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## Combined on-site and tele-education to develop a locally led audiometry service in Cambodia and Bangladesh

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### Abstract

There is a scarcity of audiological training programs in low-and middle-income settings. We aimed to co-develop an audiology training program combining on-site and tele-education at two locations: a charity hospital in Cambodia and a government hospital in Bangladesh. A novel program was designed to train local staff in pure tone audiometry which forms the basis of hearing assessment in adults. Prior to training, there were no in-house audiology services for patients. A combined short bespoke in-country training program, followed by ongoing support through remote live education enabled an audiometry set up. The model also consisted of continuing quality assurance during audiological assessments via an internet platform. The programs have allowed for successful training of seven local health care workers in Cambodia and two in Bangladesh, providing accurate hearing testing of adult patients, with associated streamlining of patient referral pathways. Trainee performance in both contexts has been positive. In Cambodia, trainees exhibit highly proficient audiological skills and assess over 1000 patients annually. In Bangladesh, trainees have gained competency in hearing screening. On-site training followed by remote support allowed for a low-cost model for audiological training. Critical to success was the motivation, trust and engagement of local staff, availability of equipment, and flexibility in teaching style. The program has proven a model of training health care workers in hearing assessments. An additional outcome of this cross-cultural collaboration has been the internationalisation of higher education at home.

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## Introduction

There is a scarcity of audiological training programs in low-and middle-income settings. Here we describe the development and implementation of a novel training model for hearing assessment, combining on-site and tele-education at two hospitals: in Cambodia and in Bangladesh. We report on learner outcomes, and on the effectiveness of the program in delivery of care both in the short and long term. We also discuss the subsequent outcome of collaboration between institutions and the exchange of knowledge, supporting internationalisation within the curriculum.

## Literature

On a global scale there is inadequate expertise to address the global burden of hearing loss (Bhutta., 2019). The repercussions of unaddressed hearing loss can have a significant impact on the individual, including delayed language acquisition, poorer education and employment outcomes, and socioeconomic impacts at both an individual and societal level (Graydon et al., 2019). The gap in adequate hearing healthcare infrastructure is particularly evident in low- and middle-income countries, where there is a growing mismatch between unmet needs and available resources. The World Health Organisation (WHO) World Report on Hearing highlights a number of these barriers in service provision, including workforce shortages, calling on member states to increase coverage of Ear and Hearing care (EHC) services by 20% by 2030 (World Health Organisation, 2021).

Developing audiology services where few or none exist, is a challenge (Bhutta et al., 2019). Within low- and middle-income countries (LMICs), those providing EHC services often lack the necessary training, skills, and knowledge to service the demand, especially in rural and remote locations (Waterworth et al., 2022). Several authors have described training workers in adult or paediatric hearing screening (Ramkumar et al., 2019; O'Donovan et al., 2019), but there are few publications on training in diagnostic audiology. A report from a charity hospital in the Dominican Republic (Carkeet et al., 2014) described training health-workers in basic audiological assessment through a three-month continuous education program, which later expanded to a two-year training program. The project was enabled by the long-term relocation of an audiologist from Australia to the Dominican Republic to deliver resident training and was associated with a cost of US\$1200 per student per annum. Logistical and financial constraints may make such a program difficult to scale or translate to other contexts.

Tele-education offers opportunity for pragmatic and low-cost training in audiology, and while useful for simplified and automated hearing screening programs (Swanepoel et al., 2010), may not be as effective in diagnostic training programs. Araujo et al., (2013) reported successful web-based education of community health workers in Brazil in infant hearing health but acknowledged the importance of ongoing training for knowledge retention. It is therefore likely sustained training of health care workers is necessary for effective diagnostic training models to be effective on delivery of care.

Upskilling local health care workers with specialised skills to deliver essential services in resource limited settings offers an additional benefit of promoting internationalisation within the curriculum. Universities are placing a strong emphasis on integrating international and

intercultural learning approaches within their academic programs to increase globalisation of education and the workforce. This emphasis can equip both staff and students with a broader perspective on international issues, enabling them to work more effectively in cross cultural collaboration and to gain intercultural competencies. Moreover, a relationship between a teaching institution and a resource limited training site has the potential to serve as a catalyst for developing a new model of collaboration, knowledge sharing, and increasing global awareness and global citizenship. As universities globally increase their role in international spaces, either as educators across borders, or as recipients of international students, adapting learning and teaching methodologies to promote cultural inclusivity and support is important.

