Teaching Pediatric Otoscopy Skills to Pediatric and Emergency Medicine Residents: A Cross-Institutional Study

Caroline R. Paul, MD; Meg G. Keeley, MD; Gregory S. Rebella, MD, MS; John G. Frohna, MD, MPH

From the University of Wisconsin School of Medicine and Public Health (Drs Paul, Rebella, and Frohna), Madison, Wis; and University of Virginia School of Medicine (Dr Keeley), Charlottesville, Va
Funding Source: This work was not supported by any funding source.
The authors have no conflicts of interest to disclose.
Address correspondence to Caroline R. Paul, MD, Department of Pediatrics, University of Wisconsin School of Medicine and Public Health, 600 Highland Ave, Madison, WI 53792 (e-mail: crpaul@wisc.edu).
Received for publication March 11, 2017; accepted February 18, 2018.

ABSTRACT

OBJECTIVE: To evaluate a pediatric otoscopy curriculum with the use of outcome measures that included assessment of skills with real patients.

METHODS: Thirty-three residents in an intervention group from 2 institutions received the curriculum. In the previous year, 21 residents in a nonintervention group did not receive the curriculum. Both groups were evaluated at the beginning and end of their internship years with the use of the same outcome assessments: 1) a written test, 2) an objective standardized clinical examination (OSCE), and 3) direct observation of skills in real patients with the use of a checklist with established validity.

RESULTS: The intervention group had a significant increase in percentage reaching minimum passing levels between the beginning and end of the internship year for the written test (12% vs 97%; $P < .001$), OSCE (0% vs 78%; $P < .001$), and direct observation (0% vs 75%; $P < .001$); significant mean percentage gains for the written test (21%; $P < .001$), OSCE (28%; $P < .001$), and direct observation (52%; $P = .008$); and significantly higher ($P < .001$) mean percentage gains than the nonintervention group on the written test, OSCE, and direct observation. The nonintervention group did not have a significant increase ($P = .99$) in percentage reaching minimum passing levels, no significant mean percentage gains in the written test (2.7%; $P = .30$) and direct observation (6.7%; $P = .61$), and significant regression in OSCE (−5.2%; $P = .03$).

CONCLUSIONS: A pediatric otoscopy curriculum with multimodal outcome assessments was successfully implemented across different specialties at multiple institutions and found to yield gains, including in skills with real patients.

KEYWORDS: acute otitis media; assessment of pediatric otoscopy skills; curriculum; pediatric otoscopy curriculum

ACADEMIC PEDIATRICS 2018;18:692–697

WHAT'S NEW?

Comprehensive teaching and assessment methods are still lacking in the critical area of pediatric otoscopy. This study offers a comprehensive teaching model with multimodal assessment instruments with evidence of validity, including assessment of skills in direct patient care settings.

ACUTE OTITIS MEDIA (AOM) is the most frequently diagnosed illness in children in the United States and the most common indication for antimicrobial therapy.[1–3] However, otitis media with effusion (OME), a condition which is often misdiagnosed as AOM and which does not require antibiotics, is actually the most common condition for which antibacterial agents are prescribed.[2,3] The correct identification of children with AOM is critical, yet the diagnosis remains challenging for both learners and clinicians.[2–4] Lack of skills in pediatric otoscopy have led to an overdiagnosis of AOM, which has resulted in an increased incidence of antimicrobial resistance and higher health care costs due to unnecessary antibiotic prescriptions and surgical referrals.[2,3]

The serious consequences of inaccurate diagnosis of AOM have led to a call for greater education regarding the diagnostic certainty of AOM. Revised clinical guidelines from the American Academy of Pediatrics have specifically stressed that "educational and dissemination methods both at the practicing physician level and especially at the resident level need to be examined."[5] Yet, formal learning interventions with objectively measurable outcomes remain limited in both medical school and residency, especially for those students and residency groups who need to learn how to accurately diagnosis AOM. Recently described curricula for pediatric otoscopy still only include self-report of learners as an outcome measure.[6] To date, no pediatric otoscopy curricula have been described that involve a multimodal assessment instrument including direct observation of skills in real patients.

Currently, the skill to perform a pediatric ear exam and correctly diagnose AOM is generally assumed. Most residents graduate from their programs without completing formal learning interventions and competency assessment regarding pediatric otoscopy and the diagnosis of AOM. Given the clearly documented educational needs of accurate diagnosis of AOM, we identified learning gaps among pediatric and emergency medicine residents, instituted a standardized pediatric otoscopy curriculum, and developed a multimodal assessment instrument including direct observation of skills in real patients. We hypothesized that residents who received the formal intervention would demonstrate significant gains in pediatric otoscopy skills and the diagnosis of AOM compared with residents with only routine learning exposure.

