The Accuracy of the Hearing Screener Device as a Hearing Screening Tool for First Graders Aged 5-10 Years

Teresa Luisa I Gloria-Cruz1,2*, Jose Ryner C Carrillo2, Abner L Chan1,2, Charlotte M Chiong1,2, Erasmo Gonzalo DV Llanes1,2, Jeanette R Plete2, Ma Rina T Reyes-Quintos1,2, Ma Leah C Tantoco1, Nathaniel W Yang1,2 and Generoso T Abes1,2

1Philippine National Ear Institute, National Institutes of Health, University of the Philippines, Manila, Philippines
2Department of Otorhinolaryngology, Philippine General Hospital, University of the Philippines, Manila, Philippines

Abstract

Background: Hearing loss in children if undetected can lead to delay in speech and language development, social and emotional problems, and academic difficulties. The prevalence of screening of school-age children to detect hearing loss cannot be overemphasized. In the Philippines, there is no single uniform program for hearing screening in school children. This study examines a device that has been proposed to be used for mass hearing screening. The device is called a hand-held hearing screener (Siemens Hear Check Navigator) that displays three colors as a result: green for pass or no hearing loss; yellow and red for fail or possible hearing loss. The objective of the study is to determine the accuracy of the hand-held hearing screener device as a hearing screening tool to be used in the school setting for first graders.

Methodology: This is an analytical cross-sectional study among Grade I students conducted in three schools in Metro Manila, Philippines, during regular school days. Each child passed through five stations: collection of demographic data, otoscopy, screening with hearing screener device, screening audiometry and counseling. Ambient sound was maintained at 50 dBA or less during testing. The hearing screener device presents pure tones of 35 dbHL, 55 dbHL, and 75 dbHL at test frequencies 375 Hz, 1000 Hz, and 3000 Hz. Its results were: green light which was considered as "absence of hearing loss", and yellow and red lights which were considered as "presence of hearing loss". The results of the hearing screener device test were used to determine its sensitivity and specificity, using the results of the screening audiometry as gold standard.

Results: A total of 418 grade one elementary school children were included in the study. The hand-held screener was found to have high specificity of 97.8% (yellow results) to 99.6% (red results) but low sensitivity of 9.1% (red results) to 16.7% (yellow results). Positive predictive values for red and yellow results are 26.1% and 50% respectively. The accuracy of the red results of the hearing screener device is 95.9% and the accuracy of the yellow results of the hearing screener is 94.2%.

Conclusion: Based on this study, the hearing screener device has low sensitivity in detecting the presence of possible hearing loss in children when used in the school setting. Thus, the hearing screener device is not an ideal tool to use in the mass hearing screening of children in the school setting where there are no soundproof booths and with significant levels of ambient sound. Its excellent specificity may support its use, not for screening, but possibly for confirmation of the absence of hearing loss. For screening, its value lies in its high specificity, good accuracy rates and significant positive predictive values in detecting possible hearing loss, thus warranting a referral for a definitive hearing test. The significant level of ambient sound in this study's conduction is a limitation and may account for the low sensitivity of the hearing screener device. More studies with fewer limitations are needed that will explore and validate the use of the hearing screener device in children in the school setting.

Keywords: Hearing test; Conductive hearing loss; Audiometry

Introduction

The prevalence of hearing loss in children in the school age population has been estimated to be 9/1000; and permanent and/or transient hearing loss in one or both ears affects more than 14% of school-aged children [1]. Undetected hearing loss in children can lead to speech and language delay; social and emotional problems; and academic difficulties. The prevalence of hearing loss in children is significant enough to affect individual and standardized school test scores [2]. Thus hearing screening in schoolchildren is warranted to identify children with hearing loss and to provide the medical and/or educational assistance needed.1 In developed countries; the recommended hearing screening programs in school children entail the use of the Pure Tone Audiometer (PTA) and acoustic immittance; and conduction; or at least supervision; by a certified audiologist [3-5]. In the United States; the American Academy of Audiology recommends using PTA and tympanometry to screen populations age 3 years and older; in an acoustically appropriate screening environment [1]. In a systematic review of the effectiveness of school entry hearing screening programs; the findings suggested that pure tone sweep audiometry report high sensitivity and specificity for full PTA and therefore appear to be suitable tests for screening; that tympanometry has variable sensitivity and specificity; and that parental questionnaire and otoscopy have poor sensitivity and specificity; and are likely to be less suitable for screening [6].

