The Cost-Effectiveness and Budget Impact of a Community-based Universal Newborn Hearing Screening Program in the Philippines

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ABSTRACT

Background. In 2000, the World Health Organization recommended implementation of universal hearing screening. The Philippines enacted this policy into law in 2009 as it was found to be cost-effective for the Philippines. The model at the time used a hospital-based approached to screening. This paper examines the cost-effectiveness and budget impact of implementing a community-based universal hearing screening program.

Methods. A model was developed following a community-based hearing screening program. Parameters were obtained through literature review, secondary data analysis, and consultation with experts. Cost-effectiveness was assessed for a single birth cohort from a public payer and societal perspective.

Results. A community-based universal hearing screening program was found to be cost-saving. One-way sensitivity analysis showed that results were sensitive only to treatment rate and follow-up rate. The program is also a high budget impact program.

Conclusion. A community-based hearing screening program is cost-saving for the Philippines. Ensuring treatment and good follow-up in testing will ensure cost-effectiveness.

Key Words: cost-effectiveness analysis, newborn hearing screening, budget impact analysis, hearing loss

Background

Hearing loss is one of the top 20 contributors to the global burden of disease.[1] Congenital or early childhood onset sensorineural deafness occurs in about 0.5 to 5 in every 1 000 neonates. If the condition remains undetected during infancy, the child becomes highly at risk for having impaired language and communication development. It has been demonstrated that detection/intervention by 6 months up to before the first year of life can prevent the loss of normal development and lead to a child with communications skills at par with his or her normal peers.[2]

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Due to the potential gains of early intervention, the World Health Organization in 2000 recommended that "a policy of universal neonatal screening be adopted in all countries and communities with available rehabilitation services and that the policy be extended to other countries and communities as rehabilitation services are established."[3] Despite this recommendation, the implementation of a universal hearing screening program in member states has been varied. Developed countries like the US and Germany having greater resources and better equipped health systems were able to take up universal screening programs.[4]

Concerns of limited resources and the capital intensive universal screening has led to the development of targeted newborn hearing screening (TNHS) which utilizes a questionnaire to screen high risk infants that would require further testing. Those who pass will not undergo testing and will translate to less cost of testing for the program. However, TNHS misses around half of those with congenital hearing screening as these babies lack any risk factor.[5] Cost-effectiveness analysis done by Blanco and Moreno-Ternero (2013)[6] noted that from a healthcare facility perspective, TNHS is more cost-effective but from a societal one, universal newborn hearing screening (UNHS) is preferred. Huang et al. (2012)[7] found that UNHS and TNHS are both cost-effective for eight[8] China provinces but UNHS tend to require better program coverage, diagnosis rate and intervention rate. They also noted that eventually total savings would exceed total program implementation costs.

Santos-Cortez and Chiong conducted a cost-analysis of universal hearing screening in the Philippines. According to their computations, a universal hearing screening program translated to savings in the long term.[8] This study, along with the other literature on newborn hearing screening, has led to the creation of the Republic Act 97091 Universal Newborn Hearing Screening and Intervention Act of 2009. This cost-analysis was, however, based on model of screening conducted in the hospital prior to discharge.

An alternative model is to conduct screening at the community level linked to vaccination clinics. This was demonstrated to be a feasible model in Nigeria.[9] The screening was done by trained community health workers. They were able to cover 88% of the 2,277 eligible babies visiting vaccination clinics with a low refer rate of 4.1%. The program also experienced a follow-up rate of 61% of those who were referred for further evaluation. In this cost-effectiveness analysis, we assessed the cost-effectiveness and the budget impact of a community-based model of universal hearing screening for the Philippines.

Methods

Model Overview

We constructed a cost-effectiveness model using Microsoft Excel. We compared a community-based universal hearing screening (UNHS) program using a two-stage protocol versus a no screening scenario. We applied the model to a cohort of 2,000,000 babies and projected the number of babies who will be diagnosed and treated on time. The decision to compare only no screening with UNHS is due to the fact that the law mandates that all babies undergo hearing screening. Program costs and benefits (e.g. savings from special education, productivity gained) were expressed in net present value with an annual discount rate of 3%. For the base case scenario, we assumed that all babies who have hearing loss, regardless of time of diagnosis, will receive amplification hearing aids, special education and rehabilitation sessions. This assumption was tested in the sensitivity analysis. (Figure 1) A summary of parameters is presented in Table 1.

