Apps for Rapid Epidemiological Assessment (AREA)

Dr. Rick Grannis
Health crises are characterized by uncertainty.

Data collection to support decision making is critical.

However, field crisis management is typically:
- Chaotic and ad hoc
- Slow to collect and report data
- Unresponsive to changing data needs
- Prone to error and data loss
- Rife with inconsistent or conflicting data
- Limited in reach

“We had barely picked ourselves up after the earthquake when the cholera fell on us”

-- Jocelyne Pierre-Louis, senior Haitian health official
What Needs to be Done

Support crisis management in the field needs to be more:

- **Efficient**, through situation-dependent collection methodologies
- **Comprehensive**, through data collection from multiple sources (field teams, crowd-sourced, government and institutions)
- **Focused**, through continually re-adapting collection requirements based on acquired data and analysis
- **Responsive** to changing data requirements through enhanced coordination between operations center and field units

“We need real-time field collection to provide decision makers with actionable information to deal with epidemics” – R.M. Moore, Jr Rear Admiral USPH Frmr Ass. U.S. Surgeon General
Innovative Approach

Virtual Operations Center
- Survey Authoring
- Field Team Tracking & Coordination
- Data Aggregation & Analysis

Handheld Apps
- Collection
  - Methodology Support
  - Multi-media & Geo-tagged
  - Adaptive Re-Prioritization
- Analysis & Visualization
  - Health Risk Assessment
  - Trend & Anomaly Analysis
  - Disease Forecasting
- Decision Support
  - Resource Allocation
  - COA Development
  - Ad-Hoc Team Formation

Command
- Post-Disaster Emergency Response
- Health Surveillance and Monitoring
- Targeted Investigations
Data Collection Needs in a Crisis

- Needs to be Thorough
  - Data Collection from Multiple Field Teams
  - Crowd-sourced
  - Integrated with Social Media / Official Institutional – Government Data

- Needs to be Adaptive
  - Risk assessment drives collection
  - Continually Re-adapt Questions and Collection Requirements Based on Analysis
  - Reduced time from collection through analysis to decisions
Coordinated Information Collection Network

- Coordinated Effort between Virtual Operations Center (VOC) and Field Teams using Handheld Devices
  - Rapid, real time information sharing between VOC and field users
  - Coordination for identifying and addressing critical info gaps
- Network of intelligent sensors – Distributed Information Collection
  - Ground Truth
  - Rapidly Identify most Critical Public Health Issues
  - Support Timely Crisis Management Decision Making
Listening to the World: Crowd Sourcing

- User-Reported Data Collection
  - Basic Health Surveys
  - Damaged Infrastructure
  - Displaced persons, victims
    - Self-report status
      - Location
      - Symptoms
      - Critical needs
  - Request Help
Multiple Sampling Methodologies for Increased Efficiency and Completeness

- Crises
  - Do not have Accurate Sampling Frame
  - Do have overwhelming Non-Responsiveness
    - Due to imminent personal needs

### Two Stage Cluster Sampling
- Segment area into clusters
- Sample from each

### Respondent Driven Sampling
- Respondents recommend successive waves of respondents
- Reaches “hidden” populations that are typically overlooked
Respondent Driven Sampling (RDS)

Analyzes population specifically as a network

- Sample transition probabilities
  - e.g. proportion of relational ties inter-connecting different “types” of individuals
  - Used to estimate population transition probabilities
- Population parameters estimated from population transition probabilities
- Statistics about sampled individuals themselves Never directly used

- RDS fits path-independence assumptions defining Regular Markov process
  - As sample expands wave by wave
  - Composition becomes Independent of Initial Starting Points
  - Approximates Population Equilibrium at Geometric Rate

Becomes Independent with Depth because Human social networks have a quite limited horizon (e.g. slightly more than two steps)
21st Century Data Collection: Apps

- Basic Data Collection
  - Injuries, Symptoms, Illnesses
  - Health Data
    - e.g. caloric intake, Dietary Habits, Hygienic Customs, etc.,
- Available Services
  - e.g. Clean Water, Food, Sanitation, Shelter, etc.,
Multimedia Enhanced

- Photographs and/or Video of
  - Key Facilities/Locations
  - Damaged Infrastructure
- Geo-Tagged
Advantages of Apps

- Allows survey personnel to survey respondents quickly
- Facilitates face-to-face interviews via portability
- Facilitates multilingual survey questioning
- Provides easier data management and reduced transcription errors
- Empowered Data Collection
  - Field teams require Minimal Training
Considering the Value of Information

