Chronic Diseases, Wireless Devices, Remote Monitoring, Case Studies

What is a Chronic Disease

Chronic diseases are long-lasting illnesses such as heart disease, diabetes, asthma, and depression.

Most can be prevented by:

- Eating Right
- Exercising
- Not Smoking
Chronic Diseases

We hear about rising rates of chronic disease every day

Heart Disease Strikes 1 in 14 Women Aged 45 to 64

Diabetes Costs U.S. $98B

Occupational Asthma on the Rise

Cancer: Early Detection Pays Off

Visits to U.S. Emergency Departments at All-Time High; Number of Departments Shrinking

Mental Illness Takes Its Toll on Society

Chronic Diseases

How bad is the chronic disease crisis?

Nearly half of all Americans suffer from at least one chronic condition...

...75 cents of each dollar spent on health care goes to treat patients with chronic disease

133 million people

$1.7 trillion
Many chronic conditions go undiagnosed

One-third of people with diabetes don’t know they have it

Others are diagnosed, but not well controlled

Percent of U.S. adults with high blood pressure

<table>
<thead>
<tr>
<th>Condition</th>
<th>Treated, Controlled</th>
<th>Treated, Uncontrolled</th>
<th>Untreated</th>
<th>Undiagnosed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension (66.3 million people)</td>
<td>28%</td>
<td>15%</td>
<td>27%</td>
<td>45%</td>
</tr>
<tr>
<td>Diabetes (19.9 million people)</td>
<td>22%</td>
<td>33%</td>
<td>22%</td>
<td>5%</td>
</tr>
<tr>
<td>Hyperlipidemia (75.2 million people)</td>
<td>35%</td>
<td>22%</td>
<td>28%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Diagnosis and education are important to fight chronic disease

Millions of American adults remain undiagnosed or untreated, or their chronic conditions are not effectively controlled.

% of population with specified chronic condition
Chronic Diseases

Finding solutions to our greatest health care challenges means looking for solutions to the high cost of chronic disease

• Everyone should have access to early diagnosis of chronic conditions
• Medicines play an important role in reducing health care costs by leading to lower use of other medical services such as doctor and emergency room visits and hospitalizations
• Adherence to medication regimens is essential to controlling cost
• The growing out-of-pocket cost burden on patients (cost sharing) can lead people to forgo needed treatment
• Innovation needed to control and prevent future spending on treating chronic disease

Chronic Diseases

Public policy must encourage additional investment in new treatment.

We have a long way to go in our fight against chronic disease. In order to overcome the effects of chronic disease, we must:

• Advance sustainable "Next Generation" chronic disease prevention and management models throughout the health care system and public health infrastructure.
• Promote healthy lifestyles and disease prevention and management in every community.
• Encourage and reward continuous advances in clinical practice and research that improve the quality of care for those with prevalent and costly chronic diseases.
• Accelerate improvements in the quality and availability of health information technology (HIT) throughout the health care system.
• Reduce health disparities by focusing on barriers to good health.
Growing Chronic Care Challenge

• Over the next 10 years, *the global incidence of chronic disease is predicted to increase by 17%*, further fueling the global burden of disease. Several factors account for this driving force:
  
  – The success of modern healthcare in transforming formerly lethal diseases, injuries, and conditions (e.g., HIV, spinal cord injuries, diabetes, tuberculosis, and multiple sclerosis) into chronic conditions that require continuous treatment;
  
  – Reductions in premature mortality and increasing longevity resulting in longer-lived chronic conditions and health-related dependencies; and
  
  – Increases in the behaviors (e.g., unhealthy diet, physical inactivity, and tobacco use) that significantly contribute to many prevalent chronic diseases.
Human cost of diabetes

- **Diabetic Retinopathy**: Leading cause of blindness in working age adults
- **Diabetic Nephropathy**: Leading cause of end-stage renal disease
- **Cardiovascular Disease**: Leading cause of ulcer & non-traumatic lower extremity amputations
- **Diabetic Neuropathy**: Major contributor to public health costs (10% NHS budget)
- **Stroke**: 2-to-4 fold increase in cardiovascular mortality and stroke
Future Care Delivery Models Will Be Integrated Around Patients’ Homes & Communities

2015: care delivery model is consumer-centric

Home as the Hub
- The home, and other settings, will grow significantly as a model of choice for some care delivery (diagnostics).
- An individual’s care delivery support system has expanded to include participation by other community and family resources.

