WCPD 10 Edinburgh-Menarini Award Lecture 2018
“m-Health. Emerging science in Diabetes Care and Prevention”

Prof. A. Ramachandran

India Diabetes Research Foundation
Dr. A. Ramachandran’s Diabetes Hospitals
Chennai, India
mHealth
New horizons for health through mobile technologies – WHO 2011

‘The use of mobile and wireless technologies to support the achievement of health objectives (mHealth) has the potential to transform the face of health service delivery across the globe’
The story of m-Diabetes


2. Use of mobile technology in Primary Prevention in India. (2010-13)

3. Primary prevention Study in India and the UK.

4. WHO initiated m-Health projects.

5. National m-Diabetes programs in Senegal and India.
Original Article

Reinforcement of Adherence to Prescription Recommendations in Asian Indian Diabetes Patients Using Short Message Service (SMS)-A Pilot Study


JAPI November (2011): Vol. 59, 711-714
Improving Diabetes treatment goals using SMS

200 Adults with Type2 DM randomized into two groups in 2009

100 - Received standard treatment from the physician

100 - Received standard treatment from the physician + Re-enforcement with SMS

Followed up for 1 year to look for glycemic and non-glycemic outcome
Comparative analysis of the outcomes – Improvement in anthropometry and biochemical variables

<table>
<thead>
<tr>
<th></th>
<th>Control (n=66)</th>
<th></th>
<th>SMS (n=78)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal</td>
<td>First Year</td>
<td>Basal</td>
</tr>
<tr>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>BMI &lt; 25 kg/m²</td>
<td>21</td>
<td>31.8</td>
<td>19</td>
</tr>
<tr>
<td>PPG &lt;180 mg/dl</td>
<td>9</td>
<td>13.6</td>
<td>13</td>
</tr>
<tr>
<td>HbA1c &lt;8 %</td>
<td>21</td>
<td>31.8</td>
<td>32</td>
</tr>
<tr>
<td>TC &lt;200 mg/dl</td>
<td>53</td>
<td>80.3</td>
<td>61</td>
</tr>
<tr>
<td>TG &lt;150 mg/dl</td>
<td>44</td>
<td>66.7</td>
<td>52</td>
</tr>
<tr>
<td>HDLc &gt;40 mg/dl</td>
<td>44</td>
<td>66.7</td>
<td>49</td>
</tr>
<tr>
<td>LDLc &lt;100 mg/dl</td>
<td>40</td>
<td>60.6</td>
<td>54</td>
</tr>
</tbody>
</table>

Basal Vs First year - *p<0.02, **p<0.007

JAPI  november (2011) • vol. 59: 711-714
The story of m-Diabetes


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Major Primary Studies in Diabetes

- Diabetes Prevention Study - Tuomilehto et al – 2001
- Da Qing Study - Pan et al – 1997
- Diabetes Prevention Program – 2002
- Kosaka et al – 2005
- IDPP 1 – A.Ramachandran et al – 2006
- Indian SMS Study - A.Ramachandran et al – 2013
Cumulative incidence of diabetes in intervention groups in IDPP

Cox Proportional Hazards Model

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Cumulative Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>55.0%</td>
</tr>
<tr>
<td>Lifestyle modification (LSM)</td>
<td>39.3%</td>
</tr>
<tr>
<td>Metformin (Met)</td>
<td>40.5%</td>
</tr>
<tr>
<td>LSM + Met</td>
<td>39.5%</td>
</tr>
</tbody>
</table>

Ramachandran et al *Diabetologia* 2006;49:289–297
Major conclusion of IDPP-1

Conversion of IGT to Diabetes
(Relative Risk reduction)

Life style modification = 28.5% (P<0.018),

Metformin = 26.4% (0.029)

LSM+ Metformin = 28.2% (P<0.022)

Ramachandran et al Diabetologia 2006;49:289–297
Comparison of IDPP, DPP (USA) and DPS (Finland)

<table>
<thead>
<tr>
<th></th>
<th>IDPP (India)</th>
<th>DPP (USA)</th>
<th>DFS (Finland)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (Yrs)</strong> (mean,SD)</td>
<td>45 ± 5.7 *2</td>
<td>50.6 ± 10.7</td>
<td>55 ± 7.0</td>
</tr>
<tr>
<td><strong>BMI (Kg/m2)</strong> (mean,SD)</td>
<td>25.7 ± 3.4 *</td>
<td>34.0 ± 6.7</td>
<td>31.2 ± 4.5</td>
</tr>
<tr>
<td><strong>Metformin</strong></td>
<td>500 mg/day</td>
<td>850 mg bd</td>
<td></td>
</tr>
<tr>
<td><strong>LSM</strong></td>
<td>Moderate</td>
<td>Intensive</td>
<td>Intensive</td>
</tr>
<tr>
<td><strong>Wt Loss</strong></td>
<td>NS</td>
<td>Significant</td>
<td>Significant</td>
</tr>
</tbody>
</table>
Facing the Challenges in Primary prevention

