IS 2955 Special Topics: SAHI

mHealth

Lecture 1

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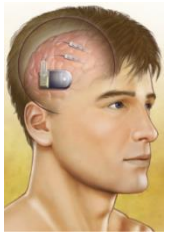
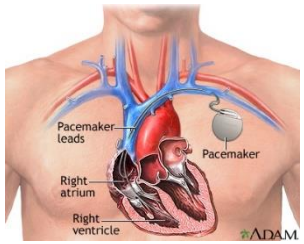
Paradigm Shift in Health care:
Anywhere anytime, personalized health

Continuous Monitoring and On-time intervention





in-body/out-body implantable/ wearable devices, sensors

- *Anywhere*, *Anytime* Personalized Healthcare/medicine

Enablers

- Medical devices, IoT & Sensor technologies
- Mobile and Web technologies,
- Social networking, Cloud computing, Location based services
- Big Data analytics – AI, ML, ….

Many value added features/services

Integrated Care

Self-care

Social Support

Anywhere, Anytime Healthcare
Secure and privacy-aware

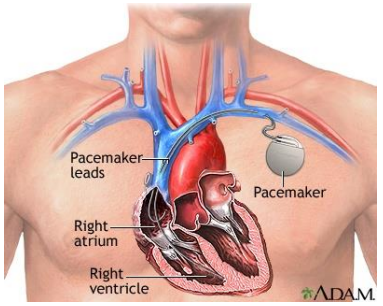
- Enablers of this new paradigm
  - E-health informatics
  - Sensor technologies
  - Mobile devices (including smart phones)
- Value added features
  - Monitoring devices and On-time intervention
  - Integrated Care
  - Self-care
  - Social Support

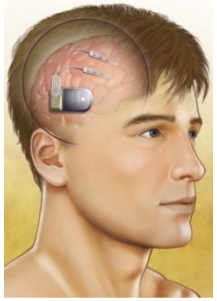
Monitoring devices and On-time intervention

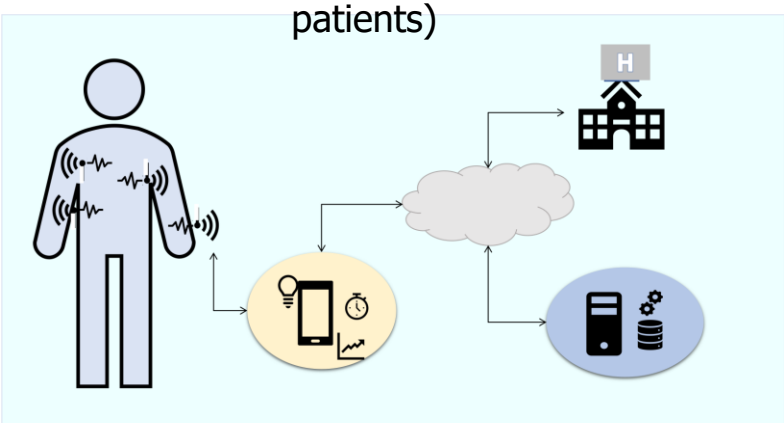
- Miniaturization of sensor devices + wireless
  - "Remote monitoring cuts patient dealth by 45%" (Dept of Health, UK Report) – help intervene
    - Blood pressure, sugar, etc.
- Monitoring beneficial for atleast
  - Lifestyle and general well being monitoring
  - Chronic disease or condition management
    - Cardiac arrhythmia, diabetes, ..
  - Clinical workflow mgmt
    - Telehealth, face-to-face care, in-patient care workflow, ..

Health Monitoring applications

- Health status monitoring device types;
  - In-body: implantable devices
    - Pacemakers, defibrillators, neurostimulators (physiological conditions)
    - Wireless; implant reader receives data
  - On-body: wearable
    - Motion sensors, blood pressure meters
  - Additional monitoriny of environment is also important
    - Katz's ADL (Activities for Daily Living: bathing, dressing, toileting,..) – for Geriatic care (elderly patients)







The Microsoft launched project "MediNet" remote monitoring on the health status of diabetes and cardiovascular diseases in remote areas in Caribbean countries

Integrated Care

- Typical patient treatment may involve
  - Physician → diagnostic lab → prescription
  - Physician need info generated by other care givers
    - Health records have info from several care givers; may relate to multiple diseases, …
    - Maybe fragmented; dispersed across providers
    - COORDINATION is critical
  - Mobile lifestyle – services should be available
    - Integration needed :
      - Across the hospitals; cross-border, etc.
    - Nationwide health Information Network (NHIN)
      - Information sharing among federal agencies, hospitals, and doctors' offices

Integrated Care

- Integration is key
  - Consolidate healthcare services and workflow: horizontal & vertical integratior
  - Horizontal –
    - Among independent healthcare provides
    - e.g., integrate hospitals and nursing homes
  - Vertical –
    - Combine/coordinate interdependent service providers
    - e.g., integrate primary care and specialty care

Self-Care

- Self-care behaviors
  - Seeking relevant health information and evaluation of options
  - Monitoring ones vital signs
  - Maintaining healthy lifestyle choices
  - Making informed decisions about one's health
  - Center piece of self management is: *Personal Health Record* (PHR) [may include Gene info in future]
- Decision support tools need to be integrated with PHR
- Current PHR systems
  - Microsoft's Health Vault; The Patient Portal, MyChart, MyOscar
  - About 70M in US have access to PHR systems
- SmartPhone Apps are the new frontiers !!
  - BMI cal; RunKeeper, CDC Vaccine Schedule, SleepBot, etc.

Social Support

- Social connectedness/support
  - Provides mechanisms to help in health & wellbeing
    - Collective sharing (patientslikeme.org)
    - BodySpace – social fitness and weight-loss app
    - Need to be careful about misinformation !
  - Healthcare social network is on the rise
    - Relevant research at LERSAIS:

      LEAF for IPV survivors (Intimate Partner Violence)
      - Community of: Care providers, friends/family, legal and social entities, mentors (survivors)
      - Privacy is key

      (Talk to Prof. Palanisamy and Me)

YouTube: https://www.youtube.com/watch?v=YfsRJWgwncU&feature=youtu.be

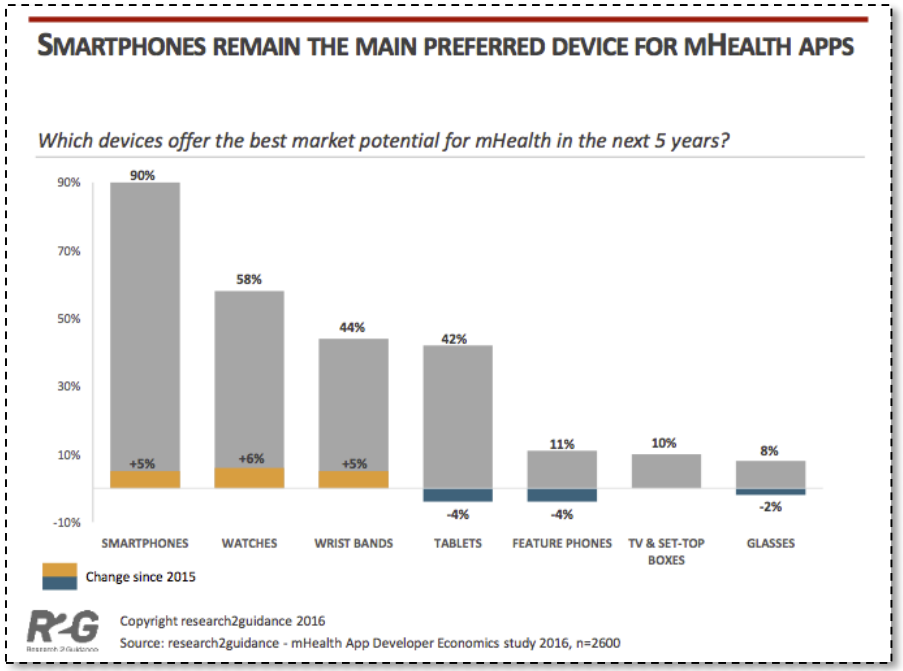
mHealth

- Mobile and Wireless technologies are at the core:
  - facilitate data collection, patient engagement and support for healthcare professionals
  - use of mobile technologies—**wearable, implantable, environmental, or portable**—by individuals who monitor or manage their own health, perhaps with the assistance of individual caregivers or provider organizations.
  - Can support clinical care—including diagnosis and disease management—or wellness goals such as losing weight, eating a healthy diet, quitting smoking, or becoming physically fit.

mHealth & SmartPhone

- Why smart phones are attractive platforms for healthcare practices? (Zubaydi et al., 2015)
  - pervasiveness,
  - computational capabilities,
  - user-friendly interface,
  - built-in sensors,
  - availability,
  - mobility,
  - Connectivity

Nearly 1.5 mobile devices per capita by 2019, based on estimations by Cisco Visual Networking Index



Monitoring & service

Four general categories: (Kotz et al.,2016)

- Physiological monitoring:
  - heart rate, blood pressure, etc.
- Activity and behavior monitoring:
  - movement, physical, social activity, and health-related behaviors such as eating and addictive behaviors.
- Information access:
  - medical records, activity, or behavior data—and decision-support tools.
- Telemedicine:
  - communication between patients and caregivers and/or providers.