Integration and Leveraging
- Medical services are integrated with wellness activities, care delivery processes are integrated with health plan operations.
- IT functionality enables us to leverage scarce or specialized clinical resources - MDs, RNs, and other clinical staff.

Secure and seamless transitions
- Warm Handoffs: This human skill sets and operational processes to deliver care and services effectively, efficiently, and compassionately.

Customization
- Occurs at any level of the members’ journey with KP (covering health plans, cost sharing, individual care pathways, and communication modalities.)
- The member drives customization and KP responds.

Medicare DM Demos: Little Evidence of Success

- **Medicare Health Support** (MHS) expands DM into Medicare
  - MHS has attracted worldwide attention
  - Legislation required roll out if successful
- Elements of MHS model
  - Focus on highest cost/risk population (frail elderly)
  - Randomized control trial
- Results to-date: little evidence of success
Findings from Four Demonstrations

- No effects on adherence or self-care
- Only 3 of the 20 programs reduced hospitalizations or gross costs
- No effects on mortality
- Scattered modest effects on quality indicators:
  - Diabetes: Telemedicine improved HbA1c, cholesterol, blood pressure
- Patients love the programs

Why Doesn’t DM Work Better?

- Changing patient and provider behavior is HARD:
  - Limited use of behavior change models
  - No incentive for physicians to communicate
- Some patients too ill, others not at short-run risk:
- Programs don’t collect timely hospitalization and Rx info
- Usual care providers are minimally engaged
- Programs led by marketers, not clinical experts:
  - Ineffective use of available data
  - Unfamiliar with unique needs of the elderly
- Contact info poor in population-based models
- Improvements in quality of care don’t guarantee better patient outcomes in short run
Model #1: Disease Management Model

- Medium sized, privately & publicly held companies
- $2 billion revenues in 2007 (Source: DMPC)
- Payers are increasingly assembling DM components
- Key elements
  - Telephonic services, centralized call centers
    - Support patient lifestyle change
    - Promote evidence based practice
  - Started as carve-out model
  - Guaranteed savings promoted by DMPC
  - Focusing on highest cost, highest risk patients
- Challenges: physician buy-in, proprietary IT
- Major players:

Model #2: Chronic Care Model

- Pioneered at Group Health Cooperative
- Key elements
  - Rushed practitioners not following established practice guidelines
  - Lack of care coordination
  - Lack of active follow-up to ensure the best outcomes
  - Patients inadequately trained to manage their illnesses
- Challenges: no reimbursement, academic/research focus
- Protagonists:
Successor of MHS

- December 2006 – Congress passed the Medicare Medical Home Demonstration (MMHD)
- MMHD similarity to MHS: high cost, chronic patients; multiple comorbidities
- MMHD differences from MHS
  - No requirement of 5% guaranteed savings
  - Physicians can keep 80% of savings

Technologies for DM

CONSUMER TECH INFRASTRUCTURE
- Internet
- Smart houses
- Personal communications devices – PDAs, cell phones, etc.
- Broadband – cable, DSL, satellite
- Digital cameras, video
- Wireless – 802.11, Bluetooth, RFID, etc.
- Voice recognition, etc.

EHEALTH APPLICATIONS
- Electronic Health Records (EHRs)
- Personal Health Records (PHRs)
- Remote patient monitoring
- Fitness/wellness/prevention
- Self care support
- Physician/patient secure messaging
- Home telehealth/telecare
- Decision support systems
- e-Prescribing
- e-Disease Management
- e-Clinical Trials
- Predictive modeling
- Computerized Physician Order Entry
- Quality evaluation web sites
- Patient reminder systems, etc.
Role of IT in Disease Management

Patient Facing
- Personal assessment tools (HRA)
- Predictive modeling
- Call center
- Patient-provider communication tools (IVR, email)
- Decision support tools (CDSS)
- Clinical integration tools
- Disease registry
- Electronic Medical Record

