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UNIVERSITY

The Role of Wireless Medical Technology in Global Health

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Traditional Bioinstrumentation Path

Develop technology



Find a problem to
solve

Advantages:

- Low risk
- Low cost

Disadvantage:

- Limited applicability





Part I

Introduction

Part II

Developed Countries

Part III

Developing Countries

Part IV

Concluding Remarks





Part I

Introduction

Part II

Developed Countries

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**





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





Global Health –

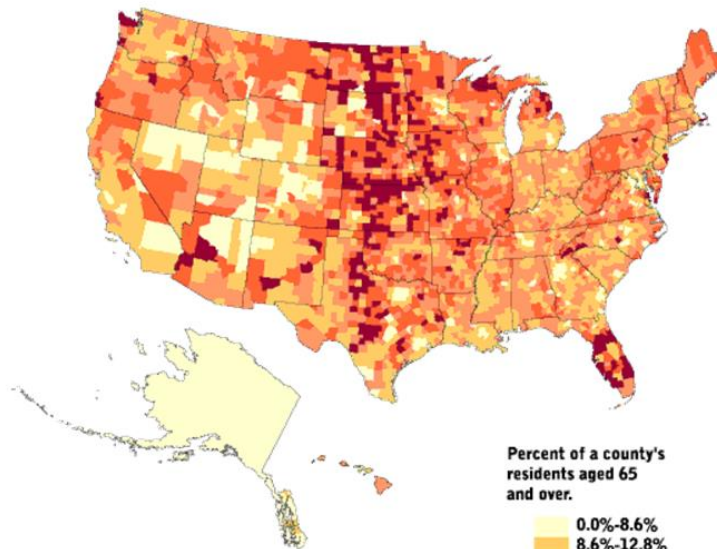
- The age of the growing global population depends on the economical development of the region
- Industrialized countries grow by increasing their life expectancy
- Developing countries grow by decreasing child mortality (improving child survival rates)
 - Causes of child mortality:
 - Neonatal causes (36%)
 - Pneumonia (19%)
 - Diarrhea (17%)
 - Malaria (8%)

Source: www.unicef.org/www.worldvision.org

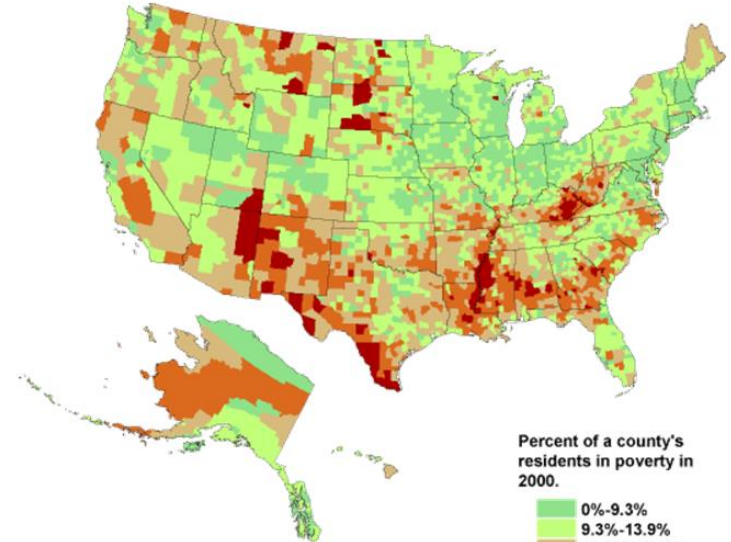
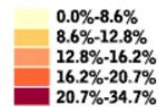




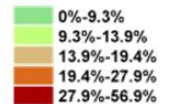
Age and poverty distribution in the US



Percent of a county's residents aged 65 and over.



Percent of a county's residents in poverty in 2000.





Double burden of disease



World Health
Organization

Overweight/obesity, 2008

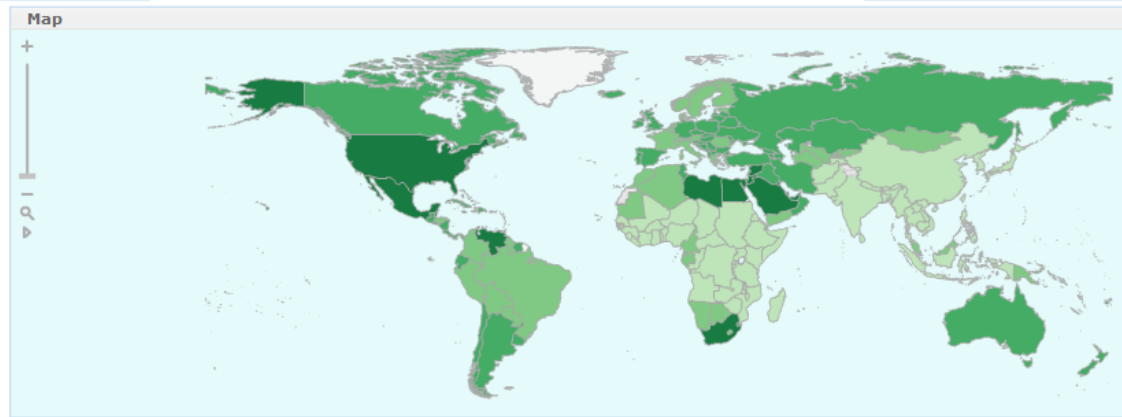
Prevalence of obesity**, ages 20+, age standardized: Both sexes

View more indicators

Filter by WHO region

View static maps

Country	Data
Egypt	34.6
Jordan	34.3
United Arab Emirates	33.7
South Africa	33.5
Barbados	33.4
Qatar	33.1
Mexico	32.8
Bahrain	32.6
Solomon Islands	32.1
Fiji	31.9
United States of America	31.8
Syrian Arab Republic	31.6
Libyan Arab Jamahiriya	30.8
Venezuela (Bolivarian Republi...	30.8
Trinidad and Tobago	30.0
Vanuatu	29.8
Argentina	29.4
Iraq	29.4
Turkey	29.3
Chile	29.1
Czech Republic	28.7
Lebanon	28.2



* BMI ≥ 25 kg/m² | ** BMI ≥ 30 kg/m²

Bar Chart



Prevalence (%)

<10.0
10.0-19.9
20.0-29.9
≥30.0
Not applicable
No data

- http://gamapserv.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.”**

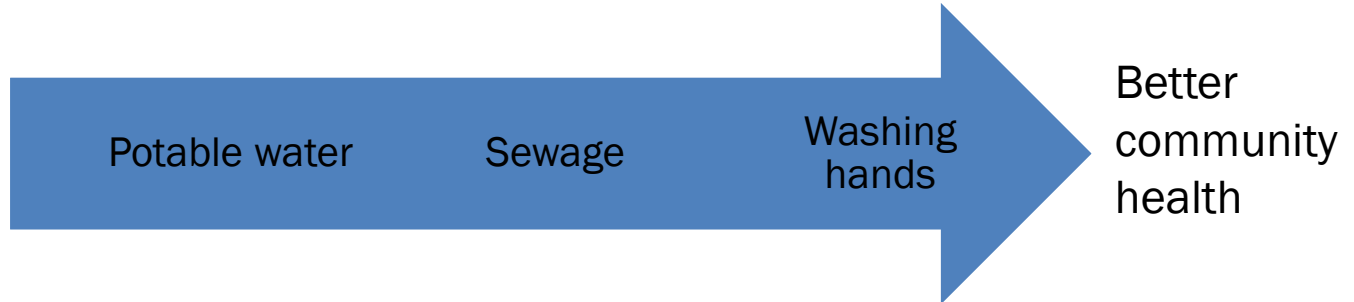
– Rita Mae Brown (“Sudden Death”)