Patient vital signs / physiological data:

- heart rate,
- breathing rate
- blood glucose level,
- blood pressure,
- body temperature,
- brain activities,
- Electrocardiogram (ECG/EKG)
- peripheral oxygen saturation (SpO2)

Environmental measures

mHealth Device Examples

- **TICKR:** heart rate monitor by Wahoo Fitness
- **iBGStar:** a blood sugar meter
  - about the size of a USB memory stick
  - Compatible with: iPhone and iPod
  - tracks glucose and insulin
  - automatically synchronizes data with the iBGStar Diabetes Manager on the phone
  - tag meals and exercise, graph data and share data via email with health care providers

- **FitBit Surge:** smartwatch
  - Compatible with: iOS and Android
  - tracks heart rate, sleep patterns, and calories burnt during a workout.
  - gets notifications from smartphone
  - supports Bluetooth wireless connectivity

- **Forerunner 920XT** smartwatch
  - Tracks heart rate, calories burnt, elevation (via barometric altimeter)
  - Counts steps, swimming stroke
  - supports Bluetooth wireless connectivity

Characteristics

- IP enabled and wireless connectivity
- Compact and easy-to-wear
- Low-power consumption

mHealth Devices

IP enabled and wireless connectivity

Wireless standards for mobile health devices:

- Bluetooth Low Energy (BLE), BLE sensor devices may operate for many years without need to replace the battery
- ANT is a low-power proprietary wireless technology which operates in the 2.4 GHz bandwidth spectrum. Its primary goal is to allow **medical** and ***sports*** sensors to communicate with a display unit
- ZigBee is a low-power wireless specification based on IEEE Standard 802.15.4-2003

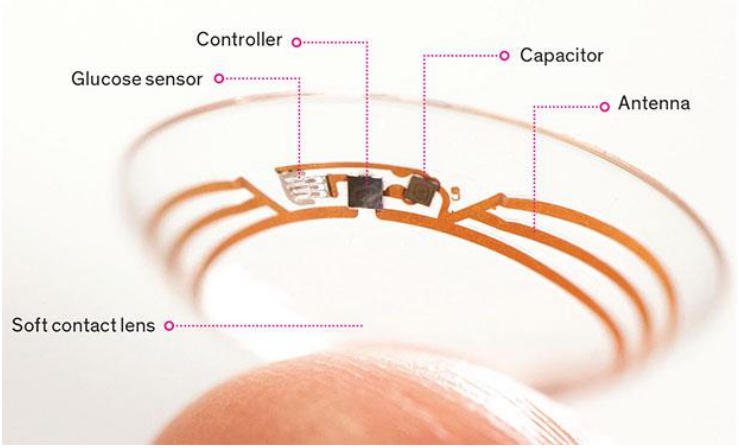
TABLE I. COMPARISON OF WIRELESS CONNECTIVITY STANDARDS

Wireless Technology	Peak power consumption	Throughput ≈	Range ≈
IrDA	10mA	1Gbps	5cm
Nike+	12.3mA	272bps	10m
BLE	12-16mA	305kbps	50m
ANT	17mA	20kbps	10m
ZigBee	30-40mA	100 - 250kbps	100-300m
NFC	30-40mA	424kbps	10cm-1m
Wi-Fi	116mA	6Mbps	150-500 ft

Health Monitoring applications

Blood sugar level monitoring (Almotiri et al., 2016)

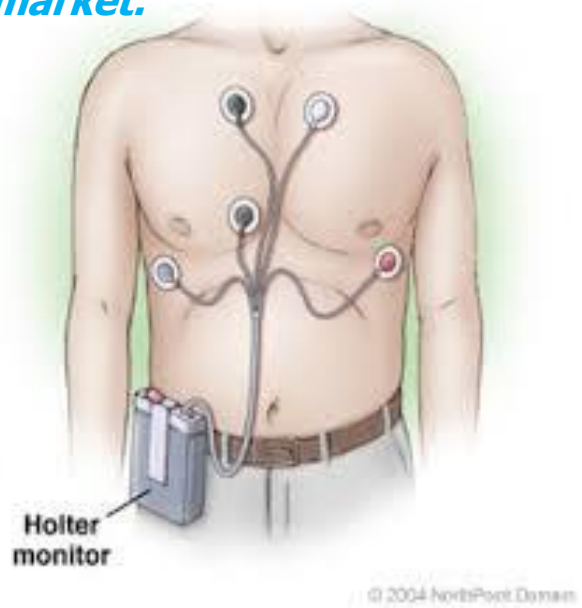
- Diabetes is a serious chronic disease with major economic and social impact.
- Blood sugar testing is an important part of diabetes care.
- A self-testing mobile device that can measure blood sugar level on the go is important for treatment plan and preventing long-term complications of diabetes.
- Google and Swiss based pharmaceutical company Novartis, has announced partnership for developing smart contact lenses:
  - for people who suffer from diabetes
  - ***take the tears in a person's eye and measure the glucose levels***



Health monitoring applications

Electrocardiogram (ECG) monitoring

- (ECG) is a simple test that records the heart's electrical activity.
- A regular heart's activity monitoring by a handheld ECG device is both effective and provides long term cost savings for cardiac patients.
- Existing ECG monitoring devices such as Holter are inconvenient for long-term use due to their size and twisted wires.
- ***Wireless ECG monitoring devices that can connect to remote IoT server are emerging in market.***



Health monitoring applications

Blood pressure monitoring

- High blood pressure or hypertension is a serious risk factor that may leads to heart attacks, strokes, etc --its diagnoses and monitoring is critically important.
- Blood pressure changes from minute to minute, continuous monitoring helps to better understand the cardiovascular health of the patient.
- Wearable blood pressure monitors are automatic and can record blood pressure for 24/7, while patients can do their normal daily activities.

Health monitoring applications

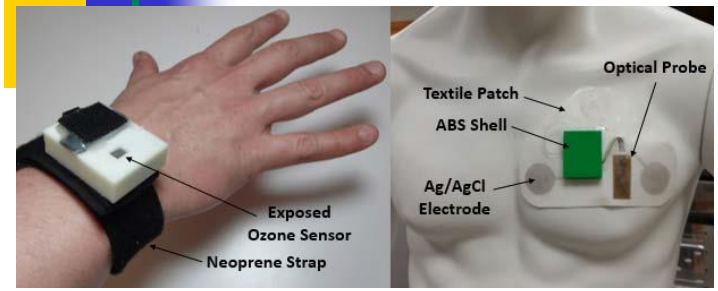


Fig. 2. (Left) Neoprene wrist strap with ABS plastic shell containing the circuitry for measuring ozone concentration, PPG, motion, temperature, and humidity. (Right) Textile patch with ABS plastic shell containing circuitry for measuring ECG, PPG, wheezing, and motion.

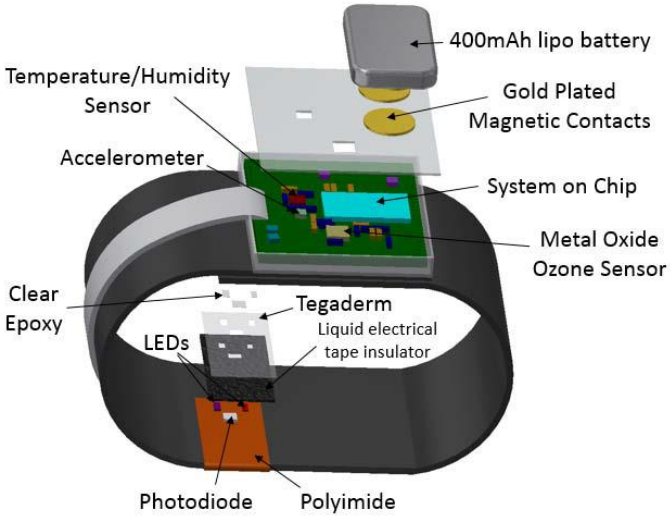


Fig. 3. Exploded view of the wristband device, including the layers of the optical probe.

