Training of Nurses in Ear Examination and Hearing Screening in the School Setting (Phase II): A Cross-Sectional Study

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ABSTRACT

Objectives. To determine the agreement between 1) ear examination findings of the otorhinolaryngologist using an otoscope and trained elementary school nurses using a penlight, 2) hearing screening findings of the otorhinolaryngologist and elementary school nurses, both using the Philippine National Ear Institute (PNEI) Method of 512 Hz Tuning Fork Test (TFT) and 3) PNEI Method of 512 Hz TFT findings and screening audiometry findings.

Methods. In this continuing study, nurses residing in the venue of the study, and previously trained in ear examination using a penlight and hearing screening using the PNEI 512 Hz TFT, conducted these in school children who attended the hearing screening and medical mission. Otoscopy, PNEI Method of 512 Hz TFT, and screening audiometry were then conducted on the children by the otolaryngologist. The nurses and the otolaryngologist performed independent and blinded assessments.

Results. Eighteen nurses and ninety children participated in the study. Data subjected to Kappa statistics showed good agreement between nurses and otorhinolaryngologist's findings in the examination of the external canal and tympanic membrane and in PNEI Method of 512 Hz TFTs, and between the PNEI Method of 512 Hz TFT and screening audiometry.

Conclusion. PNEI methods of penlight ear examination and 512 Hz TFT may be effective tools for early detection of common ear conditions and hearing screening in Filipino school children. These may be conducted in the school setting not only by otorhinolaryngologists but also by adequately trained school nurses.

Key Words: hearing screening, tuning fork test, hearing in children

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Introduction

In the Philippines, the most common causes of hearing loss in school children are Otitis Media and Impacted Cerumen, resulting in prevalence rates ranging from 8-40%.[1,2] Despite the significant prevalence of hearing impairment, there is no standard mass hearing screening for school children. This may be attributed to the unavailability of equipment, personnel, or ideal audiologic settings as recommended standards by developed countries. Because of the importance of detecting hearing loss as early as possible, there is a need for a hearing screening program in schoolchildren that is valid, reliable, accurate, feasible and practical. The Philippine National Ear Institute (PNEI) partnered with the Department of Education and conducted a series of training workshops and research activities since 2004 for the development of a hearing screening program in school children. The PNEI proposed a PNEI Hearing Screening Method consisting of ear examination using the clinic or office penlight and PNEI Method of 512 Hz Tuning Fork Test(TFT). From these, a phase 1 published study[3] concluded that school nurses may be effectively trained in ear examination using a penlight to screen for the presence of ear wax and discharge. This ability of trained nurses may be used to conduct mass hearing screening in the school setting. Also, the nurses were able to produce significant sound pressure levels with mean SPL of 56.3 dB with the use of the PNEI Method of 512 Hz TFT. Mean sound pressure levels produced indicate possible standardization of the technique.[3] Thus, these may be used for a hearing screening program for schoolchildren.

In this continuing study, the nurses who have completed the training workshops were now tasked to perform their learned skills on the school children in the actual school setting. The objectives of this study are 1) to determine the agreement between the ear examination findings of the otorhinolaryngologist using an otoscope and the elementary school nurse using a penlight and 2) to determine the agreement between the hearing screening findings of the otorhinolaryngologist and elementary school nurse, both using the PNEI Method of 512 Hz TFT and 3) to determine the agreement between the PNEI 512 TFT

findings and the standard screening audiometry findings. These objectives are geared for the process of validating an accessible, widely applicable and viable method of hearing screening using the current set-up in public schools. School nurses who were initially validated with the PNEI Method of 512 Hz TFT are currently evaluated in the school setting and were asked to perform the method. Their otoscopic findings and tuning fork test results were validated by ORLs and standard screening audiometry, respectively.

Methods

2.1 Participants

Inclusion Criteria

The school nurses included in the study were those who have completed the training workshops on PNEI Hearing Screening Method and could produce an average of at least 35 dB of sound with the tuning fork using the technique taught in the PNEI workshops.

Exclusion Criteria

The school nurses excluded in the study were those who have not undergone training by the PNEI, and those who could not produce an average of at least 35 dB of sound with the tuning fork using the technique taught in the PNEI workshops.

