

Telehealth Approaches to Pediatric Otitis Media: Applications, Devices, and Clinical Outcomes—A Scoping Review

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Abstract

Background: Otitis media (OM) is one of the most common pediatric infections worldwide. Conventionally, accurate diagnosis depends on in-person pneumatic otoscopy, which is not always accessible, contributing to delayed care and inappropriate prescribing, especially in underserved settings. Rapid advances in telemedicine and digital tool have accelerated the development of remote approaches for assessing pediatric ear diseases, while maintaining diagnostic quality, care models, and real-world outcomes have not been comprehensively mapped in children.

Objective: To map existing technologies and operational models employed in telehealth for pediatric OM and report their diagnostic and implementation outcomes to guide practice and further research.

Methods: Between January 1, 2010, and August 31, 2025, a scoping review guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) was performed (protocol not registered). PubMed, MEDLINE, Web of Science, and Cochrane CENTRAL were systematically searched for studies that reported on the clinical implementation of telemedicine or digital health in children (<18 years) with suspected or confirmed OM. Two reviewers independently extracted and charted the following study characteristics: telemedicine model, technology, users, comparators, outcomes, and limitations.

Results: Of the 805 records searched, 46 met the inclusion criteria. These studies have been performed in diverse countries and settings. Asynchronous store-and-forward tele-otoscopy was the most frequently used approach. The rest used either synchronous or hybrid models. When images were captured by trained personnel and reviewed by experienced clinicians, diagnostic consistency with in-person microscopy was substantial. However, the diagnostic yield was highly dependent on the level of training: structured instruction improved video capture by parents and nonspecialists, whereas brief or written-only guidance resulted in low rates of diagnostically useful videos. Telemedicine approaches improved access, supported perioperative follow-up, and, in some contexts, reduced re-examinations and promoted more judicious antibiotic use. However, televisits without otoscopy were associated with lower confirmation rates of middle-ear effusion during tympanostomy tube placement.

Conclusions: Tele-otoscopy and adjunct digital tools have been demonstrated to be feasible, achieving diagnostic accuracy comparable to in-person assessments, while enhancing access and service efficiency. However, important evidence gaps remain, including the need for large multisite trials, evaluation of long-term child outcomes, economic evaluations, and robust external

validation of artificial intelligence (AI)-based diagnostic tools. Standardization of image capture protocols and integration into hybrid care models should be prioritized for scaling up.

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Original Manuscript

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Abstract

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Keywords: pediatrics; acute otitis media; otitis media with effusion; telemedicine; telehealth; smartphone otoscopy; digital otoscopy; artificial intelligence; tympanostomy.

Introduction

Telemedicine has expanded rapidly across pediatrics over the past decade, further accelerated by the coronavirus disease (COVID-19) pandemic. Telehealth performance is disease-specific, determined by whether robust remote proxies for the examination exist and are embedded in workflows. For ear disease, this principally entails dependable tympanic-membrane visualization and measures of middle-ear status.

Within this context, otitis media (OM) is among the most common pediatric infections worldwide and a leading cause of healthcare visits, antibiotic prescriptions, and tympanostomy tube placement [1]. Acute OM (AOM) and OM with effusion (OME) impose substantial morbidity, reduced quality of life, and increased healthcare costs across diverse settings [2]. Accurate diagnosis hinges on direct visualization of the tympanic membrane and assessment of middle-ear status—ideally by pneumatic otoscopy—which requires specific training and equipment [3]. Limited access to otolaryngologists and pediatricians, particularly in rural and underserved regions, contributes to delayed assessment, inappropriate treatment, and non-indicated antibiotic use [4].

Concurrently, digital health technologies relevant to ear disease have proliferated, including smartphone-connected and USB video otoscopes, non-smartphone digital otoscopes, remote monitoring platforms, and early artificial intelligence (AI)-assisted decision support. When paired with appropriate workflows, these tools enable asynchronous review by experts or real-time supervision, and can be complemented by adjunct tests such as tympanometry or acoustic methods [5–8]. Emerging studies suggest that telemedicine can approximate in-person diagnostic performance for pediatric OM when image capture is standardized and operators are trained, while also reducing barriers to care and supporting antibiotic stewardship [7,8]. However, important uncertainties remain regarding feasibility, usability, and sustainable integration clinical practice.

Given the rapidly expanding yet fragmented evidence base, we conducted a scoping review to: (1) map the technologies and care models employed in telehealth for pediatric OM, (2) summarize diagnostic and implementation outcomes and (3) identify evidence gaps to guide future research and clinical implementation. This review further aims to identify key barriers and enablers of feasibility and to provide actionable guidance for implementing pediatric OM telehealth—across technologies, care models, and settings.

Methods

Overall Study Design

A scoping review was performed guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR) guidelines [9]. The review process progressed through the stages outlined in the framework of Arksey and O'Malley [10], which included formulating the research question, identifying relevant studies, selecting studies, extracting

and organizing the data, and synthesizing, summarizing, and presenting the findings. The protocol for this scoping review was neither registered nor published.

Search Strategy

Between January 1, 2010, and August 31, 2025, PubMed, MEDLINE, Web of Science, and Cochrane CENTRAL databases were systematically searched using a predefined strategy developed by three authors (MN, RA, and MH). The full search terms used are provided in **Multimedia Appendix 1**. Additionally, a manual search was performed to screen the reference lists.