Asthma monitoring

- Observation is the key to asthma management.
- When, where and what triggers an attack is very critical to maintain an adequate environment and alleviating symptoms.
- Dieffenderfer et al. * developed a wearable sensor system consisting of a wristband and chest patch for understanding impacts of ozone on chronic asthma conditions.
  - The data from the device is streamed and transferred to a server for cloud storage.

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5124429/

"A Giant Shift in Healthcare"

- mHealth provides emerging diagnostic techniques
- Don't require a patient to seek the help of a healthcare provider or even to experience a symptom.
- Diagnose people even before they seek treatment.

Examples:

- "cadence of" typing can predict cognitive decline in older adults
- gait-recognition technology to detect changes in how a person walks and moves, which may indicate neurologic conditions

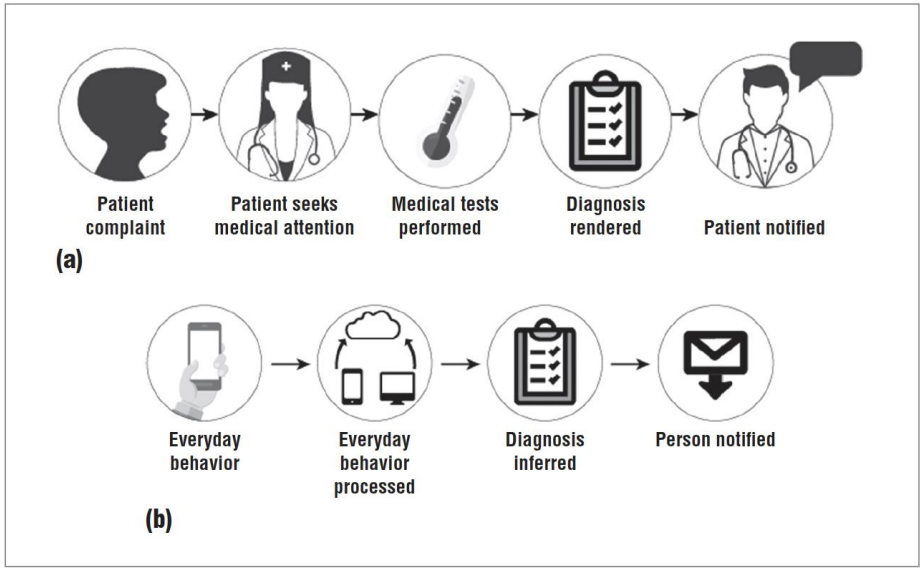


Figure 1. The shifting paradigm in the timeline for a diagnosis: (a) the historical timeline versus (b) the emerging timeline. Note that the patient initiative is much lower in the emerging paradigm.

Effects on Healthcare Services

- m-Health affects the way we understand healthcare services in different aspects
  - m-Health is patient-oriented and personalized
  - higher efficiency and reduced costs
    - Better clinical decisions!
  - simplifies the access to services
  - Improved quality of care
  - Biomedical ethical principles → "diagnosis without test" and preventive! Need to consider privacy tradeoff

- mHealth systems will replace some traditional healthcare services
- The number of visits to hospitals OR hospitalizations is decreasing
- Higher impact and more promising results in middle or low income countries (according to WHO reports

Case Study / Some Sample mHealth Applications

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

- A mobile and unobtrusive platform that enables the *accurate monitoring of physical activities in daily life*
- Integrated into a healthcare system supporting out-of-hospital services (the integration of the mobile platform with an EHR)
  - providing access for both the clinician and the patient
- Main focus: describe and evaluate a complete data processing chain for recognizing different activities and estimating their intensity level.

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

System Overview

- EHR (Electronic Health Record)
- Clinician's web interface
- Interactive TV interface
- Mobile platform

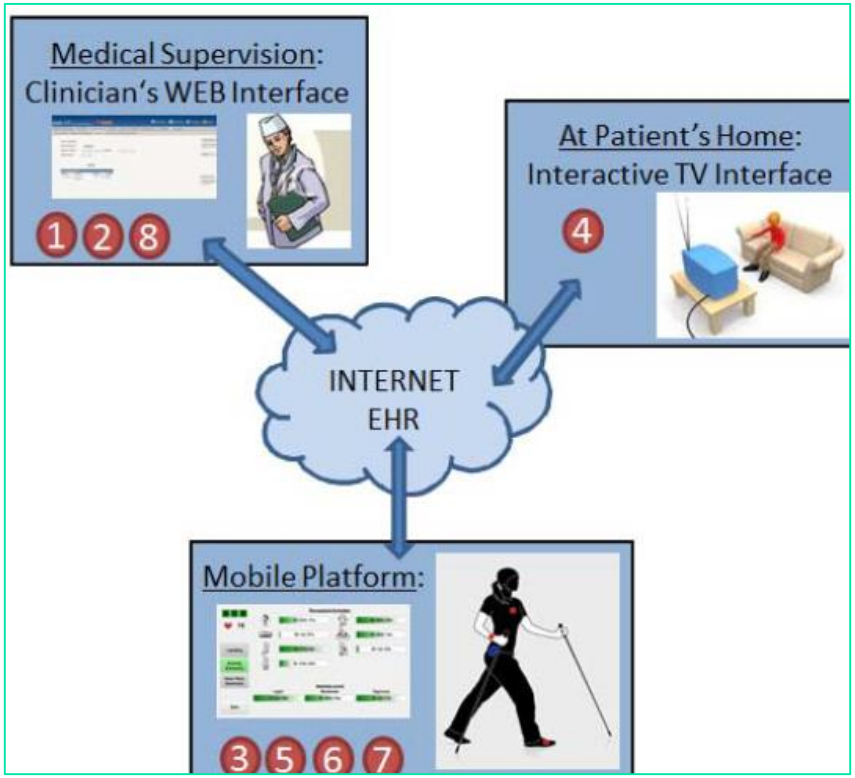


Figure 1. System overview: major components of the proposed system for aerobic activity monitoring and support in daily life.

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

System Overview

EHR:

- Stores a comprehensive summary of the medical record & collected activity information
- Medical record includes:
  - general health profile of the patient,
  - history of the patient's visits
  - results of laboratory and other medical tests
  - diagnoses, medications, surgeries
  - care plan definition
- Activity information is communicated and stored in a binary message format
- These messages are collected during one day and then sent to the EHR at the end of the day

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

System Overview

Clinician's web interface:

- Provides a web based user interface to the EHR for the physicians.
- Enables the clinician:
  - to view and edit the medical record of the monitored subject
  - to ***define a personal program*** of aerobic activities for the subjects on daily basis
  - to define and upload educational material for each patient
  - to view a summary of the patient's performed activities over a specific day

Interactive TV interface:

- Provides the monitored subjects with the means to use the system's services.
- A patient can
  - view his own subset of the EHR
  - view educational material his clinician assigned to him
  - see the ***defined program*** of aerobic activities for the current day

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

System Overview

Mobile platform:

- The main purpose of the mobile platform: *monitor user's daily activities by collecting and processing sensory data, and give feedback to the user*

1) Hardware setup:
   - three **inertial measurement units** (IMUs), a **heart rate monitor** and a **mobile companion unit**
   - Each IMU contains two 3-axis MEMS accelerometers, a 3-axis MEMS gyroscope, and a 3-axis magneto-resistive magnetic sensor
   - **Companion unit**: Viliv S5 UMPC (Intel Atom Z520 1.33GHz CPU and 1GB of RAM), carried by the users in a custom bag fixed on their belt.
2) Mobile application

- The main functionality of the aerobic activity monitoring system is to tell:
  - what activity the user has performed
  - for how long and with what intensity
- Both *activity recognition* and *intensity estimation* - are regarded as classification problems

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

Data Processing

- Steps of data processing chain of the mobile application: *preprocessing*, *segmentation*, *feature extraction* and *classification*
- only data from one accelerometer is used for classification
- 137 features were extracted: 133 features from IMU acceleration data and 4 features from the heart rate data.
  - From the segmented 3D-acceleration data, various signal features were calculated in both time and frequency domain: mean, median, standard deviation, peak acceleration, correlation between each pair of axes, energy, peak frequency, spectral entropy and power ratio of different frequency bands.
  - From the heart rate data, the features (normalized) mean and gradient are calculated

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

Evaluation

1) **Data Collection:**

- **Nine subjects**: eight males and one female.
- The subjects were mainly employees or students at a research institute, aged 27.22 ± 3.31 years, and having BMI of 25.11 ± 2.62 kgm^{-2}
- a *labeling tool* was integrated into the mobile application
  - Using it, the beginning and end of each of the performed activities could be marked on the Viliv companion unit
  - provided timestamped activity labels

Figure 3. Mobile application: start screen of the labeling tool. This screenshot was made while the subject was performing the activity *sitting* during data collection. All sensors are operating correctly, and the subject's heart rate is 63 beats per minute in the moment of this screenshot, as indicated in the top left corner.

