Ear, Nose & Throat Journal
1–6

DOI: 10.1177/0145561320950992
journals.sagepub.com/home/ear
SAGE

Comprehensive Community Screening of Otological Patients by Trained Technicians Using a Telemedicine Device: An Efficient and Cost-Effective Way to Triage Patients With Ear Diseases

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Abstract

Objective: To emphasize the benefits of tele-otology in community screening of patients with ear diseases. **Methods:** A retrospective study of all patients screened and treated under the Shruti tele-otology program between 2013 and 2019 was conducted. It involved screening, diagnosis, medical management, surgical intervention, and rehabilitation using hearing aid. The study focused on underprivileged and underserved community of rural and urban slums across 12 states of India. The study was conducted using a telemedicine device called ENTraview, that is, a camera-enabled android phone integrated with an otoscope and audiometry screening. **Result:** A total of 810 746 people were screened, and incidence of various ear diseases was recorded. Ear problems were found in 265 615 (33%) patients, of which 151 067 (57%) had impacted wax, 46 792(18%) had chronic suppurative otitis media, 27 875 (10%) had diminished hearing, 12 729 (5%) had acute otitis media and acute suppurative otitis media (ASOM), and 27 152 (10%) had problems of foreign body, otomycosis, and so on. Of the total 265 615 referred patients, 20 986 (8%) reported for treatment and received treatment at a significantly reduced cost through Shruti program partners. The conversion rate of nonsurgical and surgical procedure was also compared, and it was found that, while 9% of the patients opted for nonsurgical treatment, only 3% opted for surgery in the intervention group giving a significant *P* value of .00001. **Conclusion:** The potential for telemedicine to reduce inequalities in health care is immense but remains underutilized. Shruti has largely been able to bridge this gap as it is an innovative, fast, and effective programs that address the ear ailment in the community.

Keywords

tele-otology, ENTraview device, telemedicine, community ear screening, hearing loss

Introduction

Hearing loss is a growing, yet often undiscussed, public health concern.[1] According to World Health Organization (WHO), over 5% of the world's population comprising of 466 million people have disabling hearing loss, and by 2050, over 900 million people (1 in every 10 people) will have disabling hearing loss.[2] Globally, hearing loss has been identified as the fifth leading cause of years lived with disability.[3] In India, 6.3% of the population is estimated to have some level of hearing loss.[4] Untreated hearing loss significantly impacts communication abilities, quality of life, and has serious psychosocial and economic ramifications.[5]

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Received: April 28, 2020; revised: July 27, 2020; accepted: July 28, 2020

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Given the inadequate ear care infrastructure of the country and the immense need within underserved population, Medtronic developed Shruti program as an innovative cost-effective way to address the problem of ear disease and hearing loss, across the care continuum of screening, referral, and treatment. Shruti is the first technology-driven program that has integrated comprehensive ear care involving screening, diagnosis, treatment, and hearing rehabilitation of the individuals identified with ear problems. The program was launched in 2013 as a pilot project,[6] and in early 2017, Shruti was launched as a social business across India. Shruti has collaborated with several state governments, private hospitals, and organizations to provide quality ear care to patients at a significantly lower cost. Shruti partnered sites are functional in many states like Punjab, Haryana, Uttarakhand, Delhi, Uttar Pradesh, Bihar, West Bengal, Telangana, Assam, Karnataka, Tamil Nadu, Madhya Pradesh, Rajasthan, Gujarat, and Maharashtra. Shruti has collaborated with Delhi government under National Program for Prevention and Control of Deafness (NPPCD) to run successful pilots. Pilots were run with the Delhi government under NPPCD and mobile health scheme. The objective of the pilot was to assess the feasibility of operating this technology by a paramedical staff in a community where infrastructure was lacking. Such partnerships with the government can lead to a significant improvement in awareness and access to treatment for people with ear problems.

