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 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?

Brian DeRenzi

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D-Tree International

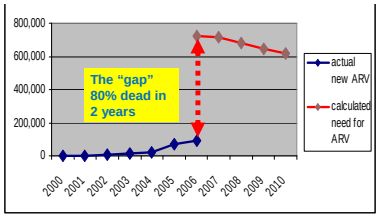
- Non-profit based in Boston, MA
- Medical algorithms on mobile devices
- Help over-burdened health workers
- Gather data from the field

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

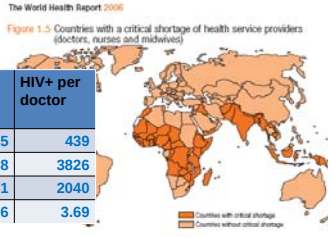
- Estimated 600,000 adults not receiving needed ARV treatment



AIDS in South Africa

- Patient to doctor ratio is very high
- 29.1% national HIV prevalence[1]

COUNTRY	Doctors per 1000	HIV+ per 1000	HIV+ per doctor
South Africa	*0.489*	215	439
Tanzania	0.023	88	3826
Rwanda	*0.025*	51	2040
United States	*1.629*	6	3.69



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

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

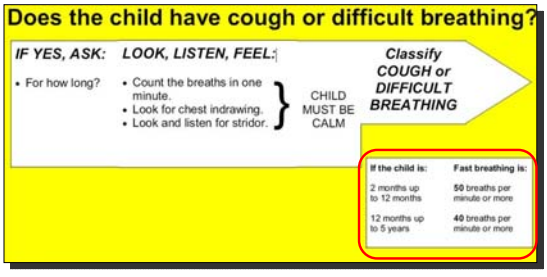
IMCI

- 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

- 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

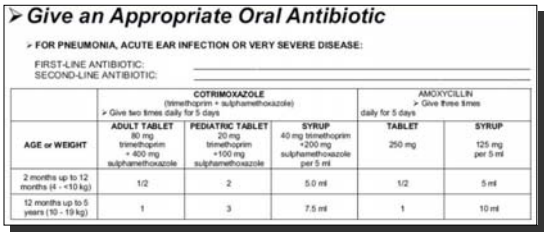
IMCI Example



IMCI Example

SIGNS	CLASSIFY AS	TREATMENT (Urgent pre-referral treatments are in bold print.)
• Any general danger sign or • Chest indrawing or • Stridor in calm child.	SEVERE PNEUMONIA OR VERY SEVERE DISEASE	➢ *Give first dose of an appropriate antibiotic.* ➢ *Refer URGENTLY to hospital.**
• Fast breathing.	PNEUMONIA	➢ *Give an appropriate antibiotic for 5 days.* ➢ Soothe the throat and relieve the cough with a safe remedy. ➢ Advise mother when to return immediately. ➢ Follow-up in 2 days.
No signs of pneumonia or very severe disease.	NO PNEUMONIA: COUGH OR COLD	➢ If coughing more than 30 days, refer for assessment. ➢ Soothe the throat and relieve the cough with a safe remedy. ➢ Advise mother when to return immediately. ➢ Follow-up in 5 days if not improving.

IMCI Example



➢ **Give an Appropriate Oral Antibiotic**

➢ FOR PNEUMONIA, ACUTE EAR INFECTION OR VERY SEVERE DISEASE:

FIRST-LINE ANTIBIOTIC: _____

SECOND-LINE ANTIBIOTIC: _____

	COTRIMOXAZOLE (trimethoprim + sulphamethoxazole) ➢ Give two times daily for 5 days			AMOXYCILLIN ➢ Give three times daily for 5 days	
AGE or WEIGHT	ADULT TABLET 80 mg trimethoprim + 400 mg sulphamethoxazole	PEDIATRIC TABLET 20 mg trimethoprim +100 mg sulphamethoxazole	SYRUP 40 mg trimethoprim +200 mg sulphamethoxazole per 5 ml	TABLET 250 mg	SYRUP 125 mg per 5 ml
2 months up to 12 months (4 - <10 kg)	1/2	2	5.0 ml	1/2	5 ml
12 months up to 5 years (10 - 19 kg)	1	3	7.5 ml	1	10 ml

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

e-IMCI

- 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

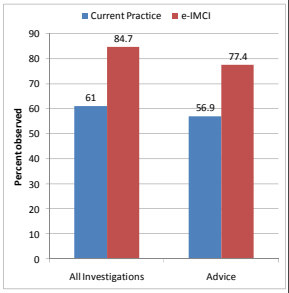
- Started with 5 clinicians
- Four clinicians completed study
- Goals:
  - Discover usability issues
  - Discover if e-IMCI helped adherence
  - Determine how e-IMCI effects patient visit

Study Design

- 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

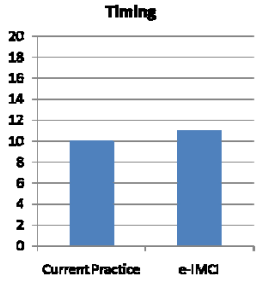
Adherence

- 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

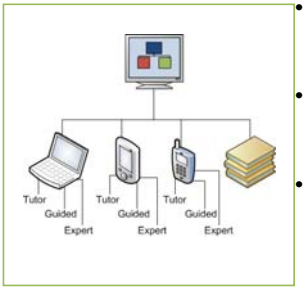
e-IMCI for Training

- 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

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D-Tree International

dimagi

IHRC

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)

2)

3)

4)

5)

6)

7)

8)

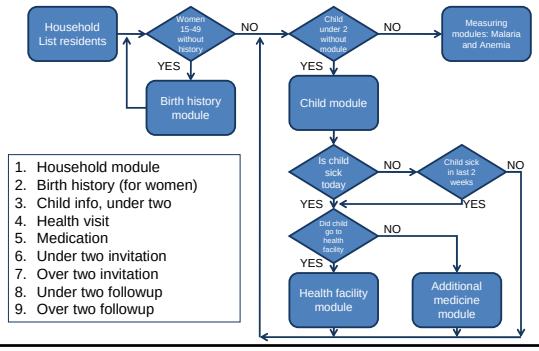
Southern Tanzania Survey

- 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
- Paper: Chi 2008, Cheng et al.

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?

UW
MS
LUMS
Home

WHO Health Metrics Network

HMN

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?

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Links

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