Shift in paradigm

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:

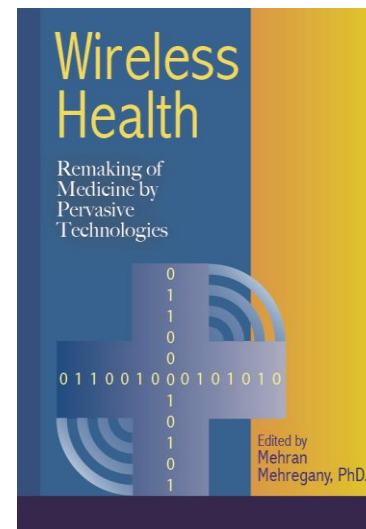
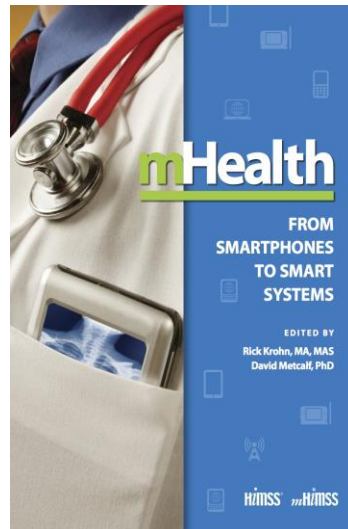
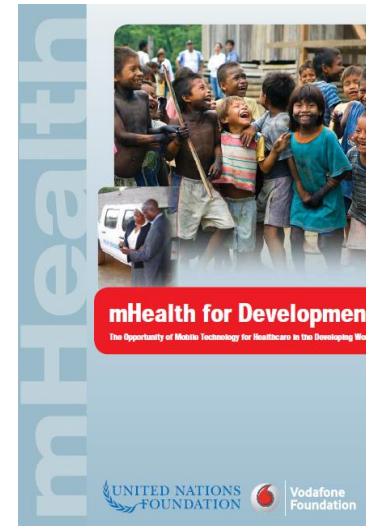
- **Rapid adoption rates**
- **Quasi-universal connectivity (global information transfer)**

Good candidate to provide the next paradigm shift in healthcare





Wireless and Global Health





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**

Source: Vital Wave Consulting. mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World. Washington, D.C. and Berkshire, UK: UN Foundation-Vodafone Foundation Partnership, 2009.





Part I

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Part III

Developing Countries

Part IV

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Convergence of Pervasive Technologies

