Computing and the Developing World
CSEP 590B, Spring 2008
Lecture 6 – Mobile Devices and Healthcare
Richard Anderson, Brian DeRenzi

Administration
• Next week, MONDAY, May 12
  – Yaw Anokwa (Open MRS)
  – David Edelstein, Grameen Technology Foundation
  – Joydeep Pal, UC Berkeley
• Classroom Presenter Video
• Upcoming Lectures
  – May 12, Multiple topics
  – Anokwa, Edelstein, Pal
  – May 21, Education
  – May 28, Data Collection
  – Tapan Parikh
  – June 4, Non-literate Uis
• sydney2.dyn.cs.washington.edu

Highlights from Lecture 5
• Sardine Fishing in Kerala
  – Mobile phones transform agricultural market
• Warana SMS Project
  – Remote access to information by farmers
• Digital Green
  – Agricultural education based on locally produced content

ICT and Agriculture
• Market Information Systems
  – Positive Example www.e-krishi.org
  – In general impact is unclear
    • Improving market performance
    • Increased transparency
  – Radio based market rate reports
    • Mali

Other agricultural domains
• TV and Radio based agricultural information
• Question and answer systems
  – eSagu, IIIT Hyderabad
• Agricultural cooperative management
• Sensor networks

What role does ICT have in addressing agricultural problems of the poor?
• What is the most compelling application of ICT in agriculture?

• Are there other applications that were missed?
What role does ICT have in addressing health problems of the poor?
• Needs and resources are large, but role of computing is not clear

Delivery of medical services
• Improve health care delivery to individuals

Public health / disease eradication
• Systematic health improvements with broad benefits

Medical Study
• Understanding global health status
• Evaluation of treatment options

Today's topics
• Mobile Devices in Health Care
• Case studies
  – HIV
  – e-IMCI
  – Ifakara Health Survey
  – Apple 1997, India Healthcare Project
  – Health Metrics Network

Electronic Pill boxes
• What do they do, and why are they useful?
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D-Tree International
• Non-profit based in Boston, MA
• Medical algorithms on mobile devices
• Help over-burdened health workers
• Gather data from the field

Dimagi
• For-profit software development firm based out of Boston, MA
• Strong social mission, particularly in health – Experience in low-resource settings
• Work with NGOs, governments, academic institutions…

AIDS in South Africa
• Estimated 600,000 adults not receiving needed ARV treatment

AIDS in South Africa
• Patient to doctor ratio is very high
• 29.1% national HIV prevalence

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Doctors per 1000</th>
<th>HIV+ per 1000</th>
<th>HIV+ per doctor</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>0.489</td>
<td>215</td>
<td>439</td>
</tr>
<tr>
<td>Tanzania</td>
<td>0.023</td>
<td>88</td>
<td>3826</td>
</tr>
<tr>
<td>Rwanda</td>
<td>0.025</td>
<td>51</td>
<td>2040</td>
</tr>
<tr>
<td>United States</td>
<td>1.629</td>
<td>6</td>
<td>3.69</td>
</tr>
</tbody>
</table>

1 http://www.avert.org/safricastats.htm

AIDS in South Africa
• Counselors use PDA to determine who is healthy and who needs to see a doctor
Motivation

- This year almost 10 million children will die before reaching the age of 5
- Most live in low-income countries
- Almost 2/3 could be saved by the correct application of affordable interventions
- Every 6 seconds a child dies from a preventable cause

IMCI

- UNICEF, WHO and others develop medical protocols
- Integrated Management of Childhood Illness (IMCI)
- Address most common childhood illness
- Easy to use for lowly-trained health workers

IMCI

- Originally developed in 1992 by WHO and UNICEF
- Adopted by over 80 countries worldwide
- Integrated most common causes of childhood illness into a single approach

IMCI Example

Does the child have cough or difficult breathing?

