The Role of Wireless Medical Technology in Global Health

Enrique Saldivar, MD, PhD
Founder of Cardio6
“The desire to understand the world and the desire to reform it are the two great engines of progress”

-Bertrand Russell
Wireless and Global Health

Part I
   Introduction

Part II
   Developed Countries

Part III
   Developing Countries

Part IV
   Concluding Remarks
Wireless and Global Health

Part I
Introduction

Part II
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Part III
Developing Countries

Part IV
Concluding Remarks
The challenge

• There is an unmet need to provide healthcare in the aging population in industrialized countries as the medians of their population are expected to further increase

• There is an unmet need to provide healthcare in the growing population of emerging economies

• There is an unmet need to provide healthcare in the newly urbanized populations in developing economies facing the double burden of disease
The challenge

Needs

• Societies with aging populations
  • Prevention, treatment and early detection of degenerative diseases, including cardiovascular disease, cancer, hypertension and diabetes

• Societies with younger segments of their population
  • Solid structure to provide vaccines, nutritional education, perinatal care, etc.

• Low and middle income countries -Transition to urbanization of the population. Double burden of disease.
  • Controlling infectious diseases and under-nutrition
  • Prevention of obesity and cardiovascular disease as they become more prevalent
Age and poverty distribution in the US

Source: www.CensusScope.org
Double burden of disease

http://gamapserver.who.int/gho/interactive_charts/ncd/risk_factors/overweight_obesity/atlas.html?indicator=i1&date=Both sexes
Need for Paradigm Shift

“Insanity is doing the same thing over and over again, but expecting different results.”

-- Rita Mae Brown
(“Sudden Death”)
When a major transformation in the environment results in an improvement of community health there is a shift in the medical paradigm.
Wireless technologies and the next paradigm shift in healthcare

Wireless technologies have:
• Rapid adoption rates
• Quasi-universal connectivity (global information transfer)

Good candidate to provide the next paradigm shift in healthcare
Applications of Wireless Technology in Healthcare

• Education and Awareness
• Remote data collection (lab and population studies)
• Remote monitoring (telemetry)
• Communication and training for healthcare workers
• Disease and Epidemic Outbreak Tracking
• Diagnostic and treatment support

Wireless and Global Health

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Total Health Expenditures

How big is it?

Current National Health Expenditures, $4 Trillion (~ $6 Trillion projected by 2027)

Centers for Medicare & Medicaid Services, Office of the Actuary

Centers for Medicare & Medicaid Services, Office of the Actuary
### Chronic Diseases 75% of the Cost

<table>
<thead>
<tr>
<th>Disease</th>
<th># in U.S.</th>
<th>Wireless Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alzheimer's</td>
<td>5 M</td>
<td>Vital signs, location, activity, balance</td>
</tr>
<tr>
<td>Asthma</td>
<td>23 M</td>
<td>RR, FEV1, Air quality, oximetry, pollen count</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>3 M</td>
<td>Ultrasound self-exam</td>
</tr>
<tr>
<td>COPD</td>
<td>10 M</td>
<td>RR, FEV1, air quality, oximetry</td>
</tr>
<tr>
<td>Depression/Mood Disorders</td>
<td>21 M</td>
<td>Med compliance, activity, communication</td>
</tr>
<tr>
<td>Diabetes</td>
<td>24 M</td>
<td>Glucose, hemoglobin A1C</td>
</tr>
<tr>
<td>Heart Failure</td>
<td>5 M</td>
<td>Cardiac pressures, weight, BP, fluid status</td>
</tr>
<tr>
<td>Hypertension</td>
<td>74 M</td>
<td>Continuous BP, med compliance</td>
</tr>
<tr>
<td>Obesity</td>
<td>80 M</td>
<td>Smart scales, caloric in/out, activity</td>
</tr>
<tr>
<td>Sleep Disorders</td>
<td>40 M</td>
<td>Sleep phases, quality, apnea, vital signs</td>
</tr>
</tbody>
</table>

Table from Eric Topol, M.D.
Wireless Health Value Proposition

Enhancing quality
Targeted care, at the right time, based on collection and/or communication of relevant health data and information. New care possibilities that are enabled through continuous monitoring, wireless communication and/or rich new databases of disease conditions.