The ideal sample size based on prevalence of hearing loss is 279 ears or at least 140 children. The children were considered a homogenous group in terms of their ability to participate in the ear examination and to respond to the hearing screening tests. The ideal sample size of nurses is 30. The nurses were also considered as a homogenous group, since they all underwent the same training and evaluation on hearing screening.

2.2 Study setting

The study was conducted during a mission last April 26, 2006 at Daet Elementary School, a public school in Daet, Camarines Norte. Daet is a first class municipality, and is the provincial capital of Camarines Norte. It has a total population of 80,632 divided over 16,267 households. Daet has a total land area of 5,861 hectares, of which, 189 hectares or 3% are classified as urban area, and 5,672 hectares or 97% are classified as rural area. Barangay VII, where Daet Elementary School is located, has a total population of 2,425,000 spread over 477 households.

2.3 Study Design: Cross-sectional Study

The otorhinolaryngologist who conducted the training workshops provided an orientation for the nurses and a review regarding the skills that have been learned previously. The nurses again practiced on each other during the first hour and also practiced the striking of the tuning fork so each of them would produce an average sound level of at least 35 dB.

Each school nurse was then randomly assigned 3 to 7 children each to be in charge of during the mission. The school nurse will perform the penlight ear examination and the tuning fork hearing screening test on the children assigned to them in the specified stations of the mission.

The mission had seven stations for the school children. General data and vital signs were taken in Station 1. The patient's medical history, with emphasis on the otologic history, was elicited in Station 2. Otoscopy was done in Station 3, and screening tuning fork tests were conducted in Station 4. Screening audiometry was done in Station 5. The schoolchildren then had a general physical examination, including an otorhinolaryngologic head and neck examination, in Station 6. Station 7 is where the parents of each child were given home medications and instructions based on the assessment and plan generated from Station 6.

Station 1: General Data and Vital Signs

The parents of the children were interviewed by doctors and barangay health workers. The child's name, age, sex, height, weight, heart rate, respiratory rate, and axillary body temperature were recorded.

Station 2: History

The parents were interviewed by an otorhinolaryngology consultant and a resident regarding the chief complaint; history of ear discharge (onset/duration, frequency, color, character, smell, consults made, medications taken, and last application of otic drops or intake of oral antibiotics); other symptoms like hearing loss, tinnitus and vertigo; past-, family-, birth/maternal-, immunization-, and personal/social history. It is assumed that the resident is equal with the consultant in obtaining the history.

Station 3: Otoscopy

The children underwent ear examination with the use of a penlight by the school nurse assigned. Findings were recorded by means of filling in a questionnaire that addressed appearance and content of the external ear canal, visualization of the eardrum and characteristics of the ear drum.

After the school nurse has performed ear examination using a penlight, an otolaryngology consultant and the chief resident conducted otoscopic examination in all the children. It is assumed that the chief resident's skill in otoscopy is equal to the consultant's. Otoscopy using a Welch-Allyn Otoscope was done to determine:

Appearance and Content of the External Auditory canal such as:

Normal or With Findings. Findings include by this study's definitions:

Retained Cerumen, defined as cerumen, wet or dry, scanty or many, in the external auditory canal wherein the tympanic membrane may still be visualized either in part, or in its entirety.

Impacted Cerumen, defined as cerumen filling the entire circumferential plane of the external auditory canal with resultant non-visualization of any part of the tympanic membrane. The depth or breadth of the impaction is not assessed, and is not considered in the definition.

Discharge, defined as any fluid in the external ear canal.

Visualization and Appearance of the tympanic membrane and presence of pathologies such as:

Otitis Media, defined as inflammation of the middle ear, regardless of etiology and duration, characterized by one or more of the following signs: hyperemia of the tympanic membrane, air-fluid levels behind the tympanic membrane, tympanic membrane perforation, and/or ear discharge.

A normal otoscopic exam is recorded when the external auditory canal does not have any hyperemia, inflammation, cerumen, foreign body, discharge, and debris. The tympanic membrane should be grayish-white, translucent, not retracted or bulging, and with the normal anatomic landmarks visualized.[4]

Station 4: PNEI Method of 512 Hz Tuning Fork Test (TFT)

Tuning fork testing was done using a standard 512-Hz tuning fork. It was performed on each child by two examiners using the specific technique taught in the workshops: first by the nurse-in-charge, then immediately after by the otorhinolaryngologist and the senior resident.