METHODS

SUBJECTS

The study was performed in compliance with Health Insurance Portability and Accountability Act (HIPAA) regulations and with approval from the Institutional Review Boards of the University of Wisconsin School of Medicine and Public Health and the University of Virginia School of Medicine. All subjects signed written informed consents before their participation in the study.

A nonintervention group (NIG) consisted of a historical cohort of 21 pediatric and emergency medicine residents from the University of Wisconsin who were evaluated with the use of a written test, an objective standardized clinical examination (OSCE), and direct observation of pediatric otoscopy skills in real patients at the beginning of their internship years in 2011 and at the end of their internship years in 2012. An intervention group (IG) consisted of 33 pediatric and emergency medicine residents from the University of Wisconsin and the University of Virginia who were evaluated with the use of the same 3 outcome assessments at the beginning of their internship years in 2012 and at the end of their internship years in 2013. A final evaluation group (FEG) consisted of 21 pediatric residents in the IG who were evaluated with the use of direct observation of pediatric otoscopy skills in real patients at the end of their residencies in 2015.

LEARNING EXPOSURES

The learning exposure of the NIG to pediatric otoscopy and the diagnosis of AOM consisted only of routine learning on clinical rotations, with no formal interventions including lectures or web-based training. The IG received routine learning on clinical rotations along with the developed curriculum on pediatric otoscopy and diagnosis of the AOM, with no other formal learning interventions. The FEG received only routine learning on clinical rotations during the remainder of their residencies.

CURRICULUM INTERVENTION

The curriculum intervention consisted of a single 3-hour multimodal teaching session given by 1 of 3 experienced faculty members with opportunities for didactics, discussion, demonstration, practice, and facilitated feedback. The curriculum was performed in a clinical skills center as part of the formal educational lecture schedule of the residency programs and included a didactic lecture, a small group session focusing on clinical interpretation of tympanic membrane findings, and hands-on training. Content consisted of an overview of pediatric ear anatomy, key components of the approach to pediatric ear examination, a systematic method to describe the tympanic membrane, and the clinical presentation and diagnostic criteria of AOM and OME.[7,8] An otoscopy skills checklist was developed that highlighted the key components of the approach to pediatric ear examination and consisted of multiple content domains: discussion with the caregiver, equipment, distraction techniques, holding positions, and specific portions of the examination, including general technique, pneumatic otoscopy, and cerumen removal (Supplemental Digital Appendix 1).[9] The faculty member demonstrated the skills checklist, and residents then used the checklist to practice otoscopy skills on each other and on mannequins chosen to represent children of varying ages with facilitated faculty feedback. The mannequins (Diagnostic and Procedural Ear Trainer, Model LFO1090U, Nasco Healthcare, Fort Atkinson, Wisconsin; and Ear Examination Simulator, Model M88, Kyoto Kagaku Company, Kyoto, Japan) consisted of plastic replicas of the head and torso of an infant, toddler, and preschool age child and were similar in design to mannequins typically used for cardiopulmonary resuscitation training. Hands-on training did not include practicing otoscopy skills on real patients in a clinical setting.

OUTCOME ASSESSMENT

The following 3 outcome assessments were used to evaluate the curriculum intervention:

1) A written test consisted of 24 multiple-choice and fill-in-the-blank questions on the description of tympanic membrane and the differentiation between AOM, OME, and the normal ear, which was based on validated images from Enhancing Proficiency in Otitis Media (ePROM; Supplemental Digital Appendix 2).[7] The test underwent content and process review by curriculum development and medical education experts at the University of Wisconsin and by pediatric infectious disease and primary care physicians at the University of Wisconsin and the University of Virginia who specialized in pediatric otoscopy and AOM. Independent blinded examiners scored each deidentified written test.
2) An OSCE included assessment of the diagnosis of AOM with the use of a peer-reviewed and validated pneumatic otoscopy trainer.[10] The otoscopy trainer (Diagnostic and Procedural Ear Trainer, Model LFO1066U) consisted of a mannequin head with auricle, ear canal, and cartridge containing the eardrum and middle ear space, which could be filled with air and fluid to simulate tympanic membranes with and without effusions. One of three experienced faculty members assessed the residents using the skills checklist. The faculty members had from

