Information as Medicine
Created by Healthcare Information Technology

Your heart rate is not high enough. Pace up!!

Naoki Nakashima, MD PhD
Associate Professor
Medical Information Center
Kyushu University, JAPAN

Appreciation for Prof. Nohara, Dr. Hiramatsu, Prof. Ashir, Prof. Inoue, Mr. Maruf, Mr. Partha, Mr. Kuroda and many….
Steep increase in lifestyle-related diseases! Worldwide, especially in Asia Pacific!!

- Aged population is increasing as birth rate is decreasing
- The percentage in the population of lifestyle-related diseases such as diabetes mellitus, hypertension and dyslipidemia based on visceral fat obesity (metabolic syndrome), caused by a high fat diet and an insufficiency of exercise, is increasing
- Severe complications such as stroke, myocardial infarction, dementia, renal failure, foot amputation and blindness are increasing
- Cancer, also a lifestyle-related disease, is increasing
- These diseases now account for 70% of deaths in Japan
- Prevention of these diseases is an important aim to better the quality of life in old age
### The concept of Information as medicine

**Information can be medicine!**
If the information is provided in a timely & appropriate manner

<table>
<thead>
<tr>
<th>Ordinary medicine (Tablet)</th>
<th>Information as medicine (Info-Medicine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate dose provided</td>
<td>Appropriate information provided</td>
</tr>
<tr>
<td>Function through blood concentration</td>
<td>Function through change of attitude and daily behavior</td>
</tr>
<tr>
<td>Assayable and stable effect</td>
<td>Assayable by IT, but need to be more stable</td>
</tr>
<tr>
<td>Side effects</td>
<td>Side effects (too much diet or exercise)</td>
</tr>
</tbody>
</table>

Info-medicine concept was proposed by Prof. H Tatsumi in Sapporo Medical University
When monitoring the blood sugar

Oh, I forgot to inject insulin.
I should do it now!

In the train...

Hmm, walking from the next station is not a bad idea!

During the dinner...

Oh, I forgot to take medicine.

You are eating dinner. Did you take medicine?

You’ve got on the train? How about walking home from the next station?

When you are jogging...

Oh, It may be too fast. I should be careful, because I have a heart disease.

Heart rate is too high, slow down!

Your blood sugar is too high. Did you use insulin?

When monitoring the blood sugar

Oh my God, I forgot to inject insulin. I should do it now!
How to assess the effect of info-medicine
Now we can automatically detect daily behaviors on time through IT!

Sample sensor data of a person standing position in a rising elevator

Precise answer rate was 89% in 22 kinds of behaviors

Real time recommendations through mobile communication devices using network
To create Info-Medicines

- We should know how to change the patients’ attitude and daily behavior
  
  (Which information? What kind of timing? How to inform?)
  
  - Collection of daily behavior Information
  - Accumulation of large amounts of data and analysis
  - Assurance of Medical Safety

- We also consider assessment of outcome and cost effectiveness
To make this system available to everyone...

--The Info medicine concept is useful for variety of chronic diseases, and even for health guidance and mental healthcare in healthy people

--Efforts to establish Global Standards have already been launched in APEC, OECD, ISO etc, in healthcare field, also in IHE, HL7, DICOM etc...

--Common (Global) rules on privacy information protection are required

--Data Analysis Technology should also be further provided
“Carna”, a Disease Management trial project for Chronic Diseases in Japan
It aims the primary and secondary/tertiary prevention of diabetes mellitus/complication through prior interventions by the call-center. Carna’s goal is to establish a high quality medical care system with reasonable cost.

“Carna” is the Name of the Roman Female God of Health
Sensor Network for diabetic patient in 2009

- **Weight Scale**
- **Blood Pressure**
- **Blood Sugar**
- **Behavior Detector** (accelerometer)

**Devices Connected to Home Server**
- **Router**
- **FOMA** (NTT docomo)

**Internet Connections**
- **IP**
- **FOMA-NW**
- **SoftBank-NW**

**Smartphone Connections**
- **Manual input**
- **Bluetooth**
- **Blood Sugar**
- **Behavior Detector** (accelerometer)
Result 2009-1  Rate of operating detected by entire log

This shows the operating rate during the experiment (3 months)

<table>
<thead>
<tr>
<th>kg</th>
<th>Weight</th>
<th>mg/dl</th>
<th>Blood sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>mmHg</th>
<th>BP (Diastolic)</th>
<th>mmHg</th>
<th>BP (Systolic)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Automatic Recommendation e-mail
(+= an email)
Result 2009-2

We could figure out weight control of patients

• Various patterns were shown (upper, middle)

• Real time recognition of sickness (lower)
Result 2009-3
Change of measurement frequency by recommendation