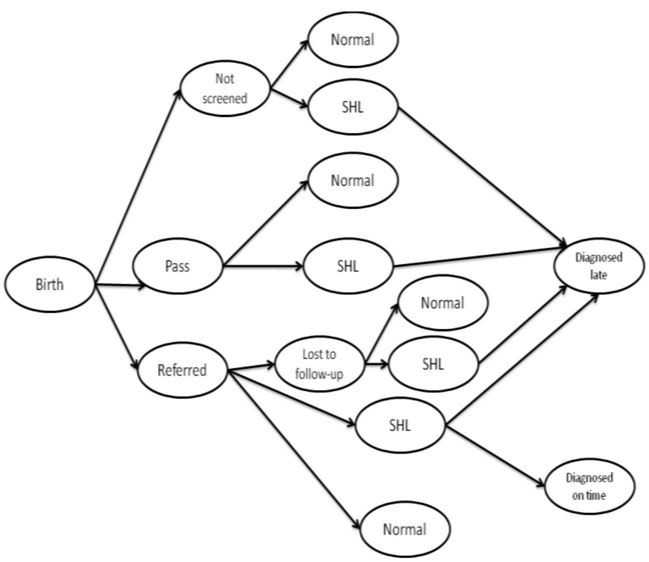

Figure 1. Model Diagram for Universal Hearing Screening. Notes: Pass – passes first screening; Referred – referred for further screening; SHL – Severe hearing loss; Normal – no severe hearing loss

The figure shows the possible "states" a baby will pass through over time. The first level will sort babies into (1) not screened, (2) pass, and (3) refer. Those who pass or who are not screened can be normal or have severe hearing loss. Those with severe hearing loss will then go to the "diagnosed late" group. Among those who are referred, some will be lost to follow-up, some will be normal on confirmatory test, and some will be diagnosed to have severe hearing loss on time. Some of those who are lost to follow-up will have severe hearing loss and will be diagnosed late.

There would be three outcomes of the screening program: normal baby, baby with hearing loss diagnosed on time (before six months) and baby with hearing loss diagnosed late. The number of babies with hearing loss overall is given by the formula:

Number of babies with hearing loss = population x prevalence of hearing loss

Due to the limited data regarding the accuracy and impact of screening for severe-profound unilateral hearing and mild bilateral hearing loss in the Philippines, we only modeled the impact of screening for profound bilateral hearing loss. The number of babies with hearing loss diagnosed on time will be given by the formula:

Number of babies with hearing loss diagnosed on time = population x program coverage x refer rate x follow-up rate x sensitivity

The number of babies with hearing loss who will not be treated on time will come from:

1. *Babies not screened = population x (1 – coverage) x prevalence of HL*
2. *Babies falsely diagnosed to be negative = population x coverage x (1 – sensitivity)*
3. *Babies with HL who did not complete screening = population x coverage x sensitivity x (1 – follow-up rate)*
4. *Babies detected but not treated on time = babies diagnosed on time x (1 – treatment rate)*

For number (4), we assumed in the base case scenario that all babies detected on time will be treated on time and thus (4) is zero in the base case scenario. We test this assumption in sensitivity analysis. To generate numbers of normal babies who will incur costs due to being labeled as false positive we used the refer rate obtained from pilot programs in the Philippines:

False positive babies who completed screening = population x (1 – prevalence) x coverage x refer rate x follow-up rate

This number was computed using the refer rate instead of specificity to simplify computation of additional diagnostic test costs due to high refer rates.

The prevalence of severe-profound bilateral hearing loss in newborns the Philippines is estimated to be 1.38 per 1,000 births. The screening program is envisioned to be conducted in community health centers tied to the vaccination program and thus would assume coverage rates to be similar to the first dose vaccination program. We then use the referral rates and follow-up rates obtained from programs implemented at a tertiary hospital and community setting.