DM Provider Facing
- Personal Health Record
- Call center
- Patient-provider communication tools (IVR, email)
- Decision support tools (CDSS)
- Clinical integration tools
- Disease registry
- Electronic Medical Record

Engage
- Identify, Validate, Stratify, Enroll
- Personal Health Record

Intervene
-Educate, Coordinate, Treat
- Educational tools (websites, audio library)

Monitor
- Outcomes, Feedback, Follow-up
- Remote monitoring (biometric, tele-monitoring)

$34 B Market for Healthcare Unbound Technologies by 2015

ADL/elder
- $0.35
- $0.37
- $0.47
- $0.59
- $0.73
- $0.98
- $1.2
- $1.6
- $2.0
- $2.4
- $3.0
- $3.7

Chronic
- $0.10
- $0.13
- $0.22
- $0.38
- $0.65
- $1.2
- $3.8
- $12.1
- $23.1
- $26.3
- $25.7
- $26.7

Acute
- $0.00
- $0.00
- $0.00
- $0.00
- $0.01
- $0.02
- $0.65
- $2.0
- $3.6
- $3.5
- $3.0
- $3.2

Total
- $0.45
- $0.50
- $0.69
- $0.97
- $1.4
- $2.1
- $5.7
- $15.7
- $28.7
- $32.3
- $31.7
- $33.6

(Numbers have been rounded)
The Multiparameter Remote Patient Monitoring (RPM) Market is Migrating...

- **From**
  - High unit prices rooted in the industry’s early focus on medical device markets and business models
  - Proprietary devices, proprietary IT, non-interoperable data
  - Low unit volume, moderate margins per unit
  - Competition based on vendor lock-in through high switching costs

- **To**
  - Low unit prices as the technology evolves toward consumer markets and consumer business models
  - Interoperable devices, common IT platforms, and interoperable data
  - High unit volume, low margins per unit
  - Competition based on value-adds and service
Systemic Barriers

- Reimbursement
- HIPAA: Privacy/confidentiality issues
- Physician workflow
- Technology maturity
  - Infrastructure
  - Bandwidth
  - Interoperability/Standards
  - Friendly user interfaces

New Platforms and Networks Facilitating Interoperability & Transportability of Personal Health Information

“The sine qua non is sharing data”
Adam Bosworth, former director of Google Health

- Personal Health Records
- Corporate efforts – Microsoft Health Vault, (Google Health), Dossia
- Mobile/Wireless Applications
- Hospital at Home
PHR Background

- 2 models of PHRs
  - Stand alone
  - Tethered: typically to a health plan, provider, employer
- Each has challenges
- The “populating the PHR with data” problem
- 200 PHRs on the market
- Generations of PHRs
  - 1st generation: PHR as “APPLICATION” -- an online repository of personal health information (PHI)
  - Next generation – PHR as PLATFORM

The Networked PHR
Microsoft HealthVault – Launched October 2007

Google Health – will terminate 1/1/12
QUALCOMM’s Mobile Platform (LifeComm)

Value Proposition of Mobile Technology for DM is Huge!

Chronic Disease/Condition Management is migrating
- *From* a clinical based model
- *Toward* a behavior change model

How can you **optimize** behavior change without 24x7x365 connectivity to the patient?
The Next Generation of DM Technology

*When the Technology is Just “There”*

“Ubiquitous Health”

“Sense and Simplicity”

“Pervasive Computing”

Remote Monitoring Service – Technology Enabled Support

- Fundamental right - access to technology in order to improve the quality of life
- Use of technology to enable independence and integration in the community
- Decreased reliance on paid supports
- Must ensure health and safety
- Changing the face of how services are designed and delivered
  - Overnight monitoring
  - Safety issues in the home
Some Guiding Principles

• Useful
• Affordable
• Accessible
• Easy to operate for end users
• Value added

Remote Monitoring Equipment

• Technology as a service
  – Web-based monitoring system
  – Live video or audio feed
  – Pendant
  – Camera/web cam
  – Contact or motion sensor
  – Seizure mat
  – Radio frequency identification (RFID)
  – Ultra mobile personal computing devices (UMPC)
  – Smoke detectors
Two-Way Web-Based Communication

