This study was conducted to assess the efficacy of a tele-audiological diagnostic follow-up model in a community based hearing screening program for infants and young children in rural villages in two blocks of Kancheepuram district in Tamil Nadu. In order to fulfil the aim, as a first step, a community based hearing screening program was developed and evaluated. In this community based program, the efficacy of tele-audiological diagnostic follow-up was compared to the traditional face-to-face diagnostic follow-up was assessed. Parental perception regarding tele-audiological testing was also obtained from mothers of children who underwent tele-ABR.

Seven VHWs underwent systematic training in conducting hearing screening using DPOAE. Knowledge and skill in conducting screening and assisting in ABR was evaluated. All except two VHWs obtained above 80% scores in knowledge, skill and agreement in DPOAE screening results with the audiologist. VHWs also seemed to retain the knowledge gained during training, as was reflected in the evaluations conducted six months and one and half years post training. Findings suggests that VHWs can be trained to conduct objective hearing screening using DPOAE.

Hearing screening was conducted by the trained VHWs on 687 infants and 648 young children residing in 51 villages and hamlets in Thirukazhukunram block (Group A) and 826 infants and 653 young children in 43 villages and hamlets in Madhurantagam block (Group B) of Kanchipuram district in Tamil Nadu. Even though there has been a worldwide thrust on newborn hearing screening with specific benchmarks recommended by organisations such as JCIH and American Academy of Paediatrics, this study, included young children up to the age of 5 years. Government schemes for free or subsidised cochlear implantation is available in various states of India. The age limit for availing such schemes in states like
Tamil Nadu is 6 years, in Kerala it is for children below 3 years of age and in Andhra Pradesh (now Telangana) children even up to 12 years of age were eligible and more and more states are adopting such schemes. Therefore, in the absence of a systematic screening program for detection of permanent hearing loss, in countries like India, at the time of program initiation, it is worthwhile to include young children up to 5 years of age, at least in the initial stages of the program, as they can benefit from such interventions. While this study was not designed to meet the JCIH benchmarks that are based on the hospital based models of hearing screening established in western countries, the coverage rate for babies less than 3 months, low refer rate, and better follow-up rate shows that the community based hearing screening program was successful.

The validity of DPOAE screening conducted by VHWs was assessed on 197 ears of infants and young children who had undergone DPOAE screening, using tele-ABR as gold standard. As reported in most hospital based programs, the positive predictive value was low, but the specificity of DPOAE screening conducted by VHW has high and the sensitivity was acceptable. The validity measures obtained in this study suggests that VHWs conducting DPOAE screening in the rural community is acceptable and comparable to findings reported in other studies. This study adds further to the body of literature that supports the increasing role of grass-root workers in the provision of community based health care services (Olusanya et al., 2008).

Lack of audiologists and infrastructure in rural areas has prevented the establishment of large scale hearing screening programs. In existing programs, considerable challenges with respect to follow-up for diagnostic testing has been reported, due to travel distance and possible wage loss. In this community based hearing screening program, the efficacy of two
methods of diagnostic follow-up, tele-audiological versus face-to-face, was assessed to understand if tele-audiology, which is provided locally, with available manpower, improved follow-up.

Nineteen out of 22 children who were referred for tele-audiological diagnostic testing, followed up. Three among four children referred for face-to-face diagnostic testing, followed-up. The follow-up rate for tele-audiological diagnostic testing was better than face-to-face diagnostic testing by 15%. However, the availability of tele-audiological diagnostic follow-up did not have substantial advantage in the time taken between 2nd screening and diagnostic testing.

While the results show that providing diagnostic testing via tele-mode is beneficial in increasing follow-up, it is important to determine whether such a new method is cost-effective in comparison to the existing method (Drummond, Sculpher, Torrance, O'Brien, Stoddart, 2005). The cost-effectiveness of using tele-audiological diagnostic follow-up as compared to face-to-face diagnostic follow-up was analysed by adopting the societal perspective.

Cost-effectiveness was obtained for tele-audiological follow-up conducted by using the mobile tele-van and broadband internet in an NGO in combination (as used in this study) as well as independently. The findings of this study shows that, for a single program, the use of mobile tele-van for tele-audiological follow-up though beneficial in comparison to face-to-face follow-up, involved greater costs and hence was not cost-effective. The ICER was considerably low when broadband internet based tele-audiological follow-up was conducted as the costs were only marginally higher, but the follow-up was better than face-to-face,
thereby reducing cost per follow-up. Further, at the lower estimate of equipment and manpower, irrespective of the range of follow-up, there was cost saving. Therefore, the tele-audiological follow-up using broadband internet is worthwhile, as there is a cost saving with beneficial consequence.

Parental perception regarding tele-audiological testing was obtained from 87 mothers whose children underwent tele-ABR testing. Information was obtained using a rater administered questionnaire. Responses of the mothers suggested that they perceived tele-hearing testing to be as good as being tested at a hospital. Mothers were satisfied with the quality of videoconferencing except a few mothers who faced disruption in video conferencing due to loss of connectivity. It is noteworthy that some mothers were unaware of the presence of an audiologist at the remote end, suggesting that parents must be provided adequate information about the process of tele-testing.

Wait time was perceived to be longer by few mothers due to technical issues related to connectivity and equipment snags. Travel time for tele-hearing testing was almost the same as the travel time reported by majority of mothers for seeking basic health care. Lesser travel seems to have influenced better compliance. The success of a tele-audiology application for diagnostic follow-up depends on achieving a balance between technical and social factors during implementation(Obstfelder et al., 2007).

The findings of this study suggests that diagnostic audiological testing is feasible, valid, beneficial and cost-saving, thereby opening up a way to establish large scale hearing screening programs, where there are resource and manpower constraints. A tele-health service is sustainable when it is ‘‘no longer considered a special case, but has been absorbed
into routine healthcare delivery’’ (Cradduck 2002 as cited in Singh, Mathiassen, Stachura & Astapova, 2010).

Working with other healthcare programs in the area of childhood disability may assist in providing insights into the best practices for tele-audiology (Pearce, Ching, and Dillon, 2009) and may be more cost-effective, as shared resources will lower the cost of the program and maximize the effect.

**Limitation and future direction**

While for a single program, mobile tele-van was not found to be cost-effective, it has the potential to serve remote rural locations where internet penetration is poor and maybe the only choice in such situations. Therefore, in order to reduce cost and increase the overall cost-effectiveness, multi-specialty consultation involving other specialties that concern childhood disabilities maybe attempted.

Low refer rate (with high positive predictive value), which was the strength of the community based screening, reduced the number who required diagnostic follow-up. The economic evaluation of the two methods of follow-up for diagnostic testing was conducted on a realistic field setting, therefore no effort was taken to control the participation or follow-up. A larger population based data, will help policy makers adopt the model. While it may be impractical to conduct large population studies, the results of this study may be directly applied to calculate realistic cost for an administrative unit, such as a district, by modelling. Decision analytic modelling is an accepted approach to decision making in health economics (Bergmo, 2010).