Methods

A retrospective study was conducted at SCEH, of all the patients screened and treated under the program between 2013 and 2019. The study was approved by the institutional review board at SCEH (IRB/2019/Aug/30). It involved screening, diagnosis, medical management, surgical intervention, and hearing aid dispensing. The study focused on underprivileged, underserved community of rural, and urban slums across 12 states of India. Written informed consent was obtained from all study participants.

The Delhi government pilot was conducted by Community Health Workers at 3 sites in Delhi City including 2 construction sites and at community assembly of a village, where no other specialized health centers or infrastructure existed. The screening was carried out for a period of 7 days, and 470 patients (incorporated into the main data) were identified with ear problems. All these cases were sent to the medical officer in charge of mobile health services and those that needed further interventions were referred to the nearest district hospitals.

The telemedicine device used in our study was known as ENTraview (Medtronic, Inc), a camera-enabled android phone integrated with an otoscope, audiometry screening, and a rechargeable, battery-operated light source (Figure 1). The digital camera of the smartphone captures tympanic membrane image and stores it in the memory of the smartphone, and a noise-isolating headset enables audiometry screening in semi-noisy environment. ENTraview utilizes smartphone technology and uses a store-and-forward form of telemedicine through a cloud based data management platform.

Figure 1. ENTraview.

In this store and forward technology, there is an asynchronous communication in which the health workers obtain images and collect data from the patient. The details are sent to the cloud based data platform, where the consulting otorhinolaryngologist reviews and responds at his/her convenience as described earlier.[6] This is called store and forward technology because there is no real time consultation and most of the provisional screening and diagnosis work is done by health workers.

This store and forward technology is different from a video link consultation that is also known as real-time consultation as described by Loane et al.[7] In real-time tele-otology, the physician can interact with the patient and can obtain relevant clinical information.[7] However, he/she needs to be assisted by a local technician who clicks images and facilitates a physician in interacting with the patient. All that arrangement is expensive while store and forward technology are cheaper, practical, and easily replicable across several centers.

ENTraview Device

ENTraview allows community health workers to screen patient and generate a case with a unique identification number using an embedded app in the smartphone. The case comprises of demographic details, history of various symptoms, a picture of the tympanic membrane, and the provisional diagnosis made by the field worker. Based on the provisional diagnosis, community health workers counsel the identified patients for an in-clinic ENT and/or audiology examination and relevant investigations.

Patients with diminished hearing complaints also undergo hearing screening in the field through tele-audiology. In tele-audiology ENTraview device is used to administer air conduction threshold screening at 4 speech frequencies: 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. The ENTraview kit also contains a calibrated headset which is enabled with circumaural stereo isolation headphones, with overall noise levels reduced by 25 db. A flow chart has been given below to explain the process of screening and further intervention (Figure 2).