## **Literature on Cambodia and Bangladesh**

### ***Cambodia***

Cambodia is a lower middle-income country that is predominantly rural with a population of over 16 million. During the 1970s as many as 2 million Cambodians lost their lives during the Khmer Rouge regime, with many of those health care workers. Since then, Cambodia has experienced a resurgence in population growth and economic growth. The recovery, however, has not been matched by a significant investment in public health care (Gryseels et al., 2019). The public health care in Cambodia is a decentralised three-tier system. The implementation of social health protection mechanisms, including the health equity fund amongst others, have significantly reduced out of pocket user fees, which has supported equity in access to affordable health services across the country (Annear et al., 2019). Although access to EHC is available through the public, private and non-governmental organisation sectors, a wide range of barriers remain, including a lack of EHC cadres, especially in the district health system, which is where most of the population first enter the health system (Waterworth et al., 2022). The Cambodia Demographic and Health Survey conducted in 2014 reported that 3% of individuals above the age of five suffer from hearing impairments (National Institute of Statistics DGfH, and ICF International). There is a lack of available information on ear diseases or hearing loss, making it challenging to determine the economic costs related to the unfulfilled demand. However, in the Asia Pacific region, prevalence has been estimated at 6.9%, which is amongst the highest in the world (WHO, 2018).

Between 2014 and 2016, two Cambodian doctors employed at the Children's Surgical Centre a charitable hospital in Phnom Penh, were trained to medically and surgically treat suppurative middle ear disease (Smith et al., 2018), supported by temporarily resident foreign Ear Nose and Throat (ENT) surgeons (Bhutta et al., 2019). The hospital, however, had no in-house audiology facilities to complement this program. An existing local charity (All Ears Cambodia, 2020) provided audiological services to the population of Cambodia through locally trained staff, but stated they were unable to support similar training and development at the Children's Surgical Centre hospital. To the authors knowledge, to date, there are no audiological specialty training programs in the public sector in Cambodia.

### ***Bangladesh***

Bangladesh is also a lower middle-income country with one of the highest population densities in the world, with an estimated population of 170 million people. The Rohingya people are a Muslim minority in Myanmar who had their citizenship removed in 1982 due to their inability to prove their forefathers had settled in Burma prior to 1823, a requirement to retain citizenship

(Burma Citizenship Law, 1982). A mass exodus of more than 742,000 Rohingya people took place in 2017 following waves of violence, though the Rohingya people have been fleeing Myanmar since the 1990s. More than 960,000 Rohingya refugees now live in the settlements in Bangladesh. An absence of census data relating to the Rohingya in Myanmar, means it is difficult to undertake a systematic review of their health status, however a recent review concluded that the Rohingya people face malnutrition, poor infant and child health, waterborne illness and lack of obstetric care (Mahmood et al., 2017).

Several surveys of the rural Bangladeshi population have shown that 5-6% of adults and children have chronic suppurative otitis media (Shaheen et al., 2014; Tarafder et al., 2015). However, there is no literature on the prevalence of CSOM amongst Rohingya refugees.

## Method

### Ethics

Ethics approval for this study was obtained from the Institutional Review Board of the Children's Surgical Centre. The study was exempt from ethical review in Bangladesh.

### Study design and settings

The study was conducted at two locations, with an initial needs assessment at each location.

#### ***Study location 1: Children's Surgical Centre (CSC) in Phnom Penh, Cambodia in September 2016.***

CSC is a non-governmental organisation that provides Ear Nose and Throat services, including mastoidectomy, tympanoplasty, tonsillectomy and adenoidectomy to impoverished patients free of charge. Although situated in Phnom Penh, the hospital serves patients from numerous rural communities outside the city, who rely on the facility for specialised medical care that is otherwise unavailable to them. Prior to our intervention CSC did not have the equipment or expertise to perform pre- or post-operative audiometric assessments to complement the surgical services provided. Consequently, patients had to travel to external audiology providers which were not always affordable, and they often encountered long waiting times. Many patients had already travelled long distances to reach the hospital, underscoring the imperative to offer this service locally.

As part of this study, three members of the Ear Nose and Throat team, two of the ENT nursing staff and the speech therapist, at CSC were purposively selected and invited to participate in the audiometric training program. Although the chosen staff members who participated in the study had knowledge relating to ear anatomy, none had received prior training in performing audiometric assessments.

The aim of the program was to implement a high-quality program for performing pure tone audiometric (PTA) (hearing) testing in adults. The objective was to develop competence in the hospital staff in audiological assessment, and to deliver a service that was ultimately locally led and sustainable.

Having established a clear need for the type of audiological services required at CSC, we formulated a novel strategy to ensure the successful implementation of an audiology training program. It was determined that the program would consist of initial on-site training and rapid

implementation, followed by subsequent remote support, education, and quality assurance. This was a pragmatic decision as it was evident that restrictions on resources and personnel at our institute would enable only short-duration visits by our team, with up to 2-3 visits per year, each lasting up to one week.

