Pilot Implementation of a Community-based, eHealth-enabled Service Delivery Model for Newborn Hearing Screening and Intervention in the Philippines

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ABSTRACT

Objectives. This study explores the potential of the HeLe Service Delivery Model, a community-based newborn hearing screening (NHS) program supported by a web-based referral system, in improving provision of hearing care services.

Methods. This prospective observational study evaluated the HeLe Service Delivery Model based on records review and user perspectives. We collected system usage logs from July to October 2018 and data on patient outcomes. Semi-structured interviews and review of field reports were conducted to identify implementation challenges and facilitating factors. Descriptive statistics and content analysis were used to analyze quantitative and qualitative data, respectively.

Results. Six hundred ninety-two (692) babies were screened: 110 in the RHUs and 582 in the Category A NHS hospital. Mean age at screening was 1.4±1.05 months for those screened in the RHU and 0.46±0.74 month for those in the Category A site. 47.3% of babies screened at the RHU were ≤1 month old in contrast to 86.6% in the Category A hospital. A total of 10 babies (1.4%) received a positive NHS result. Eight of these ten patients were referred via the *NHS Appointment and Referral System*; seven were confirmed to have bilateral profound hearing loss, while one patient missed his confirmatory testing appointment. The average wait time between screening and confirmatory testing was 17.1±14.5 days. Facilitating factors for NHS implementation include the presence of champions, early technology adopters, legislations, and capacity-building programs. Challenges identified include perceived inconvenience in using information systems, cost concerns for the patients, costly hearing screening equipment, and unstable internet connectivity. The lack of nearby facilities providing NHS diagnostic and intervention services remains a major block in ensuring early diagnosis and management of hearing loss in the community.

Conclusion. The eHealth-enabled HeLe Service Delivery Model for NHS is promising. It addresses the challenges and needs of community-based NHS by establishing a healthcare provider network for NHS in the locale, providing a capacity-building program to train NHS screeners, and deploying health information systems that allows for documentation, web-based referral and tracking of NHS patients. The model has the potential

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to be implemented on a larger scale — a deliberate step towards universal hearing health for all Filipinos.

Keywords: newborn screening, hearing loss, health information systems, community healthcare, healthcare delivery

INTRODUCTION

The prevalence of permanent bilateral hearing loss detected at birth is about 0.13% in the Philippines.[1] If undetected and not treated early, this results in permanent bilateral hearing loss and serious delay in speech, which can adversely affect intellectual and emotional development of the child. This can cost a family about PhP 4.3 million for special care, special education as well as account for lost income during adulthood.[2]

Newborn hearing screening (NHS) can effectively promote the diagnosis and management of hearing loss during the first 6 months, ensuring better outcomes for children.[2-6] In the Philippines, the Universal Newborn Hearing Screening and Intervention (UNHSI) Act of 2009 (Republic Act 9709) mandates that all newborns must be screened for hearing loss and if present, receive early intervention.[7] The Newborn Hearing Screening Reference Center (NHSRC) led this advocacy. It reports, however, poor NHS coverage in the country with less than 10% of Filipino newborns screened in 2020.[8] This translates to approximately 1.5 million newborns unscreened or unreported. Furthermore, around 73% to 92% of babies that required rescreening or second testing after a "REFER" NHS result were lost to follow up.[2,8] To improve the coverage and delivery of NHS in the country, one objective set by the UNHSI Act is to "develop models which ensure effective screening, referral and linkage with appropriate diagnostic, medical and qualified early intervention services, providers, and programs within the community".[7] In line with this objective, the Hearing for Life (HeLe) Project proposed a service delivery model for UNHSI, which capitalizes on the promises of information and communications technology in health and the benefits of a community-based approach in the provision of hearing healthcare services.[9] The University of the Philippines (UP) and the University of California (UC) led this initiative.

The HeLe Service Delivery Model

The HeLe Service Delivery Model proposes a community-based NHS program supported by electronic health information systems for care documentation and referral management. It connects primary care and specialty care providers within a service delivery network (SDN) in the locale through an electronic referral system.

Currently, NHS is usually performed in hospitals and specialist centers, certified by NHSRC as a Category A NHS Center, while confirmatory and intervention services are provided in Categories B to D. In the HeLe model (Figure 1), the Rural Health Unit (RHU) serves as the screening facility for newborns in their catchment area. Within a municipality, the RHU typically serves as the birthing center, and will receive referrals of parturient mothers from Barangay Health Stations (BHS) where oftentimes mothers receive their prenatal care.[10] The HeLe research program opted for enabling the RHU as a Category A Hearing Screening Center as a step towards democratizing access to the NHS. The RHU is where most babies are born, geographically and culturally closer to their families and homes. With the RHU as the screening facility, parents of newborns born in the RHU or within the community will be informed of the NHS service their child is entitled to. Newborns will be assessed for hearing defects within a day to 90 days after delivery, as part of their routine newborn care.[11] This service will be recorded in the patient's electronic medical record in the RHU.

Children with positive hearing screening results will then be referred from the RHU to their preferred confirmatory testing center through the *NHS Referral and Appointment System*, a web-based tele-referral system hosted in the National Telehealth System (NTS). The *NHS Referral and Appointment System* allows patients to automatically set their appointments for hearing diagnostic testing. Their primary care, in this case, the RHU, receives feedback on the results of the testing. This allows them to track the hearing status of their referred patient and refer them to available financial, rehabilitation, and education services in the community.

In this paper, we sought to explore the potential of the HeLe Service Delivery Model, a community-based NHS program supported by a web-based referral system in improving provision of hearing care services, specifically screening and confirmatory testing. First, we identified the existing model of care for NHS and program implementation challenges in the study sites. Second, we described the interventions designed to address the identified challenges in the implementation of the HeLe Service Delivery Model. And lastly, we presented the outcomes of the pilot, including patient outcomes, system usage, and user perspectives on barriers and facilitating factors to implementation.

MATERIALS AND METHODS

This prospective observational study was divided into three phases: (1) situational analysis of NHS implementation in the study sites; (2) pilot implementation of the HeLe service delivery model; and (3) evaluation of the model based on records review and user perspectives. Baseline data was collected from October to December 2017 while pilot implementation and evaluation data (e.g., system usage logs and user perspectives) were gathered from July to October 2018. We received ethical clearance from the ethics review board of the University of the Philippines Manila.