The child was asked to sit on a stool and he/she was given specific instructions by the examiner on the proceedings. The child then looked straight ahead with his back to the examiner. The examiner was directly behind the child, out of the child's line of vision, and, with his/ or her elbows clipped to his/her waist, struck the tuning fork against the hypothenar eminence of the opposite hand and immediately placed the tuning fork approximately 2-3 inches away from the pinna.[5] If the child heard the sound, he raised his hand on the side where he heard the sound. The examiner then tested the opposite ear. The results were either YES, meaning the patient heard the sound; or NO, meaning the patient did not hear the sound. The test was done three times per ear, by both the nurse and the otorhinolaryngologist, and the mode for each examiner was taken as the final result.

Station 5: Screening Audiometry

Hearing loss was determined using the screening audiometry as the reference standard for this study's purpose. The ideal reference standard for determining hearing loss in the clinics is the pure tone audiometry done in an audiometric booth in a formal audiological center, but for the purposes of this study, screening audiometry as described below is considered as the gold standard.

Screening audiometry in this study is air conduction testing for hearing thresholds for 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz, using a Siemens SD21 portable screening audiometer via circumaural headphones. The children were tested by an otorhinolaryngologist-audiologist, and by an audiology graduate student in a relatively quiet part of the school. The baseline ambient noise levels were measured every 30 minutes using a Digital Sound Level Meter (TES). The average noise level was found to be 54 dBA. Hearing thresholds were then determined accordingly using maximum octave band levels allowed when testing in the 250- to 8000-Hz range with ears covered as based on the American National Standards Institute S3.1-1991.[6] The computed hearing threshold was 35 dB HL.

A finding of PASS for each ear means that the child's hearing threshold for all test frequencies in that ear is at most 35 dB HL. Hearing loss is defined as having a hearing threshold of more than 35 dB HL in at least one of the test frequencies for each ear. This finding was recorded as FAIL for that particular ear.

It is assumed that the audiology graduate student's skill in performing screening audiometry is at par with the otorhinolaryngologist-audiologist.

Station 6: Physical Examination

The children were examined by an otorhinolaryngology consultant and a resident. A general physical examination was done, and ear cleaning was done when needed. Children who had impacted cerumen resistant to extraction were advised to instill baby oil in the affected ear for one week, and were instructed to follow-up with the local doctors for ear cleaning. Children with medical conditions were given appropriate medications for free when available,

prescribed medications that were not available, and referred to the local doctors for follow-up.

Station 7: Home Medications and Instructions

In this final station, a resident advised the parents of the children and dispensed available medication. The questionnaires were collected in this station. Data from the questionnaires were collated, organized, and subjected to analysis.

Results

A total of 18 school nurses participated in the mission. Table 1 shows the demographic data of the school nurses.

Table 1. Demographic data of school nurses

Initials	Age	Sex	Years in Service	Average SPL (dB) Produced with 512 Tuning Fork
HZL	36	M	8	46.6
ACA	31	M	7	37.6
JJRM	32	M	4	35.2
EPH	36	M	3	47.0
EVY	37	M	1	53.6
RCI	37	M	1	48.3
PQO	52	F	29	38.9
GPF	52	F	20	35.4
MMV	48	F	19	43.0
MGAY	36	F	7	47.3
MCA	35	F	7	40.0
MOA	32	F	7	41.8
ABV	32	F	7	45.0
MLL	33	F	6	40.0
JRC	31	F	4	35.3
CCC	29	F	3	45.2
DCY	39	F	2	41.8
NRR	33	F	1	38.9

There were 6 males and 12 females with mean age of 37 ± 9 and age range of 29 – 52 years. The years in service as a school nurse averaged 8 years ± 2 ranging from 1 to 29 years. The average SPL produced by the nurses as a group was 42.27 ± 10 dB SPL.

Ninety (90) children were included in the study. There were 40 males and 50 females with mean age of 9 years ±1, range of 4 to 16 years. They were all residents of Daet and were cooperative during the otoscopy, tuning fork tests and screening audiometry.