Table 1. Model Parameters and Ranges used in Sensitivity Analysis

	Base estimate	Ranges	Notes
Population			
Birth cohort	2,000,000	n/a	Rounded estimate from Population growth rate[14]
Lifetime	70 years	n/a	Average of male-female Life expectancy at birth[14]
Number of LGUs	1,634	n/a	
Number of Provinces	88	n/a	
OAE per LGU	1	n/a	Assumption
ABR per province	2	n/a	Assumption
SBHL prevalence	0.00138 (5.6 per 1000)		Based on pilot.
Program			
Coverage rate	98%	25 to 100%	2013 Vaccination rate for DTP1[15]
Referral rate	4%	1 to 20%	[9]
Follow-up rate	80%	25 to 100%	Based on pilot.
Treatment rate	100%	25 to 100%	Assumption
Sensitivity	86%	60 to 100%	[6]
Specificity	97.3%	60 to 100%	[6]
Service Fees			
OAE	PhP 350	PhP 200 - 600	
ABR	PhP 800	PhP 500 – 1,500	
Amplification			
Lifetime of Hearing aid	3 years	n/a	Expert opinion
Number needed in lifetime (early)	28	n/a	Computed
Number needed in lifetime (late)	23	n/a	Computed
Cost of hearing aid	PhP 50,000.00	PhP 9,000 – 75,000	Expert opinion
Hearing aid maintenance	PhP 4,000.00/yr	PhP 1,000 – 8,000	Expert opinion
Rehabilitation			
Number of sessions needed per age (early)	1y.o. – 52 2 – 3 y.o. – 104 4 - 5 y.o. – 104 6-7 y.o. – 20 8 -14 y.o. – 10 15 – 18 y.o. – 4	1y.o. – 12 - 52 2 – 3 y.o. – 24 - 104 4 - 5 y.o. – 24 - 104 6-7 y.o. – 6 - 20 8 -14 y.o. – 4 - 10 15 – 18 y.o. – 1 - 4	Expert opinion
Number of sessions needed per age (late)	1-2 y.o. – n/a 3 y.o. – 52 4 – 5 y.o. – 104 6 – 12 y.o. - 104 13 - 18 y.o. – 40	1-2 y.o. – n/a 3 y.o. – 12 - 52 4 – 5 y.o. – 24 -104 6 – 12 y.o. – 24 - 104 13 - 18 y.o. – 6 – 40	Expert opinion
Cost of Rehabilitation per session	PhP 800	PhP 800-1,500	Expert opinion; surveyed from 3 Manila-based centers
Education			
Cost of elementary education	PhP 7,600.00	PhP 4,500 to 20,000	Computed from DepEd reported MOOE and Salaries
Cost of high school education	PhP 9,000.00	PhP 9,000 to 40,000	Computed from DepEd reported MOOE and Salaries
Adjustment for special Education	PhP 20,000.00 (elem); PhP 40,000 (High school)	PhP 10,000 to 80,000	Assumption
Years of education (Early)	6 years regular elementary and 4 regular years high school	n/a	
Years of education (Late)	6 years special elementary and 4 years special high school	n/a	
Employment			
Annual income	PhP 112,000.00	PhP 60,000 – PhP 120,000	
Unemployment rate (General population)	7%	n/a	[16]
Unemployment rate (Disabled)	70%	7 to 70%	[13]
Disability weights			
SBHL untreated	0.333	n/a	[1]
SBHL treated	0.12	n/a	[1]

Note: Costs in 2015 Philippine pesos

Screening and Treatment Costs

Costs for the model will be grouped to screening and diagnosis cost, treatment costs, education and rehabilitation costs and lost wages. Costs incurred after the first year of life were converted to net present value at a discount rate of 3%. All costs were in 2015 Philippine pesos.

Screening and diagnostic costs are composed of the cost for the automated oto-acoustic emission test (OAE), the auditory brainstem response test (ABR) and the consultation fees for a hearing specialist. Babies depending on their outcome will incur various costs. Babies with hearing loss who undergo the program will incur the entire cost of tests while those who were not covered will incur none. In between are those who underwent first screening but did not follow-up or passed and as such would incur only the cost for the first OAE.