wireless
connectivity



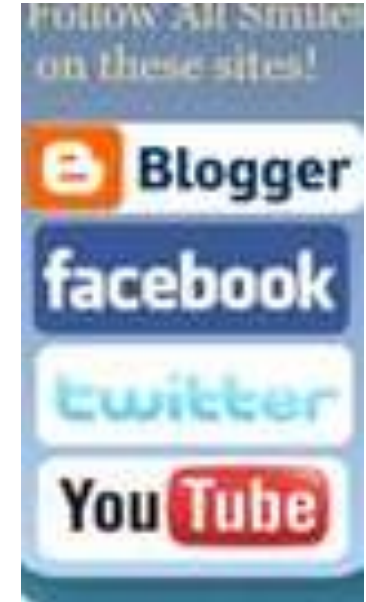
ubiquitous
sensing



social
networks

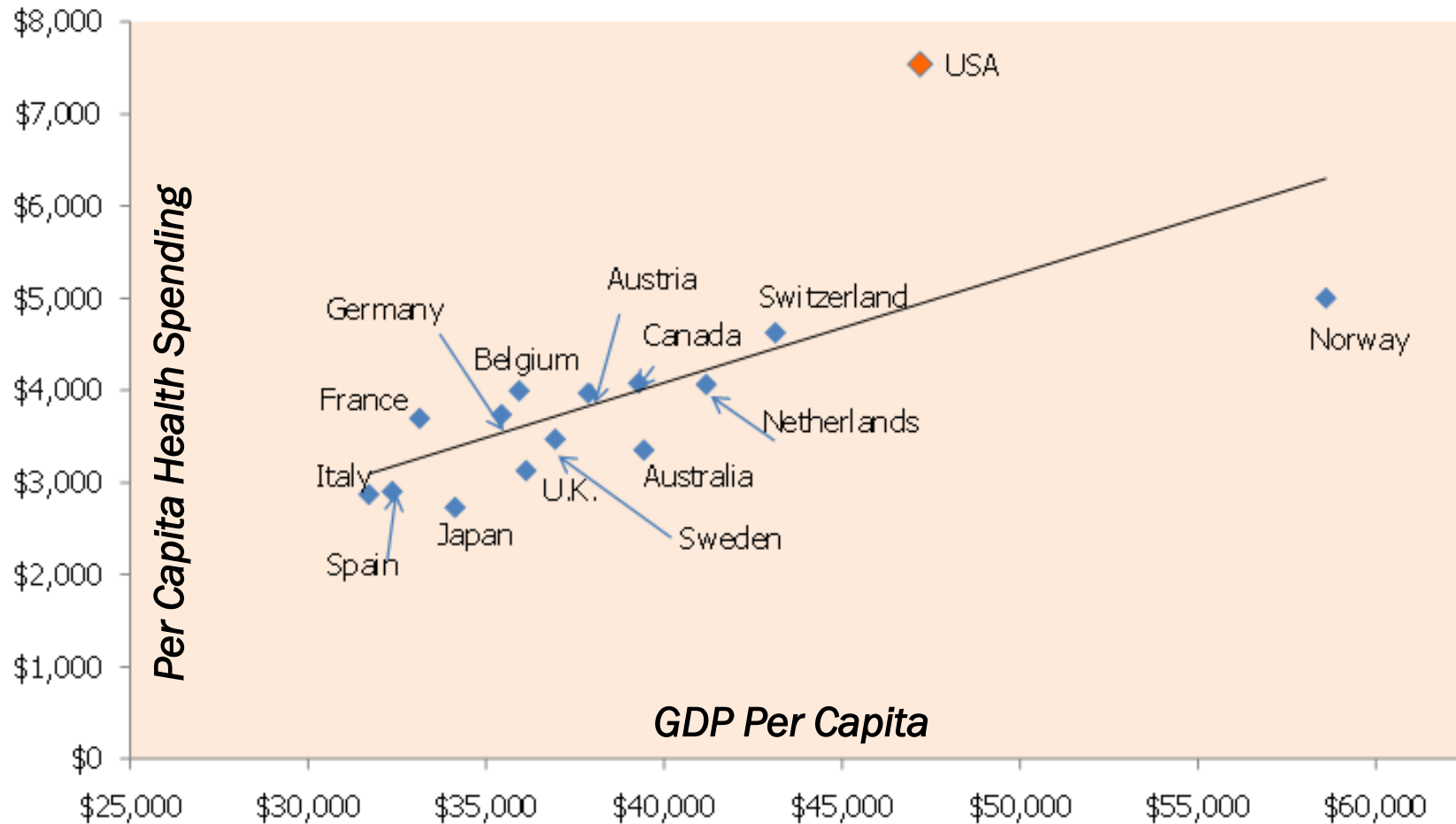


cloud
computing





Total Health Expenditures, 2008

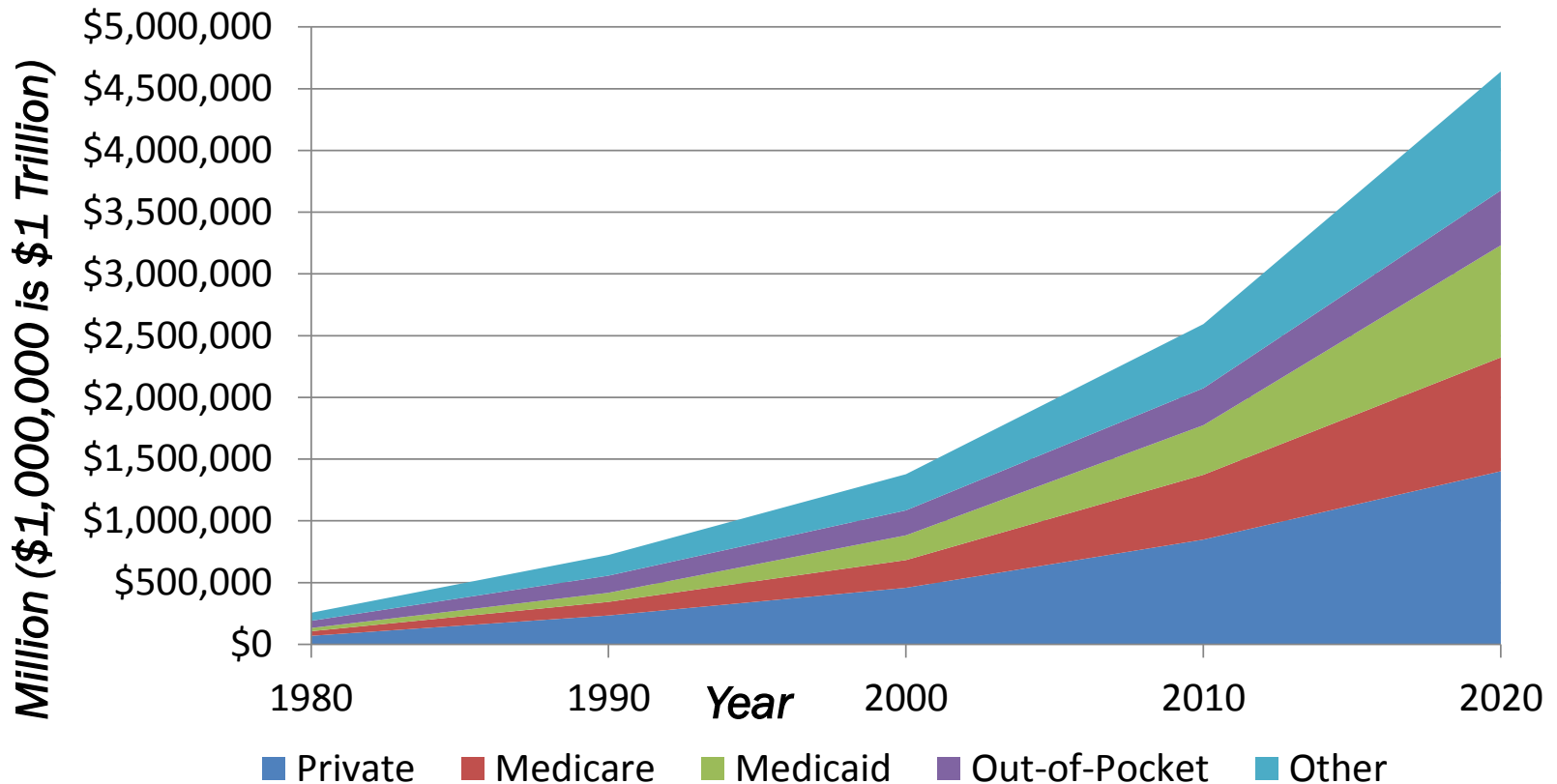


“Health Care Spending in the United States and Selected OECD Countries”, April 2011. <http://facts.kff.org/chart.aspx?ch=1952>



How big is it?

National Health Expenditures, \$2.6 Trillion in 2010



Centers for Medicare & Medicaid Services, Office of the Actuary.



Chronic Diseases 75% of the Cost

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

Table from Eric Topol, M.D.





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.





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.





Nonintrusive Monitoring

The market for wearable wireless sensors is predicted to grow to 400 million devices by 2014



Graphic from Don Jones (Qualcomm Life)



Example: Heart Failure

- Heart Rate
- Fluid Status
- Activity Level
- Posture
- Respiratory Rate
- Arrhythmia Detection
- Temperature
- EKG





Example: Compliance

proteus[®]

DIGITAL HEALTH

Digital Medicines

Shifting the care paradigm

The **ingestible sensor** is technology you swallow. Integrated into the medications you take and the products you use, it's made entirely of ingredients found in food and activated upon ingestion. Today, the sensor aids in capturing the time, identity and characteristics of what you swallow. Tomorrow, the sensor will bring critical bodily measurements from the inside, out.

Your body powers the ingestible sensor. With no battery and



Using ti
you can
text and





Example: Compliance



Pharmacy-connected GlowCaps improve medication adherence through reminders, social feedback, financial incentives and automatic refills.

VITALITY™

GlowCaps™
light and sound
remind you to take your
prescriptions every day

Vitality addresses the billion-dollar adherence problem for pharmaceutical brands, retail pharmacies and healthcare providers with a simple device — a cellular-connected pill cap.

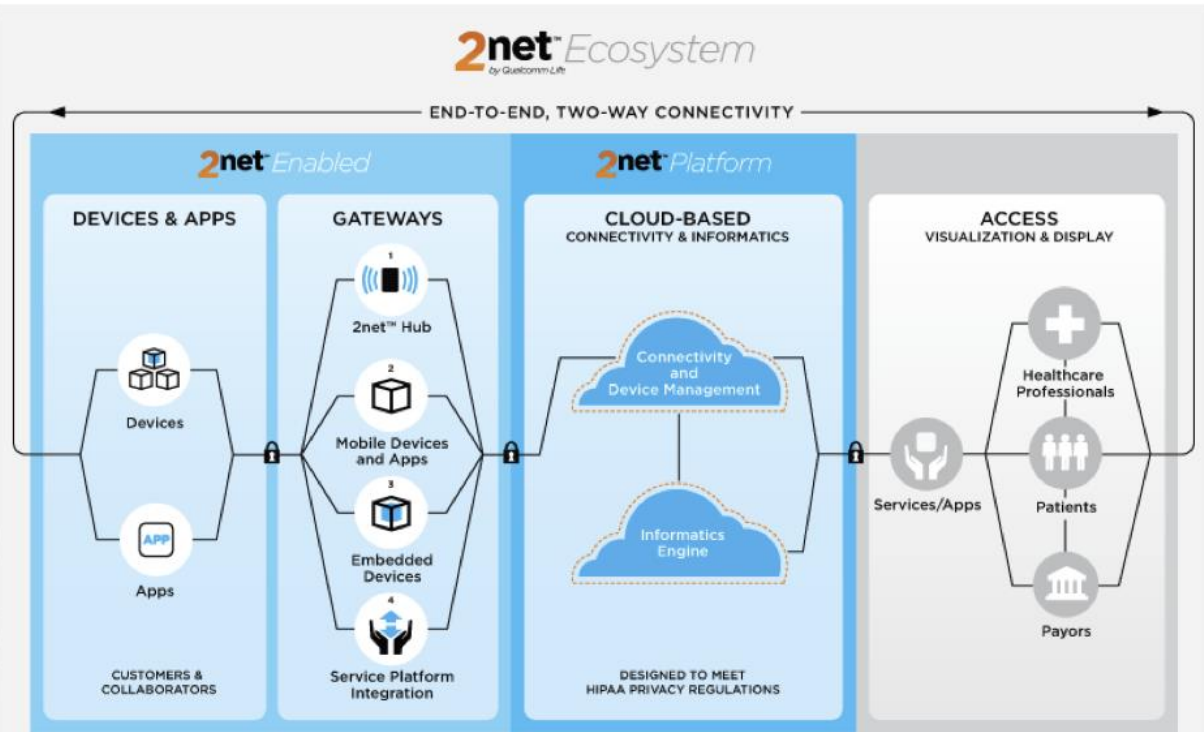
Vitality GlowCaps illuminate, play a melody, and even ring a home phone so patients don't forget. They can send weekly emails to remote caregivers, create accountability with doctors through an adherence report, and automatically refill prescriptions. Vitality improves medication adherence, health, and peace of mind.





