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MOBILE & WIRELESS HEALTH

Benefits of an Android Based Tablet Application in Primary Screening for Eye Diseases in a Rural Population, India

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Abstract To investigate the effectiveness, efficiency and cost gains in collecting patient eye health information from remote rural villages of India by trained field investigators through an Android Based Tablet Application namely 'Sankara Electronic Remote Vision Information System (SERVIS)". During January and March 2016, a population based cross-sectional study was conducted in three Indian states employing SERVIS and manual method. The SERVIS application has a 48-items survey instrument programed into the application. Data on 281 individuals were collected for each of these methods as part of screening. The demographic details of individuals between both screening methods were comparable (P>0.05). The mean time (in minutes) to screen an individual by SERVIS was significantly less when compared to manual method (6.57±1.46 versus 11.93±1.53) (P<0.0001). The efficiency of SERVIS in screening was significantly evident as 26% (n = 73) of the patients screened have been referred to campsite and 69.8% (n = 51) of those referred were visited the campsite for a detailed eye examination by an ophthalmologist. The cost of screening through SERVIS is significantly less when compared to manual method; INR 7,633 (USD 113.9) Versus INR 24,780 (USD 370). SERVIS is an effective and efficient tool in terms of patients' referral conversion to the camp site leading to timely detection of potential blinding eye conditions and their appropriate treatment. This ensures timely prevention of avoidable blindness and visual impairment. In addition, the storage and access of eye health epidemiological quality data is helpful to plan appropriate blindness prevention initiatives in rural India.

Keywords Android application · Community patient eye care · Blindness · Visual impairment · Information Storage and Retrieval · Health Communication and counselling · Rural India

Introduction

Blindness and visual impairment are public health problems globally. According to the World Health Organization (WHO) report [1], 285 million people are visually impaired worldwide. Of these, 246 million have low vision (moderate or severe visual impairment) and 39 million are blind. About 90% of the world's visually impaired live in low-income settings [1]. Timely detection of potential blinding eye conditions and its appropriate treatment can prevent 80% of all cases of blindness and visual impairment [1]. The prevalence of cataract related blindness and visual impairment is modestly high in India. However, the utilization of cataract service, on the contrary, is sub-optimal due to various reasons [2, 3]. The utilization is low especially among women, widowed and rural poor. Financial issues, stigma, ageism and low awareness of low-cost cataract intraocular lens were few factors for limited and delayed utilization of offered services by patients who were advised for cataract surgery either as part of outreach screening camps or hospitals [2, 3]. One of the major

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strategy to address these issues is to improve the community outreach screening focussing on reaching out to the rural community through household survey, local publicity and referral of patients to a locally organised eye screening camp and provision of intervention (mostly surgical) at the base hospital of the service provider such as the one run by Sankara Eye Foundation – India (SEFI) [4, 5].

The challenges for such programs traditionally have been on the quality of field work through manual household survey for detection of eye ailments. The manual data collection and management process, as seen in various other community level activities, is fraught with issues of data accuracy, documentation, reporting and decision making [6]. To address these challenges, there is a need for real time and accurate data reporting mechanism which helps in accurate case detection requiring referral for further eye examination and treatment apart from making information available at a household level. This process not only helps to make the referral system more robust but also helps in reduction of monitoring cost extensively in the field level apart from making the field workers accountable. It also makes the data available at community household level on real time basis to the manager/planner for an effective planning of eye care strategies in a given region.

There are numerous instances of using wireless technologies in the community eye care especially in rural areas. For example, using satellite links, outreach sites and primary eye care delivery centres namely vision centres transmit data and digital images to a base hospital for analysis [7]. Aravind Eye hospital uses long distance Wi-fi networking to enable video conferencing between camps and base hospital [8]. However, use of such a technology has never been tried at a household level in the community where many people with potentially blinding eye conditions go undetected. Another area that has seen tremendous growth is the availability of "smart phone based mobile apps" for data collection at the community level in the healthcare domain [9]. There is a need to leverage such technology for large scale delivery of community eye care services that addresses efficient "task shifting" to Field Investigator (FI), camp site planning, household surveys, camp site examination and surgeries at secondary and tertiary hospitals. In such a context, the role of an application such as Sankara Electronic Remote Vision Information System (SERVIS) becomes crucial and needs close examination to assess if it could become a potential option to replace existing manual method of survey.