For the model, we opted to use the current rates of PhP 350 for the OAE and PhP 800 for the ABR. The complete screening would then cost PhP 1500. We assume that the costs of these tests would include the consumables for the test. An additional PhP 50 is incurred for each baby screened which is used for the registry card.

Babies with profound bilateral hearing loss will gain maximal benefit if they receive amplification before six months. If only one hearing aid per person is used, this will translate to roughly 28 hearing aids in a lifetime (assumed lifespan of 70 years). Those who were missed are often diagnosed by age 3 and would need around 26.8 hearing aids in their lifetime. The recommended hearing aid for severe-profound hearing loss is the programmable digital hearing aid which costs PhP 50,000. The use of the more expensive hearing aid at two aids per baby is included in the sensitivity analysis. The estimated annual recurrent costs for hearing aid maintenance is at PhP 4,000. All infants with profound bilateral hearing loss will eventually require rehabilitation and special education services. We assumed that those with BHL who were diagnosed late needed the entire spectrum of rehabilitation services and special education curriculum. Those who were diagnosed on time would require a decreasing number of rehabilitation sessions and would need less years in the special education schools.[2,10] The cost of regular education was estimated using the published budget of the Department of Education for public schools.[11,12] Our computed cost of elementary education per person per year was PhP 7,600 and the value was PhP 9,000 for high school. Special education was estimated to cost twice that of regular education.

Program Costs

The screening is assumed to be conducted at the community level. In each municipality, a technician will be trained and provided with one machine. The cost of training is set at PhP 10,000. This technician will conduct screenings at the rural health unit but will also have the option of going to communities and barangays. The technician will have a monthly salary of PhP 9,000 and a travel allowance of PhP 100 per day.

Those who screen positive will undergo repeat testing and eventually ABR. The ABR will be available at two provincial facilities. Capital costs in terms of purchasing these machines were annualized over five years. Recurrent costs in the form of salary, administrative fees, and travel expenses were also included. These costs were set to not vary despite changes in the coverage of the program. (Table 2)

Costs to Society

A missed diagnosis would lead to a person with decreased capacity to contribute to society. We express this loss in terms of lost wages and decreased employment rate. We computed the expected income of an individual based on the average daily wage of PhP 456 and that the person works from 18 to 65 years old. Unemployment rate for person with disabilities was found to be higher than the general population.[13] We used the following unemployment rates: 14% for those treated on time (double that of the average population) and 70% for those with SBHL detected late.

Lacking data for disability weights for children, we utilized the disability weight for severe and profound hearing loss (0.333) for cases detected late and the disability weight for moderate untreated (0.12) for cases detected on time.[1] The DALY lost for the lifetime was computed using a discount rate of 3% and a lifespan of 70 years.

Table 2. Estimated Costs of a community-based screening program

Parameter	Value
Number of LGUs	1,634
Number of Provinces	88
Number of OAE per LGU	1
Number of ABR per province	2
OAE machine	PhP 300,000
ABR machine	Php 800,000
Lifetime of machine	5 years
Technician costs	
Salary per month	PhP 9,000.00
Training	PhP 10,000.00
Travel allowance per day	PhP 100.00
Work days	280 days
Overhead expenses per month	PhP 5,000.00
Annualized capital expenses	PhP 218,000.00
Estimated annual recurrent expenses	PhP 196,000.00
For sensitivity analysis	0.5 to 2x of computed value

Analysis

Incremental cost-effectiveness ratios were computed using this formula:

$$ICER = \frac{(Cost\ of\ UNHS - Cost\ of\ NS)}{(DALY\ loss\ of\ UNHS - DALY\ loss\ of\ NS)}$$

An intervention is cost-effective if the intervention is more costly than no screening and averts DALYs at a cost of PhP 125,096 or less (GDP = US$ 2,843.41; US$ 1 = PhP 44). An intervention is cost-saving if the cost of the intervention is less than the no intervention scenario and averts DALYs.