10–20 years of clinical experience performing pediatric otoscopy and received formal training on the diagnosis of AOM, OME, and the normal ear based on validated images from ePROM.[7] High interrater and intrarater reliability of the skills checklist was documented by having the faculty members use the checklist to assess standardized otoscopy skills with real pediatric patients in videos specifically developed to assess the accuracy of their assessment compared with the correct answers that were developed before. The faculty members received feedback on any incorrect responses when using the checklist.[9]

3) Direct observation of pediatric otoscopy skills in real patients: One of the same 3 experienced faculty members assessed the skills of residents as they performed pediatric otoscopy examinations on patients in the continuity clinic, urgent care clinic, and emergency medicine department. Patients were selected by the clinic schedulers who checked the resident patient schedules on the particular assessment days. If the patient met the age criteria of <6 years and the time was feasible for the resident and the faculty member, the pediatric otoscopy skills of the resident were assessed with the use of the skills checklist. The caregiver was asked if the faculty member could be in the room as the resident performed the otoscopy examination. High interrater and intrarater reliability of the skills checklist was documented as previously described.[9]

The IG and NIG were evaluated with the use of all 3 outcome assessments at the beginning and the end of their internship years. The FEG was evaluated by direct observation of pediatric otoscopy skills at the end of their residencies. In addition, the diagnostic accuracy of the FEG in distinguishing between AOM, OME, and the normal ear was assessed with the use of the faculty member's diagnosis of the same ear examination as the reference standard. For each outcome assessment, minimum passing level (MPL) scores expected of a resident at the end of their internship year were established a priori. The benchmarks were selected through group consensus from curriculum development and medical education experts at the University of Wisconsin and pediatric residency program directors, pediatric infectious disease, and primary care physicians who specialized in pediatric otoscopy and AOM at the University of Wisconsin and the University of Virginia. Evidence of internal structure validity included demonstration that the scores on the skills checklist significantly and appropriately increased with advancing levels of learners.[9]

STATISTICAL ANALYSIS

The percentage of residents reaching the MPL was considered to be the primary outcome for the statistical analysis, and the mean percentage gains in scores between the beginning and end of the internship years was considered to be the secondary outcome. Conditional logistic regression analysis was used to compare the percentage of residents reaching the MPL on the written test, OSCE, and direct observation for the IG and NIG at the beginning and end of their internship years, and linear regression analysis was used to compare mean percentage gains in scores among the IG, NIG, and FEG. For all tests, statistical significance was defined as a P value <.05 with the Holm-Bonferroni correction method used to adjust all P values to account for multiple comparisons.

RESULTS

The NIG consisted of 15 pediatric residents and 6 emergency medicine residents from the University of Wisconsin who were evaluated at the beginning of their internship years. Thirteen of the 15 pediatric residents and 5 of the 6 emergency medicine residents were evaluated at the end of their internship years. The IG consisted of 15 pediatric residents and 6 emergency medicine residents from the University of Wisconsin and 12 pediatric residents from the University of Virginia who were evaluated at the beginning of their internship years. Twenty-three of the 27 pediatric residents and all 6 emergency medicine residents were evaluated at the end of their internship years. The FEG consisted of 11 pediatric residents from the University of Wisconsin and 10 pediatric residents from the University of Virginia who were evaluated at the beginning of their internship years, the end of their internship years, and the end of their residencies. Three residents in the NIG and 4 residents in the IG did not receive follow-up evaluation owing to scheduling issues, including critical inpatient rotations and duty-hour constraints. Six emergency medicine residents in the IG were not included in the FEG owing to scheduling issues, and 2 pediatric residents in the IG were not included in the FEG owing to leaving their residency programs before graduation (Figure).

The mean scores at the beginning of the internship year were 56.5 ± 9.6% for the written test, 54.1 ± 10.6% for the OSCE, and 27.4 ± 4.4% for direct observation for the IG and 63.2 ± 15.0% for the written test, 43.2 ± 8.6% for the OSCE, and 52.3 ± 26.9% for direct observation for the NIG. The mean scores at the end of the internship year were 77.8 ± 7.7% for the written test, 81.3 ± 11.0% for the OSCE, and 83.6 ± 12.8% for direct observation for the IG and 66.0 ± 12.0% for the written test, 35.0 ± 8.6% for the OSCE, and 32.0 ± 14.1% for direct observation for the NIG.