Classify COUGH or DIFFICULT BREATHING

If yes, ask:
LOOK, LISTEN, FEEL

- For how long?
- Count the breaths in one minute;
- Look for chest in-drawing;
- Listen and listen for whistling

CHILD MUST BE CALM

1. Fast breathing
   - 2 months up to 57 months
   - 60 breaths per minute or more
   - 12 breaths per minute or more

2. Inadequate
   - Weak cry
   - Mom or other caregiver
   - Weak and irritable

3. Poor weight gain
   - Weight less than the age
   - Poor weight gain

IMCI Example

SIGN
- Any general danger sign
- Chest in-drawing
- Sticker in calm child

CLASSIFY AS
- PNEUMONIA
  - Use an appropriate antibiotic for 5 days
  - Stabilize the child and reduce the cough with a safe remedy
  - Advise mother when to return in 2-5 days

- NO PNEUMONIA
  - COUGH OR COLD
  - If coughing more than 30 days, refer for assessment
  - Stabilize the child and reduce the cough with a safe remedy
  - Advise mother when to return in 2-5 days

TREATMENT
- Refer immediately to hospital
- Follow up in 2-5 days
IMCI Example

- **Give an Appropriate Oral Antibiotic**
  
<table>
<thead>
<tr>
<th>AGE in WEIGHT</th>
<th>COMBINATION</th>
<th>MEDICINE</th>
<th>DOSE (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 months old</td>
<td>10 mg</td>
<td>1x1/2</td>
<td>1000</td>
</tr>
<tr>
<td>1 year old</td>
<td>20 mg</td>
<td>1x1</td>
<td>2000</td>
</tr>
<tr>
<td>2 years old</td>
<td>30 mg</td>
<td>1x1</td>
<td>3000</td>
</tr>
<tr>
<td>3 years old</td>
<td>40 mg</td>
<td>1x1</td>
<td>4000</td>
</tr>
<tr>
<td>4 years old</td>
<td>50 mg</td>
<td>1x1</td>
<td>5000</td>
</tr>
<tr>
<td>5 years old</td>
<td>60 mg</td>
<td>1x1</td>
<td>6000</td>
</tr>
</tbody>
</table>

IMCI Barriers

- Expense of training ($1150-$1450)
- Not sufficient supervision
- Chart booklet
  - Takes a long time to use
  - Natural tendency to be less rigorous
  - Social pressure

e-IMCI

- Put IMCI protocol on PDA
- Guide health workers step-by-step through the protocol
- Data collection is a by-product of care
- Can handle more complex protocols
- Interface with other devices and EMR

e-IMCI Interface

- Code based on South Africa HUPA project
- Windows Mobile 5.0
  - PDA/SmartPhone
- Contains cough, diarrhea, fever and ear pain questions and treatment
- First visit, ages 2 weeks to 5 years

Mtowa, Tanzania

- Worked with IHRDC in Mtowa, Tanzania
- Southern Tanzania
- Rural
  - Subsistence farming
  - Fishing
- Piloted e-IMCI at a dispensary
Study Design

- Started with 5 clinicians
- Four clinicians completed study
- Goals:
  - Discover usability issues
  - Discover if e-IMCI helped adherence
  - Determine how e-IMCI effects patient visit

- Started with some pre-trials to fix major bugs
- Semi-structured interview of all clinicians
- Observed 24 current practice IMCI sessions
- 31 e-IMCI sessions
- Exit interview for each clinician

Adherence

- Measured adherence by 23 questions/investigations IMCI asks the practitioner to perform
- e-IMCI significantly improved adherence to the IMCI protocol

Timing

- No substantial increase in patient visit time
- Factors:
  - Number of classifications
  - Interruptions

Clinician Reaction

- Unanimously cited e-IMCI as easier to use and faster than following the chart booklet
- Wanted to use the system for Care Treatment Clinic
- Liked being able to review answers to questions
- Asked to be in future studies
- “Sometimes since I have experience [with IMCI] I will skip things, but with the PDA I can’t skip.”

Lessons Learned

- Limitations
  - Question Grouping
  - Threshold Problem
- Requirements
  - Flexibility
- Incorrect IMCI
  - Cough syrup
- Local Preference
  - Antibiotic
  - Lab use
e-IMCI for Training

- Current training lasts 11-16 days
- Costs $1150 - $1450 per person
- Using e-IMCI to train, could reduce time and cost

User-Driven Model

- "Expert" mode
- Allow users to decide what investigations to perform
- Flexibility will encourage long-term use
- Merge with current system-driven approach to ensure correct care

Tools for protocols

- Automatically generate interfaces for different platforms
- Interfaces for the tutor, guided and expert modes
- Maintain consistent interface

Community Outreach

- Take e-IMCI outside of the health facility
- Travel village-to-village to collect health census information and deliver care

Current Status

- HIV Screening Project
  - Moving to Tanzania with a grant from the CDC
- e-IMCI project
  - Continuing in Tanzania
  - More formal study with funding from Rockefeller

