Delivering Subspecialty Health Care to Rural India using the Mobile Phone

- The Narayana Nethralaya Experience in Tele-Ophthalmology

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National Broadband Initiative
APRIL 16th 2010. New Delhi
Why ‘Subspecialty Care’?

• 74% Rural Population

• Inadequate health care delivery services – Primary Health Care (PHC) & Community Health Care (CHC). Limited private enterprise

• “Experts” in few large cities – NO access to the rural masses
# Fields in Medicine that rely on Image Based Diagnosis

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Dependence on Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dermatology</td>
<td>70% (need to touch and feel)</td>
</tr>
<tr>
<td>Radiology</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Ophthalmology</strong></td>
<td><strong>&gt; 90%</strong></td>
</tr>
</tbody>
</table>
Number of Inhabitants / Doctor

- 10,000 People / Cardiologist
- 100,000 People / Ophthalmologist
Population: 1.2 billion

Doctor: Population ratio 59:100,000 (GOI,2001)

Vitreo-Retinal Surgeons : 340 (VRSI membership,2008)

Pediatric Retina Specialists : < 15
Tele-Ophthalmology – Narayana Nethralaya Experience

- Retinopathy of Prematurity

- Largest cause of infant blindness in developed countries

- India is suffering from the “Third Epidemic”
Tele-Ophthalmology – Narayana Nethralaya Experience

- Affects Preterm & Low Birth Babies (< 2000 g)

- 47% of Infants (< 1750) suffer from “some ROP”

- 15% of these will turn BLIND if not treated
• Blindness Preventable if Detected “On Time” and timely treatment is given

• Problem: < 350 Qualified Retinal Surgeons in India

• 2 million babies born < 2000 grams every year
Every two hours 3 infants reach threshold for treatment in India*

*Extrapolation based on GOI Data (2007) and PGI, Chandigarh, NICU Incidence*
Narayana Nethralaya
KIDROP Trial
(Karnataka State Internet Assisted Diagnosis of ROP)
2007 to date
Narayana Nethralaya Initiative

Triple **T** Strategy

- **T**ele-ROP
- **T**rain peripheral ophthalmologists (ROP fellowship)
- **T**alking to and Training pediatricians & gynecologists
Transporting Equipment to the Periphery
<table>
<thead>
<tr>
<th>Day</th>
<th>District</th>
<th>Distance (Kms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>Mandya, Mysore, Chamrajnagar</td>
<td>320</td>
</tr>
<tr>
<td>Tue</td>
<td>Bangalore BBMP</td>
<td>50</td>
</tr>
<tr>
<td>Wed</td>
<td>Tumkur dist Hosur (TN)</td>
<td>220, 80</td>
</tr>
<tr>
<td>Thu</td>
<td>Kolar</td>
<td>152</td>
</tr>
<tr>
<td>Fri</td>
<td>Tumkur Pavagada</td>
<td>141</td>
</tr>
<tr>
<td>Sat</td>
<td>Bangalore Urban</td>
<td>68</td>
</tr>
<tr>
<td>Sun</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
RETCAM IMAGING IN THE PERIPHERAL NICU

Technicians Trained to image, save, retrieve and analyze the images

The images are uploaded to the website for remote “Readers”

Technician may become the “first point of health care” for the infant and mother
### Technician’s Decision Algorithm – Both eyes imaged*

<table>
<thead>
<tr>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>mature vessels upto temporal ora</td>
<td>mature vessels upto temporal ora</td>
<td>Discharge</td>
</tr>
<tr>
<td>mature vessels upto temporal ora</td>
<td>immature</td>
<td>Follow-up</td>
</tr>
<tr>
<td>immature</td>
<td>immature</td>
<td>Follow-up</td>
</tr>
<tr>
<td>immature</td>
<td>regressing</td>
<td>Follow-up</td>
</tr>
<tr>
<td>stage 1, zone 2 or 3, no plus</td>
<td>similar or less (reg, immat, mature)</td>
<td>Follow-up</td>
</tr>
<tr>
<td>stage 2, zone 2 or 3, no plus</td>
<td>similar or less (stage 1, reg, immmat, mature)</td>
<td>Immediate referral to MD</td>
</tr>
<tr>
<td>plus disease with any stage, any zone</td>
<td>any finding</td>
<td>Immediate referral to MD</td>
</tr>
<tr>
<td>any zone 1 disease</td>
<td>any finding</td>
<td>Immediate referral to MD</td>
</tr>
<tr>
<td>apropp</td>
<td>any finding</td>
<td>Immediate referral to MD</td>
</tr>
</tbody>
</table>

*Algorithm was developed with Clare Gilbert, UK in 2008*
Capturing 360 degree ORA SERRATA
Comparing Images between TWO sessions to aid diagnosis

- Fresh Hemorrhage from the ridge
- Asymmetry of Stages in two eyes
Characteristics of a good “Tele” Tool

• “Loss-Less” transfer of images – real time

• Mobility : PC based or Mobile Phone?