One-way sensitivity analysis was conducted testing the minimum and maximum range of the parameters tested. We also tested the assumption regarding timely treatment of detected individuals and assumptions regarding employment rate.

Results

Screening results

The birth cohort is expected to have 2,760 individuals with severe-profound hearing loss. A universal hearing screening program is expected to detect 67% of these individuals.

Table 3. Diagnoses Cases of Hearing Loss in No Screening versus Universal Hearing Screening (UNHS)

	Number of Individuals				
	Hearing loss in unscreened	Hearing loss in those who were not referred	Hearing loss in those who were referred but did not follow-up after first screen	Total Hearing loss detected late	Total Hearing loss detected on time
UNHS	55	379	465	899	1,861
No screening	2,760	0	0	2,760	0

There were almost equal numbers of the individuals who were missed by the program due to the test sensitivity and due to failure of follow-up for second and confirmatory tests. We also estimate 52,308 individuals who will be falsely labeled to be positive. (Table 3)

Cost Effectiveness Analysis

The estimated total direct costs of a screening program is PhP 3.182 B while the direct costs of no screening is at a slightly lower value of PhP 3.231 B thus the program is PhP 510 M more expensive. If lost wages are considered, the program is cost saving with a no screening scenario costing PhP 6,463 B compared to one where screening occurs at PhP 5.229 B. Screening leads to aversion of 11,587 DALYs lost. Using this to compute ICERs show that including direct costs only, screening is cost-effective and from a societal perspective, it is cost-saving. (Cost-effective threshold: Php 125,096.40) (Table 4)

Table 4. Comparison of Costs of No Screening versus Universal Hearing Screeing (UNHS)

	No Screening	UNHS	Difference (U – NS)
Fixed Costs	-	429,116,000.00	429,116,000.00
Diagnostics	-	854,943,783.68	854,943,783.68
Amplification	929,216,607.96	965,341,922.67	36,125,314.71
Education	1,552,639,250.43	932,116,012.87	-620,523,237.55
Rehabilitation	748,888,472.11	559,089,027.59	-189,799,444.51
Total Direct Costs	3,230,744,330.49	3,740,606,746.82	509,862,416.32
Lost wages	3,232,205,942.35	1,488,779,914.70	-1,743,426,027.66
Total Costs	6,462,950,272.85	5,229,386,661.51	-1,233,563,611.33
DALYs	17,362.22	5,655.92	-11,706.30

Sensitivity analysis

One-way sensitivity analysis was performed. The tornado diagrams show the range of ICERs if the identified parameter is modified. The dotted line shows the boundary where the intervention becomes not cost-effective. A bar reaching the left side of the line means that at certain values tested, the intervention is not cost effective. Two scenarios were computed: public payer perspective (where only direct costs are considered) (Figure 2A) and societal perspective (indirect costs are included) (Figure 2B)

From a public payer perspective, UNHS cost-effectiveness is sensitive to treatment rate, prevalence, follow-up rate, number of rehabilitation sessions needed for those diagnosed early, and coverage of the program. Cost-effectiveness was not sensitive to number of rehabilitation sessions for those treated late, cost of rehabilitation per session, cost of OAE and AABR, education costs, refer rates, recurrent costs, sensitivity, and cost of machines.

Using a societal perspective, UNHS was sensitive only treatment rate and follow-up rate. It continues to be cost-effective or cost-saving for the full range of parameters tested for cost of screening, amplification, education, rehabilitation, and fixed program costs. The findings were also robust for the tested coverage, sensitivity, unemployment rates and lifetime income values. The minimum treatment rate needed is 31% and the minimum follow-up rate needed is 24% to ensure that the intervention remains cost-effective from a societal perspective.