Improving convenience
By the mobility to patients and healthcare providers.

Extending reach
Possibilities in diagnosis, therapy and monitoring at a distance and/or in places otherwise difficult to reach.

Reducing cost
Keeping patients out of care facilities through preventative care solutions and timely diagnosis. Reducing errors and amplifying the productivity of the health care providers.
Obstacles

Technology availability
The extent and richness of solutions possible to a wide range of health problems.

Acquisition and ownership cost
Costs associated with purchasing the solutions and operating/maintaining them, respectively.

Regulatory efficiency
The time and cost associated with obtaining approval for specific solutions to particular health problems.

Reimbursement policy
Covering the cost of utilizing wireless health solutions, including when used for prevention, which is a great application opportunity for wireless health but not reimbursable for the most part today.
The global population

GDP per capita - purchasing power parity

Life expectancy at birth

Source: World Bank; CIA World Factbook
Best D-Health Strategies

- **Personalized**: The system should be individualized for patients and providers, using individual patient status and treatment history in care decisions
- **Ubiquitous**: All patients should have access to their health information, even when accessing care from providers or facilities
- **Interoperable**: All providers and systems should be able to interact and exchange information with each other
- **Interconnected**: All stakeholders and systems should be interconnected and, to the extent possible, able to leverage the same infrastructure
- **Scalable**: Systems should be able to expand functionally, in terms of the workers that use them and the populations they serve
- **Sustainable**: Services and systems should be affordable without operating at a loss and should ideally result in efficiency gains to the health system
- **Secure**: Personal data should be secure from external and internal misappropriation
- **Measurable**: Service access, quality and impact should be measurable, as should adherence to the principles that govern the strategies

Vital Wave Consulting, Inc.
Five phases of health system development

- **Phase 1** High infant and maternal mortality, low life expectancy (around age 30) and low economic growth.

- **Phase 2** Significant reduction in infant and maternal mortality, as well as an increase in life expectancy and economic growth.

- **Phase 3** Further reduction in infant and maternal mortality, improving life expectancy and managed economic growth.

- **Phase 4** Continued reduction in infant and maternal mortality, drastically increased life expectancy and continued economic growth.

- **Phase 5** Near elimination of infant and maternal mortality, extended life expectancy and a stable economy.


*Vital Wave Consulting, Inc.*
Challenges for ICT in Africa

• Funding shortage

• Equipment and supplies shortage

• Insufficient quantity of skilled healthcare workers

• Populations that are uneducated about prevention and treatment of preventable diseases

• Lack of health systems infrastructure that enable communication between rural and urban centers.

Example 1: Wireless and Global Health

• Maternal health
• Neglected technological development
• Alignment with millennium goals
  • Eradicate extreme poverty and hunger
  • Achieve universal primary education
  • Promote gender equality and empower women
  • Reduce child mortality
  • Improve maternal health
  • Combat HIV/AIDS, malaria and other diseases
  • Ensure environmental sustainability
  • Develop a global partnership for development
Example 1: Wireless and Global Health

Cardiotocography – Invented late 1950s

Continuous and simultaneous monitoring of uterine contraction and Fetal Hear Rate

Used to detect and monitor fetal distress
Example 1: Wireless and Global Health

Clinical use
Example 1: Wireless and Global Health
Example 1: Wireless and Global Health

Contraction Simulator
Example 1: Wireless and Global Health

Clinical tests

CCC = Lin’s Concordance Correlation Coefficients
Example 1: Wireless and Global Health
Impact and commercialization
Example 1: Wireless and Global Health

Sense4Baby

A Cheap, Portable Way to Monitor Unborn Babies

A nonprofit creates a new heart monitoring machine employing wireless technology.