Acknowledgments

- Neal Lesh, Marc Mitchell, Gaetano Borriello, Tapan Parikh, Clayton Sims, Werner Maokola, Mwajuma Chemba, Yuna Hamisi, David Schellenberg, Kate Wolf, Victoria DeMenil, D-Tree International, Dimagi Inc., the Ifakara Health Research & Development Centre, the Ministry of Health in Tanzania and the clinicians in Mtwara for their support and contribution to this work.
Ifakara Study

PDAs for medical surveys
• Data Entry at Point of Collection
• Large scale survey in Tanzania using PDAs
  – Health survey of 21,000 households
  – from Emerging Themes in Epidemiology
  – Surveyors
    • secondary school education
    • no computing experience

Motivation for PDAs for surveys
• Increase accuracy and reduce cost
  – Data validation
  – Skip logic
  – Avoid double entry of data
    • Handling of paper
    • Transcription errors
    • Time in processing
    • Delayed error detection
• Opportunity for integration with GPS
• More sophisticated survey logic

What could go wrong?
• What are the potential difficulties with a large scale PDA based survey?

Concerns
1) 5) 2) 6) 3) 7) 4) 8)

Southern Tanzania Survey
• Baseline information on health and survival in young children prior to a cluster-randomized evaluation of a new approach to malaria and anaemia control
• Derive infant mortality estimates in each of 24 districts
• 21,600 households
• Undeveloped region
  – high mortality, malnutrition and illiteracy
  – simple mud-walled houses
  – subsistence farming / fishing
  – no electricity
  – few paved roads
Hardware / Software

- Palm m130, $100, 160 x 160 passive matrix colored touch sensitive screen, 4.8 x 3.1 x 0.9 inches, 5.4 oz, 8 MB memory, 16 MB expansion card
- Rechargeable lithium ion battery
  - two full working days between recharges
- Pendragon Forms 4.0
  - Forms, validation, database, synchronization

Household survey

Survey details

- After survey was delivered, some respondents were invited to weighing station
- Questions delivered in Swahili, recorded in English
- Pilot before main survey
- Data security
  - Data copied to SD cards
  - Interviewers could not update records after data copied
  - Daily backups to laptop
  - Secondary validation

Deployment

- Training of survey team
  - Two weeks, starting with PDAs and continuing to pilot surveys
- 13 teams of 7 interviewers each with supervisor
- Two support vehicles
  - Daily synchronization of PDAs

Results

- No problems
  - No lost data
  - No hardware failures in spite of harsh environment
  - Solar chargers worked fine
  - Community and interviewer acceptance of PDAs
- Initial survey data available two days after completion of surveys
- Cost per survey
  - $0.85 per household
  - $1.25 for similar paper based survey

Discussion

- High acceptance of PDAs
  - Interviews showed interviewees PDAs during consent procedure
- PDA Approach
  - More pre-training preparation than paper based
  - Survey needed to include logical consistency checks
  - Upfront costs reduced time later on
- Easier to modify PDA surveys that paper forms
- Possible extensions
  - Design of survey logic for PDA delivery
  - Integration with GPS
Apple Study: CHI 1997

- Develop mobile computing device to be used by Auxiliary Nurse Midwives (ANMs) in rural India
- Apple Research Labs and Government of India
- 1994-1997
- Target device: Apple Newton
- Ajmer district, Rajasthan

Auxiliary Nurse Midwives

- 350,000 ANMs in India
- 2 years training in basic health care
- Treat minor ailments, hospital referrals, pre and post natal care, vaccinations, malaria testing, promotion of contraception
- Home visits by foot/bicycle/moped
  - About 9 house calls a day, 45 people

Record keeping

- Weekly/Monthly reports
- Village data
  - Well location
  - Malaria spraying
- Household data
  - Head of household
  - Number of people
  - Couples and contraceptive methods
- Medical
  - Illnesses
  - Vaccinations
  - Referrals
  - Operations
- Pregnancies
  - Pre/Post Natal records
  - Birth attendants
  - Supplies dispensed
  - Notes on difficulties
  - List of people attending talks
  - Immunization record for child
- Diary
  - List of house calls

Apple field study

- “Something we noticed immediately was that the records she kept about her activities had little bearing on the events which actually took place”
- “Nor did there appear to be any incentive for the ANM to complete the records accurately”

Paper work

- ANM adept at filling out forms and ledgers
- Forms arose from continual introductions of new programs (with distinct reporting structures)
- Multiple mistakes made in filling out forms
- Villager data suspect