1. Scaling up the efforts to reach large numbers
2. To make it cost-effective especially with less personnel involvement.
3. A strategy which could be modified and tailored effectively with less efforts.
New Study

Primary objective

To evaluate whether tailored mobile phone messaging (SMS) encouraging lifestyle changes could reduce incidence type 2 diabetes in Indian men with impaired glucose tolerance (Pre-diabetes)

Ramachandran A et al, Lancet Diabetes Endocrinol, 2013
Effectiveness of mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: a prospective, parallel-group, randomised controlled trial

Ambady Ramachandran, Chamukuttan Snehalatha, Jagannathan Ram, Sundaram Selvam, Mary Simon, Arun Nanditha, Ananth Samith Shetty, Ian F Godsland, Nish Chaturvedi, Azeem Majeed, Nick Oliver, Christofer Toumazou, K George Alberti, Desmond G Johnston,

India Diabetes Research Foundation & Dr. A. Ramachandran’s Diabetes Hospitals, Chennai, India.
Imperial College, London, UK,

Funded by UK- India Education & Research Initiative (UKEIRI) by British Council
Study design

Population of interest
IGT (High risk group)

Intervention group
Randomization 1:1 ratio
Followed up for 2 years (6 monthly visits)

Control group
Standard care advice

Analysis

Standard care + Motivational text messages
Recruitment of study subjects

8741 screened
- 5997 excluded
  - 4692 had normoglycaemia
  - 1305 had diabetes
- 2744 had impaired glucose tolerance
  - 912 excluded because of impaired glucose tolerance*
- 1832 invited for second oral glucose tolerance test
  - 463 did not agree to further testing
  - 1369 agreed to second oral glucose tolerance test
    - 832 not randomised
      - 720 had normoglycaemia
      - 69 had diabetes
      - 43 not willing to participate
- 537 randomised
  - 266 assigned to standard care
    - 10 lost to follow-up
      - 1 died
      - 5 unavailable
      - 4 not willing to continue
    - 266 analysed
  - 271 assigned to SMS intervention
    - 10 lost to follow-up
      - 7 unavailable
      - 3 not willing to continue
    - 271 analysed

2 years ..........Control & SMS

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Ramachandran A et al, Lancet Diabetes Endocrinol, 2013
Subjects’ information is stored in Server

System generated text messages to the subject

Personal feedback on text messages from the subject

Text message based “Intervention”

Storage of participants’ details & preference (frequency, type & time) on TTM-tailored text messages on lifestyle modification (Increased physical activity and healthy diet habits)

Delivery of TTM based text messages

Personal feedback from subject for change in frequency / time / type of text messages
Tran - Theoretical Model (TTM)

The Stages of Behavior Change

- **Precontemplation** (unaware of the problem)
- **Contemplation** (aware of the problem and of the desired behavior change)
- **Preparation** (intends to take action)
- **Action** (practices the desired behavior)
- **Maintenance** (works to sustain the behavior change)

Relapse

Prochaska et al. 2002
Indian SMS study
Incidence of diabetes (Cox-Proportional Hazard model)

Ramachandran A et al, Lancet Diabetes Endocrinol, 2013
Primary outcomes – Progression to Diabetes

Control group: 73 (27%)
Intervention (SMS) group: 50 (18%)
- Absolute risk reduction: 9%
- Relative Risk Reduction: 36% (95%CI:8-55)
- Number Needed to Treat: 11 (95% CI 6–55)

The intervention significantly reduced the incidence of Diabetes during the 2 year period

Ramachandran A et al, Lancet Diabetes Endocrinol, 2013
Did it really work?

1. Analysis of the effect of components of LSM.

2. Post trial follow-up study
Calculation of Lifestyle score.

(0-5)

The Lifestyle change score 0-5 was calculated according to the success achieved as per advice in the following ……….