Initially, a needs assessment was conducted for the Cambodia team, to identify any potential barriers or challenges to implementation. This involved online discussions with the ENT team at the Children's Surgical Centre, which comprised two ENT doctors, three nurses, a speech therapist, and a UK-trained ENT surgeon (who was temporarily resident and helping to develop local services). Information was gathered on the access and availability of audiological equipment and training material in Cambodia, which was found to be limited. Additionally, there was a need to determine the proficiency in spoken English of the local staff.

As part of this needs assessment, we determined that to deliver ongoing remote education and quality assurance we needed a computer-based audiometer which could link to the internet. Prior to the initial visit, a clinical room was modified to provide an environment with low ambient noise levels, thus significantly reducing extraneous background noise and enabling accurate hearing assessments to be performed. Simple and cost-effective modifications included blocking gaps under the door and placing foam padding around the room.

Once the needs assessment was completed, we developed a tailored training program for the local staff. Similar to the training provided to the Master of Audiology students at the University of Melbourne, we included both theoretical and practical components. The training did differ from that of University of Melbourne training in that content was created based on needs of the Cambodian team; it needed to be easy to follow for non-English speaking students and could be referred to and adapted during and after the onsite visit. Teaching material was developed in consultation with the local ENT team at the Children's Surgical Centre. Several lectures and interactive tutorials covering introductory concepts were designed specifically for the Cambodian trainees. The teaching material had a strong focus on visual aids to circumvent the anticipated language barrier, and the fact that audiological test results are recorded graphically and symbolically, made such an ambition easier to achieve.

### ***Study location 2: Ukhiya Specialised Hospital in Cox's Bazaar, Bangladesh in October 2022.***

Ukhiya Specialised Hospital was constructed and equipped by UNHCR (the UN Refugee Agency) as a provider of specialist care to both the local community and the Rohingya refugee population. It opened in July 2022.

For the Bangladesh site, needs assessments were conducted via online meetings between the visiting European clinical team and the supporting team in Bangladesh. Information was gathered on the availability of audiological services, which were found to be non-existent. Due to limited access to electricity in the refugee camp, a portable battery powered screening audiometer was used. Hospital facilities did not include a sound treated room and physical modifications were not possible. Instead, we made adjustments to optimise testing conditions: isolating a clinical room from extraneous, environmental noise and minimising background noise to allow for accurate hearing assessment. Simple modifications included moving all footfall

activity away from the area, with two clinical rooms adjacent to the room used for assessment kept empty.

Following completion of the needs assessment, a theoretical and practical training program was developed, for four local doctors (considering the level of English proficiency of those enrolling in the program).

### **On-site intensive training**

The training program in Cambodia commenced in September 2016, with three Australian-trained audiologists from the University of Melbourne (each with at least 5 years' experience in university teaching), delivering a five-day intensive training course to two of the ENT nursing staff and the speech therapist at CSC.

The program combined theoretical and applied learning. Theoretical knowledge was delivered through didactic lectures in the English language, with PowerPoint slides to accommodate the fact that this was a second language for the trainees. Teaching comprised foundational concepts of basic audiology practice, including auditory anatomy, pure tone audiometry and masking. Knowledge acquisition was assessed by asking trainees to deliver a brief presentation to all hospital staff on what they had been taught. Applied learning was delivered in tandem with the theoretical knowledge so trainees could implement what they had learnt immediately. This comprised of trainees participating either as an observer during PTA, or by conducting PTA themselves under the direct supervision of an audiologist. To facilitate learning and mentorship, each trainee was paired with one visiting audiologist and all audiograms were conducted at elbow.

Experiential learning was student led rather than the typical model where teachers are in charge. The collaboration between teacher and student was an essential aspect of the program given the students would need to be responsible for their own learning, and critically reflect on their abilities once teachers were offsite following the intensive program. This teaching was based on values provided by Shor et al., (1987) whereby teachers encourage student-centered learning. Each trainee received approximately eight hours a day of direct one-on-one supervision which comprised both simple and highly complex audiograms, allowing trainees to practice both knowledge and skills. Over the course of the week, each trainee personally tested a minimum of 30 patients of varying complexity.

After five days of training, each trainee's accuracy in performing PTA was evaluated by assessing the frequency of supervisory intervention required. The pedagogical approaches consisted of a combination of the gradual release of responsibility model (Pearson et al., 1983) and Vygotsky's zone of proximal development (Vygotsky, 1978). Both theories supported effective learning, using scaffolding and supportive activities to ensure learners gained confidence over the weeklong trip. By the end of their onsite intensive training, all five trainees had gained confidence and required only infrequent or low-level supervision (i.e., only minor errors in testing corrected). Intervention was then able to continue to the next stage, comprising tele-education and remote support.