To identify potential study sites, we conducted a mapping of NHSRC-certified Category A to D facilities

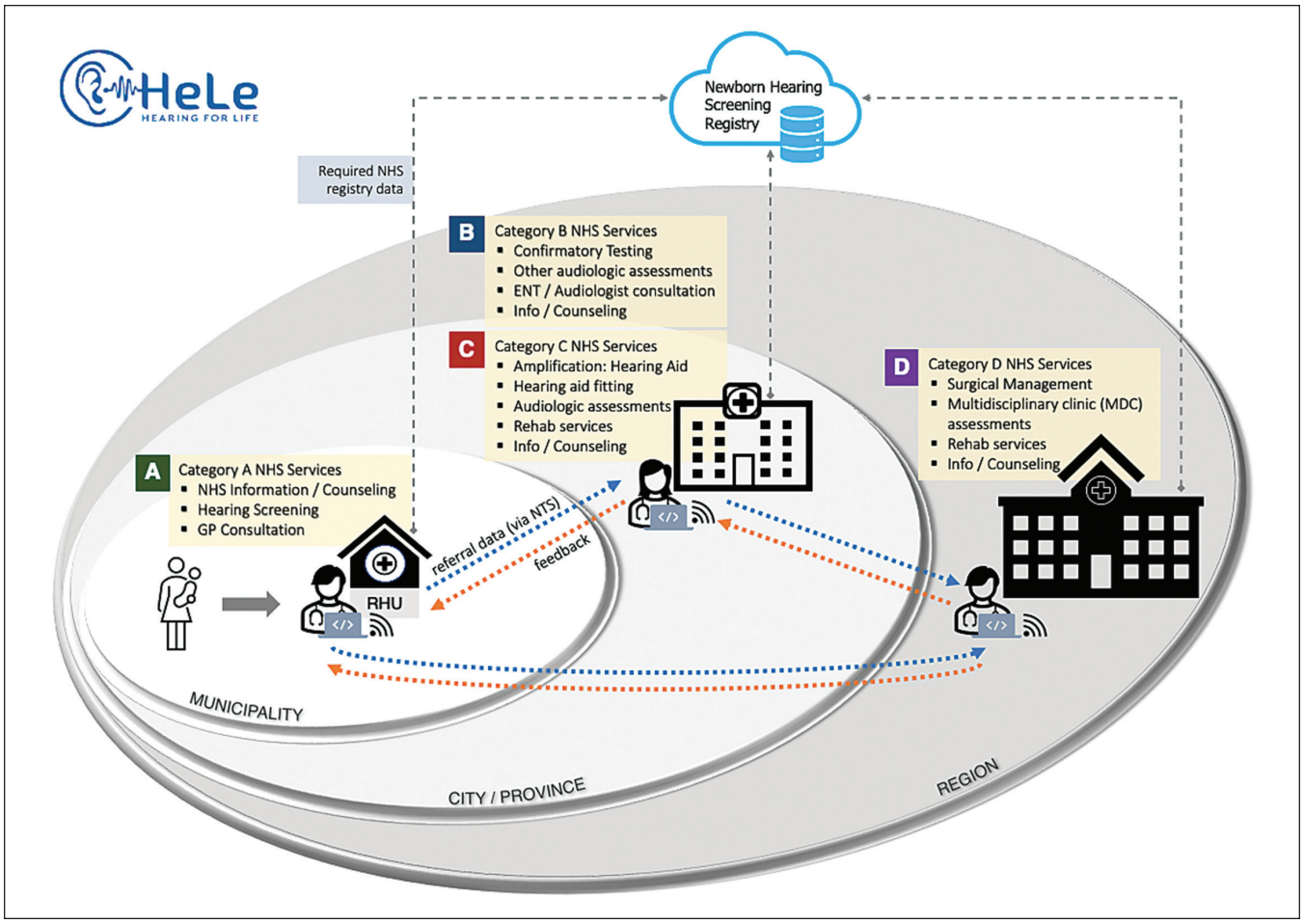

Figure 1. The HeLe Service Delivery Model.

Abbreviations/Legend: RHU, Rural Health Unit; NHS, Newborn Hearing Screening; NTS, National Telehealth System; Categories of Newborn Hearing Centers: A, Category A Newborn Hearing Screening Center; B, Category B Newborn Hearing Diagnostic Center; C, Category C Newborn Hearing Diagnostic and Intervention Center; D, Category D Newborn Hearing Diagnostic, Intervention, Surgical, and Rehabilitation Center.

in the country, and Rural Health Units (RHUs) that adopted the Community Health Information and Tracking System - Electronic Medical Record (CHITS-EMR)[12] and had previous experience implementing telemedicine. We identified Region VI - Western Visayas as the site for setting up an NHS SDN. Four RHUs, one Category A NHS facility, and one Category B NHS facility participated in Region VI. We also engaged three RHUs from Romblon to test the model in a setting where there were no certified NHS facilities. Situational analysis through key informant interviews and site visits was done to determine the NHS implementation and referral flow in the communities, and to assess challenges relating to the provision of NHS services. Together with key stakeholders from partner communities, we identified interventions to address perceived barriers to implementation of the HeLe Service Delivery Model. These were presented to the sites and a Memorandum of Agreement was signed prior to deployment. Healthcare providers (HCPs) from the study sites underwent a blended-learning program, which involved a computer-based training course, a three-day face-to-face training session and onsite coaching. The last day of the course involves a screener certification process conducted by the NHSRC.

To test the system, a newborn hearing screening day was organized by participating RHUs. It sought to increase awareness among the community on the importance of the NHS and that the service would be available in the RHU. The event was also designed as a practice for the HCP who partook in the HeLe capacity building program.

Children aged 0-3 months, who have yet to undergo NHS, were recruited. Babies beyond three months of age presented to the clinic for NHS were also included. Informed consent was obtained from all parents of these infants. NHS was done using a commercially available Otoacoustic Emission (OAE) device. Healthcare providers, who received HeLe training and passed the certification process, conducted the NHS and documented the screening done in the CHITS - Newborn Hearing Screening Module. During the NHS

day in the communities, the HeLe research team – composed of ENTs, clinical audiologist, and telehealth trainers – were present on site to provide guidance on NHS and use of the deployed information systems. For patients who presented with "REFER" hearing screening results, the final hearing screening test was done by the HeLe audiologist or ENT for confirmation. In both RHU and Category A pilot sites, NHS data of babies, whose parents consented to have their data captured in the system, were included in the study.