Maternal monitoring: A device designed by the West Wireless Health Institute measures fetal heart rate via an ultrasound monitor (lower belt) and maternal contractions via another sensor (higher belt), and then transmits the data via Bluetooth to a tablet (left). Credit: West Wireless Health Institute

An inexpensive portable device could make it easy to monitor fetal health in remote locations, and it might also provide an alternative more expensive machines currently used in doctors' offices in the developed world.
Example 1: Wireless and Global Health

Sense4Baby
Example 1: Wireless and Global Health

Perceived usefulness
- Pregnant women:
  - Informative
  - Allows interaction with clinicians and boosts confidence
  - Involvement with labor
  - Freedom of movement, privacy
- Clinicians:
  - Interactive, flexible
  - Eases congestion and workload
  - Time-saving (quick documentation)

Perceived ease of use
- Pregnant women:
  - Painless
  - Light
- Clinicians:
  - Portable, convenient
  - Non-invasive
  - Requires little skill

Attitude
- Pregnant women:
  - Comfortable
  - Reassuring
  - Concern for safety, hygiene
- Clinicians:
  - Accurate
  - Allows improved clinical decision-making
  - Give “piece of mind”
  - Promotes teamwork
  - Could cause anxiety
  - Concern for consistent Technical function

Behavioral intention to use (acceptance)
- Pregnant women:
  - Encourages ambulation, flexibility
  - Easy to use, light
  - Safety of Bluetooth technology
  - Positive utility with improved awareness
- Clinicians:
  - Valuable
  - Easy-to-use, portable
  - Commendable real-time output
  - Accurate, dependable

Fig. 2 The wireless fetal heart monitoring prototype in use at Mbale Regional Referral Hospital

Fig. 3 Technology acceptance model as applied to a wireless prototype cardiocography technology in rural Uganda. The qualitative interviews of both pregnant women and clinician participants informed the model; actual use will be explored in future studies
Example 2: Wireless and Global Health

Framework

• Cardiovascular disease is the number one killer in the world

• Half of the deaths of heart attacks occur within one hour of onset of symptoms

• Patients often do not call for help as they do not recognize the symptoms
Global Deaths by Heart Attack Per Year

Heart attacks are the leading cause of death in developed countries

8.76 million

53.40%  
46.6% *

*Based on US statistics
Requirements

• Wearable system – with patient at all times
  • A preferred location for wearables – wrist

• Capable of detecting early/warning signs

• Multiple leads for accurate detection
Actual EKG results from current prototype

Patent pending
Renderings are for illustration purposes only. The final design may vary.
Example 2: Wireless and Global Health

EKG signal comparison. Same experimental subject
Superimposed signals
Black — Clinical EKG
Red — Current Prototype results

Leads marked with * (V1-V6) are not part of the hexaxial EKG

II, III, aVF
Inferior + Right Ventricle MI

I, aVL
Lateral MI

Circumflex artery

V3, V4
Anterior MI*

V1, V2 Septal*
V3, V4 Anterior*
V5, V6 Apical*

Left anterior descending artery and septals

Right coronary artery

V1, V2 Septal MI*
Other Wearable Devices in the Market

- ONE LEAD only
- Usability ONLY in arrhythmia

Cardio6

- Measures SIX LEADS simultaneously
- Can detect heart attack (including previous events)
- Measures electrical axis of heart with applications in:
  - Obstructive lung disease
  - Ventricular hypertrophy
  - Pulmonary embolisms
  - Conduction abnormalities
## Competition/Current state-of-the-art wearable EKG devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Form factor</th>
<th>Number of leads</th>
<th>FDA approved</th>
<th>Main use</th>
<th>Advantages</th>
<th>Limitations</th>
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</thead>
<tbody>
<tr>
<td>Apple watch series 4</td>
<td>Bracelet</td>
<td>1</td>
<td>Yes</td>
<td>Arrhythmia (short term)</td>
<td>Robust platform</td>
<td>Not continuous</td>
</tr>
<tr>
<td>AliveCor*</td>
<td>Bracelet**</td>
<td>1</td>
<td>Yes</td>
<td>Arrhythmia (short term)</td>
<td>Robust platform</td>
<td>Not continuous/Diverse form factors</td>
</tr>
<tr>
<td>QardioCore</td>
<td>Chest strap</td>
<td>1</td>
<td>No</td>
<td>Fitness</td>
<td>Multiple parameters</td>
<td>Intrusive form factor/Comfortable? (♂ ≠ ♀?)</td>
</tr>
<tr>
<td>Zephyr</td>
<td>Chest strap</td>
<td>1</td>
<td>Yes</td>
<td>Vital signs monitoring</td>
<td>Robust. A Medtronic company</td>
<td>Not defined clinical market Athletes/First responders</td>
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<tr>
<td>Zio patch</td>
<td>Patch</td>
<td>1</td>
<td>Yes</td>
<td>Arrhythmia</td>
<td>Long-term/EHR integration</td>
<td>Discrete monitoring</td>
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<tr>
<td>Samsung's simband</td>
<td>Bracelet</td>
<td>1</td>
<td>No</td>
<td>Development</td>
<td>Modular/Ecosystem</td>
<td>Not available to patients</td>
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<tr>
<td>LifeTrak Core</td>
<td>Bracelet</td>
<td>1</td>
<td>No</td>
<td>Fitness</td>
<td>Integration with Calories burnt</td>
<td>EKG not clinical quality</td>
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<tr>
<td>Google wrist band</td>
<td>Bracelet</td>
<td>1</td>
<td>No</td>
<td>Research</td>
<td>Robust platform</td>
<td>For research use only</td>
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<tr>
<td>Helo EKG</td>
<td>Bracelet</td>
<td>1</td>
<td>No</td>
<td>Fitness</td>
<td>Apparent high EKG quality</td>
<td>Not defined clinical market</td>
</tr>
<tr>
<td>Amazfit</td>
<td>Bracelet</td>
<td>1</td>
<td>No</td>
<td>Fitness</td>
<td>Robust manufacturer (Xiaomi)</td>
<td>Not defined clinical market</td>
</tr>
<tr>
<td>Cardio6</td>
<td>Bracelet</td>
<td>6</td>
<td>No</td>
<td>Clinical (intended)</td>
<td>Multiple clinical applications (including heart attack detection &amp; electrical axis)</td>
<td>Startup stage</td>
</tr>
</tbody>
</table>