The otorhinolaryngology consultant and the senior resident who performed the tuning fork tests had an average produced SPL (dB) of 41 dB.

For the ear examination with the use of a penlight done by the nurses:

Of the 90 children, 22.22% (40/180 ears) had normal external auditory canals (no cerumen, no discharge), 61.67% (111/180 ears) had retained cerumen, 15.56% (28/180 ears) had impacted cerumen. Discharge was identified in 0.55% (1/180 ears).

The tympanic membrane was visualized in 67.78 % (122/180 ears) and not assessed in 32.22 % (58/180 ears). Among the 122 tympanic membranes visualized, 99.2 % (121/122 ears) was normal and only 0.82 % (1/122 ears) was labeled abnormal because it was assessed to have a perforation.

For the ear examination with the use of an otoscope done by the otorhinolaryngologist (ORL):

Of the 90 children, 34.44 % (62/180 ears) had normal external auditory canals (no cerumen, no discharge), 46.67% (84/180 ears) had retained cerumen, 18.33 % (33/180 ears) had impacted cerumen. Ear discharge was identified in 0.55% (1/180 ears).

The tympanic membrane was visualized in 81.10% (146/180 ears) and not assessed in 18.33% (33/180 ears). Among the 146 tympanic membranes visualized, 96 % (141/146) were normal and 4 % (6/146) were abnormal. The abnormal tympanic membrane findings of the ORLs that the nurses labeled as normal were: slightly retracted (2/146 ears), retracted and hyperemic (1/146 ears),) healed perforation (2/146), whitish patch (1/146). Of the 2 healed perforations found by the ORL group, 1 was labeled as Normal and the other was labeled as Perforated by the nurses group. The 1 whitish patch labeled by the ORL was labeled not assessed by the nurses group.

Table 2 summarizes the EAC findings.

Table 2. Results of ear examination of external ear

	Normal EACs	RETAINED CERUMEN	IMPACTED CERUMEN	DISCHARGE	TOTAL
NURSES	40 (22.2)	111(61.7)	28(15.6)	1 (.55)	180 (100)
ORL	62 (34.4)	84 (46.7)	33 (18.3)	1 (.55)	180

X^2 p = 0.01

The nurses using a penlight labeled only 40 external auditory canals as normal compared with 62 that the otorhinolaryngologist detected when using the otoscope which is considered as the reference standard (Table 2).

Table 3 shows the concordance analysis between the ORLs and Nurses regarding external ear canal findings.

The nurses and the ORL both labeled 31 ears as Normal and 109 ears as with impacted cerumen, retained cerumen and in 1 ear, discharge (Table 3). Thus, it may be discerned that the nurses with the use of a penlight can learn to detect these findings of cerumen and discharge.

The nurses labeled 9 Normals which the ORL labeled as With Findings which were all actually retained cerumen (not impacted cerumen, not discharge) (Table 3). Thus, even though the nurses missed 9 ears that the ORL considered as With Findings, these were all just retained cerumen, and not considered as an abnormality.

The nurses labeled 31 ears as with cerumen which the ORL labeled as Normal. 30 of these ears were labeled as retained cerumen by the nurses and 1 as impacted cerumen (Table 3). This reflects the tendency of the nurses to overdiagnose EAC findings.

Table 3. Concordance analysis between ORLS and nurses external ear canal findings

ORLs	Nurses		Total
	YES	NO	
YES	31	9	40
NO	31	109	140
Total	62	118	180

Kappa coefficient = 0.46 S.E. = 0.07
p = 0.000

The concordance analysis resulted in the Kappa value of .46 with a p=0.000, indicating a relatively good agreement between the nurses' and the ORL's external ear canal findings.

Table 4 summarizes the Tympanic membrane findings.

Table 4. Results of examination of the tympanic membrane

	VISUALIZED	NORMAL	ABNORMAL
NURSES	122 (67.8)	121 (99.2)	1 (.82)
ORL	146 (81.1)	141 (96)	6 (4)

X^2 p = 0.88

The Nurses were able to visualize 122/180 ears while the ORLs visualized 146/180 ears. The difference was 24 tympanic membranes not assessed by the Nurses group or 13.3 % of the total number of ears examined. This may be attributed to anatomic variabilities in the ear canal, amount of retained cerumen, the technique of ear examination, in the acquisition of the skill, and the inherent difference in the skills of the ORLs and nurses.