*Corresponding author: Teresa Luisa I Gloria-Cruz, MD, MHPEd, Philippine National Ear Institute, National Institutes of Health, University of the Philippines, Manila, Philippines, Tel: (+63) 9178501322; E-mail: techgloriacruz@yahoo.com

Received May 28, 2013; Accepted June 19, 2013; Published June 26, 2013

Citation: Gloria-Cruz TLI, Carrillo JRC, Chan AL, Chiong CM, Llanes EGDV, et al. (2013) The Accuracy of the Hearing Screener Device as a Hearing Screening Tool in the School Setting for First Graders Aged 5-10 Years. Otolaryngology 3: 134. doi:10.4172/2161-119X.1000134

Copyright: © 2013 Gloria-Cruz TLI. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
 Globally, there appears to be considerable variability in hearing screening programs for school children. In the Philippines, there is no standardized program for hearing screening in school children that is recommended by the national government; physicians; audiologists and schools. This may be due to lack of advocacy; insufficient local research material to be used as basis; lack of skilled personnel and insufficient equipment such as audiometers; tympanometers and soundproof booths; as recommended standards in developed countries. There is a need for research-based evidence to formulate an applicable and feasible mass hearing screening program suited for the conditions in the Philippines. The screening program must be relevant; accurate; safe; and practical. The most common causes of hearing loss in Filipino school children are otitis media and impacted cerumen; both amenable to resolution if detected early and treated adequately [7,8]. A screening program is that which can at least identify these conditions; and any possible hearing loss; is a good starting point in the goal of formulating a standardized program in the country.

In the search for a method to recommend for a mass hearing screening program for children in the school setting; this study examines a device that has been proposed to be used for hearing screening [9,10]. The device is a battery-operated instrument called a hand-held hearing screener that proposes to check the hearing ability of a patient safely; quickly and easily; so that its correct usage may possibly be learned and done by nurses and teachers who are present in the school. This will address the concern of lack of skilled personnel or audiologists to conduct the hearing screening tests. It is intended to be used for the playback of acoustic signals with specific volume and in specific order at the push of a button. The hearing screener is easy to use; handy; requires low-maintenance and is easily available. It was used for 120 elderly patients and has been found to have a sensitivity of 85% and specificity of 100% using PTA as gold standard [10]. Using the same device; 200 adults at a tertiary hospital were screened in a quiet room and it was found to have a sensitivity of 78.4% and specificity of 95.5% using PTA as gold standard [10]. The device seems to be accurate in detecting the absence of hearing loss; but may not be as satisfactory in detecting the presence of hearing loss. It also was found in one study to be more sensitive in detecting moderate-severe hearing losses which is hearing thresholds ranging from 56-70 dB HL; and may fail to detect mild hearing loss which is hearing thresholds ranging from 26 to 40 dB HL [9]. This is also true for the screening method called the Philippine National Ear Institute (PNEI) Method; which had been found to be useful in detecting moderate-profound hearing losses [11,12]. The PNEI Method of screening for hearing concerns in school children uses the penlight to view the external ear and the tympanic membrane; and the 512 Hz tuning fork to screen for hearing loss. The 512 Hz tuning fork is struck against the examiner’s hypothenar eminence and presented to the child’s ear; and the child’s affirms hearing the sound by raising his hand. This method; when performed in the school setting by otolorinolaryngologists and school nurses; has been found to be accurate in detecting moderate to profound hearing loss in children [11,12]. The search continues for other tools that can be used for a hearing screening program in school children that may be accurate and feasible alone or in combination with other methods. Depending on the outcome of this study; combined with other researches; recommendations and algorithms may be formulated for a comprehensive hearing screening program in the school setting.

The general objective of this study is to determine the accuracy of the hearing screener device as a hearing screening tool to be used in the school setting for elementary school children. The specific objective of this study is to determine the sensitivity; specificity and positive predictive value of the hearing screener device using pure tone screening audiometry as the gold standard.

