E-Health/M-Health for the Medical Lab and better outcomes

Bernard GOUGET, Chair C-MHBLM

IFCC- Committee on Mobile Health and Bioengineering in Lab Medicine (C-MHBLM)

President-Healthcare Division Committee -Comité Français d'accréditation (Cofrac)

HYATT Regency Beograd April 11-12 2019

Transformation Drivers & Imperatives

PRIMARY CARE
MENTAL HEALTH
TELEMEDICINE
COMPLIANCE
ACCESS
DISABILITY
DATA EXPLOSION
CASE MANAGEMENT
DIABETES
OBESITY
CHRONIC CONDITIONS
PERSONAL HEALTH & WELLNESS
ASTHMA
RISING HEALTH EXPENDITURES
QUALITY OF CARE
PREDICTIVE CARE
QUALITY REPORTING
ANALYTICS
HYPERTENSION
PRODUCTIVITY
POPULATION HEALTH MANAGEMENT
READMISSIONS
REMOTE CARE
SENSITIVE DATA
COLLABORATION
HOME REHABILITATION
ELDERLY CARE
VACCINATION
PATIENT EDUCATION
OUTREACH
HOSPITAL READMISSIONS
SOCIAL BENEFITS & ADMINISTRATION
PREVENTION
PRIVACY
PATIENT ENGAGEMENT
MOBILE HEALTH
PANDEMIC MANAGEMENT
eHEALTH
AGING POPULATION

SHORTAGES OF SKILLED WORKFORCE	NEW DISEASES & NEW LIFESTYLES	EXPLODING COSTS & NEW INVESTMENT NEEDS	CITIZENS' CHANGING EXPECTATIONS

Are we prepared for the new age of digital healthcare?

Definition *e*-Health

- **eHealth** refers to the use of information and communications technologies in healthcare.

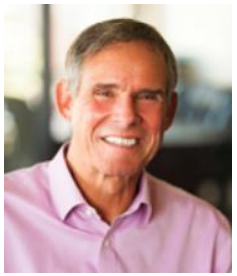
- **eHealth** covers a lot of field in the intersection of medical informatics, public health and business, refering to health services and information delivered or enhanced through the Internet and related technologies.

- **the term characterizes not only a technical development, but also a state-of-mind**, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology."

- "**eHealth = Medicine + Communication + Information + Society**" [Gunther Eysenbach].

Factors influencing the eHealth market

- **Increasing participation of consumers** in digital health outside of hospital settings
- **Increasing awareness and acceptance** by healthcare professionals
- **Evidence of efficacy** of eHealth technologies
- **Decreasing costs** of deployment in some technologies such cloud computing and hosted services
- F**avorable regulatory climates** and improved support for **interoperability**
- **Pressure to decrease healthcare costs**
- **Rise in aging population** and incidences of **chronic diseases**



Preparing the Healthcare workforce to deliver the digital future

The Topol review (02.2019)

- **We are at a unique juncture in the history of medicine**, with the convergence of genomics, biosensors, the electronic patient record and smartphone apps, all superimposed on a digital infrastructure, with artificial intelligence to make sense of the overwhelming amount of data created.

- **This remarkably powerful set of information technologies provides the capacity to understand**, from a medical standpoint, the uniqueness of each individual – and the promise to deliver healthcare on a far more rational, efficient and tailored basis.