Pendant
Pan, Tilt and Zoom Camera

Seizure Mat
UMPC

Mobile Technologies

- 57% of Americans age 65 and older have a cell phone
- More than 80 percent of U.S. physicians will have smartphones by 2012—up from 64 percent in 2009
- 4.6 billion mobile subscribers end of 2009
Health Information Technology

- US putting $19 Billion into HIT
- Spending on HIT rapidly increasing by 2012
  - 80 percent of physicians and 58 percent of non-users plan to implement Electronic Health Record programs
  - 72 percent of the hospitals increasing HIT implementation

Telehealth

- American Reinvestment and Recovery Act of 2009 - $7 Billion
  - Broadband Expansion
  - Distance Learning and Telemedicine Expansion
- e-visits and 24x7x365 nurse call centers in every state
- 2008: over 200 telehealth networks connecting 2000 institutions
Medication Optimization

- Medication information, dispensing, adherence, and monitoring.
- Medication use is ubiquitous among older adults, with **90% of older adults using one or more prescription medications** per week.
- New England Healthcare Institute: **$290 billion in healthcare savings**

### Goals

**Medication Reconciliation**
- **Assess**
  - Goals
    - Patient history includes a complete and accurate medication list
    - Patient needs are accurately conveyed and understood

- **Prescribe**
  - Example Technologies
    - Medication List Software
    - Personal Health Records (PHR)

**Medication Adherence**
- **Dispense**
  - Example Technologies
    - Medication List Software
    - Personal Health Records (PHR)
    - Teleconsultations
    - Online Patient Education
    - Cognitive Assessment Tools
    - Pharmacy Kiosks

- **Administer**
  - Example Technologies
    - Medication Adherence Devices
      - Integrated and standalone, simple and advanced function

- **Monitor**
  - Example Technologies
    - Personal Biometric Testing Devices
    - Wireless Communication Devices
    - Personal Health Records (PHR)

**Medication Monitoring**
- Goals
  - Routine dosing and tracking of medication
  - Reports and trending information from medication log generated
  - Clinician adjusts medication as needed
  - Prescriptions refilled
Remote Patient Monitoring

– Remote collection of patient information using a device: *physiological, emotional, location*

– RPM benefits:
  • support patient self-management
  • early diagnosis
  • reduce ED and hospital services
  • shift responsibilities to non-clinical providers
  • improve care coordination
  • Built in patient education programs
  • improve patient and provider satisfaction

Remote Patient Monitoring

RPM Process in Integrated Health Care Systems

Patient interacts with telehealth device

Data collected includes:
• Vital signs (blood pressure, glucose meters, pulse oximeters, weight, etc.)
• Physical and emotional well-being assessment

Patient information is collected & transmitted

Data transmitted over:
• Video over low-bandwidth POTS
• Video over IP
• LAN/WAN

Patient information is used in treatment

Results include:
• Enhanced communication between caregivers, providers, and patients leads to improvements in care coordination and caregiver support
• Reduce unnecessary visits
• Improve medication compliance

Note: POTS is “plain old telephone service.” IP is “internet protocol.” LAN/WAN is “local area network/wide area network.”
Assistive Technologies

<table>
<thead>
<tr>
<th>Activity/Application of Technology</th>
<th>Example technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Large button cellular phone</td>
</tr>
<tr>
<td>Computer Access</td>
<td>Voice recognitions software</td>
</tr>
<tr>
<td>Environmental</td>
<td>Smart HVAC systems</td>
</tr>
<tr>
<td>Sensory</td>
<td>Cochlear implants</td>
</tr>
<tr>
<td>Mobility and Transportation</td>
<td>Smart Wheelchair</td>
</tr>
<tr>
<td>Seating and Positioning</td>
<td>Posture optimization devices</td>
</tr>
<tr>
<td>Vision and Reading</td>
<td>Visible light audio information transfer systems</td>
</tr>
</tbody>
</table>

Remote Training / Simulation

– Professional, paraprofessional, family caregivers

– Modalities
  • E-learning
  • Video-classroom training
  • Remote simulation
Remote Training / Simulation

– Virtual Simulation Center for Geriatric Care Learning: Cornell University's Center for Environmental Geriatrics

Cognitive Fitness/Assessment

– Cognitive training tools

Nintendo DS Brain Age

Source:
www.brainage.com

Dakim

Sources:
www.ecumen.org
www.dakim.com

Posit Science

Source:
www.positscience.com
Social Networking

– Social networks help older adults communicate, organize, and share with other older adults and with their care providers.
– Caregivers and clinicians can use social networks to manage and coordinate care for an older adult.