• Quick to install, Easy to use and SECURE

• Disease specific templates

• Multiple consults – teaching and training
Peripheral Centre:
Uploader User Interface

ABO Compression Technology:

Headquarters:
Viewer User Interface
Image Review
1908 infants: 14 months : 18 Centres: 350 km radius

<table>
<thead>
<tr>
<th>TOWN (M)</th>
<th>TOWN (MA)</th>
<th>No of babies screened</th>
<th>Birth Weight (grams)</th>
<th>Period of Gestation (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>387</td>
<td>1322</td>
<td>31.1</td>
</tr>
<tr>
<td>RURAL 1 (A)</td>
<td></td>
<td>146</td>
<td>1496</td>
<td>32.9</td>
</tr>
<tr>
<td>RURAL 2 (K)</td>
<td></td>
<td>442</td>
<td>1366</td>
<td>31.6</td>
</tr>
<tr>
<td>RURAL 3 (T)</td>
<td></td>
<td>199</td>
<td>1502</td>
<td>32.9</td>
</tr>
<tr>
<td>URBAN 1 (MSR)</td>
<td></td>
<td>436</td>
<td>1198</td>
<td>30.1</td>
</tr>
<tr>
<td>URBAN 2,3 (P)</td>
<td></td>
<td>298</td>
<td>1298</td>
<td>31.0</td>
</tr>
</tbody>
</table>
NRHM – Narayana Nethralaya PPP for 6 more districts

Since September 2009 – Three batches, ongoing

Expansion to other states

Thailand, Kenya, Ghana, Bhutan, Srilanka
## Estimated ROP Case Load

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>6 C category District</th>
<th>No. of PHCs</th>
<th>Population (08-09)</th>
<th>Deliveries (08-09)</th>
<th>No. of Premature/LBW deliveries (10%)</th>
<th>ROPs of col no. 7 (50%)</th>
<th>ROPs requiring treatment (15%)</th>
<th>Cost of ROP treatment (@ Rs. 4000/case)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bidar</td>
<td>5</td>
<td>1740031</td>
<td>41</td>
<td>34228</td>
<td>3423</td>
<td>1712</td>
<td>257</td>
</tr>
<tr>
<td>2</td>
<td>Gulbarga</td>
<td>10</td>
<td>3660387</td>
<td>108</td>
<td>81199</td>
<td>8120</td>
<td>4060</td>
<td>609</td>
</tr>
<tr>
<td>3</td>
<td>Raichur</td>
<td>5</td>
<td>1969521</td>
<td>43</td>
<td>34544</td>
<td>3454</td>
<td>1727</td>
<td>259</td>
</tr>
<tr>
<td>4</td>
<td>Koppal</td>
<td>4</td>
<td>1401644</td>
<td>47</td>
<td>21589</td>
<td>2159</td>
<td>1080</td>
<td>162</td>
</tr>
<tr>
<td>5</td>
<td>Bijapur</td>
<td>5</td>
<td>2061418</td>
<td>63</td>
<td>43168</td>
<td>4317</td>
<td>2158</td>
<td>323</td>
</tr>
<tr>
<td>6</td>
<td>Bagalkot</td>
<td>6</td>
<td>1896918</td>
<td>46</td>
<td>37242</td>
<td>3724</td>
<td>1862</td>
<td>280</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>35</td>
<td>348</td>
<td>178890</td>
<td>25197</td>
<td>12599</td>
<td>1890</td>
<td>7560000</td>
</tr>
</tbody>
</table>
Tele-ophthalmology model for ROP management

By Anand Vinekar, MD, FRCS

Dr Anand Vinekar describes how tele-ophthalmology models for ROP can be used in developing countries, using a successful Indian programme as a case study.

“... A possible model for middle income countries.” – OT, Europe
Tele PACS

• Efficient workflow
• Compare prior studies for progressive disease evaluation

Ophthalmic Camera

Ophthalmic TelePACS Server

Remote Viewing

Reporting Modules

1

2

3

4

Upload

Secure WEB Download

Progressive Viewing

PC

Ophthalmic Worklist

Ophthalmic Viewer

OR

iPhone

• Lossless compression
• Encrypted
• Secured
• Studies captured by digital Fundus camera
• Uploader installed on Fundus camera workstation
• Uploader encrypts, compresses losslessly and transmits Studies to Server over LAN or WAN

• Stores Studies for download.
• Provides user services over the WEB such as:
  • Viewer download
  • Worklist creation
  • Workflow management.
  • Admin functions
  • User authentication

• Remote Ophthalmologist logs-in at the Server over WEB.
• Downloads viewer one time from server.
• Downloads worklist from server.
• Selects studies to download from the worklist.
• Downloads studies realtime and progressively views
• Uses Viewer tools to analyze images.