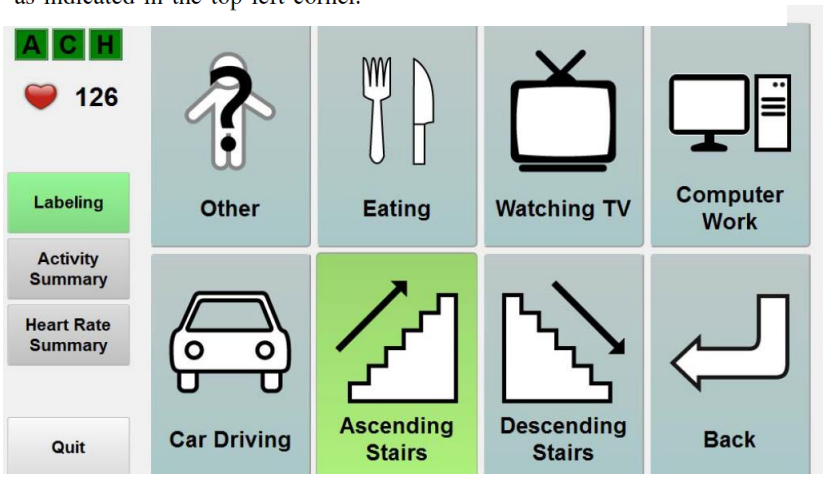


Figure 4. Mobile application: labeling of various everyday activities.

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

Evaluation

2) Defining the Classification Problems:

- Two classification problems: **activity recognition** & **activity intensity** recognition
- three classes are defined for intensity
  - light, moderate and vigorous effort
- The ground truth for these classes is based on the metabolic equivalent (MET) of the activities:
  - activities of light effort (< 3.0 METs);
  - activities of moderate effort(3.0-6.0 METs)
  - activities of vigorous effort (> 6.0 METs)
  - Classifier: boosted decision tree (trained with the Weka toolkit)

Table I
LIST OF ACTIVITIES PERFOMED DURING DATA ACQUISITION, AND THEIR RESPECTIVE CLASSES IN THE INTENSITY ESTIMATION AND ACTIVITY RECOGNITION TASKS.

Activity	Intensity Estimation	Activity Recognition
Walking	Moderate	Walking
Running	Vigorous	Running
Cycling	Moderate	Cycling
Lying	Light	Lying
Sitting	Light	Sitting/Standing
Standing	Light	Sitting/Standing
Ascending stairs	Vigorous	Other
Descending stairs	Moderate	Other
Car driving	Light	Other
Ironing	Light	Other
Folding laundry	Light	Other
Vacuum cleaning	Moderate	Other
Dusting	Light	Other
Nordic walking	Moderate	Nordic walking
Rope jumping	Vigorous	Other
Playing soccer	Vigorous	Other

An Integrated Mobile System for Long-term Aerobic Activity Monitoring and Support in Daily Life

Evaluation Results

- Subject independent validation:
  - classifiers are trained on a certain number of subject (9 subjects in this case) and are used afterwards by new subjects, who are not in the training data set
- Intensity estimation task:
  - Overall performance: 93.34%
  - Analysis of selected features: heart rate information is important for the intensity estimation of physical activities.
- Activity recognition task:
  - Overall performance: 87. 17%
    - Classification performance decreases with the inclusion of the "other" class compared to the presence of only few basic activities
    - but the applicability of the mobile application in real-life scenarios becomes much higher

Table II
CONFUSION MATRIX OF THE INTENSITY ESTIMATION TASK

Annotated intensity	Estimated intensity 1	2	3	Performance [%]
1 - Light	9776	663	6	93.60
2 - Moderate	366	6970	226	92.17
3 - Vigorous	6	91	2280	95.92

Table III
CONFUSION MATRIX OF THE ACTIVITY RECOGNITION TASK

Annotated activity	Estimated activity Lie	Sit/ Stand	Normal walk	Run	Cycle	Nordic walk	Other	Performance [%]
Lie	1727	1	0	0	0	0	0	99.94
Sit/Stand	89	2883	0	0	0	0	386	85.85
Normal walk	0	0	1695	0	0	4	494	77.29
Run	0	0	0	577	0	0	258	69.10
Cycle	0	0	1	0	1370	0	101	93.07
Nordic walk	0	0	262	0	0	1173	274	68.64
Other	0	689	9	39	7	1	8344	91.80

HELPP Zone / LEAF

Some of our efforts: Intimate Partner Violence (IPV)

30% of women impacted globally (as per WHO, CDC)

Collaboration with:

- Rose Constantino (School of Nursing)
- Balaji Palanisamy (SCI)

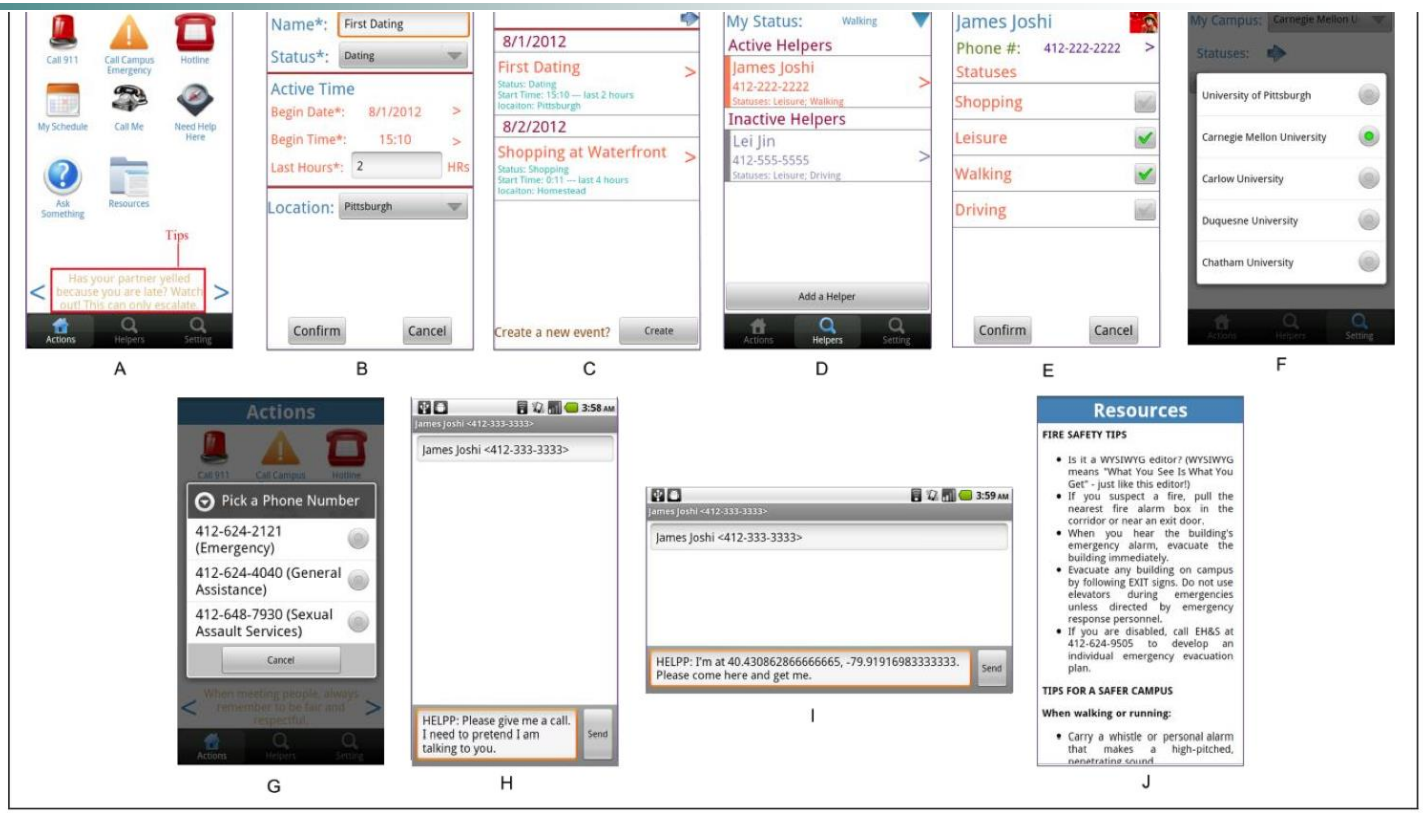
HELPP Zone

(Health, Education on safety, Legal Participant Preferred)