Measurement number

Lower measurement frequency

Measurement number

Higher measurement frequency

Weight Histogram

BS Histogram

BP Histogram

Measurement number

Interval (day)

number

Interval (day)

number

Interval (day)

number

green: Before
Red: After

green: Before
Red: After

green: Before
Red: After
Result 2009-4  Recommendation by behavior sensing
Changes between before and after recommendation

Walking and Bicycle use were increased by recommendation

By recommendation as 「Because you did not walk enough, let’s walk aiming 20 min today!」

By Detection of hard exercise

By recommendation as 「How is your condition today? Do not have too much exercise, please!」

Change of behavior after recommendation

- **Walking**
  - Before: 0 min
  - After: 10 min

- **Bicycle**
  - Before: 0 min
  - After: 5 min

Change of behavior after recommendation

- **Walking**
  - Before: 0 min
  - After: -5 min

- **Bicycle**
  - Before: 0 min
  - After: 5 min
Care of chronic diseases will be transferred from hospital to home.

Outcomes, effectiveness, safety are all needed in both Admission and Home care.
Studies in 2011～2012

Analysis of medical process and outcomes in hospital

- Hospital; Saiseikai Kumamoto Hospital

- **Purpose;**
  - Relation analysis between objective data (including sensor data) of patient and final outcomes (medical, economic, satisfaction, etc.) to identify “clinical indicators”
  - All medical procedure and assessment on clinical pathway are included (Done)
  - We want to detect other clinical indicators from sensor data which are not described in clinical pathways.

- **Method**
  - Use patients on outcome-oriented clinical pathway
  - Set up varieties of sensors on patient and ward
  - Set up wearable sensors on nurses which recognizes nursing behaviors on nurses mapping with the patients by RFID
  - Use mathematic statistics and machine learning method
Analysis of medical Process and outcomes in hospital

- Noise sensor
- Bed sensors (Respiration, heart beat)
- Temperature and humidity sensor
- Illuminance sensor
- Blood pressure
- ECG
- Blood Sugar
- 3-axis accelerometer
- O2 Hemoglobin
- iPod touch (Sound, touch)
- RFID (mapping with patient)
- RFID reader (mapping with nurse)
Analysis Result of 4days-PCI Clinical Pathway (N=135)

- Objective Variable: Duration of Hospital Stay (≤4 days: 0, Length of stay ≥5 days: 1)
- Analysis Method: Logistic Regression

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Odds</th>
<th>95%-confidence interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.12*</td>
<td>1.02-1.23</td>
<td>0.015</td>
</tr>
<tr>
<td>Can eat meals (3rd day)</td>
<td>73.52*</td>
<td>1.46-3692.33</td>
<td>0.032</td>
</tr>
<tr>
<td>No problem on puncture site (3rd day)</td>
<td>23.12*</td>
<td>1.14-467.57</td>
<td>0.041</td>
</tr>
<tr>
<td>Stability of Vital signs (4th day)</td>
<td>32.55*</td>
<td>1.55-684.94</td>
<td>0.025</td>
</tr>
</tbody>
</table>

We can extract 4 CIs from 27 outcomes
Patient’s Data (from Admission Date to Discharge Date)

Red lines shows Nurse enter/exits the room

Heartbeat

Activity

Heartbeat2

Respiration

Movement

Humidity

Temperature

Noise Level

Illuminance
Nurses with Three Accelerometers and RFID tag
Results of nursing action recognition using test data

Average of all classes is 62.2% (11.8%-100%)
Collected Data Volume (As of Oct. 2012)

- **Patient Data (93 patients)**
  - From Apr. 2011 to Jul. 2011 [without RFID data]
    - Environment sensor & Accelerometer 570 hours (70 hours per patient), ECG 410 hours, Bed sensor 228 hours
  - From Aug. 2011 [with RFID data]
    - Environment sensor & Accelerometer 5600 hours (66 hours per patient), ECG 4060 hours, Bed sensor 4100 hours

- **Nurse Data**
  - Simulated Nursing Data (41 behaviors)
    - Total 70 hours of 4994 data (120 data per behavior)
  - Real Nursing Data without RFID data
    - Total 4600 hours
  - Real Nursing Data with RFID data
    - Total 4400 hours [82 hours data is labeled by RFID]
RELATIONS BETWEEN NATIONAL GDP AND SERVICE DIFFUSION RATE

By Prof. Akihiko Shinozaki in Kyushu U
RELATIONS BETWEEN LITERACY RATE AND SERVICE DIFFUSION RATE

△ Internet  ○ Phone(Fixed)  × Mobile Phone

By Prof. Akihiko Shinozaki in Kyushu U
PORTABLE CLINIC PROJECT
AN AFFORDABLE, USABLE, SUSTAINABLE AND PREVENTIVE HEALTHCARE SYSTEM FOR UNREACHED PEOPLE

Stratification by results of health check-up by portable clinic

- Normal; none
- Subnormal; Brochure
- Abnormal; Telemedicine
- Serious ill; Telemedicine and visit hospital

“Triage”