Materials and Methods

The protocol of the study was approved by the Ethics Review Board of the University of the Philippines-National Institutes of Health; and conducted in three schools in Metro Manila; Philippines; during regular school days. All grade one elementary school children whose parents or guardians gave consent were included. There was 73% coverage of the entire population under study. Each child passed through five stations:

**First station:** Assignment of a chart and collection of demographic data.

**Second station:** Otoscopy by an otolorinolaryngologist on each ear of the child using a Welch-Allen otoscope.

For the Third and Fourth stations; the use of a soundproof booth is ideal. However; a soundproof booth is expensive to construct and is not available in majority of the schools. A soundproof booth was thus not available for use in the schools included in this study. Thus; prior to the test; the ambient sound in each of the test rooms was determined. Best efforts were done to control the ambient noise and it was repeatedly determined and noted using TES 1350A Sound Level Meter prior to each child's screen in stations three and four. The hearing screener (Siemens Hear Check Navigator) test and the screening audiometry test for each child were conducted only when the ambient noise was 50 dBA or less. When the ambient sound was greater than 50 dBA; the environment was controlled; and the test proceeded only when the ambient sound had dropped to 50 dBA or less.

**Third station:** hearing screening with the hand-held hearing screener device; Siemens Hear Check Navigator; located in a relatively quiet room of the school. It is intended to be used for the playback of acoustic signals with specific volume and in specific order at the push of a button. The Hear Check screener presents pure tones of 35 dBHL; 55 dBHL; and 75 dBHL at test frequencies 375 Hz; 1000 Hz; and 2000 Hz [13]. The device was held gently to the head of each child; the cover completely surrounding the ear ensuring contact with the skin all around. The Start button was pressed and a short automatic functional test was performed. The three light indicators would all flash; indicating that the hearing screener was ready to begin the actual test. The Hear Check would then automatically present the acoustic signals to the child as mentioned. The child was instructed to raise a hand when a tone was heard; and the examiner pressed the button every time the child raised his/her hand. The test for the particular frequency was terminated automatically when the button had not been pressed within 20 seconds. The result of the test was indicated with a red; yellow or green light. A green light result indicates the absence of hearing loss; a yellow light indicates a mild hearing loss and a red light indicates a moderate to severe hearing loss [13]. Hearing screener device test results were designated as observed values. In the statistical analysis of this study; a green light was considered as "absence of hearing loss"; and both yellow and red lights were grouped together as "presence of hearing loss".

**Fourth:** Screening audiometry in a separate quiet room. An audiologist blinded to the results of the ear examination; otoscopy and hearing screener conducted screening air conduction audiometry for frequencies 500 Hz; 1000 Hz; 2000 Hz and 4000 Hz. Thresholds were determined for each frequency. Usually; hearing screening entails presenting a 25 dBHL pure tone at 500 Hz; and 20 dB HL at 1000 Hz; 2000 Hz and 4000 Hz and use this in conjunction with

---

Citation: Gloria-Cruz TLI, Carrillo JRC, Chan AL, Chiong CM, Llanes EGDV, et al. (2013) The Accuracy of the Hearing Screener Device as a Hearing Screening Tool in the School Setting for First Graders Aged 5-10 Years. Otolaryngology 3: 134. doi:10.4172/2161-119X.1000134

Otolaryngology
ISSN: 2161-119X Otolaryngology, an open access journal

Volume 3 • Issue 2 • 1000134
tymanometry to determine whether a child passes the screening or not [14]. However, according to Johnson; “a variety of procedures are presently used in hearing screening programs for children from infancy through high school. Depending upon the goal of the screening program, the procedures may be used in various combinations” [15]. Usually screening occurs at the frequency ranges of 500–8000 Hz at 20–25 dBHL. Some pure tone screening procedures may include threshold measurements. In this study; the Modified Hughson-Westlake procedure was followed [16]. For the determination of the threshold that would be considered as “pass” for the screening test; ambient sound level results were noted to set a screening audiometry threshold that would distinguish between “pass” and “fail” results. The hearing thresholds of four audiologists with normal hearing were tested by PTA in each room; taking the ambient sound in the room into consideration. Their average threshold was 40 dB HL and thus the “pass” level for the screening audiometry in this study was set at 40 dB HL. Any threshold of greater than 40dB HL in any frequency was considered as “fail” for the screening audiometry.