Just-in-time communication and intervention from and by trusted contacts

Text based messasing

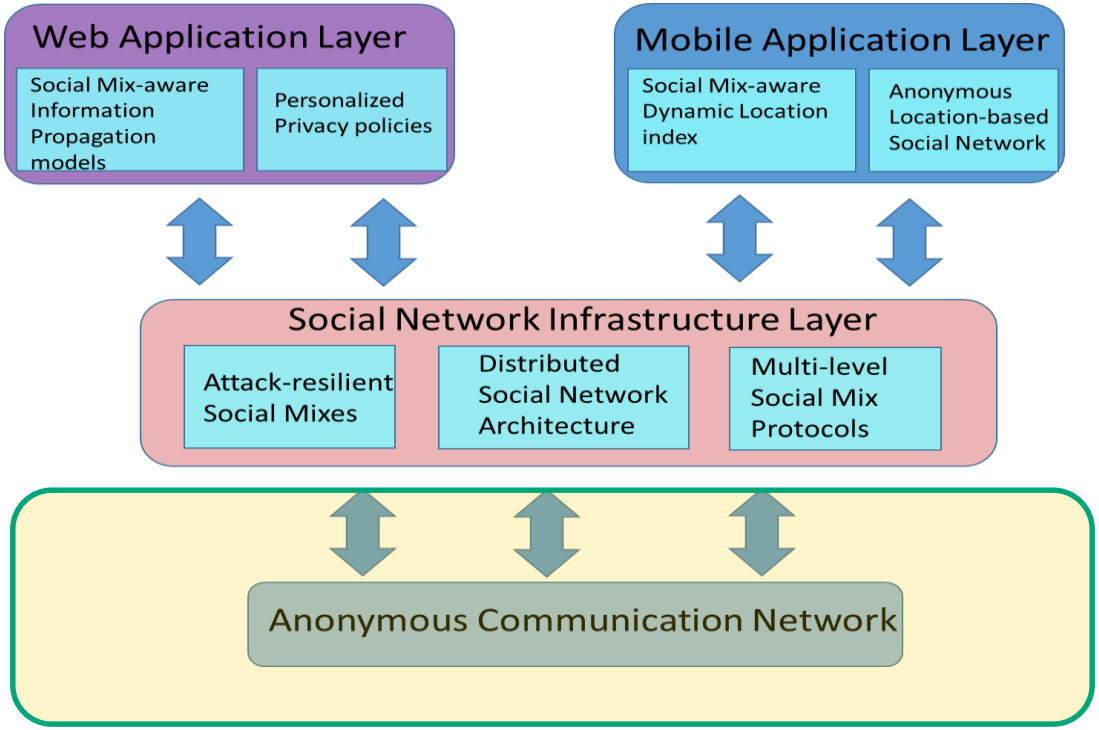
Dynamic trusted contacts



Rose Constantino, Amirreza Masoumzadeh, Lei Jin, James Joshi, Joseph Burroughs, Dominique de la Cruz, "HELPP Zone App and TMI: Disrupting Intimate Partner Violence in College Students" 2013 International Nursing High-end Forum (INHF), China, 22nd - 23rd June, 2013.

A. Masoumzadeh, L. Jin, J. Joshi, and R. Constantino, "HELPP Zone: Towards Protecting College Students from Dating Violence," in iConference 2013 Proceedings, 2013, pp. 925-928.

LEAF System:
(Lending Encouragement, Affirming Futures)



Web app
Social Network
Mobile app

LEAF:A Privacy-conscious Social Network-based Intervention Tool for IPV Survivors

Balaji Palanisamy Sheldon Sensenig James Joshi Rose Constantino†
School of Information Sciences, University of Pittsburgh †*School of Nursing, University of Pittsburgh*

LEAF Social Network

(a) An example LEAF netw

Privacy and Anonymity

Protecting Source Privacy
sender's identity cannot be inferred

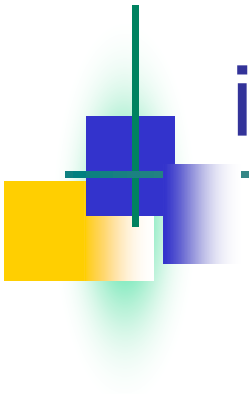
Protecting Participant Privacy
willingness to participate increases when anonymity is guaranteed

Protecting Recipient Privacy
Recipient may wish to forward a message from another user to his friends remain anonymous

Protecting Location Privacy
Users should be able to use location-aware resources without revealing their location

Social Mix Mechanism

ymous communication



iMHere

iMHERE

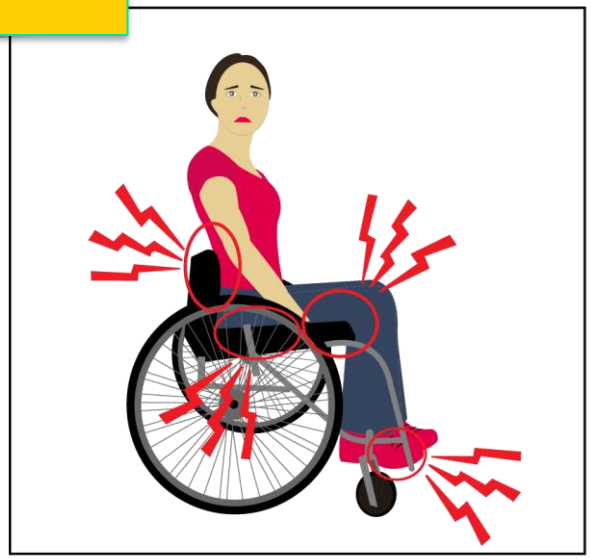
- Individuals with chronic conditions
  - vulnerable to secondary complications that can be prevented with adherence to self-care routines.
  - Account for 75% of health care expenditure in US (^0% globally)
- Spina Bifida (SB)
  - the most common permanently disabling birth defect in the United States.
  - Chronic conditions population that is susceptible to hospitalization due to UTI and skin wounds
- iMHere (Interactive Mobile Health and Rehabilitation)
  - Smartphone app + Clinician portal

Chronic disease management

- Prior mHealth approaches to CDM
  - Stand alone local app
    - Diet or nutrition tracking apps
  - Monitoring apps using store-and-forward data transfer
    - Remote health monitoring – heart rate, blood pressure
  - Consumer referential medical apps
    - Educational aps to help consumers manage chronic conditions – self-identification and management
  - Text messaging for engaging patients – most widely used
  - Simple voice call, either in person or using interactive voice response - traditional