• Creates reports via WEB reporting feature or Word upload.
• Electronically signs and sends to Patient Site or forwards to consultant.
iPhone Log-In Screenshots

Home screen of hospital or clinic

Your institution here
iPhone Viewer Screenshots

Image with Thumbnails

Compare Images
iPhone Reporting Flow
## PC vs Cell Phone
### Remote Image Viewing

<table>
<thead>
<tr>
<th>PC Based</th>
<th>Mobile Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet Required</td>
<td>Network – 2G, 3G</td>
</tr>
<tr>
<td>Variable speeds – rural areas</td>
<td>Better coverage</td>
</tr>
<tr>
<td>Less Mobility</td>
<td>Anywhere, Anytime</td>
</tr>
<tr>
<td>Resolution – better?</td>
<td>Improving – “Nearly As Good” - validation</td>
</tr>
<tr>
<td>Size</td>
<td>Convenient – Pocket size</td>
</tr>
</tbody>
</table>
Wireless Market Evolution

1G
- Analog Cellular
  - Voice only

2G
- Voice
- Pager
- 10kbps data

2.5G
- Digital Cellular
  - Voice
  - Email
  - Photos
  - Web
  - ~100kbps data

3G
- Wide-Band Digital Cellular
- Video
- 300kbps-14Mbps

4G /LTE
- Wide-Band Digital Cellular
  - Video
  - High-end gaming
  - ~100 Mbps
  - 10msec
  - Flexible bandwidth

Today

Digital Cellular

~100 Mbps

Flexible bandwidth
6. Sing a different tune

*iPhone used to stave off blindness*

Who would have thought that the pricey Apple iPhone could help India's rural masses? But doctors at the Narayana Nethralaya Postgraduate Institute of Ophthalmology, Bangalore, are doing precisely that to diagnose vision loss in infants from remote areas. Over 8 per cent of India's 27 million infants each year weigh less than 2 kg and run the risk of Retinopathy of Prematurity. So long just a handful of city doctors had the know-how. Now *with the iPhone and a software developed by the i2i TeleSolutions*, the good doctors are busy saving lives across the country.
iPhone may well be nicknamed "Eye-Phone" among pediatric eye surgeons starting off on a global endeavor to prevent an eye disease that affects thousands of prematurely born infants and can cause blindness if not swiftly treated. It's not a feature Steve Jobs -- much less anyone -- could have envisioned, but pediatric eye (retina) surgeons in India and elsewhere say that when using tele-ophthalmology to cure a disease called Retinopathy of Prematurity (RoP), they find the iPhone to be the best platform from both a security and features perspective.

"Some babies born underweight are likely to be affected by RoP, which though curable, must be acted upon in a matter of days to prevent irreversible blindness. This is especially a problem in countries such as India and those of a similar socio-economic nature, where lack of adequate facilities, long distances, illiteracy and low accessibility to quality healthcare cause thousands of children to become blind every year," said Anand Vinekar, project coordinator and pediatric retinal surgeon at Narayana Nethralaya, an ophthalmological institute based here. Laboratory assistants take pictures of the retinas of prematurely born babies and transmit them via broadband to pediatric eye surgeons, who could be hundreds or thousands of miles away. These surgeons, using iPhones, enlarge the images and using the iPhone's graphics capabilities determine whether the baby needs immediate help.

Need for a standard platform
"We wanted a standard platform and the iPhone proved to be the best. With other (GSM) handsets you find that different models have different features. With a Nokia for instance, you have many models which do or do not have all the features we need. So it was easy to standardize on the iPhone," Vinekar said. The iPhone's large screen, resolution, graphics capabilities and features offered the good picture quality doctors require, and security in the form of easy-to-publish Adobe software -- which also helps to upload patient records immediately and securely, Vinekar said.

In addition to the graphics processing capabilities that the chip industry has provided through the iPhone, it is chipping in with the software used in treating RoP. This comes from i2i Telesolutions, a startup launched by an ex-Texas Instruments India executive, Sham Banerji. Banerji led the team that developed the first DSP in India while at TI in Bangalore. "The iPhone's pinch-and-drag capabilities, apart from its amazing resolution, are unrivaled in other phone models and the surgeons therefore decided that this is best-suited for this kind of application," Banerji said.

In India alone, thousands of children go blind every year. These numbers could fall as a result of efforts by Vinekar and others like him, along with the help of the government. Currently, Vinekar, with surgeons such as Anna Ilis of Calgary, Canada, are joining with regional governments and non-governmental bodies to use the broadband and the iPhone to fight blindness in newborns everywhere in the world.
“… a unique experiment in Tele-Ophthalmology provides hope to rural infants”
The Future

• Integrating Tele-diagnostic equipment

• 3G - > 4G - >x G? Faster, More secure

• Disease and Specialty Customization

• Live Webcasts, Video-Conf on the Phone, Multi sessions
The Truth Is out There....
THANK YOU

Working towards a world without ROP blindness*

* Video on YouTube