1. Reduction in Carbohydrates in Diet.
2. Decrease in portion size in Diet.
3. Decreased fat consumption
4. Decrease in BMI at least by one unit (1kg/m2).
5. Maintenance of physical activity as per advice.
Fig. 1 – Diabetes incidence in relation to the goals achieved at the end of the study period is shown. Intervention and control groups were combined for the analysis. For diabetes cases the value at the time of diagnosis was considered as the final value.
The post-trial analysis of the Indian SMS diabetes prevention study shows persistent beneficial effects of lifestyle intervention.


Participants free of diabetes ($n = 394$) were invited three years later to ascertain the sustained effect of intervention. The primary outcome was incidence of type 2 diabetes.
# Post trial follow-up Results

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Incidence of Diabetes n (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>163</td>
<td>33 (20.2)</td>
<td>14.8 -27.1</td>
</tr>
<tr>
<td>Intervention</td>
<td>183</td>
<td>29 (15.8)</td>
<td>11.3-21.8</td>
</tr>
</tbody>
</table>

RRR in the intervention group in 5 years was 30%.

Hazard Ratio: 0.70 (95% CI: 0.525 – 0.934) p=0.009.

Nanditha et al, DRCP:142 (2018) 213–221
Sustained effect of lifestyle modification (LSM) in the SMS study in prevention of diabetes in Asian Indians

Probability of remaining free of type 2 diabetes
Kaplan-Meier Survival analysis

Overall survival (%)

Time (Months)

HR=0.700, 95%CI (0.525-0.934), P=0.009

Cumulative Incidence of diabetes n (%)

<table>
<thead>
<tr>
<th>Group</th>
<th>6 months</th>
<th>12 months</th>
<th>18 months</th>
<th>24 months</th>
<th>60 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n=236)</td>
<td>27 (11.4)</td>
<td>48 (20.3)</td>
<td>56 (23.7)</td>
<td>73 (30.9)</td>
<td>106 (44.9)</td>
</tr>
<tr>
<td>Intervention (n=233)</td>
<td>10 (4.3)</td>
<td>35 (15.0)</td>
<td>45 (19.3)</td>
<td>50 (21.5)</td>
<td>79 (33.9)</td>
</tr>
</tbody>
</table>

RR=36%  
RR=30%

Nanditha et al, DRCP:142 (2018) 213–221
Text messages usher in lifestyle changes: study

Have long-term impact on lowering risk of diabetes, according to a post-trial analysis carried out by a group of scientists.

Lifestyle intervention through regular text messaging seems to have a long-term impact on lowering the risk of diabetes, according to a post-trial analysis carried out by a group of scientists. Scientists at the Dr. A. Rama Chandran’s Diabetes Hospitals in Chennai conducted the post-trial analysis on participants who received text messages through a mobile application.

Useful method: Sending text messages to participants had beneficial effects that persisted up to five years. The primary trial (2010-12) showed that mobile one-based text messaging was an effective tool to lower life style changes. The post-trial analysis taken up in 2016 found that this prevention strategy of sending text messages had beneficial effects that persisted up to five years—three years after the text messages were stopped. At the end of five years, the cumulative incidence of type 2 diabetes continued to be lower among participants who received text messages than those in the control group during the primary trial. This was published recently.

The primary two-year randomised trial compared lifestyle changes through the use of text messaging reminders in the intervention group of 271 patients versus standard care advice for 266 in the control group. At the end of the active phase, 517 of the 537 men were available for review. Among them, 73 out of the 266 in the control group and 60 of 271 in the intervention group developed diabetes. Both groups were advised on lifestyle modification. Next, the doctors wanted to find out how the SMS strategy worked.

Post-trial follow-up
“Todays Hindu newspaper 17th July 2018”

IIT-M to boost nanotech research

SPECIAL CORRESPONDENT
CHENNAI

Future of two boys uncertain as Vysarpadi school issues TC

he had suffered a fracture, mother complained to police

IIT-M to boost nanotech research

CINEMA • ARTS • EVENTS

MUSIC DANCE DRAMA

Paalam

Tomorrow 6 p.m. - Arangetram Nooelakantam, 7.30 p.m. - Thanthi Academy of Music Dance. All are Welly sponsored by NALI and NASAM CHETTY.

CHROMEPET CULTURAL ACADEMY (PH:2265180)
9444601747
The story of m- Diabetes

1. Pilot RCT using mobile phones in Diabetes.
2. Use of mobile technology in Primary Prevention in India.
3. Primary prevention Study in India and the UK.
4. WHO initiated m-Health projects.
5. National m-Diabetes programs in Senegal and India.
A pragmatic and scalable strategy using mobile technology to promote sustained lifestyle changes to prevent Type 2 diabetes in India and the UK

INDIA
Population of towns of Industries, Governmental Set-ups, Townships.