Real Patient Case

Lisa

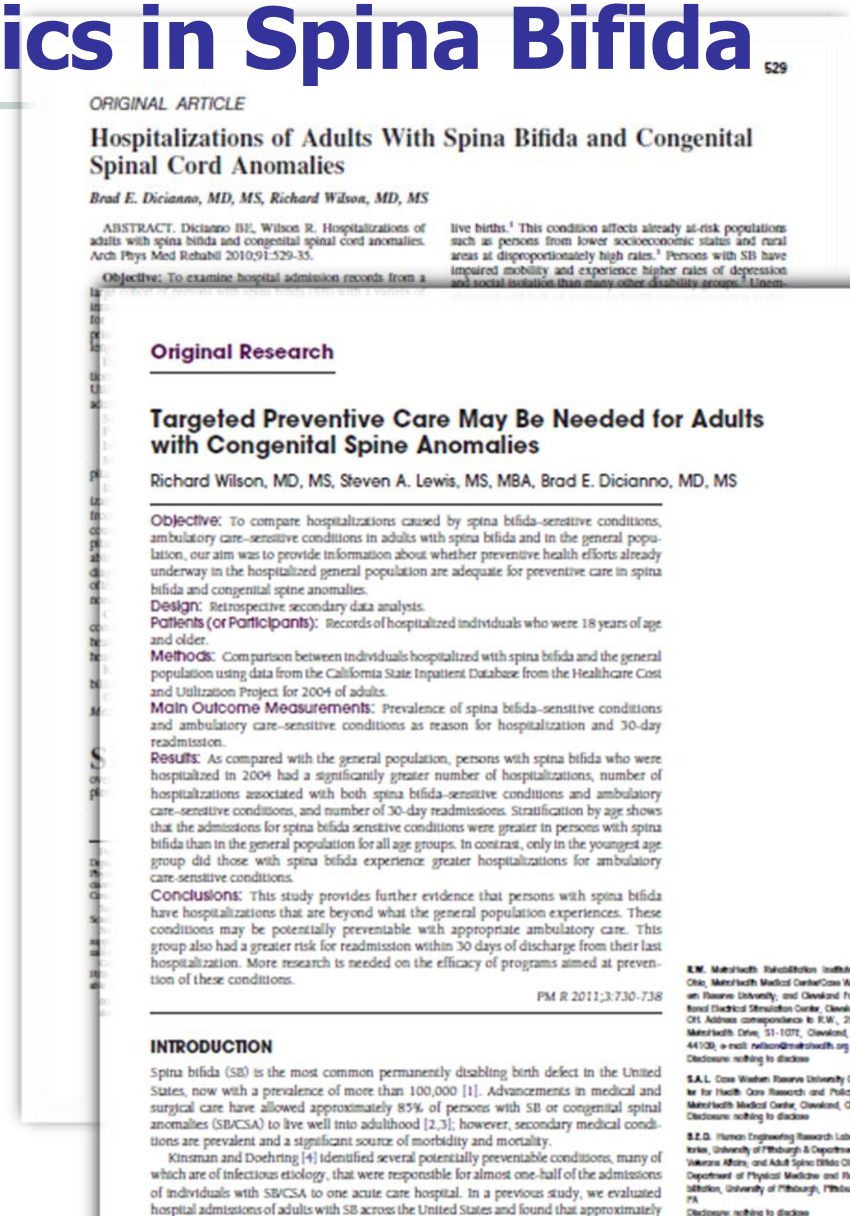


40 year old female with spina bifida and hydrocephalus develops wounds.

Wounds worsen requiring ER visits and hospitalizations. Also went to ER for minor health issues.

Health Care Statistics in Spina Bifida

- Hospitalizations
  - 3-4/yr
  - Higher 30d readmissions than gen pop
- Potentially preventable conditions
  - UTIs, wounds, catheter infections
  - 33.8% of hospitalizations
  - $364 million total cost
  - 35.7% of deaths in hospital
  - occurred most often under age 51 yrs



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ORIGINAL ARTICLE

Hospitalizations of Adults With Spina Bifida and Congenital Spinal Cord Anomalies

Brad E. Dicianno, MD, MS, Richard Wilson, MD, MS

ABSTRACT. Dicianno BE, Wilson R. Hospitalizations of adults with spina bifida and congenital spinal cord anomalies. Arch Phys Med Rehabil 2010;91:529-35.

Objective: To examine hospital admission records from a

live births.[1] This condition affects already at-risk populations such as persons from lower socioeconomic status and rural areas at disproportionately high rates.[2] Persons with SB have impaired mobility and experience higher rates of depression and social isolation than many other disability groups.[3] Unem-

Original Research

Targeted Preventive Care May Be Needed for Adults with Congenital Spine Anomalies

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Objective: To compare hospitalizations caused by spina bifida–sensitive conditions, ambulatory care–sensitive conditions in adults with spina bifida and in the general population, our aim was to provide information about whether preventive health efforts already underway in the hospitalized general population are adequate for preventive care in spina bifida and congenital spine anomalies.

Design: Retrospective secondary data analysis.

Patients (or Participants): Records of hospitalized individuals who were 18 years of age and older.

Methods: Comparison between individuals hospitalized with spina bifida and the general population using data from the California State Inpatient Database from the Healthcare Cost and Utilization Project for 2004 of adults.

Main Outcome Measurements: Prevalence of spina bifida–sensitive conditions and ambulatory care–sensitive conditions as reason for hospitalization and 30-day readmission.

Results: As compared with the general population, persons with spina bifida who were hospitalized in 2004 had a significantly greater number of hospitalizations, number of hospitalizations associated with both spina bifida–sensitive conditions and ambulatory care–sensitive conditions, and number of 30-day readmissions. Stratification by age shows that the admissions for spina bifida sensitive conditions were greater in persons with spina bifida than in the general population for all age groups. In contrast, only in the youngest age group did those with spina bifida experience greater hospitalizations for ambulatory care-sensitive conditions.

Conclusions: This study provides further evidence that persons with spina bifida have hospitalizations that are beyond what the general population experiences. These conditions may be potentially preventable with appropriate ambulatory care. This group also had a greater risk for readmission within 30 days of discharge from their last hospitalization. More research is needed on the efficacy of programs aimed at prevention of these conditions.