Table 5 shows the concordance analysis between the ORL's and nurses' tympanic membrane findings.

Table 5. Concordance analysis between ORLS and nurses' tympanic membrane findings

ORLs	Nurses		Total
	Yes	No	
Yes	118	0	118
No	3	1	4
Total	121	1	122

Kappa coefficient = 0.4 S.E. = 0.07
p = 0.000

All of the 122 tympanic membranes visualized by the Nurses were also visualized by the ORLs (Table 5). Of these, 118 were labeled as Normal and 1 was labeled as Abnormal by both the nurses and the ORLs. The 1 tympanic membrane that the nurses and ORLs agreed to label as abnormal was assessed by the nurse to have a perforation but was assessed to be a healed perforation by the ORL. This is quite acceptable in practical terms when the chance of overdiagnosing will not lead to any negative medical consequences.

The concordance analysis resulted in the Kappa value of .4 with a p=0.000 indicating a good agreement between the nurses' and the ORLs' tympanic membrane findings.

However, there were 3 tympanic membranes that were labeled as Normal by the nurses which were labeled as Abnormal by the ORLs: 2 were slightly retracted tympanic membranes and 1 was retracted and hyperemic. These may be characteristics of the early stages of Acute Otitis Media, or other forms of Otitis Media without a tympanic membrane perforation or discharge. Thus, the proposed method of ear examination with the use of a penlight by the school nurse may not be an effective method in detecting these conditions.

For the 512 Tuning Fork Hearing Screening Test:

Both the Nurses Group and the ORL Group reported 168 "YES" or Normal and 12 "NO" or abnormal responses in the same ears out of 180 ears tested (Table 6).

Table 6. Results of 512 tuning fork test

	YES (NORMAL)	NO (ABNORMAL)
NURSES	168	12
ORL	168	12

Kappa coefficient = 1.00 S.E. = 0.075
p = 0.000

Table 7 shows the concordance analysis between the ORLs' and the Nurses' TFT findings.

Table 7. Concordance analysis between the ORLS' and the nurses' tuning fork test findings

ORLs	Nurses		Total
	Yes	No	
Yes	168	0	168
No	0	12	12
Total	168	12	180

Kappa coefficient = 1.00 S.E. = 0.075

The statistical analysis resulted in the Kappa value of 1.00 S.E. 0.075, p = 0.000, (.46 with a p=0.000) indicating significant good agreement between the nurses' and the ORLs' TFT findings.

For the hearing screening using the 512 tuning fork, the nurses group and the ORL group had 100% agreement and the statistical analysis of concordance showed a Kappa=1 with p=0.000. This indicates that the school nurse can be effectively trained to detect hearing loss **with the same**

capacity as the otorhinolaryngologist using the method prescribed by the PNEI.

For the Screening Audiometry:

There were 2 children who did not proceed to the screening audiometry, thus there were only 176 ears tested.

With screening audiometry conducted by the otorhinolaryngologist and audiologist, hearing loss was detected in 6 ears out of 176 ears tested (Table 8). These belonged to 4 children screened: 2 with bilateral hearing loss, and 2 with unilateral hearing loss. **Thus, the prevalence of hearing loss detected in this study is 4.5% (4 out of 88 children).**

Table 8. Results of screening audiometry

PASS (NORMAL)	FAIL (ABNORMAL)	DROP-OUT
170	6	4

Of these 6 ears that failed the screening audiometry, the TFT as conducted by the nurses and the ORLs detected 3 ears (50%) with hearing loss. These 3 ears had average thresholds of 90 dB, 85 dB and 75 dB by screening audiometry classified as severe to profound hearing loss by audiology standards.

The other 3 ears that showed hearing loss by screening audiometry were labeled NORMAL in the TFT by both the nurses and the ORL groups. All these three ears had a highest threshold of 40 dB by screening audiometry (mild hearing loss by audiology standards) in at least 1 frequency thus they were labeled as ABNORMAL.