UK
NHS Health Checks

SCREENING

HbA1c ≥ 6.5%
DM

HbA1c 6.0-6.4%

HbA1c <6.0%

RANDOMISATION

n=2094

n=1047
Standard care

Control n=1047 Standard Care + Intervention (SMS)

Follow-up for 2 Years
The story of m-Diabetes

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Mobile health to fight NCD

« Be He@lthy Be Mobile »
(BHBM)
BHBM : 2017

• 8 countries have started (Blue)
  16 have completed official documents, ready to start (red)
• 45 + have expressed interest
## 2017 Countries Implementation

<table>
<thead>
<tr>
<th>Handbooks</th>
<th>Country Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>mTobacco Cessation</td>
<td>India, Philippines, Tunisia, Costa Rica</td>
</tr>
<tr>
<td><strong>mDiabetes</strong></td>
<td>Senegal, India, Egypt,</td>
</tr>
<tr>
<td>mCervical Cancer</td>
<td>Zambia, Burkina Faso*</td>
</tr>
<tr>
<td>mTB-Tobacco</td>
<td>Egypt</td>
</tr>
<tr>
<td>mHypertension/mGlobalHearts</td>
<td>UK*</td>
</tr>
<tr>
<td>mAging</td>
<td>India*</td>
</tr>
<tr>
<td>mCoPD/mBreatheFreely</td>
<td>Norway*</td>
</tr>
</tbody>
</table>

*mAging, mBreatheFreely, mSmartLife and mGlobalHearts toolkits are in different stages of development.*
The story of m-Diabetes

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mDiabetes in Senegal
## Results:
Increasing participation by patients and HCP

<table>
<thead>
<tr>
<th>Year</th>
<th>Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1000</td>
</tr>
<tr>
<td>2015</td>
<td>12 000</td>
</tr>
<tr>
<td>2016</td>
<td>51 000</td>
</tr>
<tr>
<td>2017</td>
<td>117 000</td>
</tr>
</tbody>
</table>

Including 8500 HCP
HCP: Profile of the sample

- Other: 7.8%
- Pharmacist: 4.7%
- Paramedic: 59.4%
- Doctor: 28.1%
HCP : Impact on awareness

Did these messages increase your knowledge about diabetes?

- Not at all: 1.4
- A little: 5.5
- To a fair extent: 5.5
- A lot: 21.9
- Considerably: 65.8
Have these messages helped to increase your self-confidence when it comes to working with a patient suffering from diabetes?

- Not at all: 0.0%
- A little: 1.6%
- To a fair extent: 8.2%
- A lot: 32.8%
- Considerably: 57.4%
Patients: Impact on awareness

Message which provided information that was new to you (topics)

- Diabetes and Ramadan: 44.4%
- Nutrition: 22.2%
- Others: 33.3%
Patients: Impact on behaviour

How often do you take more care of your diabetes control?

- Rarely: 37.8
- Sometimes: 13.3
- Often: 13.3
- Everyday: 35.6
Senegal action plan 2017-2018
Scaling-up, sustainable economic model

mDiabète
- Module "pied"
- mRamadan
- Module "enfant"
- Module "femme enceinte"
- mDiabete pour hypertendus

mHTA
- Module TBD

TBD

TBD
m-Diabetes Programme in India
Objectives

- To test the feasibility of reaching and categorising large number of people using mobile technology
- To enhance health care seeking behaviour
- To improve adherence to drug, lifestyle changes and self-care
- To assess the implementation and scope of scale up of the programme
Methodology

Registration

Categorization

The text messages on healthy diet, physical activity, adherence to medication and basics of diabetes/gestational diabetes for 6 maths

Impact evaluation at 3\textsuperscript{rd} and 6\textsuperscript{th} month by text messages

Impact evaluation at 1 year by telephonic interview

Stakeholder’s interview
Text messages sent to
N = 130 million

Total participant registered
n = 107,548

Registered by Missed Call
n = 64,267 (59.8%)

Registered by Website
n = 43,281 (40.2%)

Ramachandran et al BMJ Innovations 2018
Registered participants

Age?
Do you have Diabetes?
Yes/No

Persons with diabetes
n = 23,053 (21.4%)

Gender? Male/Female

Female

Are you a Pregnant/Lactating Woman?
Yes/No

Pregnant/Lactating Women group
n = 56 (0.05%)