Source: http://www.tyze.com

Source: http://jive.benarent.co.uk/

Barriers to Deployment

– Limited experience of most providers with technology
– Poor preparation for adopting such technologies
– Lack of financial models that document return on investment
– Limited awareness by patients/clients
– Provider concerns
– Information technology and interoperability
– Inadequate reimbursement
Classification of HC Technology

- Pharmaceuticals
- Medical Devices
- Medical Equipment
- Medical Processes and Procedures
- Healthcare Information Technology

Stages in Development of Medical Technologies

1. Scientific background and development of the idea for a product
2. Product development, approval, and distribution
3. Diffusion, adoption, and utilization of the product
Stage 1

• Involves a broad array of basic science discoveries that provide a fertile environment from which useful products may eventually emerge.
• National Institutes of Health (NIH) plays a critical role in this stage by providing funds to many organizations.

Stage 2

• Product development
  – Process of moving from basic research to implementation
• Three questions are answered during this phase
  – Is there a need and a viable market for this product?
  – Can an appropriate product be developed that accomplishes what the basic science research suggests it can?
  – Can the necessary tests and clinical trials be carried out to win the regulatory approval required for public sale and use of the product?
Stage 3

- Mixture of scientific promotion to technical experts and general marketing to the health care system.
- Availability of health insurance coverage for new products is a major factor in the eventual diffusion and use of new technology.

Policy Issues

1. Priorities determined by government may take precedence over mandates set forth by the scientific community.
2. The best way to evaluate returns from a public investment in basic science research.
3. Private sector benefits achieved as a result of significant public investments in basic science research.
Food and Drug Administration

• FDA must approve all drugs and pharmaceuticals, all medical devices, and some medical equipment.
• Clinical trials conducted during Stage 2 are central to FDA regulatory approval.

Preclinical Testing

• Sponsor must evaluate the product’s safety and biological activity through in vitro and in vivo animal testing.
• Sponsor must:
  – Develop pharmacologic profile of product’s effects.
  – Determine its acute toxicity in at least two animal species.
  – Conduct short-term toxicity studies.
Phase I

- Typically involves less than 100 healthy volunteers.
- Purpose
  - Observe how the drug works in humans, to determine general safety, and to see if there are any unexpected side effects.
- Clinical effectiveness is not measured during this phase.

Phase II

- Typically involves 250+ subjects.
- Purpose
  - Obtain a first reading about the potential effectiveness of the drug and to determine whether it is appropriate for the trial to progress to the next phase.
- Phase II also provides additional information on safety and side effects.
Phase III

- Typically involves 1000+ subjects.
- Purpose
  - Determine drug’s effectiveness and to see if side effects will need to be considered.
- If the FDA is satisfied with the results, the sponsor must submit an application to the FDA for approval as a new drug (NDA).

Phase IV

- Sponsor must continue to monitor patient experiences with the new drug and report any adverse events.
- Purpose
  - Pick up on any previously unexpected adverse reactions that may only appear with longer term or widespread use of the medication.
Drug Development Process

- Preclinical trials
  - 6 years
- Clinical trials
  - 7 years
- Final NDA approval
  - 1-2 years

Request for Technology Assessment

- Health insurance organizations will be approached by developers and/or clinicians.
- Insurance organization will then request a formal assessment of the technology.
- Request for assessment focuses on effectiveness of the technology and usually does not include any reference to cost or price.
Advantages of Technology Assessment Process

• Rigorous review of published scientific evidence.
• No discussion of economic or financial details.
• Carried out in an open public forum with all background information and discussions available to all interested parties.