Hence, the present study aimed at assessing:

(i) The efficiency of SERVIS for primary eye screening in comparison with that of standard manual paper based screening method.
(ii) The effectiveness of SERVIS for primary eye screening in comparison with that of standard manual paper based screening method.
(iii) The cost gain of SERVIS as compared to manual paper based data collection method.

Materials and methods

A population based cross-sectional study was conducted in three Indian states of Karnataka and Andhra Pradesh in southern India and Uttar Pradesh in northern India during January and March 2016. As part of the study, 300 individuals were screened with 100 from each state for each method of screening (Manual and SERVIS), with similar characteristics in different locations (in two villages for Manual Method and in three villages for SERVIS) selected within a radius of 200 km (KM) from SEFI unit. Of these, a total of 281 (93.7%) participants' data for each method was completely available for analysis including verbal informed consent. Ethics approval for the study was obtained from Institutional Review Board of SEFI and study was conducted adhering to the tenets of Helsinki declaration. For comparison of effectiveness between methods, the parameters considered were: (i) number of households screened and (ii) number of individuals screened. For comparison of efficiency, the parameters considered were: (i) time taken in minutes to do survey an individual, (ii) the number of individuals with eye disorders referred to eye camps, (iii) the number of individuals visited eye camps with an eye disorder (iv) the accuracy of household data captured and (v) screening cost.

Sankara Eye Foundation – India has been providing community outreach program in rural India for more than two decades which screens households for eye ailments. From the inception of eye screening programs, Field Investigators (FIs) have been doing household screening by manual paper based method. The details of the community outreach services offered by SEFI have already been reported elsewhere [10]. However, as described in previous sections, the manual data collection and data management process has its own disadvantages and therefore the program SERVIS was implemented as part of community outreach services to automate the process electronically thereby generating an Electronic Medical Record (EMR). The advantages of EMR as compared to conventional paper based record are well documented in the literature [11, 12].

The SERVIS application has been programmed onto a mobile device by a technical specialist software Institution in India in such a way that the eye health information including visual acuity assessment using a Snellen Eye Chart is inbuilt into the program (Fig. 1). The program documents the torch light examination findings along with presence of hypertension, diabetes and ischemic heart diseases as part of screening. Socio demographic data on age, gender, education, occupation and household income were also collected. Likewise, the

Fig. 1 Assessment of visual acuity by Field Investigator as part of house to house screening using SERVIS application inbuilt in an Android Mobile Device

device has a 48-item designed survey instrument filled by the FI as part of the household screening. The SERVIS has been built onto an android mobile phone with the following technical specifications: It is an android based tablet application with a hypertext preprocessor (PHP) backend consists of MySQL database. It supports geo tagging functionalities such as Global Pocket Radio Service (GPRS) and Geographic Information System (GIS) with 2G/3G network support system. Wireless link manager used by the application as the cellular connection in rural areas are intermittent and hence the application synchronizes the data filled as and when network connection is available. As part of household survey using SERVIS, each patient's information is Geo-tagged. Geo-tagging serves two purposes – (a) to monitor the movement of FIs (through - GPRS) (b) to provide Geo-spatial insights based upon the recorded information pertaining to each and every patient with regard to general and eye health data through GIS functionality. All the recorded data are uploaded into a cloud based server dedicated for this application. The outreach administrator (OA) can instantly review the data from any location to effectively plan for future eye camps. Before SERVIS implementation, the standard manual method was used for eye screening which formed the baseline data.

Pilot testing:

Before commencement of main study, four FIs and one OA participated in a day long orientation to get accustomed to the application. The FIs were given a day hands-on training in the field by using the SERVIS application. At the end of the pilot, two FIs were chosen randomly to be part of the main study. The FIs were standardized in eye screening by using a Snellen Eye Chart with that of an optometrist. The details of the FIs' screening standardization procedures have already been reported elsewhere [13]. The selected FIs were a Higher Secondary Examination passed personnel and the OA is a certified post graduate. The pilot testing was done in two camp locations within a distance of 100 Kilometers from SEFI in Bangalore of Karnataka state in Southern India.