Concluding Remarks

• Global healthcare is in need of a paradigm shift

• Wireless technologies have the elements to provide this paradigm shift

• Wireless Technology provides a unique opportunity to alleviate some of the healthcare disparities at the Global Scale

• Availability of technology allows short prototyping and deployment cycles
Digital Health – HIMSS Definition

Digital health connects and empowers people and populations to manage health and wellness, augmented by accessible and supportive provider teams working within flexible, integrated, interoperable, and digitally-enabled care environments that strategically leverage digital tools, technologies and services to transform care delivery.
Future work

@CardioSix
Your crystal ball

Top 10 causes of death globally 2015

Ischaemic he... Stroke
Lower respira... Chronic obstr...
Trachea, bro...
Diabetes mell...
Alzheimer dis...
Diarrhoeal di...
Tuberculosis
Road injury

Deaths in millions

http://www.who.int/mediacentre/factsheets/fs310/en/

WE CAN END POVERTY
MILLENNيوم DEVELOPMENT GOALS AND BEYOND 2015

Background
The eight Millennium Development Goals (MDGs) – which range from halving extreme poverty to halving the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 – form a blueprint agreed to by all the world’s countries and all the world’s leading development institutions. They have galvanized unprecedented efforts to meet the needs of the world’s poorest.

- Reports
- Statistics

2013: MDG Acceleration and Beyond 2015

On 25 September 2013, the President of the UN General Assembly hosted a special event to follow up on efforts made towards achieving the Millennium Development Goals (MDGs). At the Special Event towards achieving the MDGs, the Secretary-General Ban Ki-moon presented to Member States his report entitled “A Life of Dignity for All”. In the outcome document adopted by Member States, world leaders renewed their commitment to meet the MDGs’ targets and agreed to hold a high-level Summit in September 2015 to adopt a new set of Goals building on the achievements of the MDGs.

On 23 September 2013, the Secretary-General hosted a high-level forum to catalyze and accelerate further action to achieve the MDGs and enrich the deliberations of the General Assembly and beyond. The forum focused on concrete examples of scaling up success and identifying further opportunities. Additional commitments to boost MDG achievement were announced, bringing the total to more than $2.5 billion.

Goal 1: 2013 Fact Sheet
Goal 2: 2013 Fact Sheet
Goal 3: 2013 Fact Sheet
Goal 4: 2013 Fact Sheet
Goal 5: 2013 Fact Sheet
Goal 6: 2013 Fact Sheet
Goal 7: 2013 Fact Sheet
Goal 8: 2013 Fact Sheet

2010 Summit on the Millennium Development Goals

https://www.un.org/millenniumgoals/bkgd.shtml
Many thanks!