Example: Seamless Data Transfer

Connecting medical device data to patients and clinicians wirelessly.



Launch the next generation of medical devices with the 2net Platform, a unique technology-agnostic, cloud-based service designed to enable medical device connectivity. The 2net Platform offers reliable sharing and management of biometric data that can empower users to better care for themselves and others. Remotely and accurately. Around the clock — wherever you are.

Connecting the wireless health network.





Example: Data Flow



Healthcare ANYWHERE

Securely delivering critical patient information, including virtual real-time waveform data, directly from a patient's location to a doctor's mobile device.



AirStrip Technologies is a medical software development company focused on enabling mobility in healthcare. We have built and deployed an FDA-cleared platform which allows patient information - including waveforms and other critical data from EMRs, bedside monitors and devices, pharmacy, lab, and other clinical information systems - to be securely and natively accessed by physicians and nurses on their smart phones or tablets...anytime, and anywhere.





Example: Data Capture



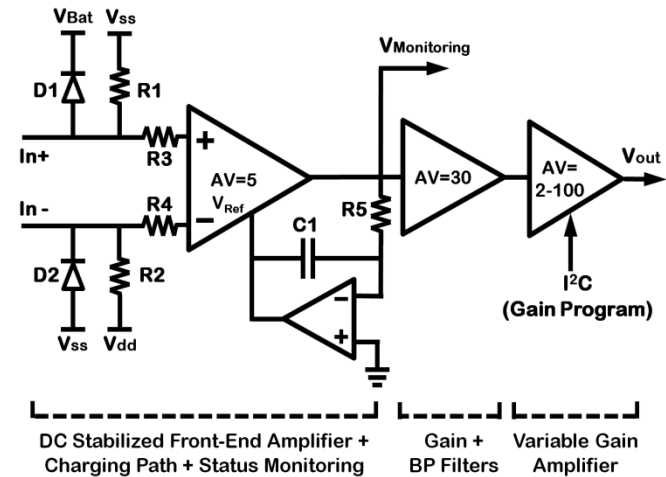
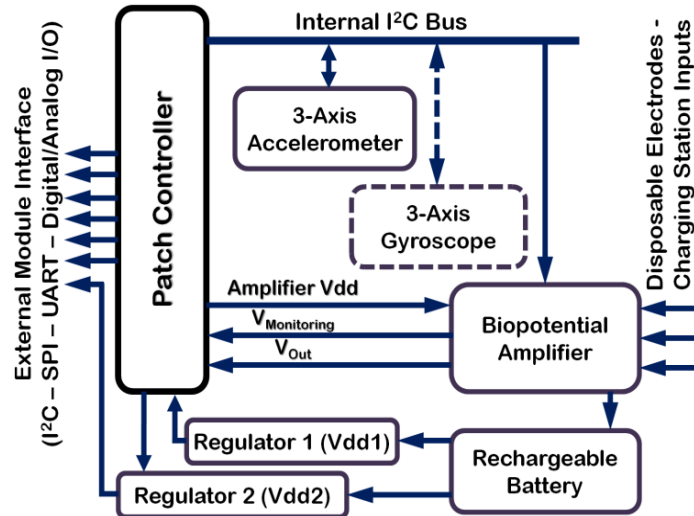
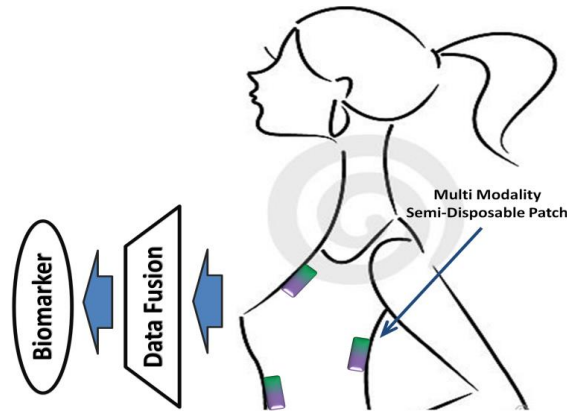
THE DEVICE

As a first offering, AliveCor has developed a clinical-quality, low-cost mobile ECG heart monitor. The device is compatible with the iPhone 4 / 4S and enables patients to monitor their heart health anywhere, at any time, and provides physicians with an additional heart health assessment tool.



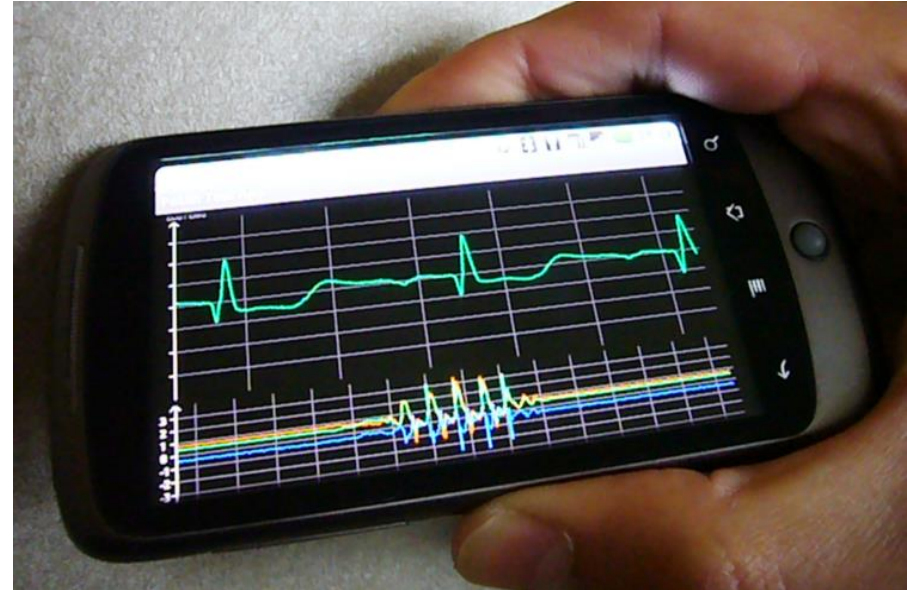
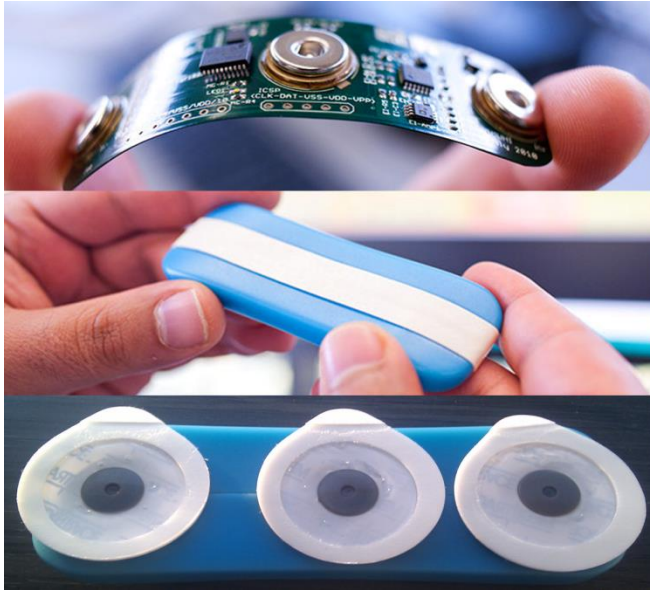


