NICT, Japan

AFFORDABLE BAN PORTABLE HEALTH CLINIC AND ITS ENHANCEMENT
Affordable BAN Portable Health Clinic and its Enhancement

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Health: Benefit to Personal & Public Health

- Nearly 80% of NCD deaths (29 million) occur in low- and middle-income countries and lead to catastrophic medical expenditures

- More than 9 million of all deaths attributed to NCDs occur before the age of 60; 90% of these "premature" deaths occurred in low- and middle-income countries

- **Affordable e-health keeps healthy workers and national interest**

Global NCD deaths under age 70 by cause of death, 2008

NCDs: Non Communicable Diseases
Relative Costs of Poor Health: Total Value of Health

- Direct Costs: Medical & Pharmacy
- Indirect Costs:
  - Worker's compensation
  - Absenteeism: A habitual pattern of absence from a duty
  - Presenteeism: An act of attending work while sick

*Time-Away-from-Work*

Edington, Burton. A Practical Approach to Occupational and Environmental Medicine (McCunney). 140-152. 2003

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BAN in BAN Portable Health Clinic

- Body Area Network (BAN) offers a wired communication or short range radio communication capability for sensors to exchange data with a gateway around a person's body (From ITU-T Focus Group on M2M service layer: M2M enabled ecosystems: e-health)
- BAN is not limited to the space around a person, but depends on the distance reachable by cables and radios

"Overview of key functional components in the e-health ecosystem for Remote patient monitoring/assisted living" from ITU-T M2M FG report
BAN and Medical BAN Technologies

- Medical frequency band for quality of service
- Low-power consumption in modulations
- Strict security enforcement
- Top-priority data transfer for emergency data
- Ensure secure SAR (Specific Absorption Ratio) level

Affordable Checkup and Telemedicine

- **BAN Portable Health Clinic (BAN-PHC):** Health check-up and telemedicine on sites, such as factories in urban areas and villages in rural areas.
- Continuous use in areas where power supply is unstable, easy-to-use interfaces to users, such as paramedics, easy network maintenance and ease of carrying.

An international joint-research project “portable health clinic,” Kyushu University Hospital, Graduate school of IS and EE, and Grameen Communications, Bangladesh. NICT cooperation: Provide low-power & secure BAN standard technologies both for medical/healthcare devices and the coordinator based on Android.
Point-of-care medical examination, categorization, and telemedicine

1. Bring-in BAN-PHC
   - Non-invasive medical BAN devices
   - Blood test
   - Urinalysis

2. Use measurement devices for automatic categorization

3. Remote diagnosis and prescription

4. Medical certificate and prescription

- B-Logic
  - Blood pressure, blood, urine, etc.

BAN-PHC System

- Remote medical help center
- Remote database

Examinees

- Use measurement devices for automatic categorization

**B-Logic: Automatic Categorization**

<table>
<thead>
<tr>
<th></th>
<th>Green</th>
<th>Yellow</th>
<th>Orange</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;140 mmHg</td>
<td>140≤</td>
<td>&lt;160 mmHg</td>
<td>160≤</td>
<td>&lt;180</td>
</tr>
<tr>
<td>&lt;90 mmHg</td>
<td>90≤</td>
<td>&lt;100 mmHg</td>
<td>100≤</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Blood Sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;100mg/dl</td>
<td>100≤</td>
<td>&lt;126mg/dl</td>
<td>126≤</td>
<td>&lt;200mg/dl</td>
</tr>
<tr>
<td>&lt;140mg/dl</td>
<td>140≤</td>
<td>&lt;200mg/dl</td>
<td>200≤</td>
<td>&lt;300mg/dl</td>
</tr>
<tr>
<td>Postprandial Blood Sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;140mg/dl</td>
<td>140≤</td>
<td>&lt;200mg/dl</td>
<td>200≤</td>
<td>&lt;300mg/dl</td>
</tr>
<tr>
<td>Urine test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SpO2</td>
<td>≥96%</td>
<td>&lt;96%</td>
<td>&lt;93%</td>
<td>&lt;90%</td>
</tr>
</tbody>
</table>

- Red: Emergent - Telemedicine - Encouragement to visit clinic
- Orange: Affected - Telemedicine
- Yellow: Caution - Provide a leaflet about health care in Bengal
- Green: Normal

Designed by Naoki Nakashima, M.D., Kyushu University Hospital and Kunihisa Kabayashi, M.D., Fukuoka University Chikushi Hospital
BAN-PHC Workflow

1. Registration
   - Registration, interview, informed consent

2. Health checkup
   - Vital Data: Triage
   - Clinical Data: Conversation Data
   - Healthcare Guideline

3. Tele Consultancy
   - Prescription Data

4. Diagnosis & Prescription

Role: doctor, coordinator, local assistant, nurse, female support, paramedic...

Population Management of Chronic Diseases

- BAN Portable Health Clinic
  - Health checkup by a sensor set
  - Stratification and health guidance by leaflet

- Telemedicine (Tele-mentoring, tele-prescription)

- Medical treatment
  - Local healthcare center
  - Continuous Telemedicine

Innovation by ICT

From Dr. Naoki Nakashima, Kyusyu University Hospital
Medical Checkup and Remote Diagnosis in Rural Area, Bangladesh

- Doctor's remote exam.
- Remote examinee
- Wait for remote
- Physical examination scene
- Measured data on android tablet
- Reg., Interview Informed consent

BAN-PHC Devices on Site

- Support International BAN Standards
- Plug-in any sensors following the open standards

- Android terminal + BAN
- BAN blood pressure with IHB*
- BAN pulse oximeter
- BAN waist/hip meter
- BAN contactless body temperature meter
- BAN blood glucose meter
- BAN height meter
- BAN weight meter

*IHB: Irregular Heat Beat
We have to think “regression to the mean”.