Study Inclusion Criteria and Exclusion Criteria

Studies were considered eligible if they were published in English between 2010 and 2025 and focused on telemedicine, telehealth, or other digital health interventions for pediatric OM. Eligible designs included qualitative, quantitative, or mixed-method approaches, provided that they reported outcomes of implementation in clinical practice. Studies that enrolled children and adolescents aged < 18 years with suspected or confirmed OM—in which patients were assessed, monitored, or treated using telemedicine-supported interventions—were included.

Conference abstracts, reviews, editorials, and study protocols were excluded. Studies were also excluded if they focused exclusively on adult populations, conditions other than OM, or those that did not involve the clinical application of telemedicine. Additionally, device prototype testing or purely technical evaluations without clinical implementation were excluded. These criteria are presented in **Textbox 1**.

Data Charting Process and Items

Data extraction was independently performed by two reviewers (MN and RA) using a standardized charting form. The following variables were systematically extracted and documented: the study identifier (author and year), country of study, and population characteristics (age and sample size), information regarding the type of user (general practitioners, otolaryngologists, caregivers, parents, nurses, or community health workers), details of the telemedicine model employed (synchronous, asynchronous, or hybrid), and the device or technology utilized (including brand, requirements for smartphone use, and integration of artificial intelligence). Furthermore, data regarding comparator, primary, and secondary outcomes; results with numerical values where available; reported limitations; and potential bias sources were also documented. Any discrepancies between reviewers were resolved through discussion and consensus.

Results

Study Selection

The database search retrieved 805 articles. Following removal of duplicates, 714 articles remained for screening the titles and abstracts. Of these, 624 irrelevant articles were excluded, and 90 articles remained. The full texts of 90 articles were subsequently evaluated for eligibility; of these, 44 articles were excluded for the following reasons: non-pediatric population (n = 5), absence of telemedicine interventions (n = 11), review or commentary articles (n = 7), unrelated to OM (n = 6), not implemented in clinical practice (n = 12), not in English (n = 1), and full text not available (n = 2). Ultimately, 46 studies were included in this scoping review (Figure 1; PRISMA flow diagram).

Characteristics of Included Studies

The 46 included studies were published between 2012 and 2025[summarized in Supplementary martrial 1][11-56]. The United States contributed the largest number (n = 11) [24,25,28,33,36-39,42-44], followed by Australia (n = 9) [11,14,15,46,47,51,52,54,55], India (n = 4) [18,23,30,41], the United Kingdom (n = 4) [29,34,35,48], and China (n = 2) [40,50], with additional studies from other countries, including developing countries. (Table1)

Table1. Summary of Studies by Country

Country	Author, year [reference]
USA (n = 11)	Chan et al., 2019 [24], Chan et al., 2019 [25], Hakimi et al., 2019 [28], Jayawardena et al., 2020 [33], Kolb et al., 2021 [36], Kleinman et al., 2021 [37], Don et al., 2021 [38], Manayan et al., 2022 [39], Schafer et al., 2022 [42], Smola et al., 2022 [43], Chan et al., 2022 [44]
Australia (n = 9)	Smith et al., 2012 [11], Smith et al., 2015 [14],Jacups et al., 2017 [15], Habib et al., 2023 [46], Alenezi et al., 2024 [47], Quick et al., 2024 [51], Habib et al., 2024 [52], Bowers et al., 2025 [54], Altamimi et al., 2025 [55]
India (n = 4)	Ramkumar et al., 2018 [18], Bhavana et al., 2018 [23], Gupta et al., 2020 [30], Deshmukh et al., 2022 [41]
UK (n = 4)	Fordington & Holland Brown, 2020 [29], Cottrell et al., 2020 [34], Schuster-Bruce et al., 2021 [35], Patel et al., 2024 [48]
China	Meng et al., 2022 [40], Jin & Fan, 2024 [50]
France	Venail et al., 2018 [21], Dubois et al., 2024 [49]
Netherlands	Gyawali et al., 2024 [53], Prins-van Ginkel et al., 2017 [16]
Nepal	Mandavia et al., 2018 [19], Gyawali et al., 2024 [53]
South Africa	Biagio et al., 2014 [12], Lundberg et al., 2017 [17]
Brazil	Wagner et al., 2023 [45]
Canada	Mousseau, et al. 2018 [20]
Finland	Erkkola-Anttinen et al., 2019 [27]

Greenland	Demant et al., 2019 [26]
Hungary	Pannonhalmi et al., 2025 [56]
Taiwan	Wu et al., 2014 [13]
Turkey	Durgut et al., 2020 [32]
Republic of Korea	Cha et al., 2020 [31]

Designs encompassed diagnostic accuracy comparisons, pragmatic service evaluations, prospective and retrospective cohorts, case series, and education and simulation trials; most studies either enrolled children exclusively or included defined pediatric subsets.

