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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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, 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.

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 otolaryngologist reviews and responds at his/her convenience as described earlier. 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. In real-time tele-otology, the physician can interact with the patient and can obtain relevant clinical information. 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).
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. 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 8,428,284 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 2,656,151 patients identified with ear problem concluded that 1,510,671 (57%) had impacted wax; 467,921 (18%) had chronic suppurative otitis media (CSOM); 278,752 (10%) were of diminished hearing; 271,521 (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 2,656,151 patients were referred for treatment, but only 209,868 (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.

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

| Diagnosis                     | Number   | Incidence | 95% CI        |
|-------------------------------|----------|-----------|---------------|
| Impacted wax                  | 1,510,671| 18.63%    | (18.55%-18.72%)|
| CSOM                          | 425,281  | 5.25%     | (5.2%-5.29%)   |
| Diminished hearing            | 278,752  | 3.44%     | (3.4%-3.48%)   |
| ASOM                          | 67,771   | 0.84%     | (0.82%-0.86%)  |
| AOM                           | 59,521   | 0.73%     | (0.72%-0.75%)  |
| CSOM, diminished hearing      | 42,641   | 0.53%     | (0.51%-0.54%)  |
| Foreign body                  | 17,671   | 0.22%     | (0.21%-0.23%)  |
| Others                        | 253,851  | 3.13%     | (3.09%-3.17%)  |
| Total screening               | 8,107,461| 3.13%     | (3.09%-3.17%)  |

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              | 265 615        | 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              | 265 615        | 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             |

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                                      | 265 615         | 20 986                          | 8%                         |              |
| Surgical conversion (myringoplasty, tympanoplasty, modified radical mastoidectomy, myringotomy with grommet insertion) | 46 792 (CSOM data) | 1539                           | 3%                         |              |
| Nonsurgical conversion                             | 21 823          | 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.

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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.

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