Screening data were entered into the CHITS - Newborn Hearing Screening Module. Patients with "REFER" NHS results were then referred by the physician to the patient's preferred confirmatory testing center via the *NHS Referral and Appointment System*. The patient and the referring facility received notifications once results were available. From July to October 2018, the researchers collected system usage logs, specifically the total number of babies screened and entered in the system, the number of babies with "REFER" NHS results, the number of referrals booked, the screening and confirmatory testing results, the number of missed appointments, and the duration between screening and confirmatory testing. Semi-structured interviews and review of field reports were conducted to identify challenges and facilitating factors in the implementation of the HeLe service delivery model. Descriptive statistics and content analysis were used to analyze quantitative and qualitative data, respectively. The Human, Organization and Technology-fit (HOT-Fit) Model[13] was used to examine the enablers of and challenges to the ICT-enabled HeLe UNHSI Service Delivery Model. We used this framework to evaluate three components for successful implementation of information systems, namely: (1) human component, which includes user attitude and user satisfaction; (2) organization component, which includes leadership, organizational support, and environment; and (3) technology component, which involves system, information, and service quality.[13]

RESULTS

Characteristics of Study Sites

Seven RHUs (R1 to R7) and one tertiary hospital (Category A) served as hearing screening centers in the study. Five pilot sites (i.e., R1 - R4, Category A) were in Western Visayas Region and three (i.e., R5 - R7) were in the province of Romblon. All study sites, except the Category A hospital, had implemented telehealth projects in their communities and had been using CHITS as their electronic medical record. Table 1 reflects the community demographics, the coverage of NHS in the community, and the status of NHS in their area at the time of the study.

Each RHU catered to an average of 34 barangays and these seven RHU serve about 304,000 individuals. Three of these RHU study sites provide healthcare services to geographically isolated and disadvantaged areas (GIDAs). The existing Category A NHS site serves the whole region, serving a population of about 2.6 million, who live in 32 local

Table 1. Characteristics of Study Sites

	Western Visayas					Romblon		
	R1	R2	R3	R4	CAT. A	R5	R6	R7
Health facility type	RHU	RHU	RHU	RHU	Hospital	RHU	RHU	RHU
Health facility level	Primary	Primary	Primary	Primary	Tertiary	Primary	Primary	Primary
Coverage	Municipal	Municipal	Municipal	Municipal	Regional	Municipal	Municipal	Municipal
Total population covered	92,128	64,826	33,086	22,208	2.6 million	50,619	22,265	18,244
No. of barangays covered	37	52	46	48	662	25	15	12
Estimated no. of live births / year	235	117	170	252	7,200	772	336	266
With GIDA	No	No	Yes	Yes	Yes	Yes	No	Yes
% of children born in the facility who underwent NBS	100%	95%	100%	100%	Not reported	100%	75%	100%
% of children who underwent NHS	0%	0%	0%	0%	Not reported	0%	0%	0%
Implements the NHS program?	No	No	No	No	Yes	No	No	No
No. of NHS device	0	0	0	0	1	0	0	0
No. of HCPs trained on NHS	0	0	0	0	3	0	0	0
With a referral process for management of children with hearing loss	Yes	No	No	No	Yes	Yes	Yes	Yes
Distance (travel time) to the nearest screening facility[A]	9.4 km (18m[B])	19.9 km (28m[B])	41.5 km (1h 5m[B])	35.6 km (1h[B])	N/A	800 m (3m[B])	53.3 km (1h 30m[B])	27.9 km (45m[B])
Distance (travel time) to the nearest diagnostic facility[A]	10.8 km (19m[B])	21.3 km (30m[B])	42.9 km (1h 8m[B])	38.4 km (1h 3m[B])	136 km (3h 47m[C])	357 km (2h 43m[D])	404 km (2h 57m[D])	385 km (2h 18m[D])

NHS, newborn hearing screening; HCPs, healthcare providers; NBS, newborn metabolic screening; GIDA, geographically isolated and disadvantaged areas

[A] estimated using Google Maps; [B] travel by land; [C] travel by land and sea; [D] land and air

government units (19 municipalities and 13 cities, further subdivided into 662 barangays). On average, 307 babies were born each year per RHU and around 7,200 were born in the Category A facility. All RHUs did not offer newborn hearing screening as part of their healthcare services. Of seven, only four reported on having an existing referral process for children with impaired hearing. On the other hand, the Category A hospital had been implementing NHS, and was one of the certified hearing screening centers in the region.

Existing service delivery models for NHS in the Philippines

Figure 2 shows four different models of hearing care service delivery in the communities based on interviews with pilot sites. We categorized these service delivery models as Model A to Model D. In Model A, the RHU refers the patient to the nearest Level 3 hospital (e.g., regional hospital) for hearing screening, diagnosis, and/or management. R1 and R2 often use this model as their communities are near the city center where Level 3 hospitals are located. In Model