Telemedicine Models, Users, and Settings

Across the 46 studies, asynchronous store-and-forward was the most commonly used approach, accounting for 31 studies (67.3%). (Table 2)

Table2. Summary of Studies by Telemedicine model

Telemedicine Model (Synchronous / Asynchronous / Hybrid)	Author, Year
Asynchronous (n = 31)	Smith et al., 2012 [11], Biagio et al., 2014 [12], Smith et al., 2015 [14], Prins-van Ginkel et al., 2017 [16], Lundberg et al., 2017 [17], Mandavia et al., 2018 [19], Shah et al., 2018 [22], Bhavana et al., 2018 [23], Chan et al., 2019 [25], Demant et al., 2019 [26], Erkkola-Anttinen et al., 2019 [27], Fordington & Holland Brown, 2020 [29], Gupta et al., 2020 [30], Cha et al., 2020 [31], Durgut et al., 2020 [32], Cottrell et al., 2020 [34], Don et al., 2021 [38], Manayan et al., 2022 [39], Meng et al., 2022 [40], Deshmukh et al., 2022 [41], Smola et al., 2022 [43], Chan et al., 2022 [44], Habib et al., 2023 [46], Alenezi et al., 2024 [47], Patel et al., 2024 [48], Dubois et al., 2024 [49], Jin & Fan, 2024 [50], Habib et al., 2024 [52], Gyawali et al., 2024 [53], Altamimi et al., 2025 [55], Pannonhalmi et al., 2025 [56]
Hybrid (n = 5)	Ramkumar et al., 2018 [18], Jayawardena et al., 2020 [33], Wagner et al., 2023 [45], Quick et al., 2024 [51], Bowers et al., 2025 [54]

Synchronous (n = 10)	Wu et al., 2014 [13], Jacups et al., 2017 [15], Mousseau, et al. 2018 [20], Venail et al., 2018 [21], Chan et al., 2019 [24], Hakimi et al., 2019 [28], Schuster-Bruce et al., 2021 [35], Kolb et al., 2021 [36], Kleinman et al., 2021 [37], Schafer et al., 2022 [42],
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In this approach, images or videos were captured by non-physicians or caregivers and interpreted remotely by otolaryngologists. This includes laptop-tethered video otoscopy in primary care [12], smartphone otoscopy with consultant review in rural clinics [19], parent-submitted videos in specialty care [22], nurse or technician capture with specialist interpretation in community programs [27,46], and a multidisciplinary pathway employing scheduled remote reviews [47]. Synchronous models accounted for 10 studies (21.7%) and included real-time postoperative reviews and acute assessments [15,20,36,37,42], whereas blended stored media with live guidance or interconsultation accounted for five studies (8.8%) [18,33,45,51,54].

Technologies and Devices

A diverse range of hardware and software solutions were reported across the included studies. (Table3)

Table3. Summary of Technologies and Key Outcomes Across Included Studies

References	Implementation / Clinical Outcome	Diagnostic Performance	Typical Setting / User
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Emergency, outpatient, school, home; clinicians, trainees, parents

Primary care; HCWs/GPs

Diagnostic concordance with in-person otoscopy was 95% with $\kappa=0.89$, sensitivity 0.94, and specificity 0.96 [19].

In a randomized comparison, trainee diagnostic accuracy improved by 11.2% using digital otoscopy and inter-rater agreement rose to $\kappa=0.69$ versus $\kappa=0.40$ with a conventional otoscope [37].

Parent-captured videos yielded 40% diagnostic-quality submissions, allowed 87% detection or exclusion of AOM during acute episodes, and achieved $\kappa=0.69$ between raters [27].

Agreement with otomicroscopy

ranged $\kappa=0.70$ – 0.81 with sensitivity 73–78% and specificity 94–98% [12].

After a second reading, agreement increased to $\kappa=0.81$ and specificity reached 0.98 [17].

Repeat confirmatory examinations decreased from 97.9% to 27.2% when digital otoscopy was used in training clinics [37].

Image acquisition required a median of ~6 minutes per case in rural outpatient workflows [19].

For home tympanostomy-tube surveillance, clinicians completed remote reviews in 1–3 minutes, families reported mean savings of ~US\$127 per episode, and satisfaction was high [38].

Short, focused training improved diagnostic agreement and enabled reliable store-and-forward workflows in primary care [12,17].

[19,20,24,27,28,33,34,35,37,38]

[12,15,17]

Home; caregivers

Outpatient; audiologists

Home; parents/patients

Discrimination of middle ear effusion achieved AUC 0.898 with sensitivity 84.6% and specificity 81.9%, outperforming commercial acoustic reflectometry (AUC 0.776). Caregivers' classifications closely matched clinicians in 24/25 ears [25].

Five-audiologist classification 86 + 2%; all Type B correctly identified. Bland-Altman in 45 intact ears: peak admittance bias -0.02 + 0.14 mL, peak pressure bias -1 + 17 daPa, and ear-canal volume bias -0.09 + 0.25 mL [44].

A clinic-based app hearing test correlated with pure-tone audiometry ($r=-0.656$) [29]. In a cohort comparison, the app arm recorded a higher proportion of symptom days (44.0%) than paper diaries (32.5%) and achieved near-complete questionnaire return [16].

Users constructed the funnel in a mean of 2.8 minutes and rated usability 8.9/10; performance was consistent across phone models following calibration.

