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
  - Joyojeet 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 Us
- 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?
Brian DeRenzi
• bderenzi@cs.washington.edu

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
• 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>0.499</td>
<td>215</td>
<td>439</td>
</tr>
<tr>
<td>Tanzania</td>
<td>0.023</td>
<td>86</td>
<td>3825</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>

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

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

1 https://www.avert.org/safricastats.htm
Tanzania

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 Example**

**IMCI Example**
**IMCI Example**

- *Give an Appropriate Oral Antibiotic*

**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

**Mtwara, Tanzania**

- Worked with IHRDC in Mtwara, 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

![Adherence Graph]

### Timing

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

![Timing Graph]

### 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

Tools for protocols

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

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

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

Community Outreach

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

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

1. Household module
2. Birth history (for women)
3. Child info, under two
4. Health visit
5. Medication
6. Under two invitation
7. Over two invitation
8. Under two followup
9. Over two followup

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 than paper forms
- Possible extensions
  - Design of survey logic for PDA delivery
  - Integration with GPS
<table>
<thead>
<tr>
<th>Apple Study: CHI 1997</th>
<th>Auxiliary Nurse Midwives</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Develop mobile computing device to be used by Auxiliary Nurse Midwives (ANMs) in rural India</td>
<td>- 350,000 ANMs in India</td>
</tr>
<tr>
<td>- Apple Research Labs and Government of India</td>
<td>- 2 years training in basic health care</td>
</tr>
<tr>
<td>- 1994-1997</td>
<td>- Treat minor ailments, hospital referrals, pre and postnatal care, vaccinations, malaria testing, promotion of contraception</td>
</tr>
<tr>
<td>- Target device: Apple Newton</td>
<td>- Home visits by foot/bicycle/moped</td>
</tr>
<tr>
<td>- Ajmer district, Rajasthan</td>
<td>- About 9 house calls a day, 45 people</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Record keeping</th>
<th>Apple field study</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Weekly/Monthly reports</td>
<td>- “Something we noticed immediately was that the records she kept about her activities had little bearing on the events which actually took place”</td>
</tr>
<tr>
<td>- Village data</td>
<td>- “Nor did there appear to be any incentive for the ANM to complete the records accurately”</td>
</tr>
<tr>
<td>- Well location</td>
<td></td>
</tr>
<tr>
<td>- Malaria spraying</td>
<td></td>
</tr>
<tr>
<td>- Household data</td>
<td></td>
</tr>
<tr>
<td>- Head of household</td>
<td></td>
</tr>
<tr>
<td>- Number of people</td>
<td></td>
</tr>
<tr>
<td>- Couples and contraceptive methods</td>
<td></td>
</tr>
<tr>
<td>- Medical</td>
<td></td>
</tr>
<tr>
<td>- Illnesses</td>
<td></td>
</tr>
<tr>
<td>- Vaccinations</td>
<td></td>
</tr>
<tr>
<td>- Referrals</td>
<td></td>
</tr>
<tr>
<td>- Operations</td>
<td></td>
</tr>
<tr>
<td>- Pregnancies</td>
<td></td>
</tr>
<tr>
<td>- Pre/Post Natal records</td>
<td></td>
</tr>
<tr>
<td>- Birth attendants</td>
<td></td>
</tr>
<tr>
<td>- Supplies dispensed</td>
<td></td>
</tr>
<tr>
<td>- Notes on difficulties</td>
<td></td>
</tr>
<tr>
<td>- List of people attending talks</td>
<td></td>
</tr>
<tr>
<td>- Immunization record for child</td>
<td></td>
</tr>
<tr>
<td>- Diary</td>
<td></td>
</tr>
<tr>
<td>- List of house calls</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper work</th>
<th>Design goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>- ANM adept at filling out forms and ledgers</td>
<td>- Project was NOT to redesign the health care system</td>
</tr>
<tr>
<td>- Forms arose from continual introductions of new programs (with distinct reporting structures)</td>
<td>- Goals</td>
</tr>
<tr>
<td>- Multiple mistakes made in filling out forms</td>
<td>- Reduce time on paperwork</td>
</tr>
<tr>
<td>- Villager data suspect</td>
<td>- Increase time spent with people</td>
</tr>
</tbody>
</table>

- 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 postnatal 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/
• uBox
  – http://www.innovatorsinhealth.org/
• D-Tree International
• Health Metrics Network
  – http://www.who.int/healthmetrics/en/
• Grameen Foundation
  – http://www.grameenfoundation.org/