Methods adopted in main study

The household survey was carried out for about five days before the camp date by two FIs per village in the selected states per week. The first two days of survey captured the data using the manual method (baseline data) and thereafter the SERVIS application was used and referred patients with eye ailments to the campsite (end line data). Due to logistics purpose, a convenience sample of two villages were selected within a radius of 200 KM from the service area hospital for data collection using manual method and another three different villages were chosen within the same radius for data collection using the new screening method of SERVIS. Participants above or equal to 50 years old who gave the verbal informed consent were screened house to house for eye disorders.

Sample size estimation

Based on a pilot study experience, on any given day by standard method of screening program, a total of 30 individuals were identified with some kind of eye ailments as part of household screening and referred to the nearest camp site. Of the referred, 16.6% ($n = 5$) of individuals made an attempt to attend the camp site for further eye examination. Considering this as a baseline estimate, with 80% power, 95% confidence level and with an assumption of 10% non-response to a screening method, a sample size of approximately 300 need to be studied in each group to detect a minimum campsite turnout rate of 10% improvement.

Time measurement

Time for both the manual and SERVIS method were noted by two independent observers one of whom was the authors (SK) in the list. Other independent observer was a local hospital team leader. The start and end time were noted in minutes for each participant.

Data analysis

Comparison of mean duration of time between the manual and SERVIS method was done by using the independent sampled t-test. Categorical data analysis was performed by using either chi-square test or fishers' exact test as appropriate. A two-

Table 1 Summary of demographic variables

Parameters	Paper based method (n = 281)	Tablet based method (n = 281)	P value
Mean age ± SD	62.0 ± 7.0	60.9 ± 7.4	0.104[a]
Gender			
Male	147	165	0.149[b]
Female	134	116	
Education			
No education	215	203	0.486[c]
≤ Grade 5	47	57	
Grade 6–10	15	19	
≥ Grade 11	4	2	

SD Standard Deviation

[a] Independent sampled t – test

[b] Fisher's Exact Test

[c] χ^2 test

sided p-value of <0.05 was considered to be statistically significant. All analysis was carried out by using the SPSS 17.0 software for Windows (SPSS, Chicago, USA).

Results

Table 1 reports the comparison of basic demographic characteristics of participants between methods. All the characteristics were comparable between groups ($P > 0.05$ for all). Table 2 depicts the efficiency and effectiveness of the SERVIS method over traditional method of data collection. On an average 52 (range: 46 to 53) individuals were screened by SERVIS from an average of 32 (range: 28 to 33) households per day by each FI. Whereas, on average 33 (range: 30 to 34) individuals were screened by manual method from an average of 17 (range: 14 to 19) households per day by each FI. The SERVIS method of screening in terms of individuals (p = 0.025), households (p = 0.034) and patient referral (p = 0.033) was more effective and significant when compared to manual method (Table 2). The conversion of referred individuals with eye ailments to camp site was significantly higher by SERVIS; 69.8% (N = 51) versus 51.9% (N = 27) (p = 0.041) (Table 2). Table 3 describes the cost of screening by each method. The startup costs that include the cost of an android mobile devise and the program development including installation in to it were INR 8000 (USD 120) and INR 4,85,925 (USD 7253) respectively. These initial costs were not part of the cost comparative analysis between methods. Post SERVIS implementation, the cost of screening has significantly reduced from INR 24,780 (USD 370.4) to INR 7633 (113.9) - a 69.2% decrease (Table 3). Previously, the OA used to devote at least eight field visits in a month as part of a monitoring visit. Similarly, a Unit Head (UH) used to make four field visits a month. Post SERVIS, these monitoring visits were limited to 4 visits a month by OA and none by UH and thus a significant reduction of man hour was possible.