Device Connectivity Standards

- 11073-10404 = Pulse Oximeter
- 11073-10406 = Pulse / Heart Rate
- 11073-10407 = Blood Pressure
- 11073-10408 = Thermometer
- 11073-10415 = Weighing Scale
- 11073-10417 = Glucose
- 11073-10441 = Cardiovascular Fitness Monitor
- 11073-10442 = Strength Fitness Equipment
- 11073-10471 = Independent Living Activity
- 11073-10472 = Medication Monitor

- 11073-20601 = Base Framework Protocol
Personal Monitoring Devices

4.0 Billion Cell Phones
Over 3 Billion More Than Any Other Computing or Consumer Electronics Device

- Connection to network
- Significant local processing

Wireless Health Connectivity Collapses Time and Space

<table>
<thead>
<tr>
<th>In-Body</th>
<th>On-Body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug Delivery Systems &amp; Sensors</td>
<td>SMART Band-Aids - in Development</td>
</tr>
</tbody>
</table>

Neurological & Diabetes
“Courtesy of Medtronic”

Urgent Care
- Identity
- Heart rate
- Respiratory rate
- ECG
- SpO2
- Temperature
- Blood pressure
- Motion

Occupational
- Heart rate
- Respiratory rate
- Motion
- Temperature
- Hydration
- Electrolytes
- Identity

Diagnostic
- Compliance
- Heart rate
- Respiratory rate
- Motion
- Temperature
- Blood pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Gait
- Identity

Fitness
- Heart rate
- Respiratory rate
- Distance/Steps
- Speed
- Elevation
- Motion
- Calories Intake

Chronic Care
- Compliance
- Heart Rate
- Blood pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Motion
- Identity

Therapeutic
- Compliance
- Heart Rate
- Blood Pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Drug Delivery
- Identity

Band-Aid® is a Registered Trademark of Johnson & Johnson Consumer Companies, Inc. 2007.
Qualcomm Challenge: Building a Platform for Sensors

- **Ultra Low Power**
  - Extended battery life
- **Security**
  - Data must remain private
- **Integration with sensors**
  - Sensor-specific processing on platform
  - Easy configuration
- **Smart nodes**
  - IP transport and protocols from sensor to servers
- **Flexible deployment topologies**
  - Star or mesh
  - Scalability

Remote Diagnostics Using Cellular Technology

- **CardioNet Wireless Solution**
- **Traditional Holter Monitor Solution**

"CardioNet proved nearly 3x more effective than LOOP event monitors for diagnosing clinically significant arrhythmias."

-The Journal of Cardiovascular Electrophysiology
Wireless Implants
CardioMEMS miniature Wireless Implantable Sensors use radiofrequency energy, to transmit real-time data to an external electronics module, which then communicates this information to the patient’s physician. These wireless devices are critical to the management of patients with congestive heart failure.

- Cardiac Output
- Blood Pressure
- Heart Rate Data

Patch Drug Delivery
A Wireless Patch Drug Delivery system, or wireless transdermal patch, is an adhesive patch with a drug reservoir that is placed on the skin to deliver a specific dose of medication. Sensors transmit data for monitoring and control purposes.

- Control Patch Activation
- Monitor Use
- Monitor Therapy
- Adjust Drug Delivery

Remote Monitoring Systems

Boston Scientific LATITUDE System
- The patient monitor enables you to “connect” your implanted device to your clinic via a standard phone line.
- Available for Boston Scientific ICDs and CRT devices in the United States, Puerto Rico and the Virgin Islands.
Remote Device Monitoring

LATITUDE Patient Management System

1. You are implanted with a cardiac device
2. Clinic receives implant form
3. Boston Scientific ships equipment to your home
4. The clinic enters your name into the remote patient management system
5. You set up the equipment at home.
6. Clinic begins managing patients

When the in-home equipment arrives at your home:

- Information to help you set up your equipment:
  - A video setup guide (in both VHS and DVD formats)
  - A detailed patient manual
  - A one-page sheet with instructions and illustrations
  - LATITUDE Patient Support number

- Set up your equipment as soon as you receive it based on manufacturer’s instructions.
- After set-up, your doctor can begin monitoring your device.
LATITUDE Patient Management System

To set up your equipment:
• Place your equipment where your sessions will take place, such as by the bedside.
• The Communicator plugs into your regular phone line and electrical outlet.
• Instructions are provided to guide you through the set-up process.

