Current and Future Opportunities for, Challenges, and Barriers to Adoption of Connected Healthcare

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Current and Future Opportunities for, Challenges, and Barriers to Adoption of Connected Healthcare

Q & A session

Q1: **Data security**: how do we ensure data security on the device and during data transfer to ensure FDA approval of the device and software applications, especially as we all want to move to a “bring your own device” model for ambulatory patients?

Q2: **Data fidelity**: Will we achieve clinically-acceptable automatic detection of clean and noisy data? What approaches are most promising?

Q3: **Data overload**: how do we manage data overload & alert fatigue for medical doctors?

Q4: **Data savant**: IBM’s Watson---- can accurate medical diagnosis be made without doctors? Is it science fiction or just fiction?
The IEEE EMBS Special Topic Conference on Healthcare Innovations and Point-of-Care Technologies will be held in Mexico from 9-11 November 2016. This conference will focus on healthcare innovations and point-of-care technologies, and their clinical translation to address challenges in global quality healthcare. The proposed conference will provide an international forum with clinicians, healthcare providers, industry experts, innovators, researchers and students to define clinical needs and technology solutions towards commercialization and translation to clinical applications across different environments and infrastructures. Panel discussions and open forum sessions along with research presentations will focus on the development, clinical translation, commercialization, implementation and user-compliance of innovative healthcare and point-of-care technologies in clinical (hospital, emergency, acute, chronic and primary care), non-traditional (consumer) and under-resourced settings.

Conference themes would include a topical coverage of (but not limited to):

- Point-Of-Care (POC) Technologies Clinical Translational of Healthcare Innovations and POC technologies
- POC Technologies in Under Resources Settings
- Lab-on-a-chip
- Devices for Molecular Epidemiology
- Compliance and Acceptance of POC Technologies
- Evidence-based Medicine
- Personalized, Preventive and Precision Medicine
- mHealth Innovations
- Wireless Communications and device data control and fusion
- Critical Care
- Medical and Healthcare Data Communication, Security, Privacy
- Infrastructure Independent Care
- Integration of innovations and point of care diagnostic devices into systems of healthcare
- Regulatory challenges (US and International)
- Global Healthcare Challenges

Conference website: http://hipt.embs.org
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Florence Hudson
Senior Vice President & Chief Innovation Officer
Internet2

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Aspirational view of Connected Healthcare

But...what are the risks?

- Trust?
- Identity?
- Privacy?
- Protection?
- Safety?
- Security?

TIPPSS

http://bit.ly/1EJnTjv
The evolution of today’s Connected Healthcare reality

- Number of connected devices is increasing with the goal to improve patient care and create efficiencies in the healthcare system: 10-15M medical devices in US hospitals today, with an average of 10-15 devices allocated per bed
- Growing “Bring Your Own Device” paradigm for providers and patients
- Proprietary/closed devices and systems are “assumed” secure
- Inadequate teamwork between medical providers, device vendors, technology innovators, cybersecurity experts, insurance companies, regulators, patients, to assess & address vulnerabilities
- ROI not agreed for improved security needs across ecosystem
- Rate of innovation is slow, and will continue to be unless we work as a Collaborative Innovation Community

“Only when we work collaboratively and openly in a trusted environment will we be able to best protect patient safety and stay ahead of cybersecurity threats”

- Dr. Suzanne Schwartz, FDA’s Center for Devices and Radiological Health

- FDA recommends that manufacturers adhere to the **NIST Framework for Improving Critical Infrastructure Cybersecurity** (Identify, Protect, Detect, Respond, and Recover).
- Calls for the creation of an Information Sharing Analysis Organization (ISAO) to collect cybersecurity threat information that is shared amongst value chain participants.
- **Failure to maintain cybersecurity** can result in compromised device functionality, loss of data availability or integrity, or exposure of other connected devices or networks.
- FDA guidance applies to the **full life cycle of a medical device** with embedded software, including firmware, and software that acts as a medical device.
- FDA recognizes that medical device security is a **shared responsibility**:
  - Healthcare facilities
  - Patients
  - Providers
  - Medical device manufacturers

“If people will follow the guidance, it represents basic common-sense principles for engineering or developing new devices.”

- Mac McMillan, Co-Founder and CEO of CynergisTek, Inc.

- **FDA recommendations** address **“basic” cyber security components** for manufacturers to address: up-to-date operating systems, security patch management, and provide audit trails for device access.