Materials cost was < US\$30 while maintaining functional parity with a commercial device; the clinical cohort excluded infants younger than 9 months, defining the initial applicability window.

Adoption was high, with 87% of families downloading the app and 74% using it between visits, and clinicians reported improved information exchange during care [29].

[25]

[44]

[16,29]

Mixed otology; clinicians & self-exam users

School & pediatric tele-audiology

Internal validation of a CNN model reported sensitivity and specificity > 98% with AUROC 1.00 across classes; external testing showed reduced sensitivity for AOM (58.3%) and OME (58.3%) with high specificity (100% and 98.1%) [49].

A low-cost USB device with DenseNet achieved 95.7% overall accuracy; for OME, sensitivity 0.765 and specificity 0.993; for cholesteatoma, sensitivity 0.794 [50].

A rule-based model reached Top-1 69.5% versus 83% Top-1 accuracy by human telemedicine reviewers [31].

In school-entry children, remote testing matched face-to-face within ± 10 dB for air-conduction at 1 kHz (98%) and 4 kHz (97.8%), bone-conduction matched in 100%/95.7%, otoscopy agreement was $\kappa=0.60$, and tympanometry agreement was $\kappa=0.90$ [54].

Live video-otoscopy outperformed still images on five of six image-quality domains, with more landmarks identified (2.79 vs 1.68) and substantial agreement ($\kappa=0.68$ video; $\kappa=0.83$ still) [51]. Using a multisensor kit in pediatrics, ear-specific sensitivity was 64.4% (tympanic membrane) and 66.1% (ear canal), with specificity consistently above 70% [45].

Systems supported self-examination and automated triage, yet generalizability across sites, devices, and pediatric populations remains limited pending broader external validation.

Image capture success reached 96.3% during remote sessions [51]. School programs achieved > 85% coverage, reduced costs relative to standard pathways, and were rated highly by families, supporting feasibility for integrated tele-audiology [54,45].

[31,49,50]

[45,51,54]

Titan (WBT) + DPOAE

Multidisciplinary tele-clinic

Community/schools; CHWs, teachers

Clinics / non-soundproof rooms

Performance is driven by the integrated, multi-test pathway rather than a single diagnostic metric [47,55].

In CHW-led screening, overall sensitivity was 96.9% with condition-specific concordance of CSOM 96.2%, wax 98.0%, ASOM 93.9%, foreign body 100%, and OME 100% [41]. When operators received only written instructions, diagnostically useful video yield was 18.1% with substantial inter-rater agreement (Fleiss' $\kappa=0.67$) and higher usefulness in older children [26].

The Hearing Test Ξ app showed $\kappa=0.059$ indicating poor agreement with conventional audiometry [32]. The hearScreen app achieved sensitivity 85% and specificity 41%, with ambient noise at 500 Hz significantly increasing false positives ($P=0.01$) [39].

Median time to diagnosis and care plan fell to 28 days compared with 450 days in standard care ($P<.001$) [47]. A hospital cost analysis estimated ~US\$67 per initial visit (vs US\$155) with a break-even point at 223 appointments and approximately three-fold greater specialist throughput [55].

In a 45-camp program, 3,000 individuals were screened; 54% were referred, 13% presented to hospital, and roughly half of presenters required surgery; procedures were delivered at about 40% of usual cost [30]. Longitudinal regional programs achieved ~85% coverage and reduced referrals and waits [11,14].

High false-positive rates led to a 66% referral rate in a cohort with 27% hearing-loss prevalence; performance was limited by ambient noise and lack of standardized calibration [39].

[47,55]

[11,14,26,30,41]

[32,39]

The most frequently employed solution was smartphone-connected digital otoscopes and otoendoscopes, such as CellScope Oto, Cupris TYM, TYMPA system, and endoscope-I, which were applied in emergency, outpatient, school, and home settings [19,20,24,34,35,37]. USB video-otoscopes, including the Dino-Lite Pro Earscope, were used to support store-and-forward applications in clinics [12,17]. Non-smartphone digital otoscopes, such as Welch Allyn Digital MacroView, TeleHealth Flexican, and Welch Allyn USB, were used for real-time follow-up and teleconsultations [15,51].

Apart from imaging, several digital tools were employed. A smartphone-only acoustic system, employing a paper funnel and the phone's microphone, enabled the detection of middle ear effusion (MEE) [25]. Mobile health applications (mHealth apps) facilitated diary-based episode detection and home management [16,29]. A low-cost, open-source smartphone tympanometer was evaluated against the Grason-Stadler (GSI) TympStar systems [44]. Decision-support innovations included the Karl Storz Smart Scope with the i-Nside app (Inception-v2) and an inexpensive (~US\$10) USB endoscope integrated with a Dense Convolutional Network (DenseNet) classifier for self-examination [49,50]. A consumer Android-tethered otoendoscope, coupled with a rule-based model, demonstrated performance comparable to that of clinicians in mixed otology settings [31]. Community programs frequently employed Medtronic's ENTraview integrated with ClickMedix, and one program employed the Mebird T5 for asynchronous case discussion [18,30,40,41]. A multisensor kit (TytoPro) enabled remote pediatric interconsultation [45]. The school-based hybrid audiology integrated Otometrics Madsen A450 audiometry, Natus Aurical Otocam 300 video-otoscopy, and Interacoustics MT10 tympanometry with videoconferencing [54]. For training, Otosim2 via AudioProConnect and a low-cost KZYEE USB otoscope improved teaching and landmark recognition [21,28]. Teslong-pen endoscopes and the Mimi hearing application were piloted for supervised home capture and hearing checks [33,53]. A structured "Ear Portal" pathway combined hearX HearScope video-otoscopy, HearScreen audiometry, Interacoustics Titan wideband tympanometry, and distortion product otoacoustic emissions (DPOAE) into a scheduled multidisciplinary review [47,55].