Wearable Meta-Sensors





Wearable Meta-Sensors

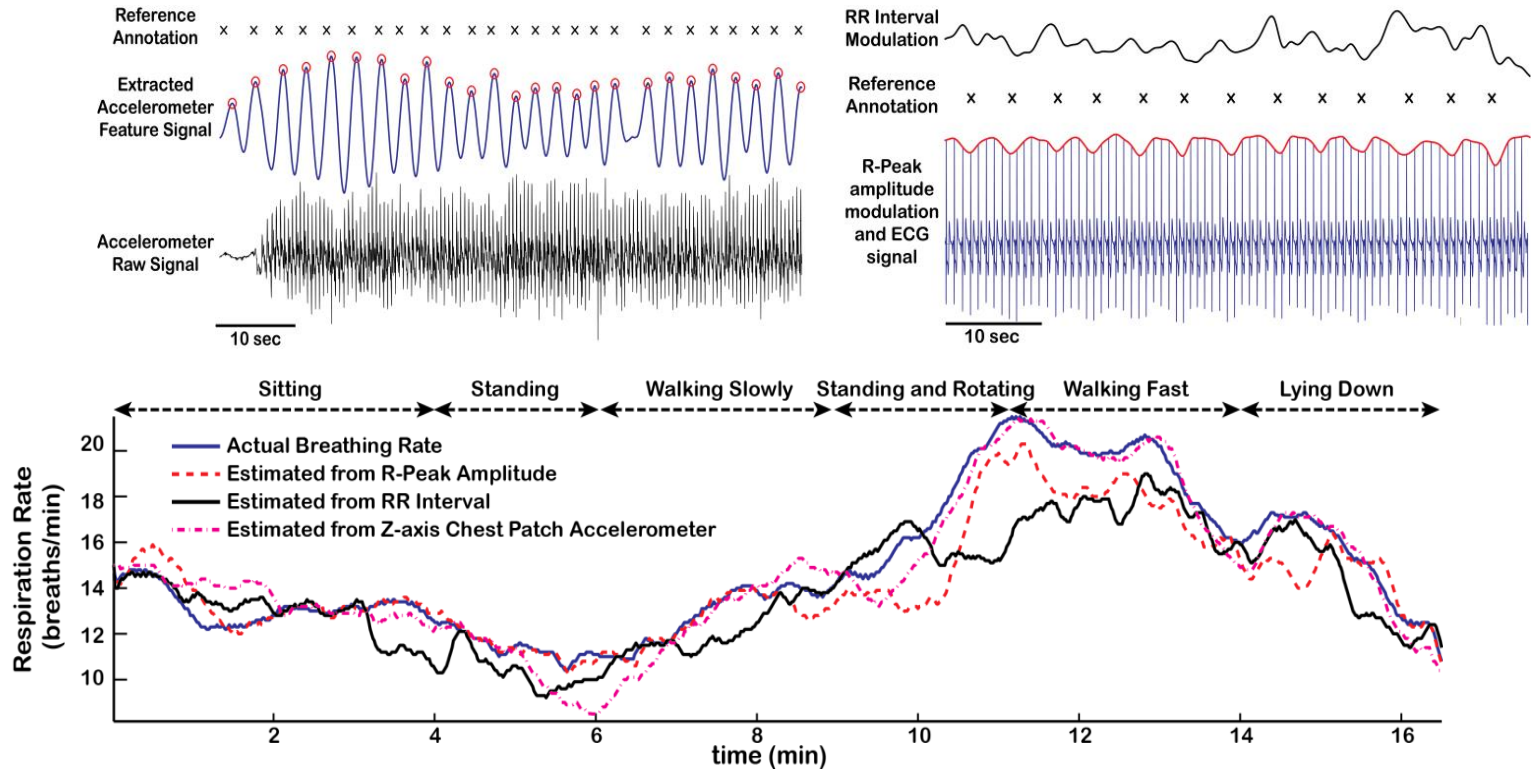


Real-time ECG and 3-axis accelerometer data visualized on an Android-enabled phone.





Wearable Meta-Sensors



Actual respiration rate and estimated respiration rate from the three different metrics described





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Part II

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Part III

Developing Countries

Part IV

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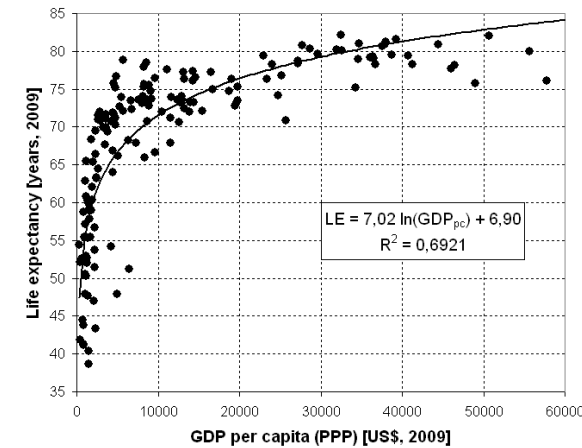
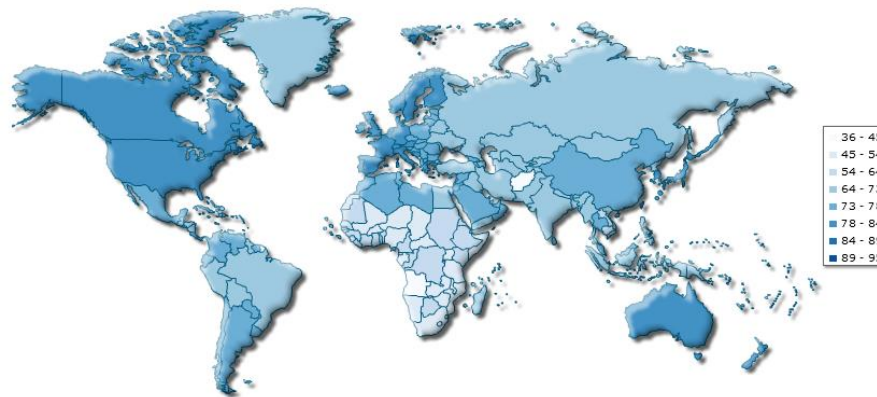