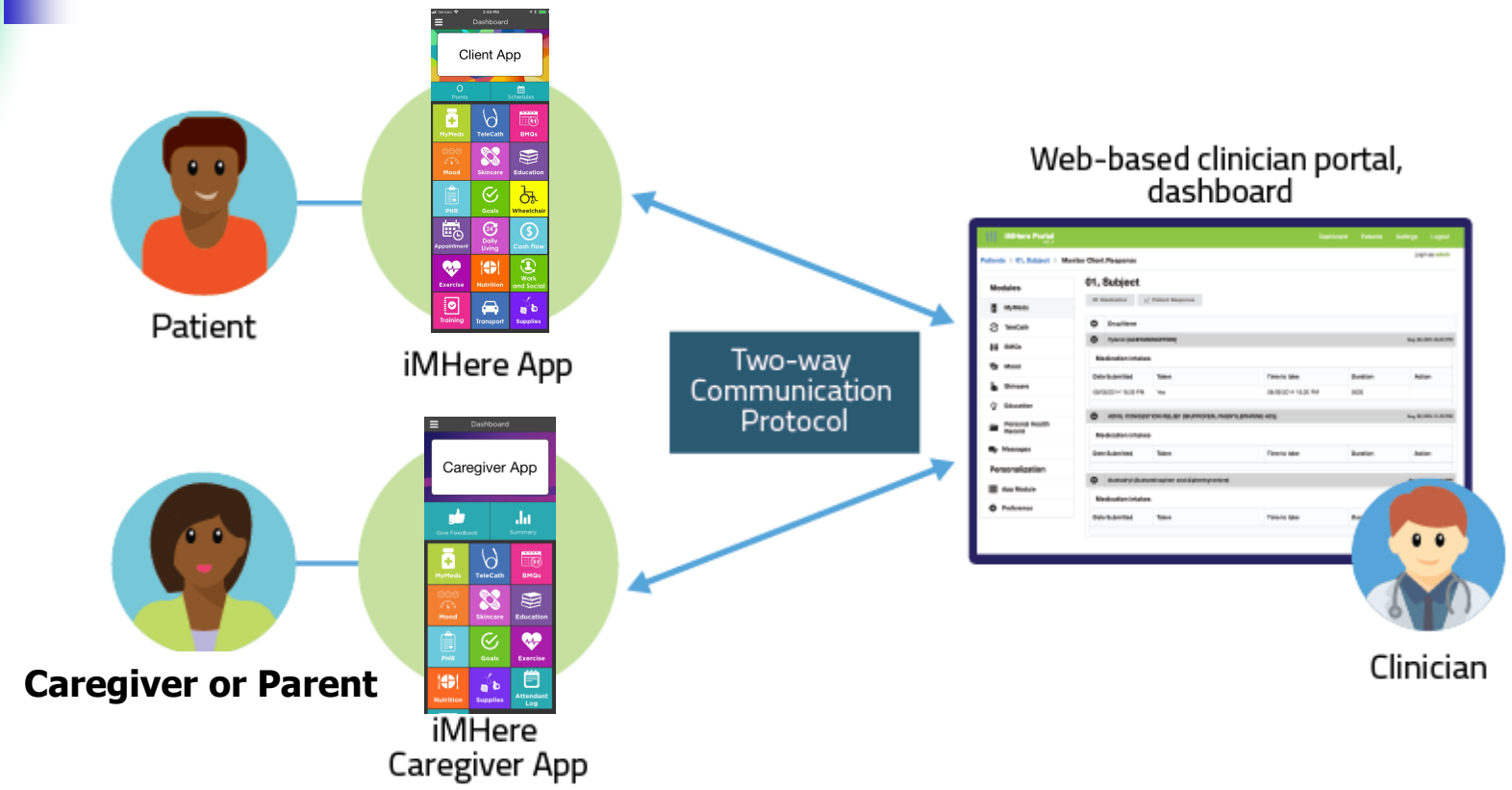
PM R 2011;3:730-738

INTRODUCTION

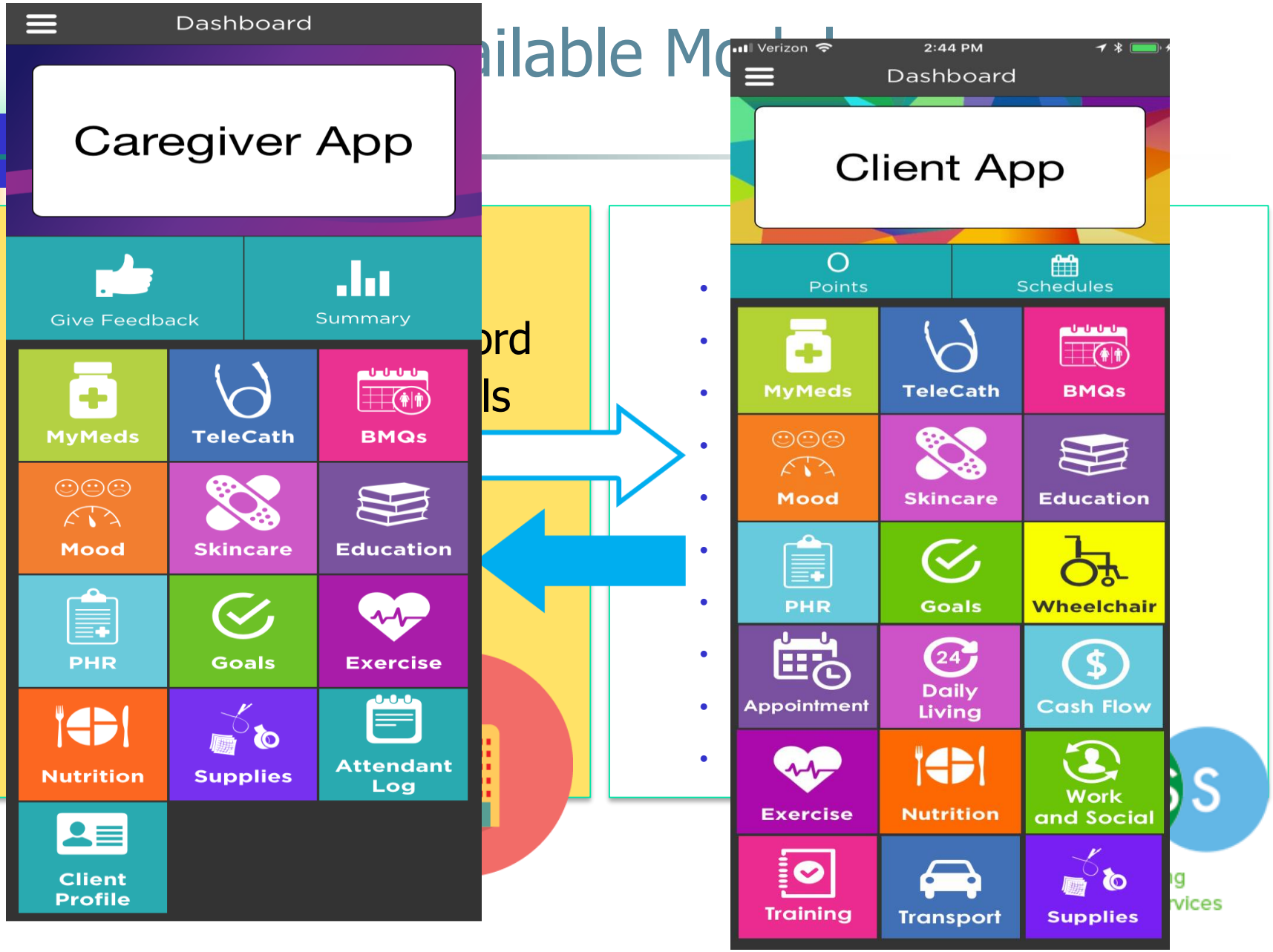
Spina bifida (SB) is the most common permanently disabling birth defect in the United States, now with a prevalence of more than 100,000 [1]. Advancements in medical and surgical care have allowed approximately 85% of persons with SB or congenital spinal anomalies (SBCSA) to live well into adulthood [2,3]; however, secondary medical conditions are prevalent and a significant source of morbidity and mortality.

Kinsman and Doehring [4] identified several potentially preventable conditions, many of which are of infectious etiology, that were responsible for almost one-half of the admissions of individuals with SBCSA to one acute care hospital. In a previous study, we evaluated hospital admissions of adults with SB across the United States and found that approximately

Medical Model



iMHere 2.0


Dashboard
Caregiver App
Give Feedback
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Mood
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Dashboard
Client App
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Schedules
MyMeds
TeleCath
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Skincare
Education
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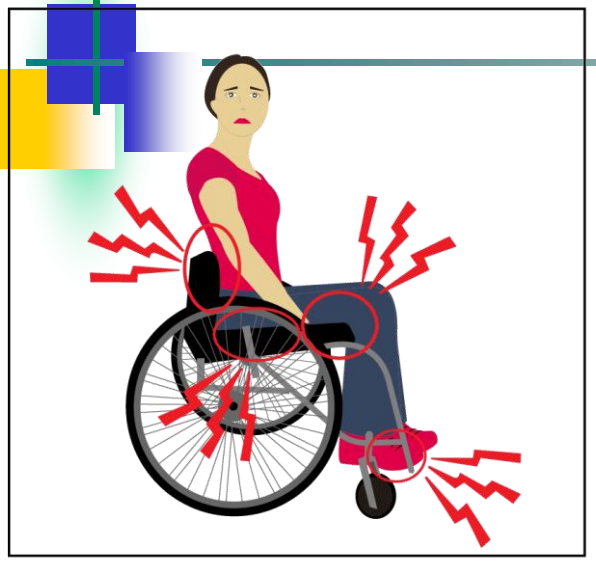
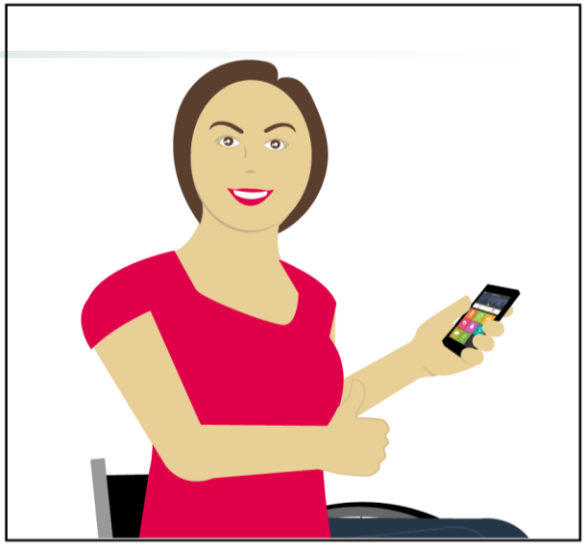
Supplies

Remember Lisa?



40 year old female with spina bifida and hydrocephalus develops wounds.

Wounds worsen requiring ER visits and hospitalizations. Also went to ER for minor health issues.



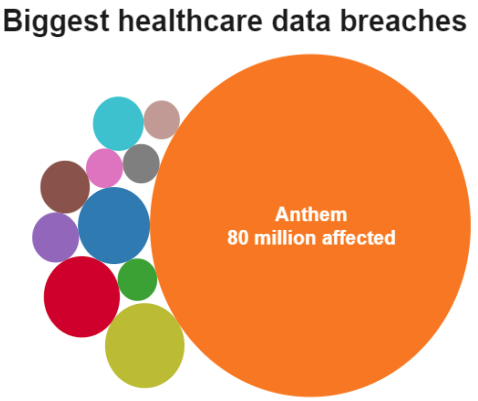
Complete recovery over 1 year period using iMHere. Stopped going to the ER.