In Bangladesh the training took place in October 2022, delivered by a UK-based audiologist from University Hospitals Sussex NHS Foundation Trust. The training coincided with a visiting

surgical service to support development of local tympanoplasty services. Audiology lectures and presentations were designed, taking into consideration the level of education and knowledge of the trainees, as well as the fact that English was their second language. Teaching focused on foundations of basic audiology practice, including auditory anatomy, pure tone audiometry and an introduction to masking.

Two local ENT doctors and two local general doctors were trained with both theoretical lectures and practical basic audiology.

Learning was assessed by trainees presenting their knowledge acquisition back to the Audiologist, testing each other, with reassessment occurring remotely four weeks post training. Practical audiology training focused on air conduction testing, however an introduction to bone conduction testing and masking was also part of the training program – though not a focus as the audiometer donated to the hospital did not have bone conduction testing capability.

Theory and practice were delivered in conjunction with trainees observing hearing testing, performing screening audiometry on each other under direct supervision and then on patients under direct supervision of the audiologist. The final step of the training was for trainees to perform screening audiometry unsupervised on each other with repeated PTA conducted by the audiologist to corroborate their findings. Results matched those of the trainees, confirming the validity of the training program.

Both local ENT doctors engaged heavily with the training and their motivation was key to the success of the training project. The two local general doctors failed to engage and didn't complete the training program.

### **Tele-education**

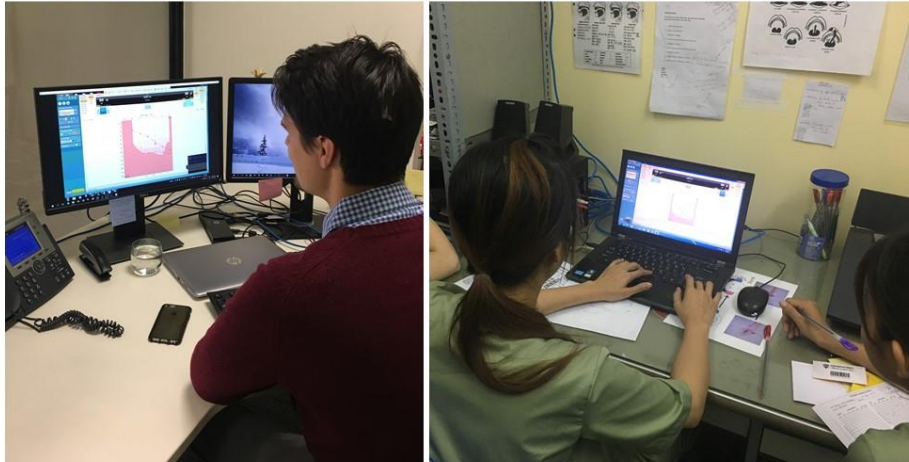
Subsequent to the intensive onsite visit, and for the first few weeks of initiating services, in Cambodia all audiological testing was performed with a live link between the local staff at CSC and a member of the audiology team at the University of Melbourne. Free-to-access software (e.g. WhatsApp, Teamviewer and AnyDesk) was used to view every audiological assessment in real-time, including the sequence and settings used on the audiometer, and to provide immediate instruction and feedback to trainees (see Figure 1). The ability to monitor real time ensured trainees were supported and allowed trainers to aid the consolidation of skills and knowledge.

The working relationship that was established during the onsite visit allowed for ease of communication and a supportive remote learning environment as trainees became more skilled with their testing. As the trainees gained confidence and competence, less and less instruction was provided but the oversight by University of Melbourne staff online was maintained. Given the time difference, patients had to be scheduled for a time of day that would allow for remote monitoring. This was not problematic as the University staff were willing and able to work outside of work hours to assist in ensuring skills were maintained as well as the accuracy of each audiogram. This required significant patience from both the trainees and trainers given the complexity of the audiograms which could sometimes take an hour per patient to complete. Given the complexity in testing, it was important that constant communication was maintained during monitoring to reassure trainees. After each complex test, debriefing occurred between

the trainee and the trainer, helping to consolidate knowledge but also to help keep trainees feeling positive and enthusiastic about their learning as often complex testing may cause students to become discouraged and to doubt their understanding.

### **Figure 1**

#### *Real-time Monitoring of Audiological Assessment Using Free-to-Access Software*



In Bangladesh, four weeks after the onsite training, the two doctors received a one-day tele-education session. This was delivered live via WhatsApp video call, with every audiological assessment supervised. This included setting up the room acoustically, ensuring extraneous background noise was reduced as much as possible, and checks completed on the audiometer prior to testing. Instruction given by the Audiologist reduced as the trainees gained confidence, but oversight was maintained throughout the session.