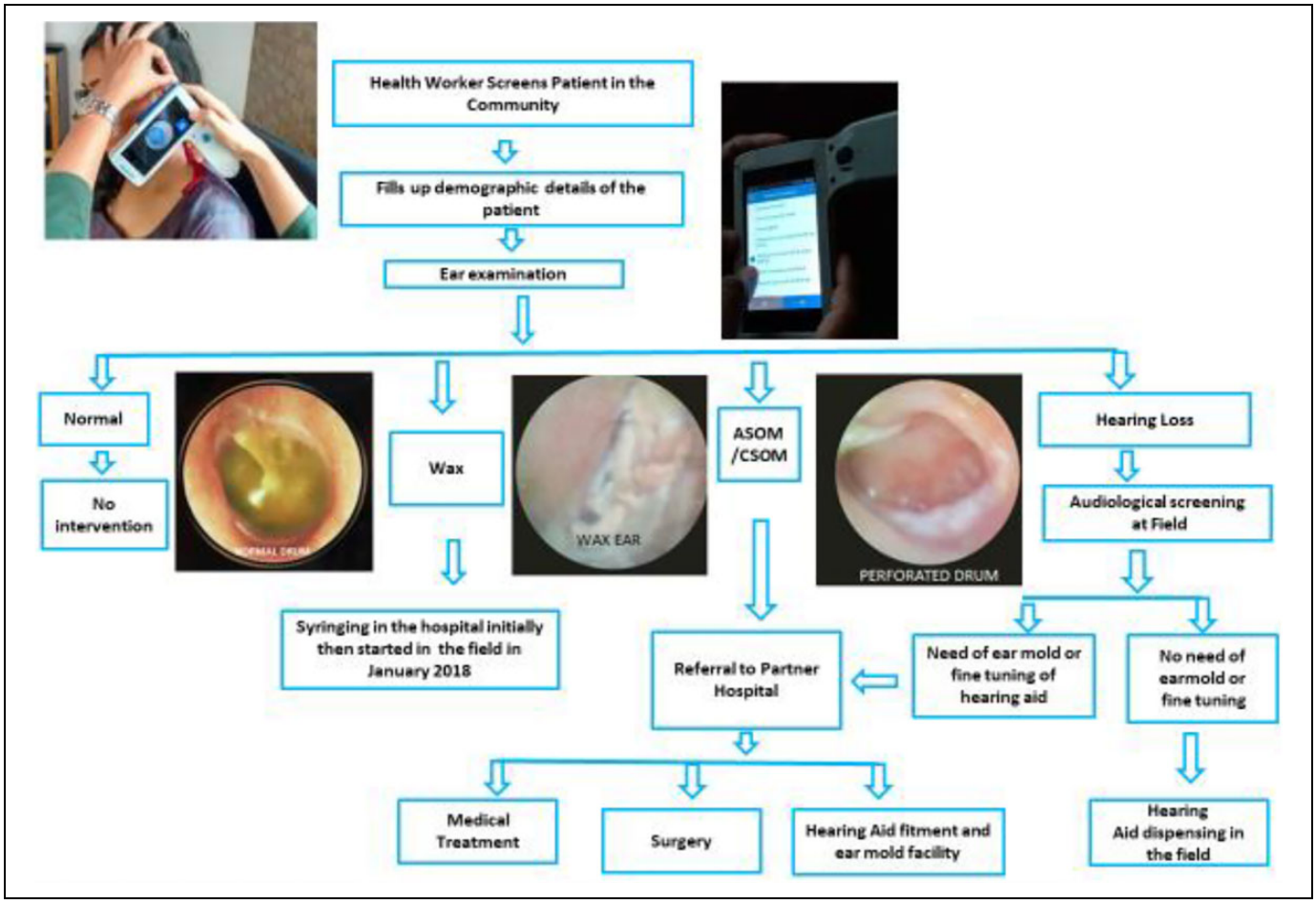

Figure 2. Flow chart. AOM indicates acute otitis media, ASOM, acute suppurative otitis media; CSOM, chronic suppurative otitis media.

Community health workers are trained on ENTraview device and field screening work using a curriculum based on the modules of Primary Ear and Hearing Care program developed by WHO.[8] This curriculum was approved by the NSDC (National Skill Development Corporation) Government of India, ministry of skill development, and entrepreneurship in 2019.

The curriculum includes comprehensive training to operate the otoscope, examination of anatomy and physiology of the ear, symptomatic approach to ear diseases, and community ear care with hands-on sessions on the device and role-plays. Special emphasis is given to empathetic patient counseling.

Results

Over the past 7 years, Shruti has become operational across India in 12 states and 115 hospitals and clinics. In this network, 205 trained community health care workers screened 8 42 284 people till June 2020. Incidence of various ear conditions identified out of total population screened in the community has been depicted in Table 1. The diagnostic breakdown of various entities had a CI of 95% of the estimated incidence rate.

Distribution of 2 65 615 patients identified with ear problem concluded that 151 067 (57%) had impacted wax; 46 792 (18%) had chronic suppurative otitis media (CSOM); 27 875 (10%) were of diminished hearing; 27 152 (10%) were of foreign body, otomycosis, and so on; and 12 729 (5%) were of acute otitis media/acute suppurative otitis media.

All the above-identified 2 65 615 patients were referred for treatment, but only 20986 (8%) reported at the base hospital. Following this, a barrier study was done, and the results have been depicted in Table 2. As a result of community intervention

Table 1. Incidence of Various Ear Conditions in the Indian Community.