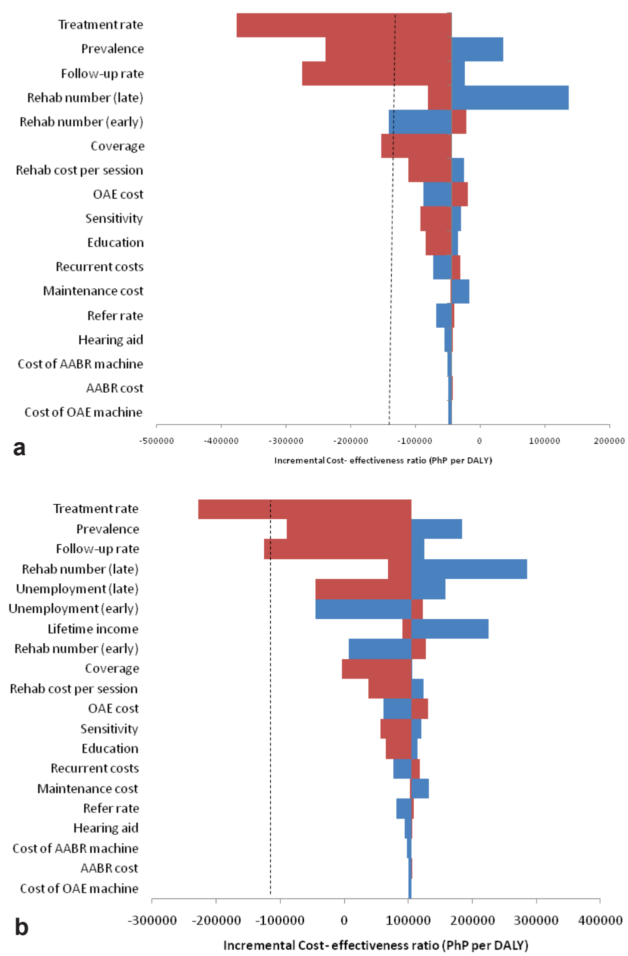

Figure 2. One-way sensitivity analysis with (A) Direct costs only and (B) Societal costs.

*Legend: **Blue** – Maximum parameter value; **Red** – Minimum parameter value; Dashed line – Cost-effective ICER, values to the left of the line imply a not-cost-effective scenario.*