Six weeks after in-person testing, audiometry was performed by the two trainees with real-time supervision by the Audiologist via WhatsApp. Due to time difference constraints and appointment times, only patients tested after 11am local time were monitored remotely. Patients whose testing proved challenging, or where the trainees had doubts about the results, were rescheduled for testing later in the day to allow for remote monitoring. Two such cases were identified and discussed via WhatsApp video call, where the trainees identified concerns with the test results/patients' ability to accurately perform testing. Repeat testing was completed with real-time supervision and the results obtained corroborated with those obtained originally. Constant communication via WhatsApp messaging was maintained during the six-week period whenever the trainees had queries. This was essential to ensure quality control of the training even when performing complex testing. During this period, trainees continued with hearing screening, helping to build confidence (see Figure 2).



## Figure 2

### *Local Bangladeshi Doctor Performing Hearing Assessment*



Since the initial training, and prior to measurement of learner outcomes, there were another three onsite visits to Cambodia (the timing of these visits was based upon trainer availability rather than as a structured component of the teaching program). During one of these visits, we recapitulated this program of on-site and subsequent remote education for another two trainees (ENT nursing background), making a total of five trainees trained.

### **Assessment of outcomes**

At eighteen months after the initial training program, trainee performance in Cambodia was measured. Performance was determined using computer pre-programmed pure tone audiograms developed in-house and provided to trainees in the English language on OTIS- a virtual patient software program. The OTIS software assesses the trainee's ability to obtain a full complex audiogram, with assessment based on accuracy of the results (i.e. similarity between the pre-programmed audiogram and the audiogram that is obtained by the trainee). The standard of assessment was similar to that for assessing students in the University of Melbourne *Master of Clinical Audiology* degree.

At the time of writing the trainees in Bangladesh have not learnt bone conduction (but is scheduled) and so assessment with the OTIS- platform is as yet not appropriate.

Establishing the performance of audiological training is important, but alone does not provide understanding of how and why a program succeeds. Whilst most studies focus on outcome-oriented goals, we also incorporated analysis of process-oriented factors, including the impact on the learning of trainees, to gain insight into experiences from the trainee's point of view.

Overall perceptions from the five Cambodian trainees and two Bangladeshi on the benefits and challenges of this training program were reported through informal semi-structured interviews conducted with the external training team face to face (Cambodia) or remotely (Bangladesh). Trainees were asked four questions, "What have been the benefits in using tele-education for training"; "What are the benefits to patients?"; "What are the benefits to the hospital?"; "What have been the challenges?" Responses were documented and summarized; however, a formal thematic analysis was not undertaken.

## Results

### Assessment of performance

Each Cambodian trainee achieved a score of >70% score on the OTIS assessment. This is equivalent to a pass using a marking rubric utilised for the University of Melbourne Master of Clinical Audiology course. Results suggest trainees were proficient in both simple and complex audiological assessments and confirmed their technical know-how.

### Trainee interviews

Overall, the five trainees in Cambodia and the two in Bangladesh reported positive experiences of the training program. When asked about the benefits of the program, the trainees expressed that they felt supported through a collaborative team-based approach. The use of the mobile-based social networking platform WhatsApp, which all trainees were already familiar with using, was particularly instrumental in connecting participants on the one platform. One trainee from Cambodia highlighted, "we already know about things like 'WhatsApp', as this is how we would usually communicate every day." The trainees also emphasised the platform's effectiveness in facilitating teamwork and rapid cross-country communication, as another trainee from Cambodia noted, "everyone can work together in a team, sharing information to many people all at once." Additionally, a trainee from Bangladesh emphasised the role of remote training in acquiring new skills and staying connected at all times, stating, "remote training helped to learn new skills and also was able to be connected with you at all times for any kind of questions which supported to minimise mistakes."

This helped overcome the issue of distance between in-country visits in an open, efficient, effective, and timely way, where all participants could ask for assistance. Trainees from Cambodia noted that "everyone can see what we do and assess whether it's correct or not" and "It's good we can complete testing and discuss each case and come up with a solution together." Additionally, trainees described how tele-education was a much more efficient way of learning due to the continuity of their learning in a safe and respectful environment. For instance, a Cambodian trainee mentioned that "we talk everyday so we are accurate in testing now. Although we have spent many hours training, we have learnt much faster than a traditional mission where we only see our colleagues for training every four months."

Trainees also described several benefits to patients, including reduced travel time and out-of-pocket costs, improved health literacy, and enhanced health outcomes. The program facilitated the streamlining of treatment pathways, reduction in waiting times for surgery, and improved tracking of post-operative outcomes. According to one trainee from Cambodia, "the patient can now save time and money by not traveling to another place." Additionally, the trainees highlighted the program's impact on patient education and support. As expressed by another trainee from Cambodia, "we can advise our patient how they can protect their hearing from noise exposure," and further emphasised, "if the patient has hearing loss, we can provide a hearing aid, so they can go to work." The immediacy of diagnostic testing was underscored by a trainee from Cambodia who stated, "there is no delay in testing, so we can identify the problem of the patient on the same day, and the patient does not have to wait for an operation."