Diagnosis	Number	Incidence	95% CI
Impacted wax	1 51 067	18.63%	(18.55%-18.72%)
CSOM	42 528	5.25%	(5.2%-5.29%)
Diminished hearing	27 875	3.44%	(3.4%-3.48%)
ASOM	6777	0.84%	(0.82%-0.86%)
AOM	5952	0.73%	(0.72%-0.75%)
CSOM, diminished hearing	4264	0.53%	(0.51%-0.54%)
Foreign body	1767	0.22%	(0.21%-0.23%)
Others	25385	3.13%	(3.09%-3.17%)
Total screening	8 10 746		

Abbreviations: ASOM, acute suppurative otitis media; CSOM, chronic suppurative otitis media.

following barrier study, the conversion rate of patient seeking treatment improved. It was found that additional 29218 (11%) opted treatment at the nearby facility, and 16221 (6%) were later treated at their doorstep with wax dis-impaction and hearing aid fitting leading to an overall 64116 (25%) patients seeking treatment (Table 3).

The conversion rate of nonsurgical and surgical procedure was also compared, and it was found that 9% patients opted for nonsurgical treatment (medical management, hearing aid, foreign body, impacted wax, and others) and only 3% opted for surgery (myringoplasty, tympanoplasty, modified radical mastoidectomy, and myringotomy with grommet insertion) in the intervention group giving a significant *P* value of .00001 (Table 4). Postoperative surgical audit done at Delhi setup revealed successful outcome in 92.5% cases at the end of 1 year.

Table 2. Results of Barrier Study Based on a Questionnaire That Was Prepared to Understand the Factors Responsible for Poor Reporting for Treatment.

S. No	Parameters	No of patients	Percentage (%)
1	Total patients identified/referred	2 65 615	100
2	Did not consider ear ailments as critical and urgent	79 685	30
3	Difficulty travelling to the base hospital	69 060	26
4	Operational error (not contactable)	61 091	23
5	Opted treatment at the nearby facility	29 218	11
6	Financial constraints	15 937	6
7	Other issues	10 624	4

Table 3. Overall Number of Patients Who Benefitted From the Treatment.

S. No	Parameters	No of patients	Percentage (%)
1	Total patients identified/referred	2 65 615	100
2	Reported at the base hospital	20 986	8
3	Opted treatment at the nearby facility	29 218	11
4	Treated at their doorstep (following barrier study data citing traveling difficulty as a reason for not reporting)	16 221	6
5	Total no of patients who received treatment	66 425	25

Discussion

Hearing loss has an enormous global economic impact, estimated at 750 billion dollars annually, with 63% to 73% of these costs incurred in low-income or middle-income countries.[5] Due to the high multitude of other health issues, hearing loss is not acknowledged despite the high burden and therefore does not get priority in a limited resource setting.[5]

As a result, ear disease remains a neglected problem, both by the patients and by our existing health care system. It neither gets enough community health support nor does it generate serious patient attention because of widespread community myths and lack of awareness.[6] Chronic suppurative otitis media may contribute more than half the global burden of hearing impairment, and eliminating it can potentially reduce the global burden by four-fifth.[6,9]

According to a 2004 WHO report on otitis media, the prevalence of CSOM in South Asia is more than 4.4%.[2] India is burdened with the highest prevalence of children with chronic suppurative otitis media and 77% of CSOM cases in India are associated with hearing impairment.[2] Common barriers related to the screening and management of patients of hearing loss include cost and availability of trained professionals, acceptance of the hearing loss, language and cultural differences, secondary disabilities, and mental health issues.[10] To address these significant barriers, in 2013, Medtronic implemented the Shruti Program in 2013 and has continued to scale it.[11]

Though we have come a long way with the screening of over 842 284 patients across 12 states, community motivation remains a major challenge that was evident from our study. It was found that only 8% patients reached the hospital for further treatment despite the hard work of promoting, educating, sensitizing, and motivating the community in addition to creating a fast track route for them at the partner hospital.