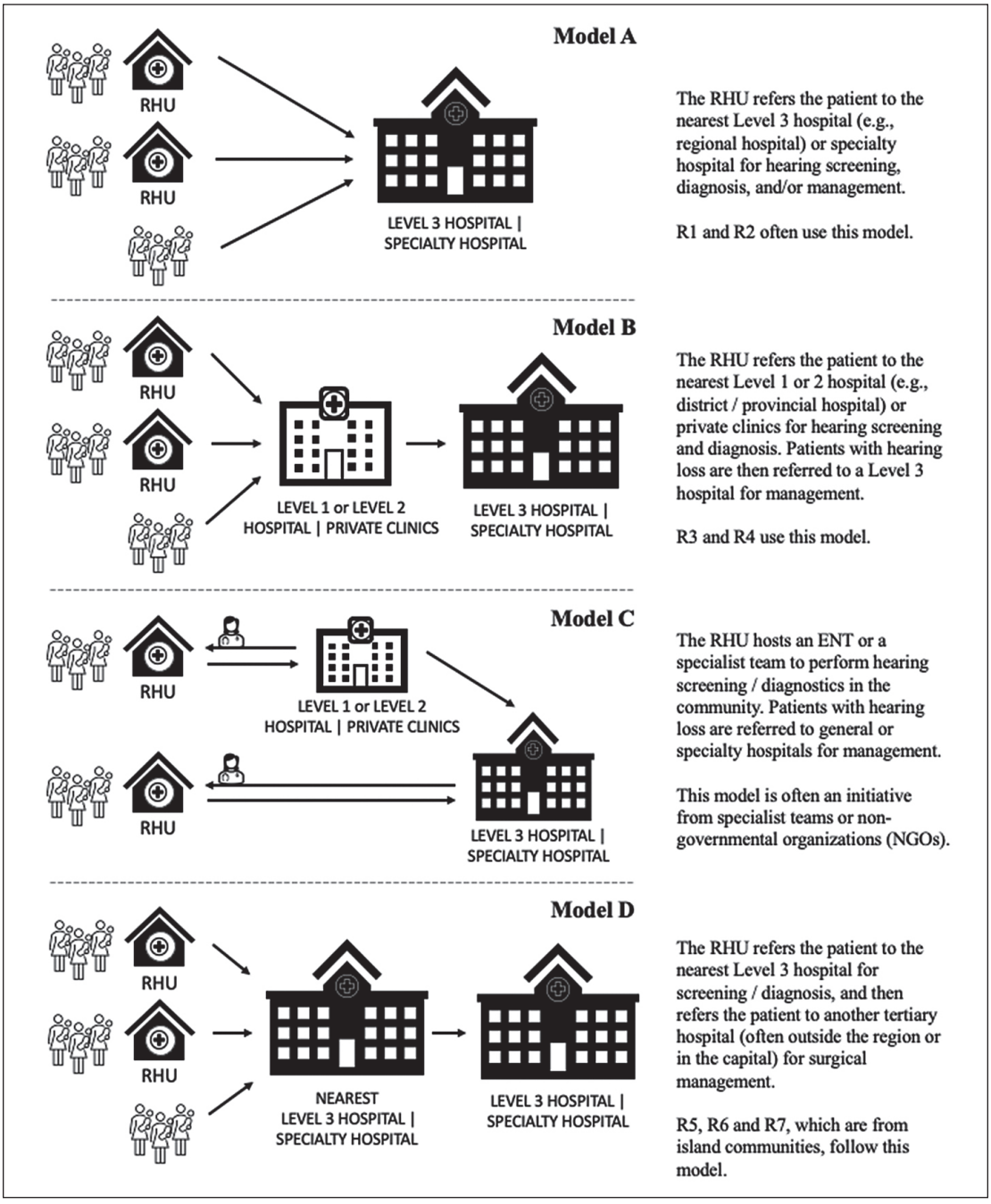

Figure 2. Models of hearing care service delivery in Philippine communities.

B, the RHU refers the patient to the nearest Level 1 or 2 hospital (e.g., district/provincial hospital) or private clinics for hearing screening and/or diagnosis, which then refers patients confirmed to have hearing loss to a Level 3 or specialty hospital for management. R3 and R4 use this model. In Model C, the RHU hosts an ENT (otorhinolaryngology surgeon) or a specialist team to perform hearing screening and/or diagnostics in the community. Identified patients are referred to general or specialty hospitals for hearing loss management. This model is not commonly used and is often an initiative from specialist teams or non-governmental organizations (NGOs). In Model D, the RHU refers the patient to the nearest Level 3 hospital for screening and diagnosis, and then refers the patient to another tertiary hospital (often outside the region or in the capital) for cochlear implantation. This is the case for Romblon pilot sites (i.e., R5-R7) where patients need to be referred outside the region, often to the National Capital Region, for interventions. In the case of the Category A NHS facility, it follows Model D, wherein patients go to the facility for screening and then referred to another Level 3 hospital or specialty clinic for diagnostics and/or intervention.

This paper is premised on challenges of these current models and the intent to demonstrate a complementary and even an alternative community-based model to improve access to NHS and early intervention.

Identified implementation barriers and Intervention design

As part of pre-deployment preparation, key stakeholders were interviewed on the existing and potential barriers to the implementation of the HeLe model. Interventions to address these barriers were designed to support the implementation of the community-based NHS program and the use of the Health Information Systems (HIS) (Table 2).

NHS Pilot Implementation Results

A total of 692 babies were screened and had their data entered into the CHITS-EMR NHS Module. Table 3 reflects the age distribution of babies screened in the RHUs compared to those from the Cat. A facility. In the RHUs, the mean age at screening was 41.9 days old (SD = 31.5) or 1.4 months (SD = 1.05). 47.3% were screened by 1 month of age (≤30 days), 28.2% between 1-2 months (31-60 days) old, 13.6% between 2-3 months (61-90 days) old, and 10.9% were older than 3 months (91 days and above). In the Category A NHS facility, the mean age at screening was 13.7 days (22.3) or 0.46 month (SD = 0.74); 86.6% were screened by 1 month of age, 6.7% were 1-2 months old, 4.3% were 2-3 months old, and 2.4% were older than 3 months. From this 692, ten babies (1.4%) received a "REFER" hearing screening result (Table 4): 60% Male, 40% Female, mean age of screening at 2.2 months, and 30% with risk factors for hearing loss. Five out of these 10 children (50%) were screened at the RHUs while the other half were from the Category A NHS facility. In the RHUs, 4.5% (5/110) of babies received a positive hearing screening result compared to 0.9% (5/582) in the Category A NHS facility.

Of the ten, eight (80%) were referred through the web-based *NHS Referral and Appointment System*. And, among these eight referrals, seven babies (87.5%) were confirmed to have bilateral profound hearing loss while one patient (12.5%) missed his confirmatory testing appointment and was lost to follow up. We found that 1.8% of babies screened in the RHU and 0.9% of those screened in the Category A NHS facility had bilateral profound hearing loss. The mean wait time, or the time elapsed between screening and confirmatory testing, was 17.1 days (SD = 14.5). Babies screened in the RHU were diagnosed with hearing loss within 14 days (SD = 2.8), while those from the Category A site were confirmed to have hearing loss by 18.4 days (SD = 17.5).