Sensors and network which are easy to operate

(Grameen medical lady (Nursing students))

Call Center
(Disease Management Office by doctors)

Info-medicine
- Ordinary, emergency
- Phone call
- Email
- Phone Web

Remote-prescription
health checkup – telemedicine program in Bangladesh in 2012

Registration and 1st question

1st Health checkup

Triage &

Education by leaflets only for

Telemedicine

Advice & tele-prescription &/or Push to visit at clinic

Registration and 2nd question

2nd Health checkup

Triage &

Education by leaflets only for

Telemedicine

Advice & tele-prescription &/or Push to visit at clinic

(n=8690)
Portable Clinic in Attachecase Summer Version 2012

- Barcode reader
- Name cards with barcode
- Measure (Height, Waist, Hip)
- Pulse oximeter (Oxygen in blood)
- Blood sugar meter
- Blood pressure
- Thermo meter
- Urine tester tape (protein, sugar)
- Weight scale
- Mobile modem
- Android terminal
- Buttery
- Paper and pen

Installed BAN (IEEE802.15.6)
A new standard for body sensors

Including 1) sensor devices, 2) transmission system, 3) data management software, and 4) doctor call center services
The BAN Standard IEEE802.15.6

First Medical BAN published in Feb 2012

- 1 common MAC with 3 physical layers (PHYs)
- Quality of Service (QoS) is ensured
- Strict Security Enforcement
- Low Power Consumption
- Secure Specific Absorption Ratio (SAR) Level
Ekhaspur, Bangladesh

Health Checkup Site

Health checkup
- Blood Pressure & Blood sugar
- Pulse oximeter
- Urine test
- Height, waist, hip & weight

Registration & questionnaire

Telemedicine & Tele-prescription
Matching by sex because of Islam

System support and data management

Male doctor
Female doctor
Results of Pilot study in 2012 (July to Nov)

The first checkup (n=791)
- Healthy (10%)
- Caution (69%)
- Affected (18%)
- Emergent (3%)

The second checkup (repeat rate = 96/167=57%)
- Emergent (12%)
- Affected (88%)

First Visit
- Emergent (13%)
- Healthy (2%)

Second Visit
- Affected (43%)
- Caution (43%)

Telemedicine
Health Guidance
Results of the first health check-up

<table>
<thead>
<tr>
<th>Color Status</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>1419</td>
</tr>
<tr>
<td>Yellow</td>
<td>5588</td>
</tr>
<tr>
<td>Orange</td>
<td>1471</td>
</tr>
<tr>
<td>Red</td>
<td>212</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8690</strong></td>
</tr>
</tbody>
</table>

- **Healthy**: 16.3%
- **Caution**: 64.3%
- **Affected**: 16.9%
- **Emergent**: 2.4%

N = 8690
What we got from PHC study

• Big Data
  – Also probably got good results of health improvement (under analysis)
• Issues of system to feedback
• Issues of operation to feedback
• Relationship with Bangladesh

We will continue the project in 2013
Intensified Healthcare System in Disaster Area

The Third Parity Disease Management Office

Call Center

Risk Stratification And Intervention
- Sensor monitor
- Telemedicine
- Visiting care
- Emergency

Medicine Delivery
- Provide Info-Medicine
  - Medicine (daily / emergency)
  - phone call
  - e-mail
  - web

Remote Prescription
Chronic Dis and Mental health

Telemedicine from Remote Area

Evacuation Center

Temporary house

Aged or High Risk Patient

EHR/PHR

Cloud Computing

DB
Disease Management Provider

Data Center (Fusion sensor data with medical information)

EHR/PHR

EMR/CHOE

DB

EAN

Call Center

PAN

WAN

mobile phone

PC

Blood sugar

Pulse meter

Blood Pressure

Behavior meter

Weight Scale

Digital Terrestrial TV

Aged or High Risk Patient

Provide Info-Medicine (daily / emergency)
- phone call
- e-mail
- web

Medical Support Coordination

Visualize Sensor Data

Dr Specialist

Family Dr

Healthcare providers

Care Provider

Tele-medicine

Care Provider

- phone call
- e-mail
- web

Dr Specialist

Family Dr

Healthcare providers

Care Provider

Tele-medicine

Care Provider

- phone call
- e-mail
- web

Dr Specialist

Family Dr

Healthcare providers

Care Provider

Tele-medicine

Care Provider

- phone call
- e-mail
- web

Dr Specialist

Family Dr

Healthcare providers

Care Provider

Tele-medicine
Direction of Technology Transfer


By International Standards

Further improvement of Technology and Solution

Needs in Dev. Countries + Japanese Solution (As a New Seeds) II New Solution

Feedback to Adv. Countries (Reverse Innovation)

Diffuse to other Dev. Countries
Thank you for your attention!

This research has been mainly supported by Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)

Any Questions?

For further information, please contact:

Naoki Nakashima
nnaoki@info.med.kyushu-u.ac.jp