- **Device manufacturers will only need to report vulnerabilities to the FDA** when they compromise the device’s clinical performance with potential for serious, adverse health consequences.

- Making the **guidelines into regulations** will further ensure public safety from an industry dependent upon compliance and regulations.

- **Constant vigilance and guideline modifications** will be needed to stay abreast of the latest threats to public safety.

Sources:  
Mitigating risks in Connected Healthcare

- Multi-factor authentication
- Multi-level security, “Defense in Depth”
  - Hardware, firmware, software, service level security
  - From application, EHR/EMR, through the network to the device, including the provider, patient, payer
- Requires end-to-end ecosystem partnerships
  - Across the technology ecosystem: chip to device to network to servers to storage to software to cloud
  - Technologists, providers, device manufacturers, standards, policy, payers, patients
Addressing TIPPSS is essential to achieving safe, secure, scalable Connected Healthcare adoption.

Across elements of connected ecosystem:
- Users
- Devices
- Gateways
- Communications
- Clouds
- Software
- Services
- Data
Questions & Answers…
Thank You
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@FloInternet2
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Panel Discussion:
Current and future opportunities for, challenges, and barriers to adoption of connected healthcare

Connected / Mobile Healthcare: Consumer Electronics Industry Point of View

June 28, 2016
Insoo Kim, Ph.D.
Samsung Research America
Connected / Mobile Healthcare Ecosystem

**Sensing**
- EEG
- Temperature
- Blood Pressure
- Activity
- UV Radiation
- Glucose
- BIA
- Sox, Nox Dust
- VOC, Toxic chemicals
- Walking

**Hub / Gateways**
- Data transfer
  - Transferring of collected data through mobile devices
  - Fixed gateways for data collecting/transferring

**DB / Analytics**
- Data analysis
  - PHR, EHR data storing
  - Analysis of collected data to find useful meaning

**Service / Consultant**
- Healthcare service
  - Providing healthcare service from the data analysis

**Consumer Region**

**Provider Region**
Samsung’s Fitness Device Portfolio (current)

- S Band
- Gear Fit
- Gear S
- S Health
- HRM Belt
- Body Scale
Samsung’s Direction to Mobile Healthcare

- **Smartphone with physiological signal sensing**
  - Blood glucose, body temperature, heart rate, SpO2, body fat, stress (Lifewatch)
  - ’12 CE approved

- **Smartphone connected device**
  - Body temperature, heart rate, ECG, SpO2, body fat, stress (Scanadu)
Connected Healthcare System & Challenges

Challenge 1: Device Interoperability

Sensor data through
SMART Health SDK + GPS

Android App
- Personalized Dashboard
- Personalized Asthma Regimen
- Personalized Health Quizzes
- Personalized Notifications

User App

Medical Advice
Prescription

Web Front-end for Reporting and Dashboards

Query API

EHR/PHR Server

HTTP
REST API

EMR/PHR

Patient Data Update

Challenge 2: Handshaking

Health Professionals

Patients
## Challenge 1: Device Interoperability

<table>
<thead>
<tr>
<th>IEEE 11073 PHD</th>
<th>ANT+</th>
<th>Samsung</th>
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<tr>
<td>Pulse oximeter</td>
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<td>Basic electrocardiograph</td>
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<td>ECG monitor (Heart Rate Monitor)</td>
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<td>Independent living activity hub</td>
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<td>Medication monitor</td>
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<td>Multi Sports Speed &amp; Distance Monitor</td>
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<td>Stride Based Speed &amp; Distance Monitor</td>
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<td>Speed and Distance Monitor</td>
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<td>Sleep Monitor Insulin Pen Data Logger</td>
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Standardization & Test Beds

- Industrial Internet Consortium (IIC)
  - Application-specific testbeds
  - Build vertical eco-system

- Open Interconnect Consortium (OIC)
  - Standardization (Smart Home/IoT)
Challenge 2: Cloud-based Data Analytics

Sensor data through SMART Health SDK + GPS

Android App
- Personalized Dashboard
- Personalized Asthma Regimen
- Personalized Health Quizzes
- Personalized Notifications

Real-time Data Analytics
Per-Patient Personalization Rule Engine

Data Warehouse

User data over secure HTTPS*

Data Analytic Platform (Cloud Server)

User App

Web Front-end for Reporting and Dashboards

Medical Advice Prescription

Query API

EHR/PHR Server

EMR/PHR

User data over secure HTTPS*

Query API

Patient Data Update

Patient EMR data

Personalized Results

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Challenge 2: Cloud-based Data Analytics
Security & Privacy