- Compute Value of Information (VOI) to identify questions that most reduce risk uncertainty
- Re-prioritize questions for biggest payoff

\[
VOI(Q) = \sum_{R \in \text{Risks}} \text{Importance}(R) \cdot VOI(Q, R)
\]

\[
VOI(Q, R) = \prod_{q \in Q} \text{Prob}(Q = q) \cdot [\text{Uncertainty}(R)|(Q = ?) - \text{Uncertainty}(R)|(Q = q)]
\]
Virtual Operations Center

- Centralize Understanding
- Facilitate Collaborative / Real Time Data Sharing
- Fuse Field Collected Data with Crowd Sourced / Social Media Data
- Track Progress of Data Collection
- Determine Reporting Gaps
Understanding for Action

- Coordinate Understanding
  - Share Information / Analysis with Field Units
  - Transmit revised Data Collection requirements to Field Units
- Act on Understanding
  - Allocate Resources
  - Coordinate Field Operations (e.g. Quarantine, Direct to Aid Station, etc.)
Intelligent Assessment

- Risk Assessment Models crafted with AREA guidance
  - Continually Re-analyze
Forecasting

- Forecast Disease Incidence / Prevalence Trends
  - Identify Impending Crisis
  - Identify Deviations from Expected – Anomalies
- Course of Action Selection - Geospatial Resource Allocation – Identify Key Individuals / Locations for Interventions
- Forecast Effectiveness of Interventions
Talking to the World

- Information Dissemination
  - News Alerts
  - Information / Directions (e.g. Evacuation, etc.)
Targeted Communication

- Specific content to specific users
  - Based on user location
  - Based on user responses / how answered questions
- Respond to requests for information
  - e.g., damaged infrastructure, basic health surveys, etc.
- Provide feedback / Evaluate effectiveness of responders
Pilot Study: Nutrition Deficiency

- Surveyed six *culturally diverse* Los Angeles neighborhoods
- Objective: Determine extent to which residents’ nutritional choices were:
  - Influenced by their neighbors
  - Influenced by convenience / availability
- If poor nutritional choices reflect availability
  - Incentivize food stores to locate in area
Nutrition Deficiency Study Success

- Replicated significant portion of previous Los Angeles Family and Neighborhoods Survey (LA FANS)
- Produced essentially same results for Small fraction of what it cost to conduct conventional survey
  - i.e., create accurate / exhaustive sampling frame of population
  - sample rigorously
  - compensate respondents so sufficiently that most cooperate reliably and accurately

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<th>LA FANS</th>
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Pilot Study:
Drug Rehabilitation

- Used AREA to study
  - Hundreds of drug rehab centers in Los Angeles County
  - from detox to residential to outpatient
- Among centers
  - No data coordination
  - Data collection is not a priority
  - Incomplete / Inconsistent information
  - No way to track individuals across facilities
Drug Rehabilitation Study Success

- Established virtual operations center
  - Collected data from all sites
  - Identified gaps in information
- Supplemented with field teams conducting respondent-driven sampling of patients
- Successfully forecasted future trends in drug usage!
National Center for Medical Readiness (NCMR)

- Provides medically oriented education / training for medical / non-medical personnel to prepare them to save lives in emergency situations
- Delivers courses at Calamityville®
  - 52-acre austere training environment.
- Instructors are experienced veterans / first responders
- Medically oriented disaster response training
- Collaborative laboratory for researchers investigating issues involving medical readiness
Example NCMR Exercises at Calamityville

- **Mass-Casualty Event**
  - Earthquake scenario…multiple casualty event
  - 123rd Special Tactics Squadron responds via Blackhawk H60
  - Victims triaged and transported to staging area at WPAFB

- **SWAT Law Enforcement Scenario**
  - Hostage scenario
  - SWAT team responds and assesses situation
  - Plans and launches assault and rescue

- **Air Force Para-Rescue Mission**
  - Covert evacuation of multiple civilians & DEA agents in foreign country
  - Evacuation convoy strikes roadside IED…severe injuries result
  - Locate, stabilize and transport injured and non-injured
IMC Collaboration and Evaluation

- International Medical Corps (IMC) provides
  - Humanitarian assistance / Disaster relief
  - Disease surveillance
  - Emergency health care
  - Nutritional support

- IMC has agreed to:
  - Field Test AREA prototype versions with affiliated organizations in selected on-going disaster(s) such as Syrian and Somali refugees, Turkey, Lebanon, Ethiopia, etc.
  - Provide usability feedback for improvements and modification