Fifth: An otorhinolaryngologist who had knowledge of the screening proceedings and results conversed with the child for immediate feedback; reviewed the child’s record and made recommendations based on the findings in a letter addressed to the parents. Recommendations included proper ear care and health advice for the children with normal results. For children with findings that needed further medical management; recommendations included sending the child immediately to the school clinic for urgent cases; appropriate advice; a listing of institutions where health delivery can be obtained; and contact information of the medical hearing screening team; including schedule of service hours for free consultation.

Each ear was treated as a separate subject in the statistical analysis using statistical stata version 9; EBM calculator version. Evaluation of the accuracy of the hearing screener device as a diagnostic test using sensitivity; specificity; positive predictive value; negative predictive value and likelihood ratio was done; with the results of the screening audiometry as gold standard.

Results

A total of 418 children were included in the study. Table 1 shows demographic data regarding the study population. All children belonged to the first grade level of the elementary parochial schools included in the study. The children’s ages ranged from 5-10 years with mean age of 6.8 years old. There were 238 males and 180 females. There were no significant nutrition and medical concerns in the children identified at the time of the study.

Statistical analysis conducted on a per year basis yielded abnormal otoscopy findings in 22.9% (191/836) of all the ears examined. These findings include impacted cerumen; otitis media and canal stenosis. Table 2 shows the proportions of the findings in relation to the number of ears examined. None of the children included in the study had evidence of any prior ear procedure or ear surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacted Cerumen</td>
<td>19.3 (159/824)</td>
</tr>
<tr>
<td>Otitis media</td>
<td>4.6 (31/668)</td>
</tr>
<tr>
<td>Canal stenosis</td>
<td>0.1 (1/824)</td>
</tr>
<tr>
<td>Abnormal findings</td>
<td>22.9 (191/836)</td>
</tr>
</tbody>
</table>

*Abnormal findings include impacted cerumen, retracted or bulging tympanic membrane, tympanic membrane perforation and canal stenosis

Table 2: Proportions of the abnormal otoscopy findings in relation to the number of ears examined.

Hearing screener testing results is shown in Table 3. Out of the 418 children; seven were not available anymore for the hearing screening tests because they needed to go home in the same school bus before the tests could be done. The 1 child with canal stenosis also had no hearing screening tests done for the stenotic ear. Thus, a total of 411 children completed the screening with one child only having 1 ear tested; yielding a total of 821 ears subjected to the test.

The mean ambient noise level is 52.8 dBA; with standard deviation of 6.98; and range of 38.6 to 70dB. Considering ambient noise levels of 50dB; any screening audiometry average threshold of greater than 40 dBHL for frequencies 500 Hz; 1000 Hz; and 2000 Hz was set as abnormal audiometry findings. The proportion of ears with abnormal audiometry findings is 4.7% (39/821).

The results of the statistical analysis for the accuracy of the hearing screener device in detecting hearing loss using the screening audiometry as gold standard are also shown in Table 3. The hearing screener device yielded green results for 792 out of 821 ears (96.5%); yellow results for 23 out of 821 ears (2.8%) and red results for 6 out of 821 ears (0.7%). The red and yellow results; being indicators of hearing loss; were analyzed for specificity and sensitivity. Analysis showed specificity values of 99.6% for red results and 97.8% for yellow results. Sensitivity values were 9.1% for red results and 1.7% for yellow results. The accuracy of the red results of the hearing screener device is 95.9% and the accuracy of the yellow results of the hearing screener device is 94.2%.

Discussion

Screening is a component of preventive medicine. Preventive medicine is primary; secondary and tertiary. Primary preventive measures are used to prevent the onset of a specific disease; secondary preventive measures are used to detect disease and tertiary preventive measures are used to manage an existing disease; with the goal to restore a patient to highest function; minimize the negative consequences of the disease; and prevent disease-related complications [17]. Screening tests are examples of secondary preventive measures. This study examined the usefulness of the hand-held screener device as a mass hearing screening tool for children in the school setting.

In the 418 children; the most common abnormal conditions found on otoscopy are impacted cerumen and otitis media; consistent with reports in published local literature [7,8]. Thus, a hearing screening program in the local setting should be designed to be able to detect these two consistently common conditions in school children.

An ideal screening test is accurate. The hearing screener device must be able to correctly identify children who have hearing loss (sensitivity) and those who do not have hearing loss (specificity).