The global population

GDP per capita- purchasing power parity



Life expectancy at birth



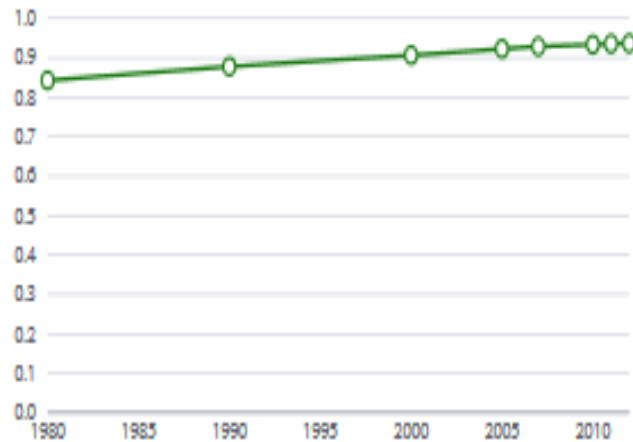
Source world bank; CIA World Factbook



HDI

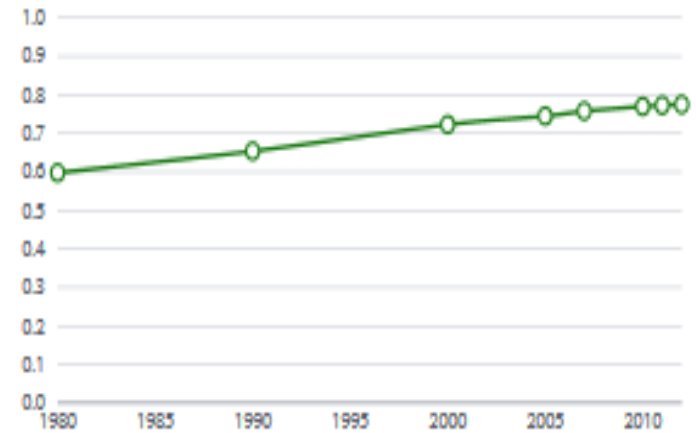
USA

Trends 1980 - Present



Mexico

Trends 1980 - Present



<http://hdr.undp.org/en/countries/profiles>

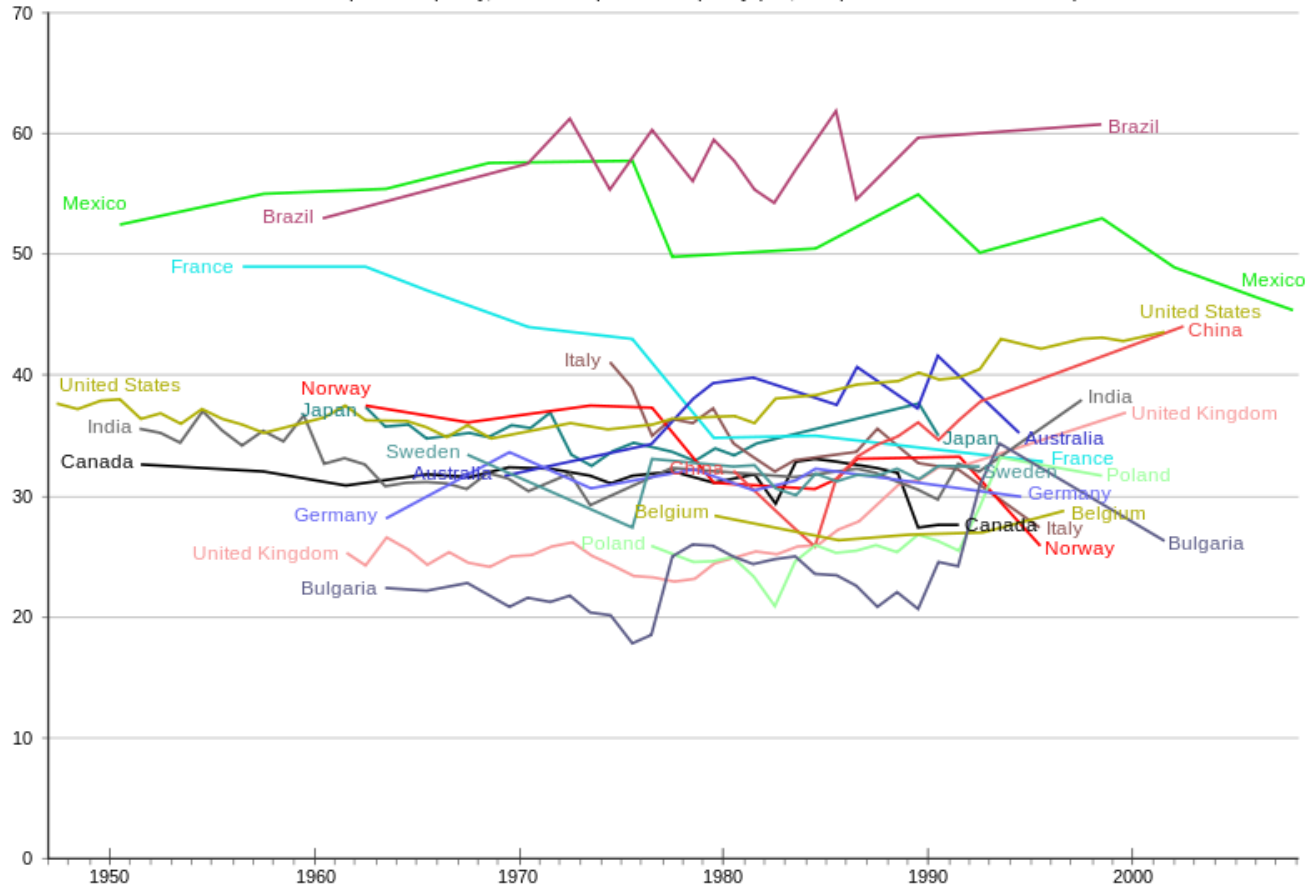




Gini Index

Gini Index - Income Disparity since World War II

where 0 is perfect equality, and 100 is perfect inequality (i.e., one person has all the income)





Best e-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

Source: eTransform Africa: Health Sector Study. *March 7, 2012. Vital Wave Consulting, Inc.*





Five phases of health system development

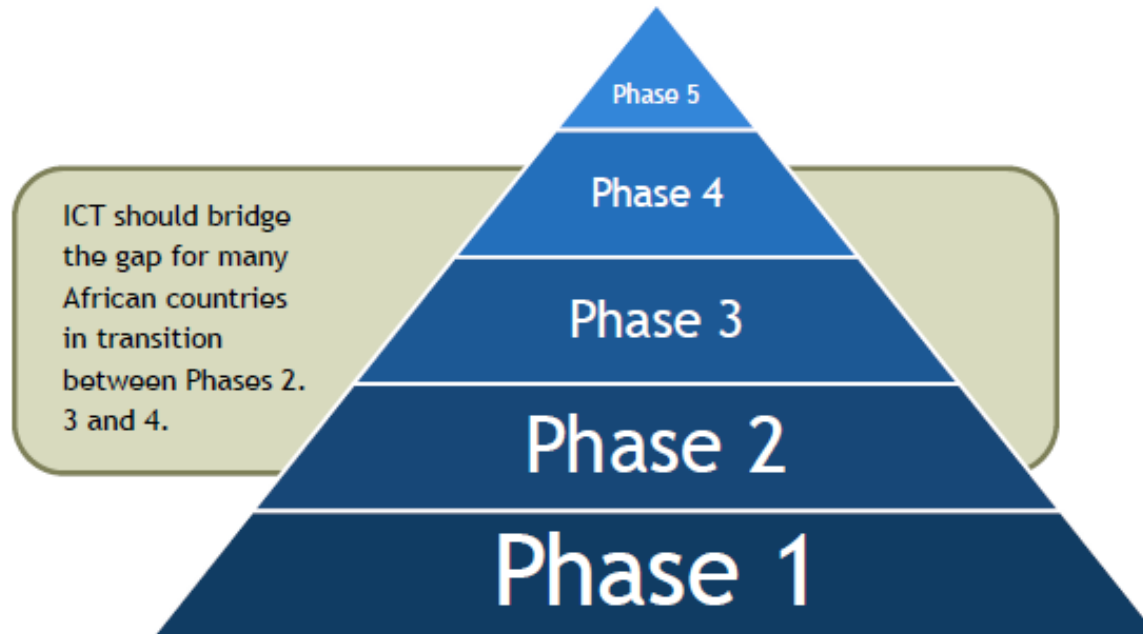
- **Phase 1** High infant and maternal mortality, low life expectancy (around age 30) and low economic growth.
- **Phase 2** Significant reduction in infant and maternal mortality, as well as an increase in life expectancy and economic growth.
- **Phase 3** Further reduction in infant and maternal mortality, 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