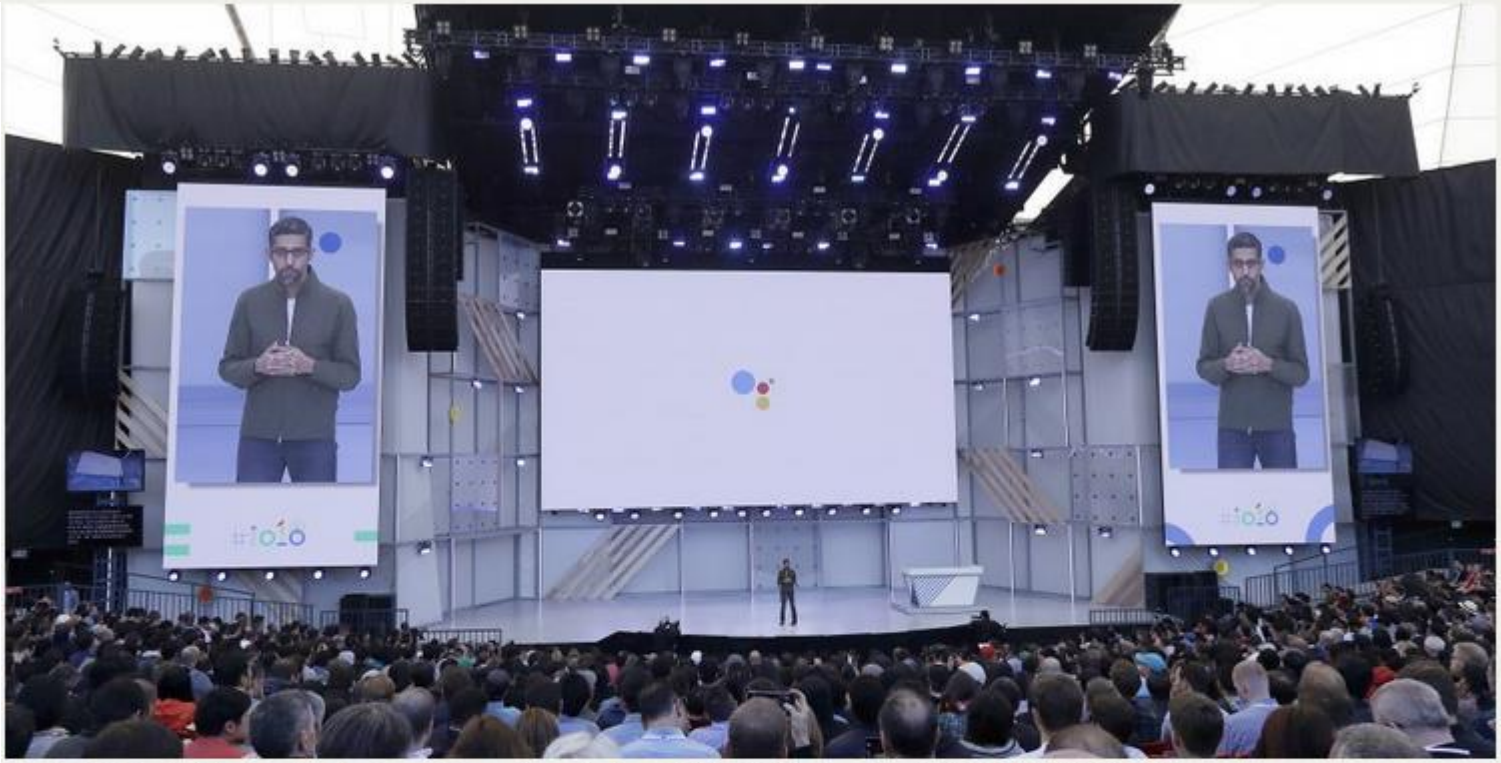
NBIC as a new technology wave: **N**anotechnology, **B**iotechnology**, Informatics and** Cognitive Science (AI)

- **Nanotechnologies** allow us to manipulate matter at a scale of a billionth of a meter, or even at the scale of the atoms
- **Biotechnology**, the B refers to a number of techniques which also includes genetics, and regenerative cell biology
- **I**T **the computing power** allows to multiply the efficiency of research > **Big Data**
- **C stands for cognitive science > AI**
-
- > NBIC convergence will lead to a fantastic **new wave of innovations**
- > Second radical idea: introducing transhumanist thinking

for enhancing human capabilities and serving human needs

2018: A Landmark Year for Artificial Intelligence

PUBLISHED: DECEMBER 27, 2018
AUTHOR: NIKKI GLADSTONE



Google CEO Sundar Pichai speaks at the Google I/O conference in Mountain View, California on May 8, 2018. (AP Photo/Jeff Chiu)

Earlier this year, Google CEO Sundar Pichai made a bold claim about artificial intelligence (AI), calling it "one of the most important things that humanity is working on. It's more profound than, I don't know, electricity or fire."

It's a dramatic statement, but it is one of many made in 2018 that reflect the perceived promise of the technology, all of which point to a common narrative found in this year's news coverage: the future is here and AI is driving its arrival.