Families of two patients (from R7) with suspected hearing loss were not referred through the system. The nearest confirmatory center for Romblon was in Metro Manila, which required the patients to travel by plane, and other costs that were burdensome. Instead, these patients were referred to a local ENT providing confirmatory testing services in the island. Of note, however, the Province of Romblon does not have certified hearing confirmatory centers based on the official list for the Philippines maintained by the NHSRC. The local ENT specialist had no fixed schedule for confirmatory testing since the service appears to depend on the number of patients to be tested. Thus, confirmatory testing of these two patients was not done even after four weeks after NHS, within the HeLe research period.

Facilitating factors and challenges in implementing the HeLe UNHSI service delivery model

Table 5 reflects the human, organizational, and technical facilitating factors, and challenges in implementing the HeLe UNHSI service delivery model. Under human factors, the positive attitude of HCPs to implement NHS, their familiarity with HIS, and being a certified Category A NHS screener facilitate NHS implementation in their locale. The presence of legislations, executive leadership and champions, partner facilities for diagnostics/intervention, and capacity-building programs support the NHS program at the organizational level.

Challenges identified to NHS implementation include the HCPs' need for confidence building to perform NHS, perceived inconvenience in using HIS, cost concerns for the patients, and lack of readiness of the local health system to shoulder the cost. At the organizational level, the lack of facilities providing NHS diagnostic and intervention services remains a major block in ensuring early diagnosis and management of hearing loss in the community. The costly hearing screening equipment, equipment failures exaggerated by delays in repairs, and unstable internet connectivity were identified as technical challenges in implementing the HeLe UNHSI service delivery model.

Table 2. Interventions Designed to Address Perceived Barriers in the Implementation of the Community-based NHS Program and Use of Health Information Systems

Barriers Identified	Intervention to address these barriers
Human Factors	
Poor awareness of NHS, especially among HCPs	• Orientation of HCPs on the NHS program and the UNHSI Act • Engagement of the Municipal Health Officer (MHO) as a champion to initiate and support NHS awareness campaigns in the community
Lack of trained / certified NHS screeners	• Orientation of HCPs on the NHS program and the UNHSI Act • Engagement of at least 3 HCPs to undergo training on NHS and the new systems • Development and deployment of a computer-based training course on NHS and teleaudiology to introduce new concepts / skills • Conduct of a 3-day face-to-face training course, which includes the NHS Personnel Certifying Course • Onsite coaching of HCPs during the NHS day
HCP attitude on the use of health information systems	• Engagement of known early technology adopters during the HeLe pilot implementation • Engagement of MHOs with positive attitude on electronic HIS adoption • Development of the NHS Referral and Appointment System that can be integrated into the users' current workflow
Organization Factors	
No local policy supporting NHS implementation in the community	• Engagement of the Local Government Unit (LGU) through the Mayor. • Signing of a Memorandum of Agreement between the University and the LGU to approve and support the pilot implementation of the program • Engagement of the MHO as a champion to introduce and support a new health program or NHS-related policies
Lack of specific arrangements organizing the UNHSI SDN within the locale	• Engagement of Category A to D NHS facilities within a locale / region to organize a UNHSI SDN
Lack of appropriate room / environment to conduct hearing screening in the RHU	• MHOs were engaged to identify potential areas in the RHU (or municipality) where hearing screening can be conducted • Specific scheduling of NHS service was also considered as a potential strategy to efficiently manage resources. RHUs can set a specific day per week / month to conduct NHS, similar to other public health programs/ services
Poor tracking of children with positive NHS results and those with confirmed hearing loss	• Development of an EMR module for NHS documentation • Development of the NHS Referral and Appointment System that allows the referring physician to receive referral feedback on the hearing status of the patient
Technology Factors	
Lack of hearing screening equipment	• Provision of a hearing screening equipment to the community during the HeLe pilot implementation • Introduction of certified hearing screening device distributors in the country to the RHU • Introduction of the HeLe research program and approach to UNHSI to certified hearing screening device distributors in the country (ergo, another potential business model or distribution channel)
Lack of equipment / updated equipment to support the use of HIS	• Provision of new desktops and servers to study sites • Provision of NHS equipment
Unstable internet connection	• Development of a system that allows HCPs to input patient data even offline, and only requires internet connection when an eReferral needs to be sent

DISCUSSION

Our findings provide proof of the potential of a community-based NHS program supported by ICT-enabled HIS in improving coverage and provision of UNHSI services in the country. We have identified enablers, barriers, and lessons in the implementation of the HeLe service delivery model, which can be used to design interventions for a large-scale deployment.

The poor awareness among HCPs and lack of local policy supporting community-based NHS and about the UNHSI program were identified as the main barriers to the implementation of the Law in the communities. This was apparent in our study where only four of the seven RHUs

Table 3. Age Distribution of Babies Screened in the RHUs and the Cat. A NHS Facility

Age at Screening (days old)	Babies screened in the RHU (n = 110)	Babies screened in the Cat. A NHS facility (n = 582)
≤30	52 (47.3%)	504 (86.6%)
31-60	31 (28.2%)	39 (6.7%)
61-90	15 (13.6%)	25 (4.3%)
≥91	12 (10.9%)	14 (2.4%)
Mean age (SD)	41.9 days (31.5) *or* 1.4 month (1.05)	13.7 days (22.3) *or* 0.46 month (0.74)

Table 4. NHS Results in HeLe Pilot Implementation Sites

Facility	Total number of babies screened	Babies with "REFER" NHS results (%)	Babies referred via NHS Referral and Appointment System (%)	Babies confirmed to have hearing loss (%)	No Show [A] (%)	Mean Wait Time [B] (SD)
R1	11	1 (9.1)	1 (100)	1 (9.1)	0 (0.0)	12 days
R2	14	1 (7.1)	1 (100)	1 (7.1)	0 (0.0)	16 days
R3	21	1 (4.8)	1 (100)	-	1 (100)	-
R4	17	0 (0.0)	N/A	N/A	N/A	N/A
R5	2	0 (0.0)	N/A	N/A	N/A	N/A
R6	5	0 (0.0)	N/A	N/A	N/A	N/A
R7	40	2 (5.0)	0 (0)	-	-	-
Cat. A	582 (84.1)	5 (0.9)	5 (100)	5 (0.9)	0 (0.0)	18.4 (17.5)
All RHUs	110 (15.9)	5 (4.5)	3 (60)	2 (1.8)	1 (20)	14.0 (2.8)
Total	692 (100)	10 (1.4)	8 (80)	7 (70)	1 (10)	17.1 (14.5)