But … Security & Privacy significant concerns

Privacy and Security are the most important concerns

Healthcare is ar vulnerable industr

David Kotz et.al, "Privacy and Security in Mobile Health: A Research Agenda,



"57% of consumer .. report being skeptical of the overall benefits of health information technologies such as patient portals, mobile apps, and electronic health records mainly because of recently reported data hacking and a perceived lack of privacy protection by providers"

"The unwillingness of patients to comprehensively divulge all their medical information rose to 87 percent in the fourth quarter of 2016"

Alarming: Users are concerned " … that their pharmacy prescriptions (90 percent), mental health notes (99 percent) and chronic condition (81 percent) data is being shared beyond their chosen provider and payer to retailers, employers, and or the government without their acknowledgement."
(**as per a Black Book survey**)

Security and Privacy Issues/Challenges

- At-large

Enablers

- Medical devices, IoT & Se
- Mobile and Web technolog
- Social networking, Cloud c Location based services
- Big Data analytics – AI, M

Inherit all their

Levera

Security & Privac Healthcare IT

HEALTHCARE CYBERSECURITY IS IN CRITICAL CONDITION

Severe Lack of Security Talent
The majority of health delivery orgs lack full-time, qualified security personnel

Legacy Equipment
Equipment is running on old, unsupported, and vulnerable operating systems.

Premature/Over-Connectivity
'Meaningful Use' requirements drove hyper-connectivity without secure design & implementation.

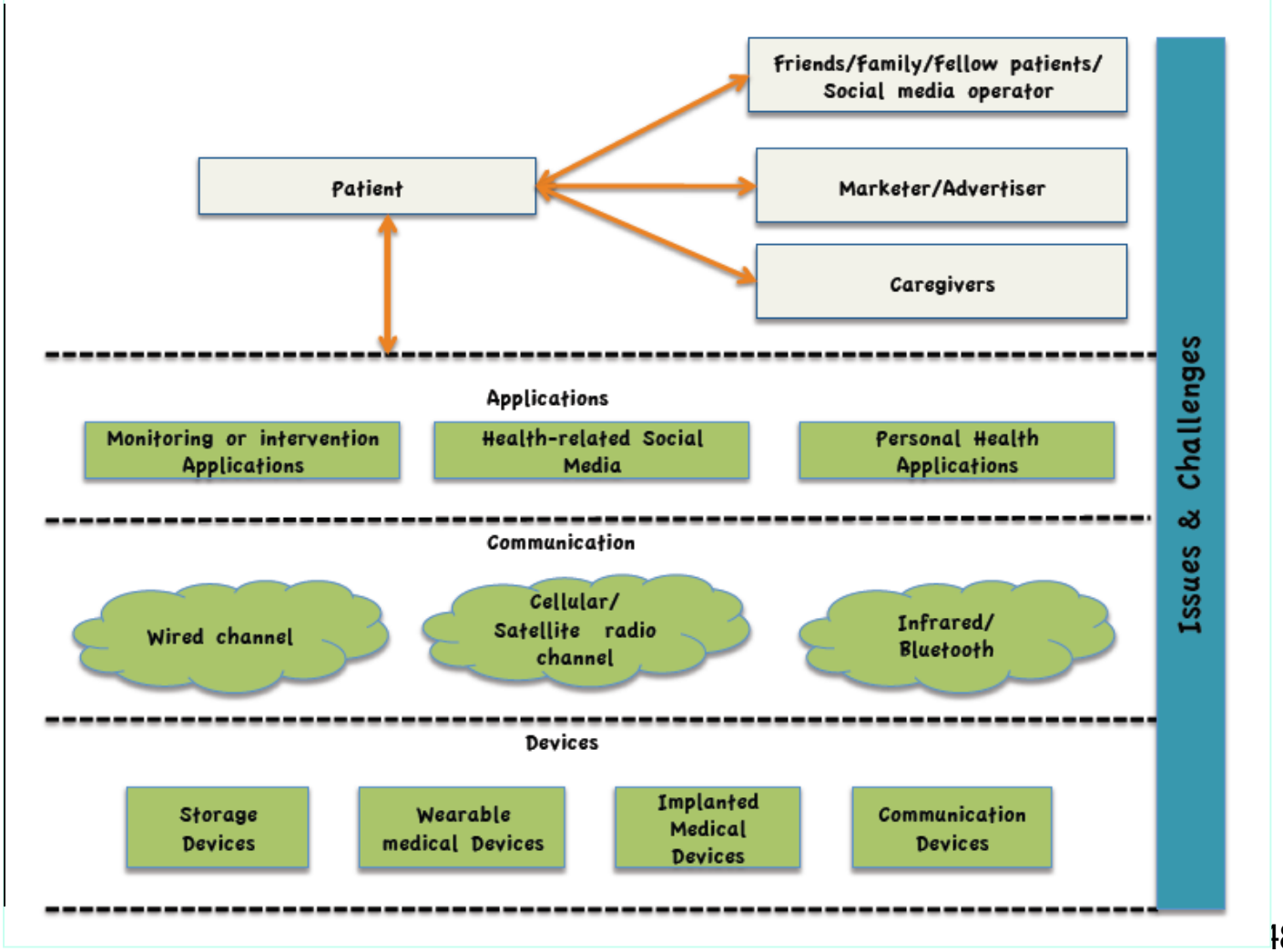
Vulnerabilities Impact Patient Care
One security compromise shut down patient care at Hollywood Presbyterian and UK Hospitals

Known Vulnerabilities Epidemic
One legacy, medical technology had over 1,400 vulnerabilities

Source: Healthcare Industry Cybersecurity taskforce June 2017

Security and Privacy Issues/Challenges

Laws, Regulations, Policies



Security and Privacy Issues/Challenges

		Issues	Security problems	Approaches	Challenges
	User Plane Demographics, Health condition, Physical ability, Mental ability	Demographic profiles and physical & mental abilities of patients are not the same.	- Attacks using non-technical and unintentional vulnerabilities - Targeted attacks on patients with certain characteristics	Human and social factor analysis	- Rich & diverse privacy & security requirements - Security solutions are challenged by human and social factors
Legacy / Mobile / Cloud Infrastructure	**Application Plane** EMR, Tele-Health apps, Personal Health Apps (PHR mgmt, tracking), Health-related social media (OSN, VC)	- Health records are fragmented and dispersed in many facilities - In Tele-Health, a mosaic of applications work with each other, creating a highly collaborative environment - Personal health apps collect extraneous personal info - Quality of information in social media is highly variable	- De-anonymization and inference attacks by linking different data trails - Many possibilities of unauthorized access and identity theft - Social engineering attacks cripple social support systems	- Testing and certification - Design-by-contract - Principle of least privilege - Access control - Data Masking - Cryptographic protocols - Education and training	- Closed systems are hard to analyze - "Break the glass" situations circumvent access control - Cryptographic solutions are computationally intensive and not flexible -"Big data" challenges protection mechanisms
	Communication Plane Wire (copper, coax, fiberoptics, etc.), bluetooth/Zigbee, Satellite/Cellular radio, Infrared wave	- Sensitive patient information is transmitted over public Internet - From monitoring devices to EHR, data travels through multiple vulnerable communication modalities - Wireless communication may cause electromagnetic interference to medical devices (disruption)	- Denial of service impacting monitoring, integrated care, self-care, and social support - Breach of confidentiality of patient info due to tapping or emanation - Loss of data integrity causing erroneous monitoring & wrongful intervention	- Virtual private networks - Intrusion detection - Message authentication - EMI testing	-Wireless, Ad-hoc and opportunistic networks are naturally vulnerable - Cryptographic solutions are computationally intensive and not flexible - Tele-health and emergency care rely on on-time data transmission
	Device Plane Embedded/wearable Medical Devices, Mobile/ Smartphone, Application Hosting Devices, Storage Devices	- Medical devices are resource-constrained - Implanted devices are sensitive to modification - Wearable devices are easily exposed, prone to interference - Healthcare providers have little or no control over the 3rd party cloud infrastructure	- Prone to sleep deprivation attacks - Attacks on patients' physical safety - Offline hardware attack - Failed or compromised devices impacting integration, self-care, and social support	- Device encryption - Fail-secure device design - Device-level access control	- Hardware is hard and expensive to analyze - Unrealistic trust on cloud provider & auditing in cloud is challenging - Researchers have limited or no access to device hardware and firmware

Summary

- mHealth apps – examples
- S&P Challengessaur