Source: eTransform Africa: Health Sector Study. *March 7, 2012. Vital Wave Consulting, Inc.*





Five phases of health system development



Source: eTransform Africa: Health Sector Study. *March 7, 2012. 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.**

Source: eTransform Africa: Health Sector Study. *March 7, 2012. Vital Wave Consulting, Inc.*





Current classification of wireless networks

- **Wireless personal area networks – small area communications. Low power radios**
- **Wireless local area networks – interconnectivity to the internet (WiFi)**
- **Wireless metropolitan area networks – interconnection of several WLANs**
- **Wireless wide area networks – cities and suburban areas**
- **Mobile device networks – based on cellular towers. Cover large geographical areas**
- **Wireless body area network – interconnect wearable devices with a central unit**





Proposed functional classification of wireless infrastructures

- **Basic wireless infrastructure- fundamental communications**
 - **Emergency situations.**
 - **Education.**
 - **Disease outbreaks.**
- **Supporting wireless infrastructure- administrative functions.**
 - **Vaccine tracking.**
 - **Inventory.**
- **Development wireless infrastructure-development**
 - **framework for innovation in healthcare**

Source: Saldivar, E. Mobilis in mobili: Wireless health solutions for a morphing medical challenge. Proceeding of the IV SPIE Conference in Biosensing and Nanomedicine Vol. 8099, 2011





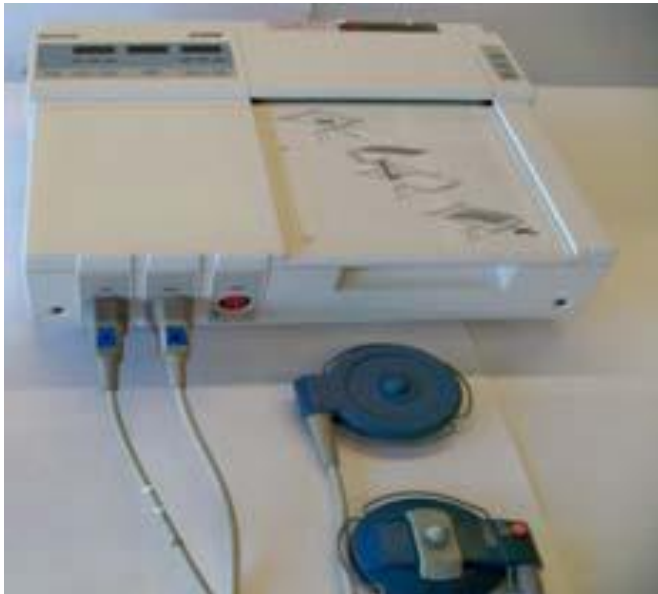
Example: Wireless and Global Health

- **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**





Challenge



Cardiotocography – Invented late 1950s

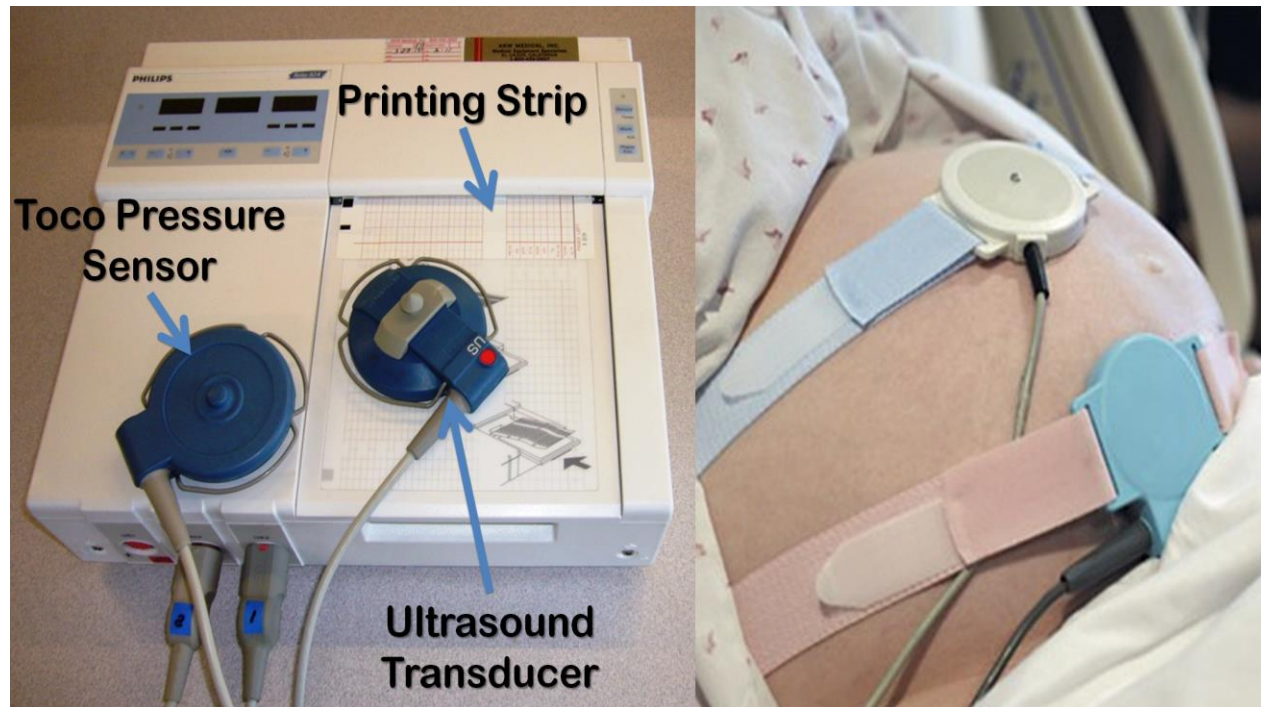
Continuous and simultaneous monitoring of uterine contraction and Fetal Hear Rate