Diagnostic Performance

When images were captured by trained operators and interpreted by experienced clinicians, tele-enabled programs showed substantial agreement with in-person otomicroscopy. In a primary-care cohort, asynchronous video-otoscopy yielded Cohen's κ values of 0.70–0.75 with sensitivities of 73–78% and specificities of 95–97% [12], and repeated readings in another clinic improved from κ 0.70 to 0.81 with specificity up to 0.98 [17]. Smartphone otoscopy used by trainees with remote consultant review achieved 95% ear-level concordance with on-site specialist otoscopy (κ 0.89; sensitivity 0.94; specificity 0.96) and 100% concordance with referral decisions [19]. For training, pediatric emergency department (ED) residents demonstrated similar diagnostic accuracy when using a smartphone device compared with a traditional otoscope (0.74 vs. 0.69; non-significant). However, novice users tended to favor the conventional tool, as they felt confident with it [20]. In a separate academic comparison, digital otoscopy improved trainee accuracy by 11.2%, increased inter-rater agreement from κ 0.40 to 0.69, and reduced repeat confirmatory examinations from 98% to 27% [37]. Parent and non-specialist performance was highly dependent on training and cooperation. After structured teaching, parents produced sufficient-quality videos in 67% of submissions, 40% of which supported a specific diagnosis, enabling AOM detection or exclusion in 87% of acute episodes, with substantial inter-rater agreement [27]. In contrast, a brief tutorial yielded lower agreement with

pneumatic otoscopy (parent κ 0.42 vs. physician κ 0.74), while automated cerumen alerts showed negligible agreement, highlighting the advantage of structured teaching [22]. Without hands-on training, local health care workers produced diagnostically “useful” videos in only 18% of cases, with insertion errors and cerumen as major barriers; usefulness increased proportionally with child age [26]. For MEE, the smartphone acoustic method achieved an AUC of 0.898 with 85% sensitivity and 82% specificity and surpassed commercial acoustic reflectometry, with caregiver performance approximating that of clinicians [25]. A smartphone tympanometer demonstrated ~86% classification agreement with commercial devices with only minor bias in the peak admittance and pressure [44]. However, a pediatric hearing test app demonstrated very poor agreement with booth audiometry ($\kappa \approx 0.06$), and a clinic screening app demonstrated sensitivity of 85% but specificity of 41%, with ambient noise at 500 Hz contributing to false positives [32,39]. AI-supported classifiers have demonstrated high performance metrics on curated datasets but lower sensitivity for OM and limited external validation across devices and sites [31, 49, 50].

Clinical and Implementation Outcomes

Tele-enabled programs have broadened access and accelerated clinical decision-making. A school/community program completed 2,111 assessments in 1,053 children, demonstrating 85% coverage. In another evaluation, it reduced waiting times and tertiary referrals as the program expanded [11,14]. A General practitioners-to-ear, nose, and throat (ENT) specialist smartphone endoscopy pathway was able to manage 83% of the 53 referrals remotely, with a median specialist response time of 48 minutes [34]. Community screening of 3,000 individuals generated 54% of referrals, but only 13% were ultimately presented for hospital evaluation; nearly half of those evaluated required surgery, underscoring the barriers of pathway follow-through [30]. A telehealth-supported surgical model achieved 80% clinical resolution, 88% hearing improvement, and reduced travel costs for postoperative review [15]. Home tympanostomy-tube surveillance demonstrated high inter- and intra-rater agreement, rapid clinician review (1–3 minutes), and high family satisfaction with reported time and cost savings [38]. The “Ear Portal” pathway substantially shortened time to diagnosis and care plan (median 28 days) and, in economic analysis, lowered per-visit costs, reached break-even after ~223 appointments, and increased specialist throughput [47,55]. A community service integrating smartphone otoscopy with tablet audiometry discharged most patients at their first visit at a lower cost than other services using conventional methods, with rarely changed decisions by specialist review [48]. However, televisits, which were performed predominantly without ear imaging, produced similar rates of tube recommendations but substantially lower documentation of effusion at surgery compared with encounters that incorporated ear imaging, indicating a potential risk of suboptimal decision-making when otoscopy is omitted [36]. During the COVID-19 pandemic, telehealth encounters were overall less likely to end with tube recommendations, underscoring the limitations imposed by restricted physical examination [42]. A multisensor interconsultation device demonstrated high agreement for several systems but lower sensitivity for ear canal and tympanic membrane findings than conventional methods, reinforcing the necessity of dedicated otoscopy using generalist kits [45]. In pediatric telehealth, live video-otoscopy provided superior image quality and landmark visualization compared to still images, supporting synchronous visualization when feasible [51]. A school-entry hybrid model demonstrated close agreement with face-to-face audiometry and tympanometry, with acceptable agreement for otoscopy [54].