Corollary to this, 3 ears that were considered NORMAL by screening audiometry were labeled ABNORMAL in the TFT by both the nurses and the ORL groups.

Table 9 shows the concordance analysis between the TFT and the Screening Audiometry. The Kappa value of .48 indicates a statistically significant good agreement between the PNEI 512 Hz TFT and the screening audiometry.

Table 9. Concordance of tuning fork test results and screening audiometry, all ears (n=176)

Tuning Fork Test of Nurses and ORL	Screening Audiometry Normal	Screening Audiometry Abnormal
Normal	167	3
Abnormal	3	3
Total	170	6

Kappa=.48 p=0.000

Discussion

The goals of the study are not only to assess the success by which the training of school nurses can develop in them skills at par with the otorhinolaryngologist in examining the ear canal and in conducting hearing screening with a tuning fork, but also to assess the effectivity of the skills being taught as tools for detecting ear conditions that can result in hearing loss in children.

The results of the study showed statistically significant good agreement between the nurses' and the otorhinolaryngologist's findings in the following: when using the PNEI method of ear examination of the ear canal and tympanic membrane as compared with otoscopy, and when conducting the PNEI 512 Hz hearing screening method. This indicates that the school nurses can be trained to effectively conduct the methods of hearing screening proposed by the PNEI. Because of the limitation of the study with regards sample size, this indication is valid only for the subject population studied.

The more meaningful question then is: Does the method prescribed by the PNEI in hearing screening effective? The statistical analysis of concordance between tuning fork test findings for both nurses and ORL groups and screening audiometry findings revealed a Kappa value= .48 with p=0.000. This indicates that the agreement between the tuning fork test hearing screening results and the screening audiometry is good and this finding is statistically significant. Thus, the PNEI method for mass hearing screening in schoolchildren may be recommended for use since it is comparable with screening audiometry that is recommended in developed countries.

The prevalence of hearing loss of 4.5% found in this study is comparable with those reported in local and foreign literature,[1,2,7] proving once again the importance of hearing screening especially in children so that early intervention can be provided.

The limitations of the study include, first, the selection of subjects. Convenient sampling was done because whoever came to the mission were all considered as subjects. In relation to this, the number of subjects is also not the ideal sample size of 279 ears, thus statistical conclusions have to be qualified. The study has to be continued to include more subjects so that more statistically adequate generalizations can be stated. Thus far, conclusions may be limited to the subject population studied. Another limitation of the study is that the inter-observer variability among the school nurses was not observed. To do this, there must ideally be a standard set of subjects who will all be assessed by all the school nurses included in the study so as to form more valid conclusions regarding their ability to have learned the skill and also to give more strength to the standardization of the technique. This study considered the nurses as a homogenous group, with the same educational, training and professional backgrounds, and thus the same ability to learn the skills. Standardization of the techniques learned were assured through observation of performances of the penlight examination and tuning fork tests to be the same and the determination of the average SPL of the sounds produced during the conduction of the tuning fork test.

Conclusion

The study showed that there is good agreement between the nurses' and otorhinolaryngologists' results when they conducted the PNEI methods of 1)ear examination of the ear canal and tympanic membrane and 2) 512 tuning fork hearing screening on children. The study also showed that there is good agreement between both the nurses' and otorhinolaryngologists' 512 tuning fork test results and the screening audiometry results.

Thus, this study indicates that the PNEI methods of penlight ear examination and 512 tuning fork test may be effective tools for detection of common ear conditions and hearing screening in Filipino school children. These may be conducted in the school setting not only by otorhinolaryngologists but also by adequately trained school nurses.

This is an evolving multi-phased program that is not only research-oriented, but also service and training – based. Thus, there will be continued monitoring of the school nurses with regard to this hearing screening program for school children. Research will continue to further validate, first, the efficiency of training the nurses so that they acquire skills at par with the specialist, and secondly, the accuracy of the penlight examination in detecting common ear conditions and the tuning fork test in determining hearing loss. Other areas which warrant research are the performance of the screening audiometry in a portable hearing booth and also, the agreement between screening audiometry findings done in the school setting and pure tone audiometry findings done in the standard audiologic center.

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