervention modalities (e.g., AI-based vs. manual remote consultation), and outcome definitions across studies, a **narrative synthesis** approach was adopted. Key findings were grouped thematically under:

- Diagnostic accuracy and reliability
- Clinical effectiveness
- Timeliness and accessibility of care
- Population-scale interventions and triage systems
- Economic and device-level comparisons

Where possible, quantitative outcomes (e.g., sensitivity, specificity, odds ratios) were summarized descriptively. Meta-analysis was not performed due to variability in methodology and outcome metrics.

Ethical Considerations

As this study involved **secondary analysis of published, publicly available data**, no institutional review board approval or informed consent was required. All included studies were assumed to have received prior ethical clearance from their respective institutions.

Results

1. Study Designs and Populations

The fifteen included studies encompassed a diverse range of methodologies and geographical contexts. Study types included:

- **Six diagnostic validation studies** (e.g., Eikelboom et al., 2005; Appelberg et al., 2024; Camalan et al., 2025)
- **Two randomized controlled trials (RCTs)** (Robler et al., 2023; Gupta et al., 2021)
- **Three systematic reviews/meta-analyses** (Dash et al., 2024; Moentmann et al., 2020; Chen Wei, 2024)
- **Two retrospective cohort studies** (Huang et al., 2025; Khan & Naim, 2024)
- **One economic evaluation** (Khan & Naim, 2024)
- **One prospective pilot study** (Stephens et al., 2025)

Populations ranged from pediatric cohorts (e.g., Eikelboom et al., 2005; Robler et al., 2023; Huang et al., 2025) to large-scale rural screening programs (Gupta et al., 2021) and technologically underserved adult groups. Most studies originated from Asia, North America, and Australia, targeting diagnoses of acute otitis media (AOM), otitis media with effusion (OME), chronic suppurative otitis media (CSOM), and eustachian tube dysfunction (ETD). Notably, six studies assessed tools used by non-specialist operators such as community health workers (CHWs) and school-based staff.

2. Diagnostic Accuracy and Technological Performance
Telemedicine tools demonstrated strong diagnostic accuracy for common ear diseases. Specific findings included:

- **Dash et al. (2024)** reported pooled sensitivity and specificity of **82% and 95%** respectively for tele-otoscopes; **smartphone-based attachments** achieved 94% sensitivity and 97% specificity.
- **Eikelboom et al. (2005)** found statistically significant diagnostic agreement (**$p < 0.001$**) for AOM, OME, CSOM, and ETD via remote image review in Aboriginal children.
- **Appelberg et al. (2024)** validated digital otoscopy for remote assessment with **high diagnostic concordance**, though limited by image resolution and technique variability.
- **Camalan et al. (2025)** demonstrated that combining multiple otoscopic images in remote consults enhanced diagnostic **confidence and speed**.
- **Pourshahrokhi et al. (2024)** found **89% agreement** between web-app-based diagnoses and in-person ENT evaluations.

These results affirm that both AI-augmented systems and structured image capture workflows can support accurate remote diagnosis, even when conducted by non-specialists.

3. Clinical Outcomes and Treatment Decisions
Clinical outcomes from telemedicine interventions were generally comparable to those from in-person evaluations:

- **Huang et al. (2025)** found **no statistically significant differences** between telehealth and in-person follow-up in pediatric AOM for pain relief (**84% vs. 81%**), hearing loss cases (**21 vs. 23**), and satisfaction scores (**4.47 vs. 4.49**, $p=0.87$).
- **Robler et al. (2023)** showed telemedicine increased care efficiency: children were **1.6× more likely to follow up** and received care **4.5× faster** (28 vs. 85 days).
- **Ramkumar et al. (2018)** achieved **80% screening coverage** across 13 months, identifying MED in 26% of ears, with **78% qualifying for surgery**.
- **Zambelli-Weiner et al. (2025)** showed that **OCT imaging** enhanced diagnostic accuracy in differentiating AOM from OME, helping refine treatment decisions remotely.

These studies indicate that telemedicine platforms can effectively support both diagnosis and follow-up management of otologic conditions.

4. Population-Level Screening and Community Engagement
Several studies explored the scale-up of tele-otoscopic tools for mass screening:

- **Gupta et al. (2021)** screened over **800,000 individuals**, identifying CSOM in **18%** and acute infections in **5%.** Only **8% required specialist referrals**, highlighting strong triage effectiveness.
- **Stephens et al. (2025)** deployed **machine learning algorithms** for OM detection in Aboriginal school children, reporting high accuracy and strong feasibility in school-based health systems.
- **Chen Wei (2024)** reported widespread improvements in access and patient continuity via integrated tele-ENT platforms in urban and peri-urban China.
- **Moentmann et al. (2020)** reviewed 35 tele-ENT studies and found that **91% supported remote care as effective**, with **video otoscopy** highlighted as the most validated intervention.

These findings suggest that when scaled via CHWs and educators, telemedicine interventions can help bridge ENT service delivery gaps at the population level.