Accuracy tests of the hearing screener device; with screening audiometry as gold standard; yielded specificity values 99.6% for red results and 97.8% for yellow results; and accuracy rates of 95.9% for
The screening device may be enhanced by doing repeated tests in a child; their PTA done in other institutions. The sensitivity of the hearing audiometry. This is so because the children had poor follow-up or had results of formal Pure Tone Audiometry (PTA) testing in a sound proof [9,10]. Another limitation of this study is the absence of data regarding other published studies on this particular hearing screener device and its limited sensitivity found in this study is consistent with in setting the normal threshold based on an average ambient noise number of failures in the screening audiometry; though adjustment low sensitivity of the hearing screener device; and a higher than actual mild hearing losses. The ambient sound may have contributed to the of possible hearing losses in children may not be detected especially the mild hearing losses. The ambient sound may have contributed to the low sensitivity of the hearing screener device; and a higher than actual number of failures in the screening audiometry; though adjustment in setting the normal threshold based on an average ambient noise of 50 dBa was done. The excellent specificity of the hearing screener device and its limited sensitivity found in this study is consistent with other published studies on this particular hearing screener device [9,10]. Another limitation of this study is the absence of data regarding results of formal Pure Tone Audiometry (PTA) testing in a sound proof booth for the children who were classified to have failed the screening audiometry. This is so because the children had poor follow-up or had their PTA done in other institutions. The sensitivity of the hearing screening device may be enhanced by doing repeated tests in a child; and performing the hearing screening device test and the screening audiometry in a quiet environment.

Positive predictive values also indicate the high probability of the hearing screening device's red and yellow results to be accurate in detecting hearing loss. For a red result; one is able to raise a baseline probability for presence of hearing loss of 4.1% (33/798) to 50%. For a yellow result; one is able to raise a baseline probability for presence of hearing loss of 4.4% (36/815) to 26.1%. Of the 821 ears of the children tested; 23 had yellow results and 6 had red results; totaling to 3.5% of the ears tested as probably having hearing loss. Therefore; the hearing screening device test is able to raise the probability of presence of hearing loss significantly enough to warrant a referral for a more definite hearing test. Thus; a hearing screening device's red or yellow result warrants referral to an otolaryngologist based on the high specificity; good accuracy rates and significant positive predictive values of such results.

The same analysis yielded sensitivity values of 9.1% for red results and 16.7% for yellow results. These low sensitivity values indicate that the presence of hearing loss cannot be disregarded or ruled out when the device shows a green light. In this study; the hearing screening device yielded 30 green or pass results which were classified as fail in the screening audiometry. This translates to low ability of the hearing screening device to detect possible presence of hearing loss. The hearing screening device has the tendency to miss a significant number of possible hearing losses present in children when used in the school setting; during regular school hours; when all usual school activities are ongoing; and therefore ambient noise is difficult to control in any room. The high level of ambient noise in the school setting is a limitation of this study. Because of this; it is possible that the detection of possible hearing losses in children may not be detected especially the mild hearing losses. The ambient sound may have contributed to the low sensitivity of the hearing screening device; and a higher than actual number of failures in the screening audiometry; though adjustment in setting the normal threshold based on an average ambient noise of 50 dBa was done. The excellent specificity of the hearing screening device and its limited sensitivity found in this study is consistent with other published studies on this particular hearing screening device [9,10]. Another limitation of this study is the absence of data regarding results of formal Pure Tone Audiometry (PTA) testing in a sound proof booth for the children who were classified to have failed the screening audiometry. This is so because the children had poor follow-up or had their PTA done in other institutions. The sensitivity of the hearing screening device may be enhanced by doing repeated tests in a child; and performing the hearing screening device test and the screening audiometry in a quiet environment.

A highly sensitive test is ideal for a screening examination [17,18]. Because of its low sensitivity based on this study; the hearing screening device is not an ideal tool to use in the mass hearing screening of children in the school setting without soundproof booths and with significant levels of ambient sound. Its excellent specificity may support its use; not for screening; but possibly for confirmation of the absence of hearing loss; since highly specific studies are best for confirmation.