Perimeter Level Security
- Network Security (VPN)
- Apache Knox (protocol level)

Authentication
- LDAP for user authentication
- Kerberos for system level
- Knox for Rest API

Authorization & Audit
- ACLs for Computation, Online stores, DFS

Privacy
- Data Protection with transparent data encryption (AES-NI) support
- & HIPAA compliance
Health Research at the NSF

Wendy Nilsen, PhD
Program Director, Smart and Connected Health
Background NSF

• Health research can be found in many areas in NSF and within the mission of several cross-directorate initiatives
• It is a case of use-inspired basic research. The scientific advances in basic science can be in computing, information science, engineering or social or behavioral science. The benefit to health research is important, but second to the advances in basic science.
• Three major homes for this research:
  • Smart and Connected Health
  • Big Data
  • Cyber-physical Systems
  • Core Programs
Smart & Connected Health (SCH)
Inter-Agency Program
National Science Foundation
National Institutes of Health
NSF Solicitation NSF 13-543

Wendy Nilsen, PhD
Program Director, Smart and Connected Health
Computer and Information Sciences and Engineering, NSF
Pasteur’s Quadrant

Quest for Basic Understanding

Application Inspired: Consideration of Use

Donald E. Stokes, Pasteur’s Quadrant – Basic Science and Technological Innovation, Brookings Institution Press, 1997
• To transform health:
  - from reactive to **proactive**
  - from experienced-based to **evidence-based medicine**
  - From clinic-centered to **patient center care**
  - To wellness that extends to the **home**, workplace and community
  - Move focus from disease to **health and wellbeing** at the **individual, system, and organizational level**
**Goal:** Seek improvements in safe, effective, efficient, equitable, & patient-centered health through innovations in fundamental computer & information sciences, engineering & social, behavioral & economic sciences

- **Funded** work must include & address:
  - A key health problem
  - Fill in research gaps that exist in science & technology in support of health & wellness
  - Include a research team with appropriate expertise in the major areas involved in the work

- Activities should **complement** rather than duplicate core programs of NSF & NIH as well as those of other agencies (ex. Agency for Healthcare Research and Quality / Veteran's Administration)
Clinic-based EHR Data

Patient-based Data

Information Exchange

Patient data
- Concerns
- Patient Reported Outcomes

Clinic/sensor data
- Clinical measures
- Laboratory findings
- Sensor data

Assessment
- Diagnosis
- Categorical reporting
- Prognosis/Trajectory

Plan
- Treatment planning
- Self-care planning
- Post treatment
- Surveillance

Health care System

Medical Team

Patient & Family

Community

Medical Researcher

- Risk modeling
- Diagnostic support
- Treatment selection
- Guideline adherence
- Error detection/correction

- Social support
- Precision tailoring
- Reduce disparities
- Streamline care/Efficiency
- Create a health CPS culture

- Situational awareness
- Population health
- Continuity of care
- Identify side effects
- Inform discovery
Smart and Connected Health Research Areas

**Digital Health Information Infrastructure**
- Integration of EHR, clinical and patient data
- Access to information, data harmonization
- Semantic representation, fusion, visualization

**Data to Knowledge to Decision**
- Datamining and machine learning
- Inference, cognitive decision support system
- Bring raw image data to clinical practice

**Empowered Individuals**
- Systems for empowering patient
- Models of readiness to change
- State assessment from images video

**Sensors, Devices, and Robotics**
- Assistive technologies embodying computational intelligence
- Medical devices, co-robots, cognitive orthotics, rehab coaches

**Energized, enabled, educated**

**Reasoning under uncertainty**
The following will likely result in a declined proposal:

• Intellectual merit is exclusively focused in health/health care
  ✓ SCH requires transformative advancements in computer science, engineering, behavioral and/or social sciences inspired by a need in health or healthcare

• Collaborations with medical providers who have no experience in research
  ✓ Appropriate research collaborators are key to integrating technical advancements with challenges in the health field

• Proposal is written by yourself and health collaborator is only consulted just prior to submission
  ✓ Proposed research should be influenced by health collaborators from its inception!
  ✓ Consider attending grand rounds to immerse yourself in health challenges and meet collaborators, or attend technical conferences to meet computer scientists and engineering collaborators

• Propose clinical trials or traditional disease-centric medical, clinical, pharmacological, biological, or physiological studies
NSF SCH Contacts