Table 1 compares the percentages of residents in the IG and NIG who attained the MPL on the written test, OSCE,

Table 1. Percentage of Residents in the Intervention (IG), Nonintervention (NIG) Groups Who Attained the Minimum Passing Levels (MPLs) on the Written Test, Objective Standardized Clinical Examination (OSCE), and Direct Observation at the Beginning and End of Their Internship Years

Outcome Assessment		IG	NIG	*P* Value
Written test	MPL at beginning of year	12.1%*	0%**	.16
	MPL at end of year	97%*	0%**	<.001
OSCE	MPL at beginning of year	0%*	0%**	.99
	MPL at end of year	79.3%*	0%**	<.001
Direct observation	MPL at beginning of year	0%*	0%**	.99
	MPL at end of year	75%*	0%**	<.001

*Statistically significant difference in MPL within group at beginning and end of year; $P < .001$.

**Non–statistically significant difference in MPL within group at beginning and end of year; $P = .99$.

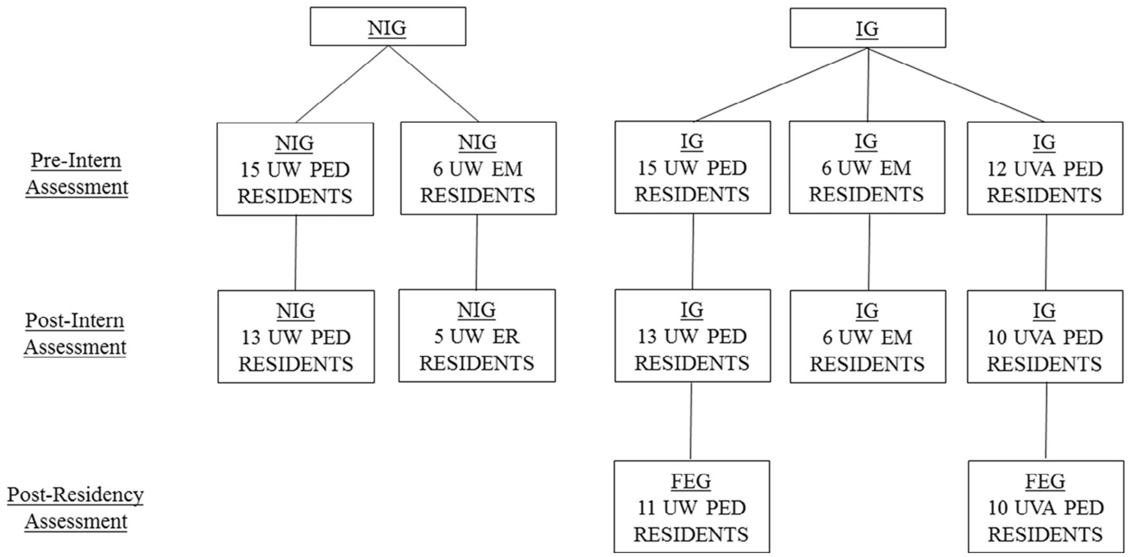

Figure. *Flowchart describing the intervention group (IG), nonintervention group (NIG), and final evaluation group (FEG). EM indicates Emergency Medicine; PED, Pediatrics; UVA, University of Virginia; UW, University of Wisconsin.*

and direct observation at the beginning and end of their internship years. There was no significant difference between the IG and NIG for the percentage of residents who attained the MPL at the beginning of the internship year for the written test ($P = .16$), OSCE ($P = .99$), and direct observation ($P = .99$). However, the IG had a significantly higher ($P < .001$) percentage of residents who reached the MPL at the end of the internship year than the NIG for the written test (97% IG vs 0% NIG), OSCE (79% IG vs 0% NIG), and direct observation (75% IG vs 0% NIG). There was a significant increase in the percentage of residents who attained the MPL between the end and the beginning of the internship year for the IG ($P < .001$) but not for the NIG ($P = .99$) for the written test, OSCE, and direct observation.

Table 2 compares the mean percentage gains in scores for residents in the IG and NIG between the beginning and end of their internship years for the written test, OSCE, and direct observation. The IG had significant mean percentage gains between the beginning and end of the internship year for the written test (20.7%; $P < .001$), OSCE (27.5%; $P < .001$), and direct observation (52.2%; $P = .008$). The NIG group had no significant mean percentage gains between the beginning and end of the internship year for the written test (2.7%; $P = .30$) and direct observation (6.7%; $P = .61$) and significant regression in the OSCE (–5.2%; $P = .03$). The IG had significantly higher ($P < .001$) mean percentage gains between the beginning and end of the internship year than the NIG for the written test, OSCE, and direct observation.