In Bangladesh, a trainee noted, "patients received consultations and also treatment, which are not easily available here; along with it, patients get to know about the extent of their hearing loss." Furthermore, the program's impact on post-operative care and reporting was emphasised by a trainee from Cambodia who said, "it has helped our doctors track post-operative outcomes and their reporting." Lastly, a trainee from Bangladesh highlighted the significance of the training in a camp setting where ENT specialists or audiologists are not readily available, stating, "in our camp setting, there is no ENT specialist or audiologist available; however, ear disease is seen commonly. This training benefited the attending doctor who regularly works at the camp setting to consult the patients."

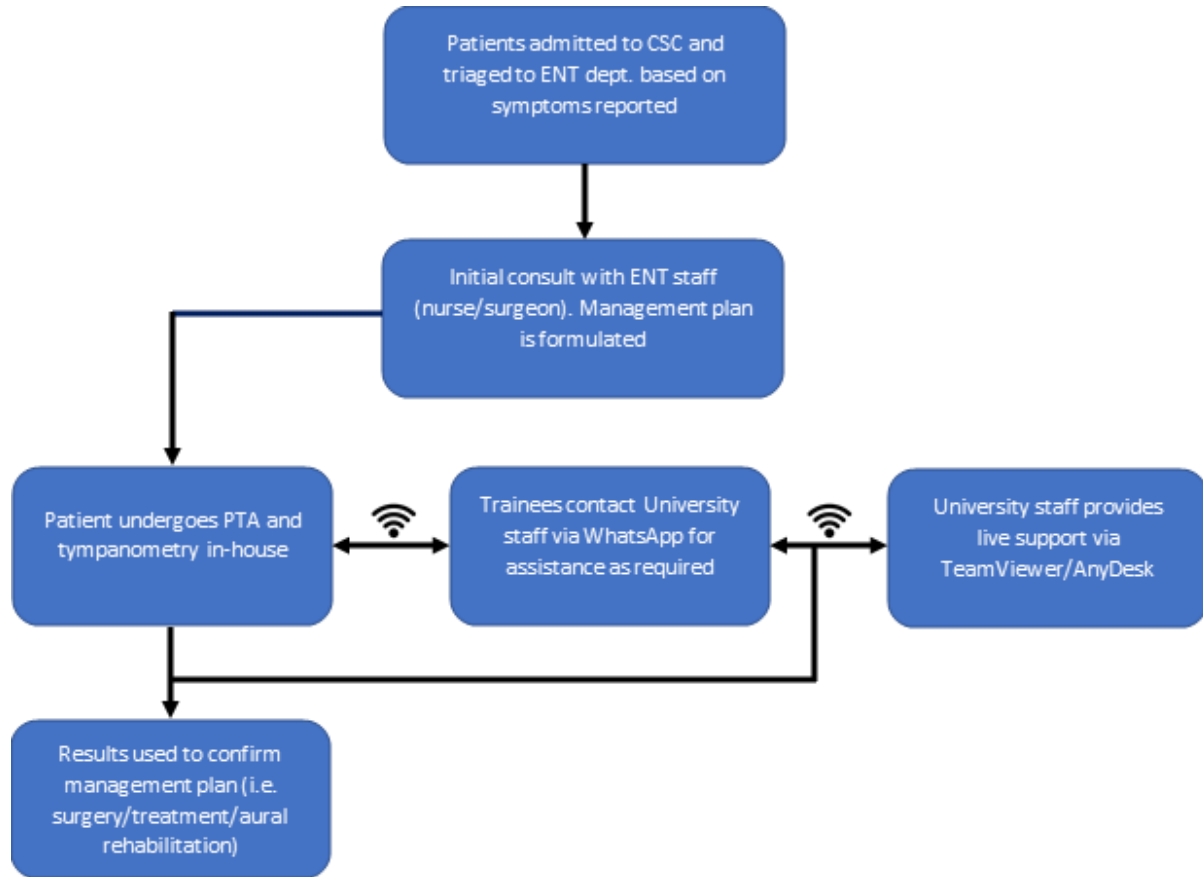
Challenges that were identified included disruption in remote training due to poor internet connectivity and technical issues, non-availability of remote training staff when dealing with a complex case, and/or language barriers. Trainees from Cambodia pointed out the impact of internet connectivity issues, with one trainee stating, "when the internet is slow, we cannot do anything." Another trainee from Cambodia highlighted language barriers and the availability of trainers as challenges, noting, "sometimes there is a problem with communication due to the language barrier, but also availability of clinicians can be a problem. For example, when the trainers are not available, it's difficult as we need to wait for a response [on WhatsApp]."