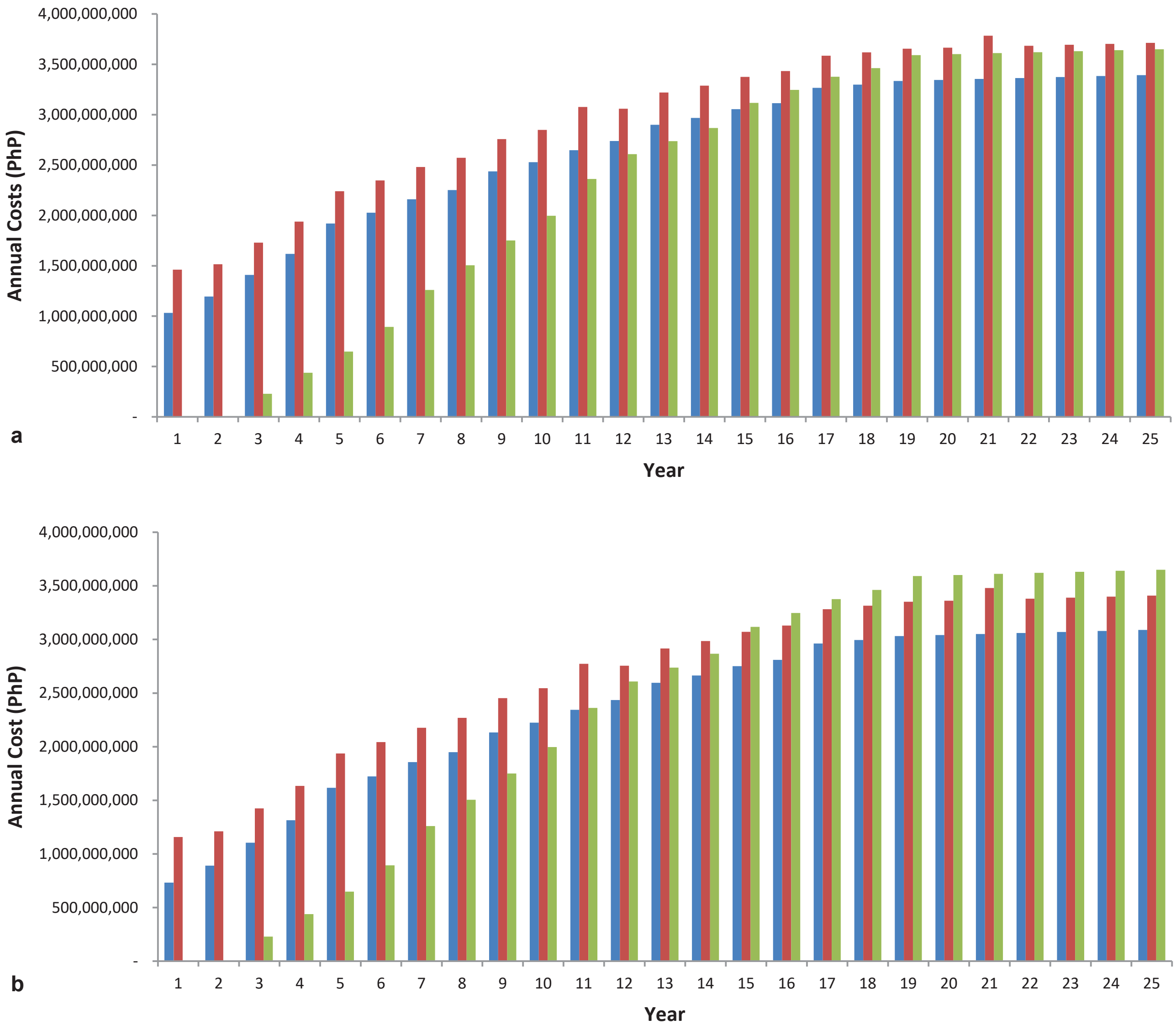

Figure 3. Twenty-Five year Annual Costs of a Universal Hearing Screening (UNHS) Program versus No Screening (A) Base Case Costs (B) Decreased OAE to PhP 200 per test.
Legend: ***Blue*** *– screening program with no facility and capital expenses;* ***Red*** *– screening program with facility and capital expenses;* ***Green*** *– no screening program.*

Budget Impact Analysis

Budget impact analysis showed that the program is a high impact program. Implementing the program for a 10-year period would cost the government a total of PhP 18.6 B if only diagnostic, treatment and education expenses are considered. Including capital and facility expenses, the cost reaches PhP 21.9 B. In comparison, not implementing a program will just cost PhP 8.7 B.

Annual program expenses were seen to increase over time becoming stable after ten years of implementation. The no screening program scenario increases rapidly starting year 3 and by year 15, the annual costs exceed annual program costs if facility costs are excluded. If capital and facility costs are included however, the annual cost is projected to be higher in the with program scenario. Some spikes are noted due to need to replace equipment and re-train individuals. Lowering the cost of OAE to PhP 200 per test drastically changes the picture. The annual costs decrease to a point that annual costs of having a program become equal to the annual cost of a no program scenario at year 11 and year 15. (Figure 3)

Discussion

Implementing a universal newborn hearing screening program is a cost-saving but a high budget impact program. Sensitivity analysis showed that the resulting cost ratios are sensitive to the follow-up after a positive screening test, probability of receiving timely treatment, and to the prevalence of the condition. Lower follow-up rates, lower treatment rates, and lower prevalence will decrease the cost-effectiveness of the program and may even render it not cost-effective. The first two factors are largely controllable and stress the importance of setting-up not just diagnostic services but treatment services as well.

In cost-effectiveness analysis, the goal is to provide decision makers with information to see if investing limited health resources will yield acceptable level of health benefits such as life years saved or episodes prevented. Interventions can be classified as cost-saving, cost-effective, or not cost-effective. Being cost-effective suggests that the intervention increases the cost compared to the status quo but if the health benefits received is worth it. In cost-saving, the intervention yields health benefits and even decreases the cost compared to the status quo.