[A]*No Show: number of patients who missed their appointment schedule*

[B]*Mean Wait Time (MWT): average duration (number of days) from hearing screening to confirmatory testing; computed by getting the total wait time (in days) for all babies from a specific facility who completed confirmatory testing (as documented on the NHS Referral and Appointment System) divided by the number of babies from the said facility who completed confirmatory testing.*

Acronyms: NHS, newborn hearing screening; SD, standard deviation; N/A: not applicable (since the baby had a "PASS" NHS result and thus, did not require a referral for confirmatory testing)

Table 5. Human, Organizational, and Technical Facilitating Factors and Challenges in Implementing the HeLe UNHSI Service Delivery Model

Facilitating Factors	Supporting statements, observations and/or reports
Human Factors	
1. ***Positive attitude and interest to implement a community-based NHS program and use HIS***	*"We're excited to implement this (NHS). It's great that we have an opportunity to pilot NHS in our communities."* HCPs involved were early technology adopters. They have previously implemented several telehealth projects in their communities.
2. ***Familiarity with the HIS deployed; previous experience with HIS use***	*"The new (health information) system is easy to learn since we've been using CHITS for years."*
3. ***Trained and NHSRC-certified local HCP as screener for hearing loss***	All HCPs trained under the HeLe capacity building program passed the NHS Category A Screener certification course. After the blended learning program, HCPs expressed confidence and excitement in being able to implement NHS in their communities.
Organization Factors	
1. ***Presence of a legislation that mandates and supports NHS implementation***	*"I think the presence of the (NHS) law will make it easier to implement this program and gather support from the LGU."* The Department of Health (DOH) Technical Working Group for UNHSI was a partner of the HeLe research program, supporting the intent of model-building a community-based UNHSI SDN.
2. ***Engaged executive leadership; presence of a champion or a leader that supports new initiatives / policies***	*"Having the Mayor onboard with this (initiative) makes it easier to implement and get support."* Mayors readily supported the HeLe research program implementation, through MOA signing. MHOs served as champions in the implementation. Two of the MHOs engaged in the project took the initiative to look into procuring their own hearing screening device. All MHOs identified staff that can be trained to do NHS, allotted an area/room for screening, and looked for resources to facilitate confirmatory testing of children with positive NHS results.
3. ***HeLe UNHSI Blended Training program***	The blended learning strategy for the HeLe Capacity building program supported knowledge and skills building, supported the predisposition and value by the HCP for NHS services for their constituents. It: • Enabled HCP of RHU and Category A NHC to practice NHS, with guidance by experts, and allowed certification as a newborn hearing screener by the NHSRC • Supported predisposition, desire and positive attitudes of HCP towards providing NHS to their constituents • Reinforced stature as innovators or early adopters of ICT for health
4. ***Accessible care; presence of a confirmatory testing center within the province***	We observed that patients referred from nearby study sites (usually less than one hour from the confirmatory testing center) were able to go to their appointments.

Table 5. Human, Organizational, and Technical Facilitating Factors and Challenges in Implementing the HeLe UNHSI Service Delivery Model *(continued)*

Challenges	Supporting statements, observations and/or reports
Human Factors	
1. ***Need for confidence building in performing NHS through practice and coaching on NHS***	*"Though we have received training on newborn hearing screening, I think more experience and guidance is still needed... especially in using the OAE."*
2. ***Perceived inconvenience in using the HeLe systems (time-consuming, additional workload)***	*"Only 1 or 2 of us are on duty every day. We do the screening, and we have other tasks as well... so usually we do the encoding in CHITS when there's free time or before our duty ends. But for cases which need to be referred, we encode them on the same day since the parents would need to know the testing schedule."*
3. ***Cost concerns for the patient-families and the lack of readiness of the local health system to shoulder costs***	Since confirmatory testing centers are limited, patients who live far from these confirmatory testing centers will need to shoulder additional travel expenses. For example, patients from the Cat. A pilot site needed to travel by land and sea to go to the nearest confirmatory center in the next province. The estimated cost of travel is Php 300-500 (not including meals), which is the minimum wage per day in the country. Confirmatory testing is yet to be shouldered by PhilHealth. *"Cost of the hearing tests can be a challenge. Right now, HeLe shoulders the confirmatory testing and even the travel expenses of the patient... without that, it might be difficult for the parents to bring their child for testing."*
Organizational Factors	
1. ***Lack of*** • ***physical access*** • ***certified confirmatory testing facilities within the province / island*** • ***regular confirmatory testing services***	Romblon has no certified NHS confirmatory center. Thus, any patient with a "REFER" hearing screening result would need to travel to Manila or to another region to get confirmatory testing. Two patients from R7 were not referred via NTS because of patient preference or incapacity to access services from the nearest certified confirmatory center in Manila. *"For confirmatory testing, we learned that a local ENT conducts confirmatory testing in the area (one of the sites in Romblon). However, the schedule of the testing varies depending on the availability of the physician, the device (which is transported from Manila), and the number of patients."*
Technical Factors	
1. ***Expensive equipment (costly hearing screening device)***	Cost of the hearing screening device ranges from Php 20,000 - 50,000.
2. ***Equipment failure or defects, delay in prompt repairs***	During the 3-month implementation in the Cat. A pilot site, the staff reported issues in their hearing screening device, which took more than 1 month to fix. During this period, no NHS was done.
3. ***Unstable internet connection***	*"Sometimes, sending the referral (via NTS) takes a while, especially when the internet connection is not stable. We need to wait a few minutes and try again."*

NHS, newborn hearing screening; NHC, Newborn Hearing Center; HCP, healthcare providers; HIS, health information systems

have a known referral process for pediatric hearing screening and management. HCPs, including MHOs, in participating sites were unfamiliar with NHS. This observation is consistent with another local study, which reported lack of knowledge on the rationale and implementation of the UNHSI program among healthcare practitioners.[14]

These findings are not surprising. Whilst the DOH (and the NHSRC) through its regional offices, might have campaigned for the UNHSI program, these RHUs were not enabled with capacity for NHS (no investments in training screeners, absence of NHS equipment). Thus, the practice and implementation of the UNHSI program is far from the consciousness of both the local government leadership and the local health departments. The lack of local policy in support of the Law is not unexpected in this context. Thus, the capacity building and policy advocacy of the HeLe research program affirms that these organizational arrangements and policy investments are foundations of the envisioned community-based NHS model that can permeate throughout the country.