Used to detect and monitor fetal distress



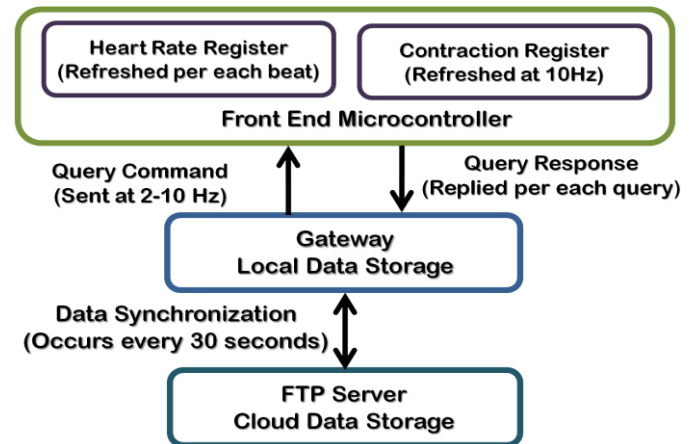
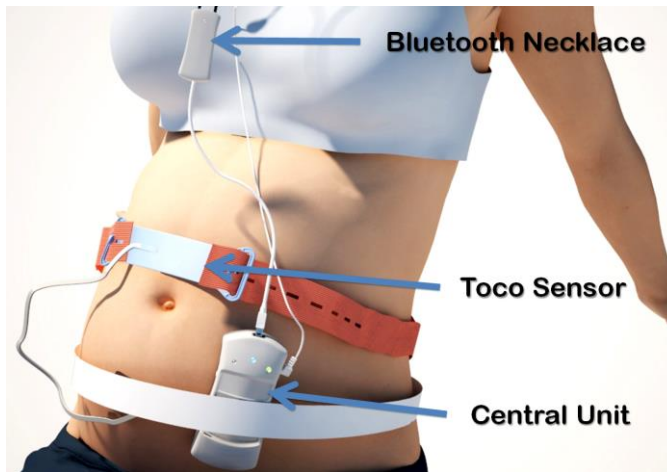


Clinical Use



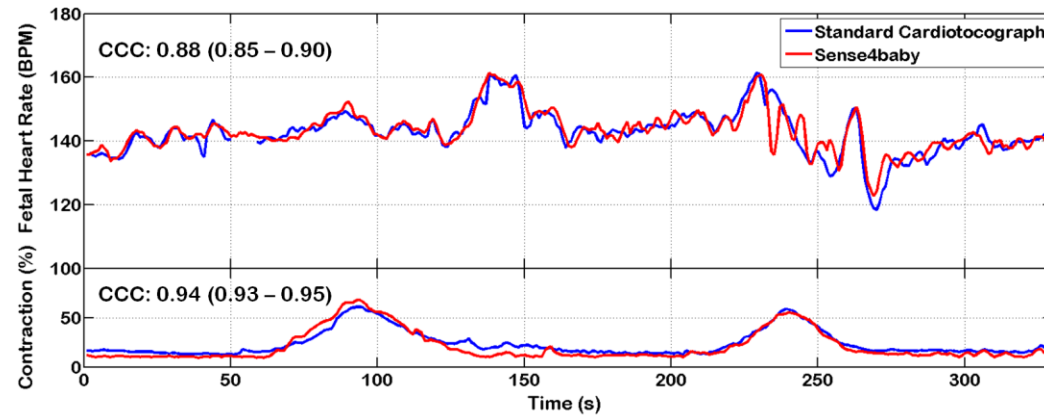
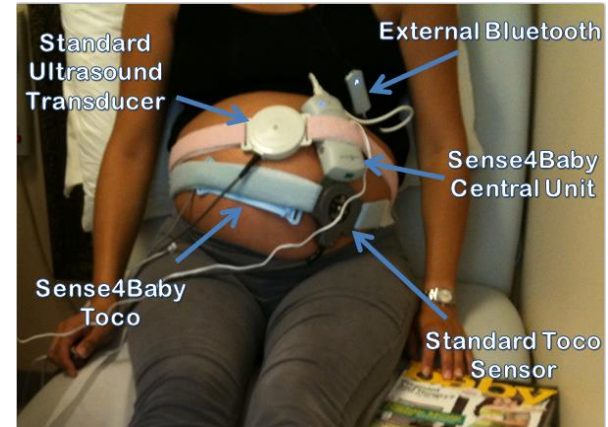
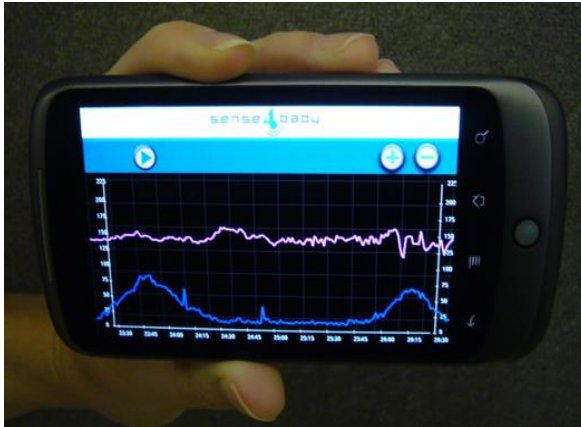


Wireless and Global Health





Clinical Tests



CCC= Lin's Concordance Correlation Coefficients

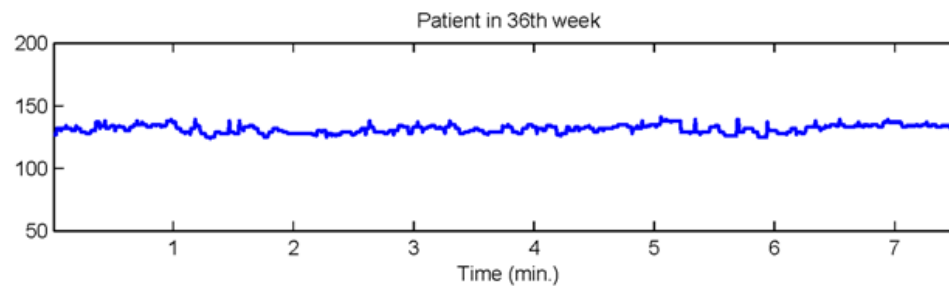
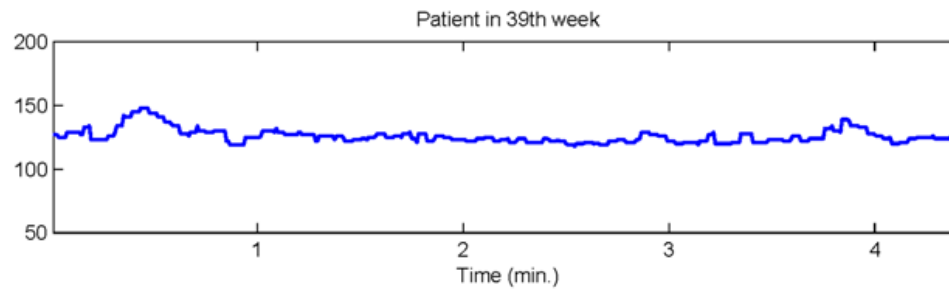
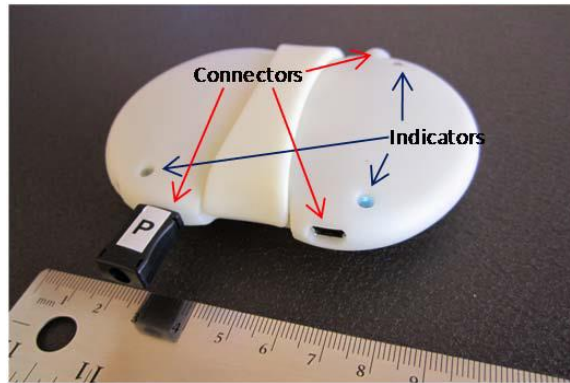


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A Cheap, Portable Way to Monitor Unborn Babies

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

WEDNESDAY, APRIL 20, 2011 | BY EMILY SINGER

E-mail

Audio »

Print

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.





Part I

Introduction

Part II

Developed Countries

Part III

Developing Countries

Part IV

Concluding Remarks





Concluding Remarks

- **Global healthcare is in need of a paradigm shift**
- **Wireless technologies have the elements to provide this paradigm shift**
- **The classification of wireless infrastructures in Basic, Supporting, and Development allows the proper planning of the necessary architecture to provide for the needs of each community**
- **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**





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Many Thanks!