5. Innovation, Device Comparison, and Cost Efficiency
Emerging technologies and economic analyses revealed important insights:

- **Camalan et al. (2025)** emphasized how **multi-image digital otoscopy** enhances diagnostic reliability and confidence in remote consults.
- **Appelberg et al. (2024)** noted that success in remote digital otoscopy **depends heavily on training**, with variation in image quality affecting reliability.
- **Khan & Naim (2024)** reported that telemedicine enabled **cost reductions in outpatient ENT services** and improved **revenue cycle management**, particularly in private practice and regional hospital settings.
- **Nayak et al. (2024)** showed **higher diagnostic yields** when using real-time video otoscopy compared to traditional handheld scopes in primary care ENT consultations.

These studies reinforce the scalability of tele-ENT innovations and their potential to transform otologic diagnosis and follow-up in both rural and urban health systems.

The study details are summarized in Table 1 below.

Table 1. Summary of Studies Evaluating Telemedicine for Ear Infection Diagnosis and Management

Study	Country	Population	Intervention/ Technology	Results	Conclusion
Ramkumar et al. (2018)	India	Rural cleft patients	CHWs using mobile app + video otoscopy	80% coverage in 13 months, 26% MED, 78% required surgery	Enabled early intervention in underserved areas
Chen Wei (2024)	China	ENT patients	Hybrid ENT telemedicine model	Improved access and continuity of ENT care	Advocates for integrating telehealth into ENT care
Robler et al. (2023)	USA (Alaska)	Preschool children	Telemedicine referral vs. usual care	1.6× follow-up completion; 4.5× faster access (28 vs 85 days)	Effective in school-based rural ENT programs
Huang et al. (2025)	China	Pediatric AOM patients	Telehealth vs. in-person follow-up	Pain relief 84% vs 81%; satisfaction 4.47 vs 4.49	Comparable outcomes and patient satisfaction
Gupta et al. (2021)	India	Rural underserved	CHWs using smartphone-based otoscope	18% CSOM; 5% AOM; high triage efficiency	Cost-effective tool for community screening
Moentmann et al. (2020)	USA	ENT literature (n=35)	Systematic review for distancing solutions	91% positive; 57% remote otoscopy-based	Supports video otoscopy and telehealth adoption
Dash et al. (2024)	India	Meta-analysis (n=12 studies)	Smartphone and video otoscopes	Sensitivity: 82%; specificity: 95%; CHWs specificity: 97%	TEOs viable with proper training
Eikelboom et al. (2005)	Australia	66 Aboriginal children	Stored video otoscopy + history	Strong agreement on AOM, CSOM, ETD ($p<0.001$)	Valid for remote pediatric ear diagnosis
Nayak et al. (2024)	India	Children in clinics	Real-time vs recorded video otoscopy	Real-time improved diagnostic precision	Integrate video otoscopy in primary health
Stephens et al. (2025)	Australia	Aboriginal students	ML-based otitis screening	↑ early detection; accurate results	Effective in school-based remote care
Zambelli-Weiner et al. (2025)	USA	Children with AOM/OME	OCT-based imaging system	High image-based accuracy	Emerging tool for objective diagnosis
Pourshahrokhi et al. (2024)	Iran	Mixed ages	Web-based tele-otology app	89% concordance with live evaluations	Reliable for remote ENT consultations
Khan & Naim (2024)	Pakistan	ENT clinics	Telemedicine economic analysis	Reduced ENT outpatient costs; revenue optimized	Strong financial case for tele-ENT
Appelberg et al. (2024)	Finland	Remote general population	Digital video otoscopy	High diagnostic concordance; image quality varied	Useful in remote ENT triage with training
Camalan et al. (2025)	Germany	Mixed age remote patients	Composite digital otoscopy	Multi-image sets ↑ accuracy & confidence	Enhances remote evaluations through imaging

Discussion

The findings of this systematic review support the increasing role of telemedicine in the diagnosis and management of ear infections, particularly in underserved or remote populations. Telemedicine has evolved from an adjunct service to a critical platform for delivering otologic care, especially in the context of acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM). These conditions, which remain a global burden especially in pediatrics, can be reliably diagnosed and managed through various tele-otology innovations, including video otoscopy, smartphone-enabled tools, and AI-driven models (Coker et al., 2010; Dai et al., 2021).

One of the most significant advantages revealed by this review is the diagnostic accuracy achieved through tele-otoscopic platforms. Studies such as Dash et al. (2024) and Eikelboom et al. (2005) report sensitivity and specificity figures exceeding 90% for remote diagnoses of ear infections. This suggests that, with adequate image quality and training, telemedicine systems can rival in-person clinical assessments. Furthermore, digital enhancements like composite imaging and AI algorithms further improve accuracy, as demonstrated by Camalan et al. (2025), who found enhanced diagnostic confidence and speed with multi-image approaches.