Applications and Implementation Feasibility

Tele-enabled tools were applied in four management scenarios for pediatric ear diseases. For AOM diagnosis, asynchronous video-otoscopy demonstrated substantial agreement with otomicroscopy

when images were captured by trained operators, as in South Africa using a laptop-tethered Dino-Lite Pro Earscope and specialist review [12], and in a primary-care study in which repeated readings of stored video sequences closely tracked the microscopic reference [17]. At the bedside, smartphone-based digital otoscopy (CellScope Oto) demonstrated accuracy comparable to, or modestly better than, that of trainees using a conventional otoscope in a pediatric ED [20]. With structured instructions, parents successfully captured diagnostically useful otoscopy videos at home, supporting remote triage for suspected AOM [27]. For post-tympanostomy tube surveillance and postoperative follow-up, home digital otoscopy with CellScope Oto enabled asynchronous specialist review and was rated highly acceptable by families. In remote Australian communities, a telehealth-supported surgical pathway cut travel and costs for postoperative care [15,38]. For screening and triage in underserved settings, school- and community-based programs—ranging from mobile ear-screening services in Queensland to large-scale campaigns using the ENTraview smartphone otoscope integrated with the ClickMedix platform—efficiently detected pathology, shortened time to specialist input, and improved surgical case prioritization, though barriers—such as transport and out-of-pocket costs—limited follow-through [11,30].

Although feasibility was consistently high across settings and devices, the diagnostic yield depended on operator training, child cooperation, and cerumen management. Parents performed better after structured teaching, but accuracy declined with only brief instructions or when wax removal was not addressed [22,27]. Hands-on practice with a live tele-otoscopy simulation using the Otosim2/AudioProConnect platform preserved accuracy and shortened task time, whereas written-only instructions under field conditions produced a low proportion of diagnostically useful videos [21,26]. Clinicians generally rated smartphone otoscopy imagery as adequate and highlighted supervisory advantages of shared visualization, including fewer repeated confirmatory examinations during training encounters [24,37]. Conversely, environmental noise and calibration issues materially influenced app-based hearing tools, which demonstrated poor agreement with booth-based audiometry in children with OME, and a smartphone screening app demonstrated high sensitivity but low specificity when ambient noise was not well-controlled [32,39].

Risk of Bias and Study Limitations

Limitations include small, single-site samples; convenience sampling; mixed adult and pediatric cohorts in some studies; lack of blinded reference standards; heterogeneous operator training; device or discontinuation issues; and industrial involvement in some implementations. Parent and non-specialist performance was sensitive to training and cerumen management, while omitting otoscopy in televisits risked misclassification of MEE [11].

Discussion

Principal Findings

This scoping review mapped a rapidly evolving evidence base for telehealth in pediatric OM. Three consistent signals are observed. First, when images are captured using standardized techniques by trained operators and interpreted by experienced clinicians, store-and-forward tele-otoscopy demonstrates diagnostic performance similar to in-person examination. In primary care and community clinics, agreement with otomicroscopy was frequently in the substantial range, with high specificity for excluding the disease [12,17,19]. Second, operator training proved pivotal: performance declined markedly with brief, unsupervised capture by parent or lay-worker; agreement with pneumatic otoscopy was low; and fewer than 20% of videos were diagnostically useful. However, structured instruction or simulation improved the performance of workers without hands-on training [21,22,26,27]. Example of practical structured training can remain minimal: a 5–10 minute tutorial, a one-page capture checklist, and brief hands-on coaching including cerumen management. Embedding a simple feedback loop on image quality further improves yield without adding substantial workload. Third, adjunct digital tools are promising: a smartphone-only acoustic method that infers tympanic-membrane mobility detected MEE with an area under the ROC curve approaching 0.90, whereas digital otoscopy platforms improved trainee–supervisor agreement and reduced duplicate examinations [25,37].

Interpretation and implications

Diagnostic performance and care models

When image acquisition was standardized and performed by trained facilitators, remote specialists and generalists demonstrated diagnostic agreement with in-person reference standards that are clinically usable for triage and management. Programs embedding store-and-forward video-otoscopy, tympanometry, and audiometry in school- and community-based screening have demonstrated high coverage, efficient specialist sorting, reduced wait times, and identified surgical candidates [11]. In primary care, asynchronous tele-referral pathways allowed most cases to be managed without face-to-face review while offering timely specialist input and educational feedback to referrers [34].

Simultaneously, telehealth visits performed without otoscopic visualization carry a risk of misclassification. In a pandemic-era cohort, children evaluated for recurrent acute OM (RAOM) via video-only visits were less likely to have effusion confirmed at the time of tympanostomy tube placement than office-based comparators (39% vs. 79%), highlighting that history alone is insufficient for surgical decision-making [36]. These findings support hybrid models—telehistory plus rapid access to digital otoscopy (clinic kiosk, drive-through nurse station, and community facilitator) or validated home solutions—especially when management depends on objective middle ear findings.