Design goals

- Project was NOT to redesign the health care system
- Goals
  - Reduce time on paperwork
  - Increase time spent with people
  - Improve quality of welfare of community
  - Increase reliability of data
  - Enable timely distribution of data
Interaction Design Approach (1994)
- Understanding / representing existing approach
- Challenge: Household records vs. individual records
  - Multigenerational households
  - Records based on head of household
    - Problem made worse since names are often the same
  - Shift to individual records

Results
- ANMs were not intimidated or hesitant about the device
- Authors suggested prototype too general
  - Focus on family planning, immunization of children under one, malaria screening (85% of population participate in one of these programs).
- Wide variety of practices by users
- Pen based UI contributed to ease of use
- Apple Newton
  - Primitive pen based computer
  - Emphasis on handwriting recognition
  - Hindi not available on the device
- UI Issues
  - Will revisit for non-literate UI discussion

Point of Care Diagnostics

PDAs for bacteriology collection
- PIH, Multidrug-resistant TB treatment in Peru
- Data collection problem
  - Patients leave sample at local health center
  - Health workers collect results and take data to PIH headquarters
    - 2000 monthly results from 120 health centers
  - Data collected on paper, copied to two other forms, then taken to central office for data entry

PDA solution
- Collect data from health centers by data entry on PDA
- Low end Palm-OS devices with Pendragon software
- Data validation and cross checking on entry
- Pilot study
  - Usability and acceptability by users
  - Processing time
  - Frequency of discrepancies
  - Cost effectiveness

Results
- Usability
  - 2-5 days training
  - Favorable response for reduced paper shuffling and quick verification
- Processing delays
  - Reduced from 54 days to 6 days
- Error rates
  - Reduced from 10% to 3% (samples with at least one error)
- Cost effectiveness
  - Cost per device: $300
  - Significant reduction on data entry time
Survey Participant Study

- Question: Does the use of technology (PDA vs. paper) influence participants survey answers?
- Survey of risk behaviors for HIV/AIDS
- Study in Luanda, Angola, 2005

Study methodology

- 10 minute interview on sexual behavior
- Results recorded on PDA or paper
- 231 participants split roughly evenly between PDA and paper groups
  - Sample from three different neighborhoods
- Questions
  - Personal characteristics
  - Comfort with interview
  - Sexual Behavior
    - Partners, condom use, sex for money, HIV testing, forced sex, use of alcohol and sex

Result

- Interviewees gave more **socially desirable** answers in the PDA condition than the paper condition
- Nine questions relating to behavior
  - +1: Socially desirable answer
  - 0: Question not asked
  - -1: Undesirable answer
- Paper: 1.4, PDA 2.4
- t(221) = -2.8, p < 0.01

Interpretation

- Why would people give more socially acceptable answers to interviewers with a PDA?

WHO Health Metrics Network

- Global Partnership that facilitates better health information
**HMN Framework**

- **Goal**
  - Increase the availability and use of timely and accurate health information at sub-national, national, and global levels by catalyzing the joint funding and development of core country health information systems.
- **Objective 1**
  - Establish the Health Information System Framework
- **Objective 2**
  - Strengthen Health Information Systems
- **Objective 3**
  - Improve global access and use of health information

**Evidence based decisions**

- **Does treatment X help?**
  - What is the appropriate target A1C for type 2 diabetics?
- **Spending choices**
  - Is it more cost effective to spend money on bed nets or spraying to reduce malaria?
- **Policy decisions**
  - Is the incidence of childhood obesity high enough to warrant a ban on french fries?

**Challenge problem: counting the dead**

- Age, cause of death of everyone in the country

**Lecture Summary**

- Mobile devices are successfully supporting medical delivery, public health, and studies
- Cell phone vs. PDA
- What would a broader platform, environment, set of services look like to support medical workers?

**What role does ICT have in addressing health problems of the poor?**

- What is the most compelling application of ICT in health?
- Are there other applications that were missed?

**Links**

- Dimagi
  - [www[dimagi.com/](http://www.dimagi.com/)
- uBox
  - [http://www.innovatorsinhealth.org/](http://www.innovatorsinhealth.org/)
- D-Tree International
- Health Metrics Network
  - [http://www.who.int/healthmetrics/en/](http://www.who.int/healthmetrics/en/)
- Grameen Foundation
  - [http://www.grameenfoundation.org/](http://www.grameenfoundation.org/)

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