If you have a phone jack in your bedroom, you may want to put the in-home monitor on the nightstand next to your bed. Your doctor decides how often to collect the data, and the remote monitoring system does the rest.

LATITUDE Patient Management System

• If your in-home equipment is the LATITUDE Wanded Communicator:
  – A blinking white action button reminds you when it is time to send your information.
  – Simply hold the wand over your device.
  – Press the blue interrogation button to send information from your device.
  – Remote monitoring, on average, takes 10 to 15 seconds to complete but may take more time if additional information needs to be collected.
  – The Communicator screen will indicate when the session is over.
LATITUDE Wanded Communicator

If your in-home equipment is the LATITUDE Wireless Communicator:

- It is recommended that your LATITUDE Communicator stay near your bedside.
- After it is set up, the Communicator can be configured by your doctor over the phone line.
- Your doctor will determine when monitoring will occur.
- You typically do not need to initiate any action.
Other in-home monitoring tools

• Your doctor may prescribe additional in-home equipment, such as a weight scale and blood pressure cuff, to enhance your follow-up care.

• These tools also make it easy for you to take an active role in managing your health.
iStethoscope for iPhone

• Dr. Peter Bentley, UCL Department of Computer Science, invented the iStethoscope application, which monitors heartbeat through sensors in the phone.
• Downloads have averaged up to 500 a day
• “Smartphones are incredibly powerful devices packed full of sensors, cameras, high-quality microphones with amazing displays”

Test Your Knowledge!

• Today, there are 38 million seniors in the United States; by 2030, that number will rise to:
  a) 25 million
  b) 39 million
  c) 75 million
  d) 100 million

Correct answer is (c)
Source: ASCP Fact Sheet (http://www.ascp.com/about/ascpfactsheet.cfm)
Test Your Knowledge!

• Of the following demographic groups, which is more apt to NOT have health insurance?
  a) Women over the age of 65
  b) Children under the age of 18
  c) Males between the ages of 18 and 24
  d) Men and women between the ages of 50

**Correct answer is (c)**

*Source: Graziadio Business Report (Pepperdine University), 2004, Volume 7, Number 3*

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Test Your Knowledge!

• According to the U.S. Census Bureau, in 2007, ___ persons of all ages were uninsured.
  a) 0 million
  b) 24 million
  c) 10 million
  d) 45.7 million

**Correct answer is (d)**
Smart Everyday Objects

• Bionic Running Shoes (Adidas)
• Posture Chair (MIT media lab)
• Moving Portrait (MIT media lab)

Smart Objects

• History table cloth (EU Equator)
• Emotional Décor (NYU)
• I/O Brush (MIT)
Smart Mugs

- Chameleon Mug
  - LCDs, bimetal strips, thermoresisters and thermochromic ink as sensors
  - A vessel which changes color, displays safety messages and/or springs a handle to demonstrate whether the fluid in it is hot or cold.
  - various sensors could detect the concentration of sugar or lactose in a beverage, warn of bad milk or mix the fluids ultrasonically.

- MediaCup

LED Display Cloth
A Wearable Display for Team Sports
(U. of Sydney)

Introduction: what does the display mean?
Two displays on the front show time limits, the left reflects the game-clock (1 minute) and the right reflects the shot-clock (10 seconds)
Four displays on each shoulder shows the number of fouls (1, 2, 3, 4)
Three displays on each side reveal how points scored (10, 20, 40)
The display on the back reveals which team is winning
Topobo (MIT)

http://www.youtube.com/watch?v=50IdK_K2NWk&feature=player_embedded#

Blendie (MIT)

- A “sensitive” blender that can express emotion.

http://www.youtube.com/watch?v=6DDkwdPaYmk
Diet-aware Dining Table
Detect what and how much you eat from the table

- **Sensing** to recognize behavior
  - Combine weight sensor and RFID sensors to track food transfer among containers
- **Interaction**
  - Natural user eating behaviors become system input (no need to operate any devices).
  - How do you design a user interface without affecting one’s appetite?