Discussion

Electronic medical records have begun to be increasingly used for delivery of health care. Data documentation in electronic records was found to be more precise and faster to retrieve than paper records [12]. Besides it, EMR ensures in data accuracy and robust analysis based on which a crucial programmatic decision can be taken. This study demonstrated that household screening program such as SERVIS was more effective and efficient in documenting online eye health information with more accuracy thus leading to robust analysis. The application gained overall acceptability in the rural community initially due to curiosity of the rural masses to the novelty of the tablet gadget. Further, the FIs were able to demonstrate more effectively the importance of eye health through Information

Table 2 Effectiveness and Efficiency gain / loss seen in various parameters for manual and tablet based method of data collection

Operational measurement	Parameter	Manual method (n = 281)	SERVIS (n = 281)	P value
Efficiency	Item 1: Time taken (minutes) to do survey per individual; Mean ± SD	11.9 ± 1.5	6.6 ± 1.5	<0.0001[d]
	Item 2: Cataract screening and referral to camp site	52 (18.5%)	73 (26.0%)	0.033[e]
	Item 3: Referred patient attended to camp site[a]	27 (51.9)	51 (69.8)	0.041[e]
	Item 4: Ophthalmologist advised for surgery[b]	21 (77.8)	40 (78.4)	0.728[e]
Effectiveness	Item 1: Average number of households screened per day[c]	17/148 (11.5)	32/157 (20.4)	0.034[e]
	Item 2: Average number of individuals screened per day	33 (11.7)	52 (18.5)	0.025[e]

[a] Denominator of the patients is equal to sample size of Item 2

[b] Denominator of the patients is equal to sample size of Item 3

[c] Total households screened in the study through manual method and SERVIS were 148 and 157 respectively. SD: Standard Deviation

[d] Independent sampled t – test

[e] Fisher's Exact Test

Table 3 Monthly monitoring cost breakup in Indian rupees for the SERVIS and manual method of data collection

Cost parameter	Manual Method		Total Cost INR (USD)	SERVIS*		Total Cost INR (USD)
	Outreach Administrator	Unit Head		Outreach Administrator	Unit Head	
Monitoring visit						
Cost per Unit	14,667 (219.3)	1613 (24.1)	16,280 (243.3)	7333 (109.6)	0	7333 (109.6)
Stationary cost (including printing)	8500 (127.1)	0	8500 (127.1)	0	0	0
Grand Total	24,780 (370.4)			7633 (113.9)		

*Monthly expenses of INR 300 (USD 4.5) for internet connectivity of a mobile device were included in the total cost of SERVIS. The team structure for Community Outreach at Service Provider has been described previously[10] and in brief as follows: Each hospital of Service Provider is known as Unit in which the Outreach and non-paying operations are overall managed by a Unit Head (UH). The Outreach Program is managed by the Outreach Administrator (OA) who oversees the outreach field team. The OA makes a total of 8 monitoring visits in a month on an average; UH makes a total of 4 monitoring visits on an average per month. INR: Indian Rupees; USD: United States Dollar

Education and Communication (IEC) materials, charts and videos loaded into the device, thereby improvement in overall patient referral to the eye camps. This may be due to the improved awareness on eye health seeking behavior of patients as a result of exposure to the IEC materials.

Increase in household coverage and referral

Multimedia content and vision charts available in the mobile application reduced the burden of carrying paper charts and visual literacy material and made the FIs more physically mobile, enabling them to reach out more households in a given time. Data entry through pre-loaded text which comes as a drop down makes it faster thereby reducing the mean time of screening significantly through SERVIS method with zero transcription error. The referral rate of individuals with eye ailments to campsite was more with SERVIS than that of manual method which can be attributable to the better counselling and patient sensitization through visual media (appropriate pictures and videos) made available in the tablet application. The application has also helped to identify patients with drop out thereby helping the team to follow up and ensure the drop out patients attend the camp. The timely and targeted reminders increased the patients attending the camp from 60% to 90% per FI per month. Earlier the preciseness of manual method was very poor limiting the information only to the Mandal and district level of individuals screened, because of which locating and identifying individual patient was difficult for successive follow up and also did not allow data to be analyzed robustly. However, with the use of SERVIS it is now achieved with 100% preciseness due to geo tagging functionality through which the application was able to use the data to provide intuitive reports for data analysis. Further, the application made it mandatory to enter all contact details of each screened individual in a household without which the survey could not proceed further.