Male

High Risk Group Questions:
1. Height & Weight
2. Family History of DM
3. History of Hypertension
4. Sedentary Lifestyle

Persons with high risk
n = 5,686 (5.3%)

Elderly Population
n = 54 (0.05%)

Are you a Healthcare Professional?
Yes/No

Healthcare Professionals
n = 385 (0.4%)

Normal Population
n = 2491 (2.3%)

Did not answer any question

Not Categorized
n = 75,823 (70.5%)
Category specific text messages were sent to persons with diabetes, pregnant/lactating women, persons with high risk, healthcare professionals, elderly population and normal population.
Methodology

Registration

Categorization

The text messages on healthy diet, physical activity, adherence to medication and basics of diabetes/gestational diabetes for 6 months

Impact evaluation at 3\textsuperscript{rd} and 6\textsuperscript{th} month by text messages

Impact evaluation at 1 year by telephonic interview

Stakeholder’s interview
### Impact evaluation at 3rd and 6th month by text messages

<table>
<thead>
<tr>
<th>Components of behavior</th>
<th>Total number of responders, n</th>
<th>Followed advice, n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet habits</td>
<td>1989</td>
<td>1138 (57.2)</td>
</tr>
<tr>
<td>Physical activity</td>
<td>1129</td>
<td>816 (72.3)</td>
</tr>
<tr>
<td>Screening for diabetes (High Risk)</td>
<td>1709</td>
<td>888 (51.9)</td>
</tr>
<tr>
<td>Checked glycemic control (Diabetes)</td>
<td>969</td>
<td>652 (67.3)</td>
</tr>
</tbody>
</table>

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Methodology

Registration

Categorization

The text messages on healthy diet, physical activity, adherence to medication and basics of diabetes/gestational diabetes for 6 months

Impact evaluation at 3rd and 6th month by text messages

Impact evaluation at 1 year by telephonic interview

Stakeholder’s interview
Impact evaluation at 1 year by telephonic interview

Interest in the programme

Number of persons responded, n(%)  

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>To know about diabetes</td>
<td>623</td>
<td>72.9</td>
</tr>
<tr>
<td>To know about healthy lifestyle</td>
<td>144</td>
<td>16.8</td>
</tr>
<tr>
<td>Shared the text messages</td>
<td>549</td>
<td>64.2</td>
</tr>
<tr>
<td>Understood and tried to follow the advice</td>
<td>646</td>
<td>75.6</td>
</tr>
</tbody>
</table>
Impact evaluation at 1 year by telephonic interview

Acceptability of the programme

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of persons responded, n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understood text message for registration</td>
<td>832 (97.3)</td>
</tr>
<tr>
<td>Participated to improve knowledge about diabetes and healthy lifestyle</td>
<td>689 (80.5)</td>
</tr>
<tr>
<td>Appreciated the contents of the text messages</td>
<td>715 (83.5)</td>
</tr>
<tr>
<td>Happy with frequency of messages</td>
<td>490 (57.2)</td>
</tr>
<tr>
<td>Requested increase in frequency of messages</td>
<td>141 (16.5)</td>
</tr>
</tbody>
</table>
Impact evaluation at 1 year by telephonic interview

Parameters of behavioural changes

<table>
<thead>
<tr>
<th>Parameters of behavioural changes</th>
<th>Number of persons responded, n(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary advice</td>
<td>352 (41.2)</td>
</tr>
<tr>
<td>Physical activity advice</td>
<td>467 (54.6)</td>
</tr>
<tr>
<td>Programme helped to improve the knowledge level on diabetes</td>
<td>482 (56.3)</td>
</tr>
<tr>
<td>Screened for Diabetes</td>
<td>97 (11.3)</td>
</tr>
</tbody>
</table>

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Conclusions from m-Diabetes program in India

1. It is possible to reach a large number of people using mobile technology with little effort in a very short time.

2. It is possible to identify and categorize people as having diabetes and those at risk by this remote method.

3. Improvement in response and sustainability need to be tested by promotional activities and continued efforts.

5. Outbound call, IVRS, email, mobile application, etc, to be tried in the future projects to improve the response from the participants.

6. A larger national project is proposed by the ministry of Health.
So far our efforts have been...........

1. Indentifying target populations......
   a. High-risk subjects
   b. Closed Communities.
   c. Health Care workers.
   d. National program.

2. Cost-effective, acceptable & sustainable strategy.
   m-Health can support at all levels
I am indeed grateful to....

My wife, Dr. Shobana
My Family
Thank You