Operators, training, and human factors

Evidence has consistently demonstrated that the person capturing the image is as critical as the device used. Hands-on coaching, cerumen management, stabilization, multiview protocols, and feedback loops consistently improved the diagnostic yield. In simulation settings, trained facilitators using Otosim2 with the AudioProConnect platform maintained expert accuracy without time penalties [21]. In clinical supervision settings, digital otoscopy improved trainee accuracy by approximately 11 percentage points and increased trainee–supervisor agreement from kappa 0.40 to 0.69, while reducing confirmatory re-examinations from ~98% to ~27% [37]. A randomized comparison in pediatric ED demonstrated similar accuracy for smartphones versus conventional otoscopy (0.74 vs. 0.69) but revealed lower confidence among inexperienced users, emphasizing the value of familiarization [20]. Given the established effectiveness of video otoscopy, careful consideration of the methods and timing of use may enable promising integration [57]. Standardized training packages and minimum quality thresholds should therefore be prerequisites for scaling, particularly for parents, community health workers, and very young children, in whom cooperation and canal size may complicate capture.

Adjunct technologies and AI

Smartphone-only acoustic reflectometry with embedded machine learning demonstrated high accuracy for effusion detection and performed comparably across platforms and even in the parent's hands [25]. This suggests a low-barrier screening pathway that does not depend on optical access, which is particularly valuable in toddlers with narrow canals or when video quality is suboptimal. Early studies of automated image classification demonstrated throughput advantages but lacked standalone accuracy for clinical deployment. Rigorous external validation using pediatric data, diverse devices, and real-world image quality is necessary before clinical integration [31]. Although numerous models using AI were developed to classify middle ear diseases based on tympanic membrane findings or short-wave infrared imaging, there were few studies addressing its actual clinical implementation [58–61]. It is therefore necessary to consider not only the accuracy of these models but also the optimal point and method of integration within the clinical workflow. In parallel, self-management apps for OME demonstrated high acceptability and reasonable correlation with clinic audiometry, supporting family engagement and between-visit monitoring rather than diagnosis [29]. Beyond the scope of this review, emerging reports on AI-enabled pathways and neonatal tele-screening suggest that, with robust pediatric, real-world validation, tele-enabled OM care could be applied earlier in the life course and automate portions of the workflow.

Safety, stewardship, and workflow

Across randomized and comparative studies, smartphone otoscopy did not increase AOM diagnosis or antibiotic prescription in emergency settings compared to conventional otoscopy, and in some trainee contexts, it was associated with fewer prescriptions, likely due to better shared visualization and supervision [24, 37]. Programs that integrate remote reviews into perioperative pathways have demonstrated high postoperative success rates and measurable cost savings for families in remote regions [15]. Overall, these findings support the use of protocolized tele-otoscopy within antibiotic stewardship frameworks and equitable access pathways that are independent of family-owned smartphones. Additionally, remote hearing screening initiatives, when paired with follow-up during rehabilitation, may integrate synergistically with OM care, ultimately contributing to comprehensive pediatric ear health services [62–64]. However, from a governance and medicolegal standpoint, few studies explicitly reported liability or indemnity arrangements. Implementation should include explicit consent, minimum image-quality thresholds with default to in-person when unmet, and red-flag escalation. Future studies should report adverse events and medicolegal frameworks.

Equity and access

Tele-otoscopy is particularly valuable in indigenous and rural settings with few specialists, where school-based or outreach models led by local health workers can achieve over 80% screening coverage and facilitate timely surgical intervention [11]. Jacups et al. reported that the telehealth model was the most cost-effective method for delivering ENT surgery to children living in remote regions, primarily by reducing patient travel [65]. However, digital divides—including device availability, bandwidth, language, and caregiver literacy—as well as age effects—with children under 24 months demonstrating lower capture quality—can widen disparities if the implementation depends exclusively on parent-performed capture or high-bandwidth platforms [26, 34]. Therefore, equity-focused deployment should prioritize community-hosted capture hubs, offline-capable apps, and provisioned hardware. In pediatrics, careful consideration of caregivers' role is essential, as their involvement is likely to further improve program effectiveness.

Limitations

This scoping review emphasized breadth rather than quantitative synthesis and therefore did not include a meta-analysis or formal risk-of-bias assessment. Limitations included the enrollment of mixed-age cohorts, lack of blinded reference standards, and the rapid evolution of device ecosystems, which may reduce the generalizability of device-specific findings. Additionally, language and publication restrictions may have led to the exclusion of relevant gray literature. Future studies should prioritize large, multicenter evaluations that incorporate standardized blinded reference standards to strengthen diagnostic accuracy across diverse pediatric populations and care settings. External validation efforts must address varied device ecosystems and real-world image quality to ensure generalizability. Comparative research is warranted to establish the relative performance and cost-effectiveness of emerging digital otoscopy, acoustic, and decision-support tools.

Conclusions

Telehealth for pediatric otitis media now spans mature technologies and care models. Store-and-forward tele-otoscopy is feasible and, with standardized image capture and brief structured training, can approach in-person diagnostic performance. Implementation quality requires predefined image-quality thresholds and a default to in-person care when those thresholds are not met. It also requires integration into hybrid workflows and basic governance covering consent, documentation, and data protection. Programs should ensure equitable access, especially in resource-limited settings. Video-only encounters without otoscopic imaging are inadequate when decisions require objective middle-ear findings. Key evidence gaps include multicenter child-level outcomes, economic evaluations—particularly in low- and middle-income countries—and external validation of AI tools across devices and sites. These priorities should guide the next phase of research and scale-up.