Increase in conversion of referrals to camp site and surgery

The improved rate of referral by SERVIS and better turnout rate of patients at campsite was possible due to active follow up by the team through the system generated referral and reminder reports. As a result the conversion of patients to campsite and for surgery at base hospital has significantly increased. The other reason for this improvement may be due to the allotment of a target to each FI who are monitored on a real time through SERVIS functionalities (GIS & GPRS) and web based reports with incentive/disincentive accorded for performance/non-performance. This improved the accountability of the FIs in their work with a view to achieve their target. This target based approach coupled with better counselling mechanism resulted in more patients reaching to campsite for further eye examination by an ophthalmologist.

Limitations

The study, however, has a limitation. A convenient sample of villages were chosen due to logistics purpose as part of this study. This might limit the generalizability of the study findings.

Conclusions

In this study, we have demonstrated that a significant shift occurred in eye screening programs after the introduction of an android based tablet application in place of standard manual documentation of screening tool. While many organizations provide vision care services to “at risk” population under community outreach programs, most are paper-based to date. This study provides an insight in to the potential for a mobile eye health field data collection and storage application such as SERVIS for

primary eye care in remote rural community. It was found that the application demonstrated a significant improvement in efficiency and effectiveness in terms of timely detection and referral of cases not only with cataract but also other potential blinding eye disorders in the community. This field trial of the SERVIS system has demonstrated that community eye care programs can become instrumental in timely detection, referral and treatment of potential blinding eye conditions efficiently and effectively using wireless and mobile technologies.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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References

1. WHO (2014). Visual impairment and blindness. Retrieved Dec 11, 2014, from WHO: http://www.who.int/mediacentre/factsheets/fs282/en/.
2. Finger, R.P., Ali, M., Earnest, J., and Nirmalan, P.K., Cataract surgery in Andhra Pradesh state, India: an investigation into uptake following outreach screening camps. *Ophthalmic Epidemiol.* 14(6): 327–332, 2007.
3. Chandrashekhar, T.S., Bhat, H.V., Pai, R.P., and Nair, S.K., Coverage, utilization and barriers to cataract surgical services in rural South India: results from a population-based study. *Public Health*. 121(2):130–136, 2007.
4. Ravilla, T., and Ramasamy, D., Efficient high-volume cataract services: the Aravind model. *Community Eye Health*. 27(85):7–8, 2014.
5. Sankara Eye hospital. Retrieved from http://www.sankaraeye.com/ on 24th March 2016.
6. Mahmood, S., and Ayub, M., Accuracy of primary health care statistics reported by community based lady health workers in district Lahore. *J Pak Med Assoc*. 60(8):649–653, 2010.
7. John, S., Sengupta, S., Reddy, S.J., Prabhu, P., Kirubanandan, K., and Badrinath, S.S., The Sankara Nethralaya mobile teleophthalmology model for comprehensive eye care delivery in rural India. *Telemedicine and e-Health.* 18(5):382–387, 2012.
8. Surana, S., Patra, R., Nedevschi, S., and Brewer, E., Deploying a rural wireless telemedicine system: experiences in sustainability. *Computer*. 41(6):48–56, 2008.
9. Kim, Y., Kim, S.S., Kang, S., Kim, K., and Kim, J., Development of mobile platform integrated with existing electronic medical records. *Healthc Inform Res*. 20(3):231–235, 2014.
10. Finger, R.P., Kupitz, D.G., Holz, F.G., Chandrasekhar, S., Balasubramaniam, B., Ramani, R.V., et al., Regular provision of outreach increased acceptance of cataract surgery in South India. *Tropical Med. Int. Health*. 16(10):1268–1275, 2011.
11. Menachemi, N., and Collum, T.H., Benefits and drawbacks of electronic health record systems. *Risk Manag Healthc Policy*. 4:47–55, 2011.
12. Tsai, J., and Bond, G., A comparison of electronic records to paper records in mental health centers. *Int J Qual Health C.* 20(2):136–143, 2008.
13. Bharath, B., Krishnaiah, S., Imtiaz, A., and Ramani, R.V., Prevalence and determinants of cataract surgical coverage in India: findings from a population-based study. *Int J Community Med Public Health*. 4(2):320–327, 2017. doi:10.18203/2394–6040.ijcmph20170001.