In Bangladesh, challenges related to internet connectivity were also emphasised, as expressed by a trainee who mentioned, "challenges in remote training were mainly internet connection. The venue we did the training in had Wi-Fi service, but the network was not good, so we had to connect 2-3 devices. If one was disconnected, we connected with the other one." Additionally, the coordination of training sessions across different time zones and government holidays posed scheduling challenges, as mentioned by another trainee, "the trainer was fully cooperative; however, we often had to select a time and date after rescheduling due to time differences and government holidays."

The collaborative nature of addressing challenges was also highlighted by a trainee from Cambodia who emphasised, "sometimes I try to understand, and I do try. I need to ask other trainees when trainers aren't available." Other challenges in training included task-sharing responsibilities and the associated pressures of working in a busy hospital setting. As expressed by a trainee from Cambodia, "when we have a lot of patients, consultations, or we have a lot of operations, it's difficult for us to study." In Bangladesh, the lack of available resources or equipment to perform additional investigations meant individuals were unable to complete full assessments and management, which were important for their training. A trainee from Bangladesh articulated this concern, stating, "our main challenge is the lack of available medicine for patients, especially within camps. Also, sometimes some diseases require investigations which are not regularly available, so it becomes a challenge to fully implement the teachings of training."

**Figure 3**

Audiological Workflow to Aid the Training Program in Cambodia.



## Discussion

Through this work, we demonstrate the feasibility and practicality of developing and implementing an audiology training program and locally led adult audiology service in a lower middle-income country. Our approach involves intensive on-site training in theoretical and applied knowledge, and subsequent remote live educational support and quality assurance. As a result of this program Cambodian trainees exhibit highly proficient audiological skills and assess over 1000 patients annually. In Bangladesh, trainees have gained competency in hearing screening, but are not testing at the scale at the Cambodia site.

Pre-requisites we identify as critical to success include committed and motivated trainers and trainees, suitable equipment, and financial resources. Both the on-site and remote education aspects were regarded as integral aspects of the program both short term and long term. The on-site training allowed intense initial training, but also the important development of relationships with local staff. The online platform-maintained engagement, encouragement, training, and supervision. Subsequent on-site visits further reinforced the established relationships and ensured maintenance of the quality of the service provided.

The program was designed with a crucial balance between strict goal setting and outcome expectations, and flexibility in the methods used to achieve them. This approach accommodates diverse learning styles and empowers local staff to tailor the service to suit local culture, resources, and needs. Overall, it is ownership of the service by local staff that has led to the service being sustained, and one that strives for continual high standards and further development.

In both study sites, the barriers identified were poor internet connectivity and time zone differences, making real-time support problematic. In Cambodia although every audiogram is signed off by a University of Melbourne staff member, there were occasions where poor internet connectivity meant a patient would leave the hospital before the audiogram had been verified. If the audiogram was found to have an error (in total, 4-5 minor errors identified over the four years of the program), the audiogram would be repeated (and signed off) prior to any medical management being provided. Language barriers could usually be overcome through the utilisation of visual aids, or use of an internet translation service.

### **Ongoing collaboration**

Both trainers and the trainees feel the program has been successful. The team continues to supplement remote education with occasional short-term site visits to Cambodia and Bangladesh, which have allowed for the maintenance of relationships, discussions on service development and quality standards, further consolidation of knowledge and skills, and have provided opportunities to train additional staff. The computer-based modules on OTIS have proven to be effective tools for training and assessment in Cambodia, further enabling trainees to strengthen clinical skills and reduce their reliance on remote support.

Two additional staff members in Cambodia (from a nursing background) have now been trained also using the same program (a total of seven now trained in Cambodia). The recent introduction of a 'train the trainer' model has helped to ensure program sustainability and that the program is locally led, owned, and maintained.

Every audiogram conducted at CSC continues to be viewed by the University of Melbourne team using WhatsApp (post testing), or in-person (live) during visits. Oversight of the audiograms continues to ensure accuracy so only verified reports are included in the patient file. There is also ongoing assistance with difficult cases and periodic evaluation to assess consistency of competency. Patients whose testing proved complex, or the trainees had doubts about the results are rescheduled for testing in conjunction with availability of University of Melbourne staff to allow for live remote monitoring. Figure 3 outlines the audiological workflow enabled through this training, which has led to a high-quality service and improved patient flow. According to our evaluation, all trainees can complete assessments for patients with complex hearing configurations, including air and bone conduction thresholds and masking, and only minor corrections are required in an estimated 2-3% of all cases. This is comparable to the performance of junior colleagues in the Audiology profession, achieving the aim of establishing a program that is locally run, capable of delivering a high-quality service that is largely independent of external input.