*Orange was increased in FY2013 because B-Logic was revised.*

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### Results of Telemedicine in FY2013

**Visitors n=7794**

- Telemedicine (n=3080)
  - Emergent (5%)
  - Affected (35%)
  - Healthy (9%)
  - Caution (51%)

*Orange was increased in FY2013 because B-Logic was revised.*

**At the first visit**

- Emergent (14%)
- Affected (86%)
- Caution (0%)

**2nd visitors, n=709**

- Emergent (14%)
- Affected (40%)
- Caution (45%)

*We have to think “regression to the mean”*

From Dr. Naoki Nakashima, Kyusyu University Hospital

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### Cost Down of Health Checkup by ROC

Prediction of Blood Sugar by Questionnaire and Health Checkup data except for Blood sugar (the most expensive test)

(Ex)

If we select the BER (Balanced Error Rate) point in ROC (Receiver Operating Characteristic) (AUC=0.959) from 15K people, we can omit 96.4% blood sugar test (in this case, we have to allow 14.2% of positive subjects).

From Dr. Naoki Nakashima, Kyusyu University Hospital
Real Technologies for BAN-PHC

- Under unstable power supply and batteries may not be charged
- Data transfer via cell phone may not be available
- Limited space/location in setting up the clinic
- User-friendly interface for examiners

Standards around E-Health and Medical BAN

- Medical frequency band for quality of service
- Low-power consumption in modulations
- Strict security enforcement
- Top-priority data transfer for emergency data
- Ensure secure SAR (Specific Absorption Ratio) level

- IEEE802.15.6 Narrow Band [US, JP, EU, 400MHz, 800MHz, 900MHz, 2.36GHz, 2.4GHz]
- IEEE802.15.4j [US, 2.36GHz]
- IEEE802.15.4n [CN, 200MHz, 400MHz, 600MHz] Coming up soon
Japan and China worked on common Medical BAN standards

Various devices

"Off-the-shelf" Android tablet

International standards but depends on radio regulations in each country
(1)IEEE802.15.6 (US, EU, Japan, China)
(2)IEEE802.15.4 (US)
(3)IEEE802.15.4n (China)

Japan, China and US worked together on common BAN standards between IEEE802.15.6 and IEEE802.15.4n

Ready for Affordable BAN-PHC business model

PORTABLE HEALTH CLINIC
Affordable healthcare for unreached and aging community

Dr. Muhammad Yunus, a Bangladeshi banker and Nobel Peace Prize recipient, inspects the first portable health clinic.

New Social Business Venture

Micro entrepreneurs

Bangladesh

Use at evacuation site in disaster-stricken area

Prime Minister of Malaysia

Global Social Business Summit 2013
7-9 Nov. in Malaysia
http://www.gsbs2013.com/home.html

Rural/Urban Patients

Portable Health Clinic

Healthcare Service

Village Healthcare Lady

Microfinance

System maintenance service

Epidemiologic study using Big data

Researchers

Medical doctors

Use at evacuation site in disaster-stricken area

FHC supported by最先端研究開発支援プログラム「超巨大データ時代に向けた最高速データベースエンジンの開発と当該エンジンを核とする戦略的社会サーキットの実証・評価」
BAN-PHC Enhancements

- Not only 2.4GHz but 400MHz to take advantage of sneak wireless and long-haul communications
- Secure 2.4GHz/400MHz Bluetooth-conduit for smartphone
- All battery-operable by BAN beam switch-over
- Support non-invasive sensors
  - BAN vein authentication to identify a person
  - Coming ... BAN non-invasive blood test

Secure 2.4GHz/400MHz Bluetooth-conduit for smartphone

Various BAN configurations

2.4GHz BAN or 400MHz BAN

BAN-Bluetooth converter

Secure communication
All Battery-operable by BAN Beam Switch-over

- BAN blood pressure with IHB
- BAN pulse oximeter
- BAN blood sugar meter
- BAN waist/hip meter
- BAN scale
- BAN vein authentication
- BAN non-invasive blood hemoglobin measurement sensor
- BAN contactless body temperature meter
- Compact wireless A6 printer

Android terminal with NFC + BAN

Transfer data and configuration by one-touch

BAN Beam

Small video 1
Non-invasive Sensors

Easy to use, No worry of infection, Inexpensive comparing to consumables

BAN vein authentication device
- Put 10,000 (20,000 fingers)
- No personal information (Only binary data)
- Off fingerprint by hard outside work
- Various middle names

Support BAN-enabled sensors
- Hemoglobin
- Red blood cells
- White blood cells
- Blood sugar
- and so on

Start clinical experiment

Non-invasive Blood Hemoglobin Measurement

Small video 2
Expansion: Cost-effective Link between Physicians and Rural Pregnant Women

578 mothers (per 100,000) die every year in Tanzania due to preventable poor quality of care during pregnancy.

1. Health Checks by community health workers by BAN-PHC at markets

2. Data Transmission
   - Option A: Ultrasound
   - Option B: Non-invasive Hemoglobin Sensor

3. Consultation by physicians with transmitted data

4. Physicians feedbacks to community health workers

5. Community health workers transmit personal feedbacks to maternal women

Pregnant women in remote areas naturally congregate in weekly local markets for shopping.

Conclusion

- Begin to provide affordable health checks and telemedicine in an attache case suitable for primary health care to BOP/MOP*
- Ready for real-use environment by BAN-PHC enhancements, but it needs to clarify entities involved in the business model
- Another BAN standard (China BAN) which will come up this year may be a trigger of BAN expansions

* BOP: Base of the Pyramid
  * MOP: Middle of the Pyramid