In this case, the investment in screening and the additional costs of early interventions would be slightly offset by the resulting decrease in overall treatment rehabilitation and education costs. The cost of the program remains higher than doing nothing but there will be gains in health as children will gain language skills and develop normally. These will be observed even in the first few years of the program if treated children are compared to untreated children.

The intervention becomes cost-saving once the societal perspective is taken and the income from successfully treated individuals is considered. In a status quo, the untreated child becomes a disabled person with limited capacity to economically contribute to society. Screening and treatment changes this situation; individuals experience normal development and have a better chance of becoming gainfully employed. The savings will be indirectly gained once the children start schooling and when they start work at around 18 years old.

Our results are consistent with the analysis by Santos-Cortez and Chiong[8] regarding the implementation of newborn hearing screening in the Philippines. Our model improved on their analysis by accounting for more variables that will affect program effectiveness, impact and costs. Our model also provided estimates of impact on health by the screening program.

We also assumed a community-based approach rather than a hospital-based approach. The community-based approach will theoretically improve coverage through implementation along with the vaccination program and will reduce refer rates[9] as it was found that testing during the first few days of life results in refer rates of up to 10%.[8] We also used updated parameters through validation with individuals involved in these screening centers and updated literature review.

The results of our analysis are consistent with the findings of Huang et al[7], Blanco and Moreno-Ternero[6], and Keren et al[14]. Huang et al[7] found that both UNHS and targeted NHS was cost-effective for various provinces in China. The results of their sensitivity analysis parallel our findings with their results being sensitive to coverage, diagnosis rate, and intervention rate. Keren[14] pointed out that increased lifetime productivity resulting from early detection and treatment in a UNHS will likely lead to long term savings.

Krishnan and Donaldson[15] point out that NBHS in developing countries are hindered by socio-economic factors and access factor such as maternal behavior towards screening and hearing loss, and geography. Program implementation may be more difficult in rural areas. These mentioned factors can affect two rates included in our model: follow-up rate and treatment rate. One possible solution included in our model is the use of a mobile technician who can visit far-flung areas with a portable OAE machine. Other features may be included to overcome challenges in rural areas.

The cost-effectiveness model showed that for the program to be successful, those who screen positive should follow-up for confirmatory testing and that those who were detected should receive the full treatment needed. There is an imperative on the program to improve availability, access, and affordability of auditory services at the same time as the screening program. Currently, only the Philippine Charity Sweepstakes provide financial assistance for hearing aids and covers only a fraction of the costs at PhP 9,000.00. According to experts, the type of hearing aid that can be bought at this amount is not likely to be sufficient to improve outcomes of those with profound hearing loss. Access to hearing aids is also limited to urban centers.

Despite the cost-effectiveness of the program, it is a high impact program and, as previously mentioned, "savings" are not likely to be felt during the first ten years of the program. The budget impact also showed that annual costs of the program (including facility expenses) will exceed the annual cost of a no intervention scenario during 20 years of program implementation. This budget impact can be mitigated if the program costs are decreased such as decreasing the cost of the test, machines used, and operational expenses. Utilization of alternative low cost tests with comparable diagnostic ability can also be considered since this will lower operational and diagnostic costs.

A limitation of our model is the exclusion of the impact of screening on babies with unilateral hearing loss and mild bilateral hearing loss. Other cost-effectiveness analyses have included this but due to the lack of data in our country regarding the prevalence and impact of treatment on outcomes; we opted to exclude this in the model. Some indirect costs such as transportation and opportunity loss of the caretaker were also not included.

Long term impact of screening on education and rehabilitation costs are also based on expert opinion rather than follow-up studies on screened Filipino babies. There is a need to establish these parameters and re-assess the program once these are determined. Due to the uncertainty, the group tested a wide range of parameters in the sensitivity analysis. Results are favorable for the program as the results were robust across the ranges tested.

Conclusion

A universal hearing screening program is cost-saving for the Philippines. Model results suggest that even if the program performance is below universal coverage, savings will be accrued. Results are sensitive to follow-up rates and treatment rates of detected individuals. To gain maximum benefits from the program, there should be measures to facilitate treatment of detected individuals and ensure that they become gainfully employed in the future.

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