Diet-Aware Dining Table: Single Interaction Example

- Bob pours tea from the tea pot to personal cup, and drinks it

  **Put on tea pot.**
  - RFID tag appears
  - Weight increases $\Delta w_3$

  **Pour tea!**
  - $|\Delta w_1 - \Delta w_1| \approx \Delta w_2$

  **Pick up tea pot.**
  - RFID tag disappears
  - Weight decreases $\Delta w_1$
Geta Sandals
Shoes (Slippers) that track where you walk

- Track people’s locations with minimal infrastructure in the deployed environment
- Footstep-based localization
  - Error accumulation (1~10%)
  - Location-aware RFID tags

http://mll.csie.ntu.edu.tw/video/geta_short.wmv
Object Locator Ring (Watch)
Track locations of everyday things

• Where did I put these everyday things?
  – Glasses, cell phones, wallets, keys, remote controls, ...
• Track locations of everyday things
  – RFID reader on ring
  – RFID tags on everyday objects
  – Ultrasonic Indoor location systems (MIT Cricket)

How does it work?

• Assumption:
  – Most objects are moved by hands
• Picking up phone:
  – Phone presence (RFID tag) detected by the ring antenna
• Carrying the phone:
  – Continuous presence (on-hand)
  – Non-presence (pocket-it)
• Dropping the phone:
  – Phone presence (RFID tag) not detected by ring antenna
• Location of the object?
More Examples

• Baby Think It Over
• Textrix VR Bike
• Smart Tachograph

Playful Tray
Encourage good eating habits in young children

• Sense to recognize behavior
  – Weight sensor underneath the tray to sense eating actions
  – Eating actions as game input

• Play to engage behavior change
  – Interactive games: coloring cartoon character or penguin fishing

• User study on 4 children (autistic)
**Playful Toothbrush**
Encourage proper and thorough brushing in young children

- **Bad teeth in young children with cognitive impairments**
- **Sense** to recognize behavior
  - Webcam to detect brushing motions
  - Brushing actions are game inputs
- **Play** to engage behavior change
  - Start with a mirror image of dirty teeth
  - Physical brushing maps to virtual plaque removal
- **User study** on 13 kindergarten children

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**Mug-Tree**
Encourage healthy habits (staying hydrated)

- **Sense** to recognize behavior
  - Tilt sensor to detect drinking actions
  - Drinking actions are game inputs
- **Play** to engage behavior change
  - Game metaphor: hydrating body -> watering a tree
Nutrition-aware Kitchen
Raise awareness of nutritional facts

- **Sense** to recognize behavior
  - Combine weight and camera sensors to detect cooking actions (change food ingredients)
  - Voice input for food ingredient label
  - Food ingredients -> meal calories
- **Play** to engage behavioral change
  - Too many calories -> overweight family member
  - Imbalanced seesaw board -> big boulder sliding down

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Nutrition-aware Kitchen
Raise awareness of nutritional facts

- **Awareness**
  - User study on 3 cooks
- **User study on 3 cooks**
  - name of ingredients, total calorie in this container, and the most recent calorie change

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Figure 7. User interface of Calorie-aware Kitchen, including (a) overview of calorie in the system; (b) recommended calorie needs and current used calories; (c) a calorie-aware game with a beloved family member to bring enjoyment of calorie control

http://mll.csie.ntu.edu.tw/video/calorieAwareKitchen_interaction.mov
Clean-your-room poster
Persuade children to put things back where they belong after using them

- **Sense** to recognize behavior
  - RFID sensors to check if things were put back on the shelf
- **Play** to engage behavioral change
  - Misplaced things -> trash in the virtual world
  - Using child's sympathy for an animal to persuade the child to put things back where they belong

ChroMirror
Persuade people to explore more colorful clothes

- **Sense** to recognize clothes & colors
  - Camera and Computer Vision
- **Play** to trigger behavioral change
  - Easily and playfully explore & experiment with how different colors look on people
Mug-Forest

- Use social pressure to encourage staying hydrated

Mug-Forest

Use social pressure for persuasion

- **Sense** to recognize drinking action
  - Accelerometer (in a phone) to detect drinking action
  - Camera to detect water level
- **Play** to use “social pressure” to cause behavioral change
  - Computer-mediated human persuasion, not computer persuasion