Looking at the low footfall, we initiated a barrier study in January 2018. A questionnaire was prepared, and the patients were interviewed telephonically (Table 2). On data analysis, 2 important observations came up: 1, that 26% patients showed interest and were willing to be treated and provided the facility made available to them in the field itself without the need of going to the hospital; and 2, 11% patients had approached a different, nearby hospital for treatment. This reinforces the fact that distance and travel are a deterrent for patients to seek treatment. Therefore, the facility of wax dis-impaction and field-based audiology with hearing aid fitment was started in the community that led to the conversion of an additional 6%

Table 4. Conversion Rate for Surgical Procedures and Nonsurgical Treatment.

Treatment	Number referred	Number of patients who presented	% of patients who presented	$P < .05$
Total referral	2 65 615	20 986	8%	
Surgical conversion (myringoplasty, tympanoplasty, modified radical mastoidectomy, myringotomy with grommet insertion)	46 792 (CSOM data)	1539	3%	
Nonsurgical conversion	2 18 823	19 450	9%	.00001

Abbreviations: CSOM, chronic suppurative otitis media.

patients who availed treatment. Thus, total 25% patients (8% at base hospital + 11% in the community + 6% at the doorstep facility, Table 3) received treatment.

Hearing loss has been termed "the invisible disability,"[12] and its impact may be profound, affecting the social, functional, and psychological well-being of the individual. According to an Impact Measurement Case Study done by Shruti team in partnership with United Nations Development Program,[13] 28% of patients who received treatment reported that they did not know who or where to go for the treatment, and 24% did not think treatment was urgent before being approached by Shruti health workers. Posttreatment, 87% of patients reported that their ear conditions had improved and 85% also reported improved daily lives. Hospital-based hearing screening programs are already functioning, but in a country like India, due to the inequity in rural-urban population, hospital-based programs cater only to small sections of the society.

Outcomes in the current study was assessed by auditing postoperative surgical results in surgical cases and by a questionnaire in those rehabilitated with hearing aids. Quantification was easy in surgical cases and was done based on graft acceptance in tympanoplasty and a dry cavity and absence of symptoms in cases of mastoid surgery. Successful outcome was achieved in 92.5% surgical cases at the end of 1 year. Those rehabilitated with hearing aids were measured using a questionnaire based on the International Outcome Inventory for Hearing Aids as proposed by Cox et al.[14] It is a 7-item survey that was conducted in 203 (120 males, 83 females) patients rehabilitated with hearing aid. The survey revealed an average scale of 4.37 that was at par with the accepted scale of 4.33 as mentioned by Cox et al.[14] Forty-five percent patients reported a significant improvement in their quality of life.

For patients who have received treatment, engagement with Shruti has led to improvements in work performance and social interactions. Shruti has also had a positive impact on the livelihood of community health care workers through training and employment. Shruti program has redefined the way health care service delivery models are set up, in resource-limited settings. However, as the program continues to scale, it has been essential to ensure that the community health care workers are engaged and motivated, as they are the backbone of the program.

Efforts are ongoing to make Shruti financially self-sustaining by scaling up the size of the program. Based on the pilot experience, as per NPPCD cell of the Government of Delhi, the patient response during screening was favorable, and the community health worker staff could adapt to the operation with proper training. Thus, it was concluded that a smartphone-based screening device is an essential 1-stop solution for otoscopy, audiometry, data storage, and tele-otology which can be applied at primary health care setup of the government. Efforts are ongoing in building similar partnerships with other state governments across India.

Conclusion

The potential for tele-otology to reduce inequalities in health care is immense but remains underutilized. Shruti has largely been able to bridge, this gap as it is an innovative, fast, and cost-effective program.

Acknowledgment

The authors acknowledge Mr. Atanu Majumdar for his assistance with the statistical evaluation of the study data.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Sachdeva Sanchi, Sahai, Garima, Bhatnagar, Kaustubh, and Ahuja Prateek declare that they are employed by India Medtronic Pvt. Ltd. at the time of submission.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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