It is recommended that further studies on the use of the hearing screening device for children be done. In particular; the hearing screening device should be studied under the ideal condition for all hearing tests: limited or absent ambient sound. If the sensitivity of the hearing screening device can be improved significantly enough when used in a soundproof booth; the hearing screening device may be used in the school setting based on this and its other qualities that are ideal for a screening tool. Its use is safe and non-invasive; feasible; practical and reasonably priced. It is also handy; easy to use; and requires low maintenance. As a screening method for hearing; its use is relevant in the sense that the condition it is screening for is clinically significant such that if left untreated; it may cause significant deleterious effects on the child. Finally; the screening for hearing loss in school children is meaningful and productive because if hearing loss is identified; the conditions that cause hearing losses have an effective treatment most of the time. This is especially true for impacted cerumen and otitis media; the two most common findings; other than normal; on otoscopy when screening children. The utility of the hearing screening device is that it will serve as a guide in decision-making. In a setting where community-based health care is significant; a comprehensive screening program takes into account the hearing screening device's easy use; portability; availability; and ease of training which multipliers in giving are access to health care.

**Conclusion**

Pure tone audiometry; acoustic immittance testing; and otoacoustic emissions; when used by a skilled examiner in a quiet setting; have been recommended standards for hearing screening in school-aged children. Thus; when available; these should be used for the detection of possible hearing problems. In the Philippines; majority of school children do not have access to such standard equipment and skilled personnel. Thus; hearing screening must be ideally brought to them during the days when they are in school. In the search for a feasible tool of hearing screening; the hearing screening device was studied and was found to have low sensitivity in detecting a possible hearing loss. Based on the results of this study; it is not an ideal instrument for hearing screening in the school setting; since an ideal screening test must have a high sensitivity. The significant level of ambient sound in this study's conduction is a concern for the possible low sensitivity of the hearing screening device. For screening; its value lies in its features of safety; portability; ease of use; affordability and high specificity; good accuracy rates and significant positive predictive values in detecting possible

<table>
<thead>
<tr>
<th>Hear check Test</th>
<th>Abnormal screening audiometry</th>
<th>Likelihood ratio for <em>+</em> test</th>
<th>Likelihood ratio for <strong>+</strong> test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive Predictive value</th>
<th>Negative Predictive value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>3</td>
<td>23.2 (4.8-110.5)</td>
<td>0.9 (0.82-1.017)</td>
<td>0.091</td>
<td>0.999</td>
<td>(0.03-0.236)</td>
<td>(0.989-0.999)</td>
<td>95.9%</td>
</tr>
<tr>
<td>Yellow</td>
<td>6</td>
<td>7.637 (3.204-18.205)</td>
<td>0.852 (0.736-0.986)</td>
<td>0.167</td>
<td>0.978</td>
<td>(0.079-0.319)</td>
<td>(0.965-0.986)</td>
<td>94.2%</td>
</tr>
<tr>
<td>Green</td>
<td>30</td>
<td>762</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

A. Abnormal screening audiometry findings is defined as any one or more findings of threshold greater the 40 dB HL for pure tones at any of the frequencies 500; 1000 and 2000 Hz

Table 3: Accuracy of the hearing screener in detecting abnormal hearing threshold.
hearing loss; thus warranting a referral for a definitive hearing test. More studies with fewer limitations are recommended that will explore and validate the possible use of the hearing screening device in children in the school setting.

Authors’ Contributions

Teresa Luisa I Gloria-Cruz; Generoso T Abes and Charlotte M Chiong conceptualized the study; Jose Ryner C Carrillo and Erasmo Gonzalo DV Llanes carried out statistical analysis; Teresa Luisa I Gloria-Cruz, Abner L Chan, Charlotte M Chiong, Erasmo Gonzalo DV Llanes, Jeanette R Plete, Ma Rina T Reyes-Quintos, Ma Leah C Tantoco, Nathaniel W Yang and Generoso T Abes performed the hearing screening in the different schools; Teresa Luisa I Gloria-Cruz prepared the final manuscript, Abner L Chan, Charlotte M Chiong, Erasmo Gonzalo DV Llanes, Jeanette R Plete, Ma Rina T Reyes-Quintos, Ma Leah C Tantoco, Nathaniel W Yang and Generoso T Abes reviewed and critically revised the final paper for submission. All authors approved the final manuscript.

Ethical Approval

National Institute of Health–Ethics Review Board; Manila Philippines.

References