In Cambodia, the program has expanded to offer a wider range of services, including tympanometry, paediatric diagnostic services and aural rehabilitation. Local trainees fit low cost

behind-the-ear hearing aids and create custom ear moulds in an on-site laboratory, which are then provided to recipients free of charge. A sound-treated room has also been built using locally sourced materials such as acoustic foam, egg cartons and other sound absorbing materials to allow for pediatric hearing assessments. In the future, the program aims to introduce newborn hearing assessments, and a cochlear implant program with remote programming support, following a similar training approach to the PTA program. The program's philosophy is to not only foster local empowerment but also ensure access to suitable and necessary follow-up interventions for all services offered. Hence, the program is structured to only provide services that will have this capability.

The program in Bangladesh is at an earlier stage, and there is need for further investment in capacity building and in developing skill-based competencies of trainees. The intention is that trainees will soon be able to diagnose more complex hearing configurations independently, and continue to develop and expand, mirroring the changes in Cambodia.

### **Implications for internationalisation and developing intercultural competency**

Initially, each program set out to offer audiological assessments to the community, addressing the resource gaps in the local health facility. While each program has undeniably delivered significant benefits to the community by offering improved management of hearing and ear-related disorders, several other positive outcomes have emerged. The collaborative relationships established among international institutions, particularly the longstanding relationship between the Melbourne and Cambodian groups, have created a sense of interconnectedness, and also played a pivotal role in developing intercultural competency. By working closely with international counterparts from a different cultural background, all participants have been exposed to diverse perspectives, communication styles and approaches to hearing healthcare. As a result, participants have not only honed their intercultural communication skills, but have also become more adept at navigating the complexities of cross-cultural collaboration which have extended beyond the realm of hearing healthcare.

The program has also contributed to the education of staff in a resource-limited setting, promoting global community engagement and global citizenship. This initiative has not only motivated staff from both universities and hospitals alike to make a meaningful contribution, but has also cultivated a profound sense of purpose and achievement.

Ongoing engagement and collaboration have become an integral part of the curriculum for audiology students at the University of Melbourne. This program aims to expose students to healthcare environments in low resource and culturally diverse settings, emphasising the importance of giving back, whilst simultaneously serving as a catalyst for developing intercultural competency. Moreover, the program has enabled local staff to develop skills and knowledge that would have otherwise been inaccessible to them, resulting in increased autonomy and empowerment. The trained staff have emerged as leaders in each healthcare setting and are highly regarded for their additional expertise. Through this education initiative, Cambodian staff have attained a distinct position in their team, specialising in a particular area and gaining greater autonomy and value within their team.

The internationalisation of audiology higher education at home continues, particularly given its increasing importance in our evolving world. With the globalisation of the economy and

advancements in technology, it is essential for tertiary audiology programs to prepare their students for a globalised profession. This international collaboration and partnership will continue to facilitate the exchange of knowledge and best practices, with a future focus on enhanced research and innovation in the field. The collaboration is also helping to address global hearing healthcare disparities, by working to improve awareness for future students who will be able to continue to promote access to care and increase the capacity of healthcare systems in resource limited settings.

## **Conclusion**

The training program, combining on-site and remote education was a knowledge exchange and capacity building exercise, in which self-reliance has been fostered. The programs most importantly have encouraged locally led and sustainable hearing testing which has become life-changing for local staff and patients. This model can be replicated for relatively little financial expense, modified to local needs and capabilities in other low resource settings, and adapted dynamically and interactively. Thus, the model holds promise, and has been proven replicable, as a scalable method to develop infrastructure and capacity for diagnosis and treatment of hearing loss.

Furthermore, the exchange and training program discussed in this paper emphasises that internationalisation can enhance the quality of audiology education by providing all members of the program with diverse perspectives, cultural competence, and international experiences, which help prepare students to work with diverse patient populations. The exposure to different cultures and realities is also beneficial to trainers, increasing awareness of diverse work cultures and better preparing audiologists to work with varied patient populations by adapting their approach to and techniques of testing.

The process outlined in the paper requires careful planning, investment, and collaboration among stakeholders. The paper has highlighted the need for institutions to create supportive policies, offer language and intercultural training, develop partnerships with international institutions, and use technology to facilitate communication and collaboration.

## **Conflict of Interest**

The author(s) disclose that they have no actual or perceived conflicts of interest. The authors disclose that they have not received any funding for this manuscript beyond resourcing for academic time at their respective university. The authors have produced this manuscript without artificial intelligence support.

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