In our situational analysis, we found that the RHU implementation of national health programs has been successful with reported coverages at 95.7% for newborn metabolic screening and 89.8% for infant immunization. The information is encouraging, that given sufficient resources and a local policy framework in place to set up the UNHSI SDN, NHS can also be implemented successfully in RHUs. The HeLe demonstrated successfully that infants identified needing confirmatory diagnostic services would also be brought by their parents for appropriate care if the conditions are enabling, as what the HeLe initiated.

The rate of babies born in the RHUs, who underwent NHS in the nearest screening facility, was reported to be unknown. That is, the MHOs verbalized that they no longer tracked the status of babies referred for NHS. RHUs reported that they often get to know their patients' hearing status

when the parents come to get a referral for special education services for their children. Poor case tracking was reported due to lack of feedback from the patient and/or the specialist. The use of the HeLe's module in the CHITS-EMR and the HeLe *NHS Referral and Appointment System* have addressed, in a large part, this concern. Tracking has become the health institution's responsibility rather than that of the patient's task to inform her/his primary care physician. That is, the patient's status is known to the relevant health providers involved in her/his care in the HeLe service delivery network through its attendant electronic health information and telehealth systems. And with available information, this lends stronger accountability for the health sector to mobilize resources, enact policy to support the community, including persons with disabilities.

For participating RHUs, we noted the presence of at least one public hearing screening center within their province. On average, the nearest hearing screening facilities from the community study sites were 26.9 kilometers (8.5 to 45.3 km) away or 44 minutes (14 to 74 minutes) away by land travel. This translates to around PhP 85.9 (PhP 28.8 to PhP 142.9) in terms of bus fare for two people (mother and companion), and about PhP 395 in daily minimum wage lost to seek care. However, despite the presence of an NHS facility relatively near the communities, babies requiring NHS still came during the 'NHS Day' that the RHU conducted with the HeLe research team. In the current set-up, the prohibitive costs of travel outside their municipality and more so, outside of the province for continuity of care remains to be a limiting factor.

The need for a community-based NHS is clear. In the one-day 'NHS Day' conducted by the RHU, 110 newborns and infants were screened. This accounts for around 5% of the estimated annual live births in the seven RHU sites. Mean age at screening was 1.4 months (41.9 days); 47.3% were screened at one month old or younger, and more than half are past the ideal age of one month for NHS. Among 582 infants screened in the Category A NHS facility, the mean age was 0.46 month (13.7 days) or less than two weeks of age; the large majority (86.6%) were screened by one month of age.

Compared to our hospital study site, babies screened at the RHU were older by about a month. Around 10.9% of babies screened were older than three months - the ideal age for *confirmatory* testing. Babies screened at the Category A NHS hospital were more likely to be younger (within 30 days old) than those from the RHUs because they underwent NHS or was scheduled for NHS prior to discharge as part of the hospital protocols. Babies screened at the RHUs during the NHS day were mostly those born at the RHUs or community lying in clinics, which had no hearing screening equipment or capability to provide NHS services. We also observed a higher percentage of babies with positive NHS results in the RHUs at 4.5% (5 out of 110 screened) in contrast to the 0.9% rate in the Category A pilot site. Though only two of the five babies with positive NHS result from the RHUs underwent confirmatory testing, the percentage of babies with bilateral profound hearing loss screened in the RHUs was at least 1.8% (or two out of 110 screened), which was at least two times higher than that of the hospital study site (0.9%, five out of 582 infants screened). Were it not for the RHU-based NHS, these 110 babies from the seven rural towns would not have been screened, and five with probable bilateral hearing loss would not have been identified and referred for confirmatory diagnosis. Further, two infants would not have been referred for definitive management for laboratory-confirmed bilateral profound hearing loss.

All babies screened during the pilot implementation period were entered in the CHITS-NHS Module. Of the 692 babies screened, a total of 10 babies (1.4% of infants screened) received a positive NHS result. Eight of these ten patients (80%) were referred via the web-based *NHS Referral and Appointment System*; seven were confirmed to have bilateral profound hearing loss while one patient missed his confirmatory testing appointment. The average wait time between screening and confirmatory testing was 17.1 days (2.6 to 31.6 days). Patients screened in the RHU were diagnosed with hearing loss within 14 days (SD = 2.8), while those from the Category A site were confirmed to have hearing loss by 18.4 days (SD = 17.5). In terms of age of the infant at confirmatory diagnosis, this translates to about seven weeks and five days, and five weeks and four days, for those screened at the RHU and hospital, respectively. These fall within the three months or 12 weeks recommended age for confirmatory testing.

Of note, those who were screened in the hospital took (on average) four days longer to seek confirmatory testing, than those screened at the RHU. For the former, the period of confirmatory testing falls within a wider range of days (0.9 to 35.9 days) compared to those who sought NHS at the RHU (11.2 to 16.8 days). Patients born in the Category A NHS facility - a large regional hospital - would hail from various parts of the island, and presumably have a broader variety of life circumstances that can affect continuity of care. Furthermore, the lack of a confirmatory testing within the island required patients from the Category A NHS facility to travel by land and sea just to go to the nearest diagnostic facility. For those screened at the RHU, parents sought more immediate action, and perhaps within a more predictable time due to better accessibility to confirmatory services (e.g., the confirmatory center is within 30 minutes away by land travel). Furthermore, the RHUs assisted the families by reminding them of their child's appointment and at times, providing transportation to the testing facility. This provides an opportunity to weave in stronger and more specific LGU support to facilitate confirmatory diagnosis. These circumstances may explain the differences in the mean wait time from screening to confirmatory testing between those screened at the selected RHUs and the Category A NHS facility. However, we also note that these differences may have simply arisen by chance due to our limited samples.