The mean scores for the FEG were 82.9 ± 10.7% at the end of the internship year and 83.1 ± 11.2% at the end of residency for direct observation. There was no significant mean percentage gain in scores (0.2% with SD of 2.1%; $P = .79$) for the FEG between the end of the internship year and the end of residency for direct observation. Furthermore, 20 out of 21 graduating pediatric residents arrived at the correct diagnosis in 4 patients with AOM, 3 patients with OME, and 14 patients with normal ears, compared with the faculty member's diagnosis of the same ear examination.

DISCUSSION

This study described a standardized curriculum for pediatric otoscopy and a multimodal assessment instrument that was feasible and effective for different residency groups at different institutions. Compared with routine learning, residents who received the curriculum were more likely to reach established minimum passing levels and to demonstrate significant learning gains in knowledge and skills. Our study demonstrated the need for formal interventions and assessment of skills with the use of a multimodal instrument with validity evidence to meet the critical patient care need of pediatric otoscopy and the diagnosis of AOM. Indeed, our assessment revealed baseline learning deficits in residents that may not have otherwise been identified. Our study further demonstrated that learned skill could be tracked longitudinally and that gains in knowledge and skills from a pediatric

Table 2. Mean Percentage Gains in Scores for Residents in the IG and NIG Between the Beginning and End of Their Internship Years for the Written Test, OSCE, and Direct Observation

	IG		NIG		
Outcome Assessment	Mean Gain (SD)	*P* Value of Gain	Mean Gain (SD)	*P* Value of Gain	*P* Value Between IG and NIG
Written test	20.7% (13.1%)	<.001	2.7% (9.5%)	.30	<.001
OSCE	27.5% (16.9%)	<.001	–5.2% (3.2%)	.04	<.001
Direct observation	52.2% (13.6%)	<.001	6.7% (9.3%)	.61	<.001

Abbreviations as in Table 1.

otoscopy curriculum could be maintained long after the curriculum was completed.

Recognizing the multimodal nature of learning pediatric otoscopy and diagnosing AOM, our assessment instrument also was multimodal in design, targeting core content knowledge and clinical skills. The use of the skills checklist allowed teaching and assessment to be performed in a very deliberate and stepwise manner, modeling the approach that an expert in otoscopy might exhibit when performing an ear examination. In addition to tympanic membrane interpretation, the skills checklist addressed frequently overlooked and often assumed proficiencies, such as communication with caregivers and holding and distraction techniques that are needed to optimize tympanic membrane visualization. In this manner, we attempted to avoid overlooking any key step to a successful ear examination and an accurate diagnosis of AOM.

Our multimodal assessment instrument underwent rigorous development and contained evidence of validity.[7,9,10] Curricula that target eventually improved patient outcomes, the highest outcome tier in medical education, require assessment instruments that contain validity evidence and include direct observation of skills on real patients during actual clinical encounters. Assessment of curricula should aim to evaluate learned skills in direct patient care settings. Although this is often assumed to be difficult and impractical, the present study demonstrated the feasibility of assessing pediatric otoscopy skills on real patients. Our successful application of the skills checklist in different clinical settings could serve as a model for the development of future assessment instruments for other core competencies across a variety of specialties.

Previous studies have described formal curricula for pediatric otoscopy and AOM. Kaleida et al first described the use of the ePROM web curriculum to teach pediatric otoscopy skills to residents but only used a written test as an outcome assessment measure.[7] Morris et al reported the use of an ear simulator to improve the diagnostic accuracy of medical students to detect simulated ear effusions in mannequins.[10] Dinsmore et al reported the use of a skills checklist to evaluate the otoscopy skills of audiology students with the use of patient actors but did not describe a formal curriculum being evaluated.[11] Nicklas et al described a pediatric otoscopy curriculum that included a mix of knowledge, skill, and attitude activity but only included self-report of learners as an outcome measure.[6] To our knowledge, formal curricula for pediatric otoscopy similar to ours, which included multiple learner groups, established competency benchmarks, and valid multimodal learning and assessment instruments, have not been described. Furthermore, no previous studies have documented that pediatric otoscopy skills gained after a curriculum could translate into actual skills demonstrated with real patients.