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- **Tiffany Lash**, Division of Discovery Science and Technology, National Institute of Biomedical Imaging and Bioengineering (NIBIB), NIH, email: tiffany.lash@nih.gov
Examples of Funded SCH Work
Privacy-Preserving Framework for Publishing Electronic Healthcare Records

**Motivation:**
- Real EHR privacy leakage is common today, even for data that meet HIPAA’s “safe harbor” standard
- The community needs:
  1) *privacy verification* tools to evaluate privacy leakage for published EHRs
  2) *privacy-preserving* techniques that thwart re-identification while maintaining utility

**Broader Impacts:**
- A prototypical system for public health researchers, to detect privacy leakage and automate privacy protection over EHR
- Develop novel educational tools for new courses and laboratory classes on healthcare, data privacy, data mining, etc.

**Technical Approach:**
- Stage 1: Recover Protected Health Information (PHI) based on published data that has been “de-identified” via automated identification of data inter-dependency through data analytics and medical domain knowledge
- Stage 2: Develop software to perform de-identification in a safe and secure manner to prevent recovery of PHI

**Transformative:**
- Inter-disciplinary study applying computer science and “big data” techniques to inform public health policy
- Significantly enhance EHR publishing, health services research, and secondary data analysis
Rehospitalization Analytics: Modeling and Reducing the Risks of Rehospitalization

Technical Approach:
- Novel clinical feature transformation methods that can handle several complexities that exist in clinical data.
- Correlation based regularization strategies to incorporate correlation between variables in the data.
- Constrained regularization method for knowledge transfer.

Motivation:
- Hospitalizations account for more than 30% of the $2 trillion annual cost of healthcare in the United States.
- Healthcare data residing at multiple sites causes challenges for data integration and effective modeling due to privacy concerns and presence of different population groups.

Transformative:
- Identifying patients at risk of readmission can guide efficient resource utilization and can potentially save millions of healthcare dollars each year.
- Ability to leverage additional sources of information from other hospital records to improve the predictive power of the existing health records.

Broader Impacts:
- Big Data Analytics for Healthcare - Tutorial presented at major conferences such as KDD, SDM. Slides: http://dmkd.cs.wayne.edu/TUTORIAL/Healthcare/
**Motivation:**
- Transform observational behavior analysis through a computational framework
- Offer new analysis capabilities and empower the mental health experts
- Model emotionally-rich human interactions through signal processing and machine learning

**Broader Impacts:**
- Technologies can apply to other application domains, e.g. meetings, negotiations, focus groups
- Encourages cross-disciplinary exposure and knowledge transfer
- Identifies new behavioral metrics, e.g. vocal entrainment

**Transformative:**
- Can improve mental healthcare and observational practice
- Can empower and provide new behavioral cues to experts (e.g. psychologists)
- Can enable scalability and knowledge discovery through big data

**Technical Approach:**
- Use real couple therapy interactions
- Use Signal Processing techniques on the acoustic, lexical and visual channels. Extract meaningful features (e.g. automatically transcribe, head motion)
- Use Machine learning to learn from human ratings
Collaborative Research: Algorithmic Approaches to Personalized Health Care

Motivation:
- **Lots of data available** in Electronic and Personal Health Records (EHRs and PHRs)
- **Current practice: ineffective and expensive**
  - Treat conditions when they become acute (in the hospital)
  - Apply generic, non-personalized treatment protocols
- Health Care system has **no ability** to process and learn from data

Broader Impacts:
- Prevent hospitalizations and treat individuals before a condition becomes acute
- Reduce the cost of hospital care (more than $30B spent on preventable hospitalizations in the US each year)
- Leverage and learn from health data available in the hospital and directly from individuals (health monitors, lifestyle data, smart phone)

Transformative:
- Develop the capability to predict future hospitalizations from the EHR/PHR of an individual
- Prediction can lead to **Prevention**
- Develop personalized disease management plans
- Develop personalized & automated medication control

Technical Approach:
- Novel inference and classification approaches (k-LRT) leading to interpretable results
- Novel joint clustering and classification
- Anomaly detection
- Adaptive control for medication control
Other Funding Opportunities

- NSF CRII (16-565) and CAREER (15-555)
- NSF Big Data (16-512)
- NSF & NIH Cyber-Physical Systems (16-549)
- NSF CISE Core Programs
Better health through a relay between basic and applied science
Questions or Comments?

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