A larger sample size is required to determine whether this differences in mean wait times between facilities are statistically significant.

Regardless, it is strategic that both approaches - *community-based and* hospital-based - must be embarked on to achieve *universal* newborn hearing screening. The Philippines has 929 private hospitals, 458 government hospitals, 662 infirmaries, 2366 birthing homes, 2590 city primary care health centers and RHUs.[10,15] The share of households, who are mostly from low-income groups, "who sought care in public hospital facilities and providers is almost twice as high (7 percent) than those who used private providers (4 percent)".[16,17]

In 2020, the NHSRC listed 1099 hearing screening, diagnostic, and intervention facilities across the country. Of these, 1072 (97.5%) are Category A Newborn Hearing Centers (NHCs), 13 (1.2%) Category B NHCs, 5 (0.5%) Category C NHCs, and 9 (0.8%) Category D NHCs. The accredited centers include both public and privately-owned facilities, varying from primary care centers, i.e., RHUs and birthing homes, to tertiary and specialized hospitals, as well as stand-alone service providers. A proportion of private facilities is stand-alone that operates by establishing partnership agreements with several public and private DOH-recognized health facilities. Though the NHSRC has noted an increase in the number of NHS facilities in the country, these facilities are mostly located in the NCR and other urban cities.

Two patients from Romblon were not referred through NTS because the nearest confirmatory center was in Manila. The patients were referred to a local ENT providing diagnostic services in the island. However, since the ENT had no fixed schedule for the test, confirmatory testing of the two patients was not done even after a four-week follow up within the HeLe research period. These infants would at least be 11 weeks and five days: almost the cut-off age where confirmatory testing is best done. This model of NHS is service delivery Model C and remains to be problematic. These two cases reflect a worrisome gap in the UNHSI program and affirms that the lack of a regular and predictable confirmatory testing service within the area severely delays care, especially early intervention for hearing loss.

Republic Act No. 11223, the Universal Health Care Law, promises to institute substantial health sector reforms to achieve better equity in health, including newborn hearing screening and hearing loss interventions. Chapters IV and V of the Law cite health care provider networks (HCPN) organized and contracted throughout the province- or city-wide health systems to deliver health services to all Filipinos. An HCPN is defined as "two or more organizations that, in the eyes of the client, are responsible for the provision of a connected overall service experience".[18] For the Pan American Health Organization (PAHO), an integrated health service delivery network or HCPN operationalizes Primary Health Care (PHC)-based systems that lead to services that are "more accessible, equitable, efficient, of higher technical quality, and that better fulfill citizens' expectations".[18] HCPN makes several of the most "essential elements of PHC-based health systems a reality such as universal coverage and access, first contact, comprehensive, integrated and continuous care, appropriate care, optimal organization and management, family and community orientation, and intersectoral action, among others".[18] Best practices can be seen in countries like Brazil, Canada, Chile, Costa Rica, and Cuba, which have long-standing support for such networks.

Lessons from these PAHO countries underpinned the HeLe research program. HCPN can be public, private or mixed. This study introduced a community-based mixed public-private HCPN for UNHSI. That is, the Category B newborn hearing confirmatory centers are privately owned and receive referrals from government RHU and hospital-based Category A newborn hearing screening centers involved in this study.

Incorporating the use of eHealth and telehealth in HCPN is/are also demonstrated in countries under the PAHO and European Regional Office[18,19], and in the US[20]. Public policy instruments and institutional mechanisms are necessary foundations.[18-20] Institutional arrangements are clinical and non-clinical guidelines and actions that are implemented in health service management. Telemedicine/ telehealth is identified as a clinical and institutional mechanism in an HCPN. Likewise, three measures shown to contribute to an effective telehealth-enabled HCPN are a single electronic clinical record, referral and counter-referral guidelines, duly supported and compensated health and allied professionals are also institutional clinical mechanisms to ensure coordinated care.[20] These elements were put in place in the HeLe. The UNHSI is enshrined in law and defined the referral and counter-referral guidelines.

Other policy and organizational enablers in HeLe are as follows: first, there was participatory governance. There was demonstration of clear leadership among institutions involved in the HCPN, the multi-sectoral governance and implementation teams (leadership of the RHUs, Category A, B to D facilities, and local chief executives, and the HeLe research team), a memorandum of agreement (a 'contract') bound the institutions. Second, there is a sound, scientific clinical policy, or basis for innovative mode of care delivery. The HeLe embedded the standard clinical practice guidelines of newborn hearing screening in the telereferral rules. There was investment for change management; that is, the HeLe - with partners - supported organizational and operational changes within the health system (participating RHU, Category A, and B to D NHC). Specifically, HeLe defined organizational processes and workflow of these medical institutions including integration of the electronic / telereferral, as well as documentation of these changes and spelling these out in the HCPN clinical (NHS) HeLe manual. These processes embedded provisions for the Data Privacy Act. HeLe engaged and retooled the health care

providers. Participatory measures meant partnership building and training the health workforce on the rationale and the organizational rules governing the use of NHS machines, the CHITS-NHS module, and the HeLe telehealth systems (referral and appointment), as well as building skills on these innovative eHealth technologies.

CONCLUSION

As research, the eHealth-enabled HeLe Service Delivery Model for UNHSI was able to excite and engage stakeholders with the demonstrated clinical and health system's efficacy. It has assured the parents of 582 infants of their hearing health, identified those with probable hearing loss, promptly referred these for confirmatory diagnosis, verified bilateral hearing loss in specific patients, and again, promptly referred these for definitive management. Since HeLe was implemented in health facilities that continue to provide services, the project already created demand for NHS in participating communities. At the conclusion of the study, the RHU already expressed trepidation for the (potential) costly maintenance (or acquisition) of the NHS machine. Likewise, sustainability of the institutional agreements for UNHSI and ensuring training of new NHS screeners are but two concerns that must be supported across time.

Nevertheless, the HeLe Service Delivery Model for UNHSI is promising. It addresses the challenges and needs of community-based NHS by establishing a healthcare provider network for NHS in the locale, providing a capacity-building program to train NHS screeners, and deploying health information systems that allows for documentation, web-based referral, and tracking of NHS patients. The model has the potential to be implemented on a larger scale – a deliberate step towards universal hearing health for all Filipinos.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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