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Conflicts of Interest

The authors declare no competing interests related to this work.

Data Availability

All data underlying this scoping review are derived from published sources cited in the Reference list. Data related to this research are available from the corresponding author upon reasonable request.

Authors' Contributions

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Abbreviations:

OM, otitis media; PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews; AI, artificial intelligence; AOM, acute otitis media; OME, otitis media with effusion; COVID-19, coronavirus disease 2019; MEE, middle ear effusion; mHealth apps, mobile health applications; GSI, Grason-Stadler; DenseNet, Dense Convolutional Network; DPOAE, distortion product otoacoustic emissions; ED, emergency department; RAOM, recurrent acute otitis media.

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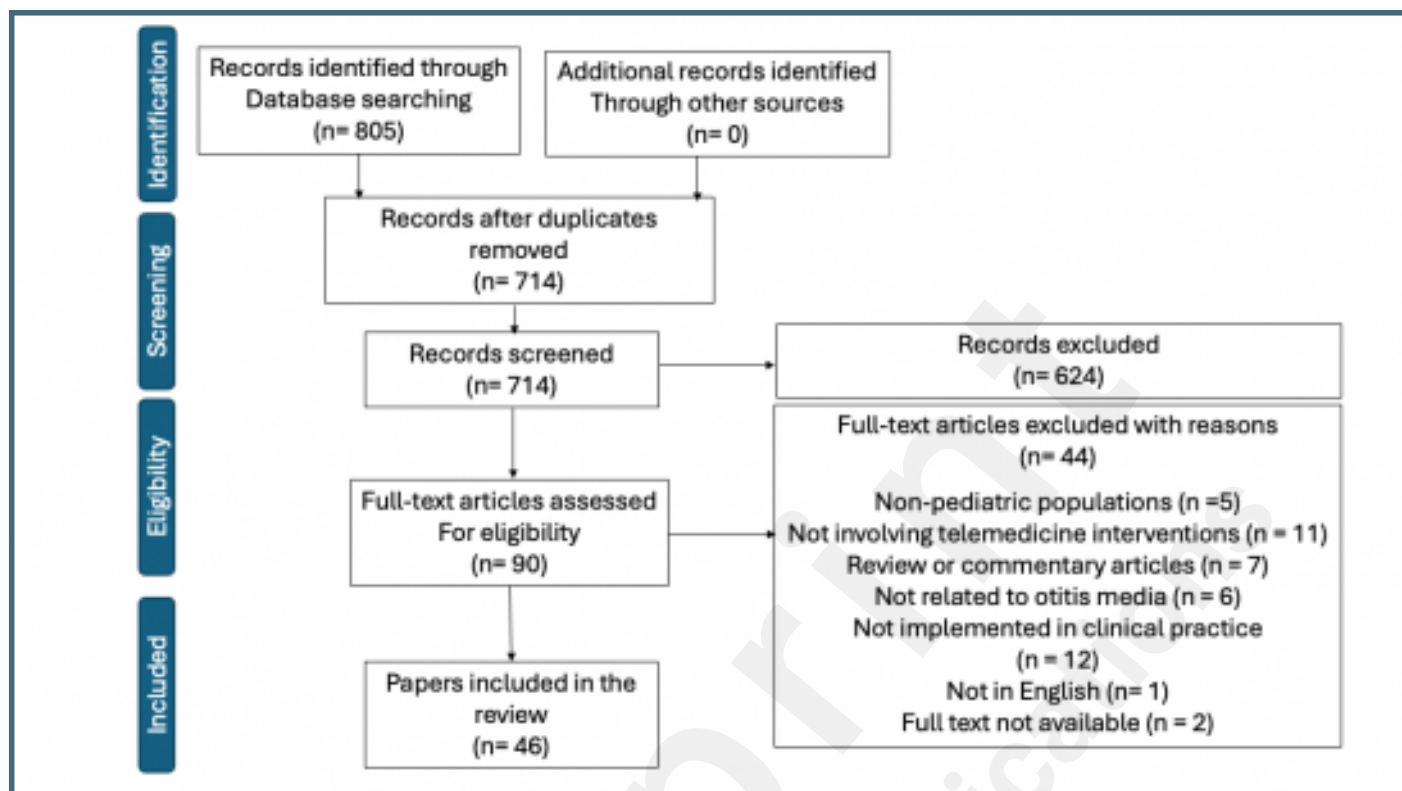
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Supplementary Files

Figures

PRISMA flow diagram.



Multimedia Appendixes

46 Studies included for this review.

URL: <http://asset.jmir.pub/assets/fc4097dbfc65baf5e556b1d594ccb15b.xlsx>

The full search terms used for this review.

URL: <http://asset.jmir.pub/assets/11d7b0474dbf411d96b64ed2f3d1c0b0.docx>

Inclusion and exclusion criteria.

URL: <http://asset.jmir.pub/assets/ebfcf0bdb0552f815477fff9a33d8d54.png>