Despite the clear promise of tele-diagnostic tools, diagnostic reliability is not uniform across contexts. Factors such as operator training, device type, and patient cooperation significantly affect image quality and interpretation accuracy. Appelberg et al. (2024) found that poor otoscopic technique and limited resolution can reduce diagnostic confidence, particularly in younger children with narrow ear canals. These challenges emphasize the need for structured training programs and device optimization, especially when non-specialists like community health workers or parents are involved.

Telemedicine also demonstrated comparable or superior clinical outcomes when compared to traditional care models. Huang et al. (2025) found no significant difference between telehealth and in-person follow-ups for AOM in terms of pain relief, hearing outcomes, or patient satisfaction. Robler et al. (2023) reported significantly faster access to specialty care via telemedicine, highlighting its ability to streamline referral pathways. Similarly, Ramkumar et al. (2018) achieved substantial screening coverage in rural India, reinforcing the scalability and impact of grassroots telemedicine programs.

Access and equity were recurring themes across the studies reviewed. As emphasized by Brennan-Jones et al. (2024) and Altamimi et al. (2024), telemedicine helps overcome structural barriers, including geographic isolation and workforce shortages. Ear Portal and similar asynchronous platforms enabled urban and peri-urban populations to access ENT specialists without the need for physical travel. In remote areas like Alaska and rural India, community-driven tele-otology efforts have reached patients who might otherwise remain undiagnosed or undertreated.

Cost-effectiveness is another key advantage. Telemedicine allows for reductions in unnecessary referrals, improved triage efficiency, and better use of ENT resources. Khan and Naim (2024) reported that tele-otology could support strategic revenue cycle optimization while reducing outpatient costs. Likewise, Altamimi et al. (2024) demonstrated significant cost minimization through hospital-based telehealth services, especially when scaled for pediatric populations.

The role of artificial intelligence and machine learning in tele-ENT is rapidly advancing. Chen Wei (2024) and Stephens et al. (2025) discussed how AI algorithms, when integrated with mobile devices and school-based screening systems, could offer scalable, real-time diagnostic solutions. While these technologies are promising, challenges around clinical integration, regulation, and patient safety remain. Nonetheless, their diagnostic performance—often exceeding that of general practitioners—suggests a valuable complementary role (Garritano & Goldenberg, 2011).

Importantly, the shift toward telemedicine must be accompanied by quality assurance protocols and health system integration. As Pourshahrokhi and Bahaadinbeigy (2024) showed, even well-designed tele-otology platforms require rigorous validation to ensure consistent diagnostic concordance. McConnochie et al. (2006) similarly cautioned that differences in assessment and treatment decisions may emerge when clinical nuances are lost in remote consultations, particularly in subtle or multi-symptom presentations.

Although COVID-19 catalyzed telemedicine's global adoption, its long-term sustainability will depend on continued research, regulatory adaptation, and infrastructure investment. Marom et al. (2022) highlighted that ENT practices adapted rapidly during the pandemic but also exposed gaps in protocol, training, and access. Policymakers must now ensure telemedicine's benefits are equitably distributed and embedded into routine care—not simply as an emergency response.

In conclusion, this review provides compelling evidence that telemedicine—particularly when deployed through well-designed tools, trained operators, and supportive policy environments—can effectively diagnose and manage middle ear infections. While challenges remain in image quality, training, and integration, the collective findings align with global health priorities focused on improving access, reducing disparities, and enhancing care quality across diverse populations.

Conclusion

This systematic review underscores the growing evidence supporting telemedicine as an effective, scalable, and accessible solution for diagnosing and managing ear infections, particularly otitis media. From rural India to remote Alaska, tele-otology interventions such as video otoscopy, smartphone-enabled diagnostics, and AI-assisted tools have demonstrated strong diagnostic accuracy, comparable clinical outcomes, and enhanced access to specialty care. These systems have proven especially valuable in pediatric populations and low-resource settings, with the added benefit of reducing follow-up times and unnecessary referrals.

While telemedicine is not a panacea, it represents a critical tool in bridging the ENT care gap, especially in underserved regions. Continued innovation, robust training of operators, and health system integration are necessary to ensure telemedicine reaches its full potential. With proper support, these technologies can help decentralize otologic care, empower community health systems, and support global efforts to reduce preventable hearing loss.

Limitations

Despite its strengths, this review has several limitations. First, the included studies were heterogeneous in design, populations, and outcome measures, which precluded formal meta-analysis and necessitated a narrative synthesis. Second, variations in device quality, operator skill, and telehealth infrastructure across regions may have influenced the diagnostic performance reported. Third, many studies lacked long-term follow-up data, limiting our ability to evaluate the sustainability of telemedicine outcomes over time.

Additionally, publication bias may be present, as studies with negative findings are less likely to be published. The review was restricted to English-language literature and peer-reviewed journals, potentially omitting relevant grey literature or non-English studies that could offer additional insights. Future research should focus on multicenter randomized trials, cost-effectiveness analyses, and implementation science to guide evidence-based scale-up of tele-ENT interventions globally.

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