Our study found that there was no further improvement in pediatric otoscopy skills in residents between the end of their internship years and the end of their residencies. This lack of gain may be due to the fact that the residents did not have the proper clinical learning environment to practice and get facilitated faculty feedback on their pediatric otoscopy skills during their 2nd and 3rd years of residency. Alternatively, the residents may have learned additional pediatric otoscopy skills on their clinical rotations during residency but not in the standardized manner that was taught in the curriculum and evaluated with the use of the skills checklist. This calls for standardization of pediatric otoscopy learning among not only learners but also faculty members.

Our study has several limitations. One limitation was that the pediatric and emergency medicine residents were not randomly assigned to the IG and NIG, because we thought that it would be unethical to limit the educational experience of a subset of residents who did not receive the curriculum intervention. Instead, a historical cohort was used as the NIG, whose learning exposure to pediatric otoscopy and the diagnosis of AOM consisted only of routine learning on clinical rotations. By choosing this type of study design, we were able to test the feasibility of our outcome assessment instrument with the use of a larger number of residents at different institutions over a longer time period. Another limitation of our study was that it could not account for other factors that may have influenced gains in knowledge. Inherent intelligence, previous otoscopy experience in medical school, and the routine learning experiences gained during the internship year may have varied between residents in the IG and NIG. In addition, baseline outcome assessment scores differed between residents in the IG and NIG, as is the case for many learners entering residency. However, our study measured the percentage of residents who attained MPLs and the percentage gains in learning. These outcome assessment measures are considered to be more meaningful than absolute scores, because they are less affected by baseline differences in learners.

The ultimate objective of medical education interventions is to improve patient outcomes.[12] Often, a single study cannot reach this ultimate objective; a rigorous methodologic approach is required. In 3 residency programs at 2 universities, we successfully improved skills in performing the pediatric ear examination by implementing and evaluating a curriculum in pediatric otoscopy. Because accurate diagnosis of AOM is a key component of pediatric practice, we recommend the curriculum for more widespread use. However, future work is needed to document improvements in the actual diagnosis and management of AOM in learners in direct patient care settings with the use of the developed curriculum and assessment instruments.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.acap.2018.02.009.

REFERENCES

1. Kaur R, Morris M, Pichichero ME. Epidemiology of acute otitis media in the post-pneumococcal conjugate vaccine era. *Pediatrics*. 2017;140:1–11.
2. Finkelstein JA, Metlay JP, Davis RL, et al. Antimicrobial use in defined populations of infants and young children. *Arch Pediatr Adolesc Med*. 2000;154:395–400.

3. McCaig LF, Besser RE, Hughes JM. Trends in antimicrobial prescribing rates for children and adolescents. *J Am Med Assoc*. 2002;28:3096–3102.
4. Rosenkranz S, Abbott P, Reath J, et al. Promoting diagnostic accuracy in general practitioners management of otitis media in children: findings from a multimodal, interactive workshop on tympanometry and pneumatic otoscopy. *Qual Prim Care*. 2012;20:275–285.
5. Lieberthal AS, Carroll AE, Chonmaitree T, et al. The diagnosis and management of acute otitis media. *Pediatr*. 2013;131:e964–e999.
6. Nicklas D, Hanson J, Lopreiato J. Acute otitis media curriculum. *MedEdPORTAL*. 2016;12:10511. Available at: https://doi.org/10.15766/mep_2374-8265.10511.
7. Kaleida PH, Ploof DL, Kurs-Lasky M, et al. Mastering diagnostic skills: Enhanced Proficiency in Otitis Media, a model for diagnostic skills training. *Pediatrics*. 2009;124:e714–e720.
8. Shaikh N, Hoberman A, Kalieda PH, et al. Diagnosing otitis media-otoscopy and cerumen removal. *N Engl J Med*. 2010;362:e62.
9. Paul CR, Keeley MG, Rebella G, et al. Standardized checklist for otoscopy performance evaluation: a validation study of a tool to assess pediatric otoscopy skills. *MedEdPORTAL*. 2016;12:10432. Available at: http://dx.doi.org/10.15766/mep_2374-8265.10432.
10. Morris E, Kesser BW, Pierce-Cottler S, et al. Development and validation of a novel ear simulator to teach pneumatic otoscopy. *Simul Healthcare*. 2012;7:22–25.
11. Dinsmore BF, Bohnert C, Preminger JE. Standardized patients in audiology: a proposal for a new method of evaluating clinical competence. *J Am Acad Audiol*. 2013;24:372–392.
12. Kirkpatrick D. Evaluation of training. In: Craig R, ed. Training and development handbook: a guide to human resource development. New York: McGraw Hill; 1976.