Technological advances impacting healthcare and the magnitude of disruption.

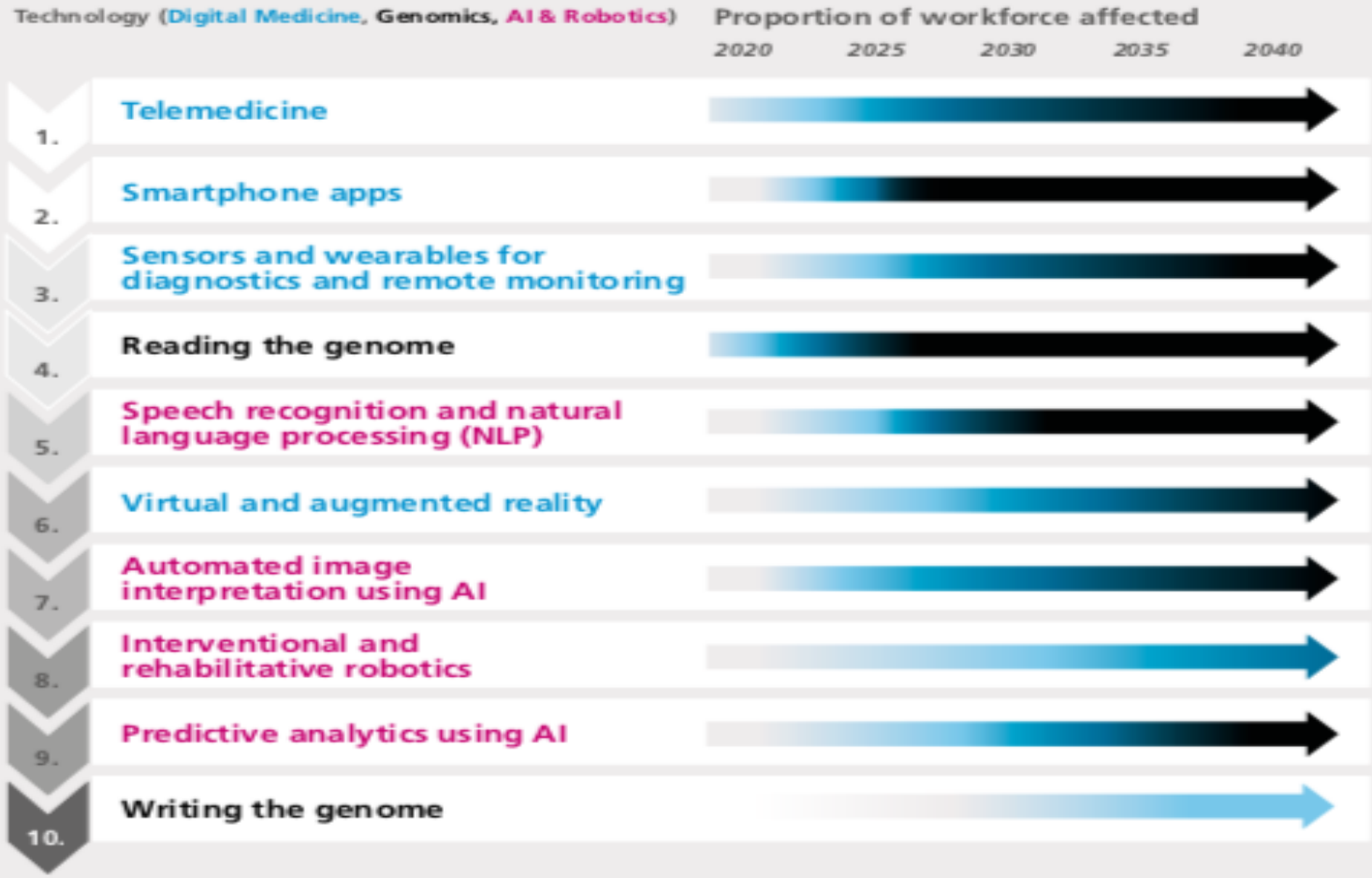


Figure 1: Top 10 digital healthcare technologies and their projected impact on the NHS workforce from 2020 to 2040

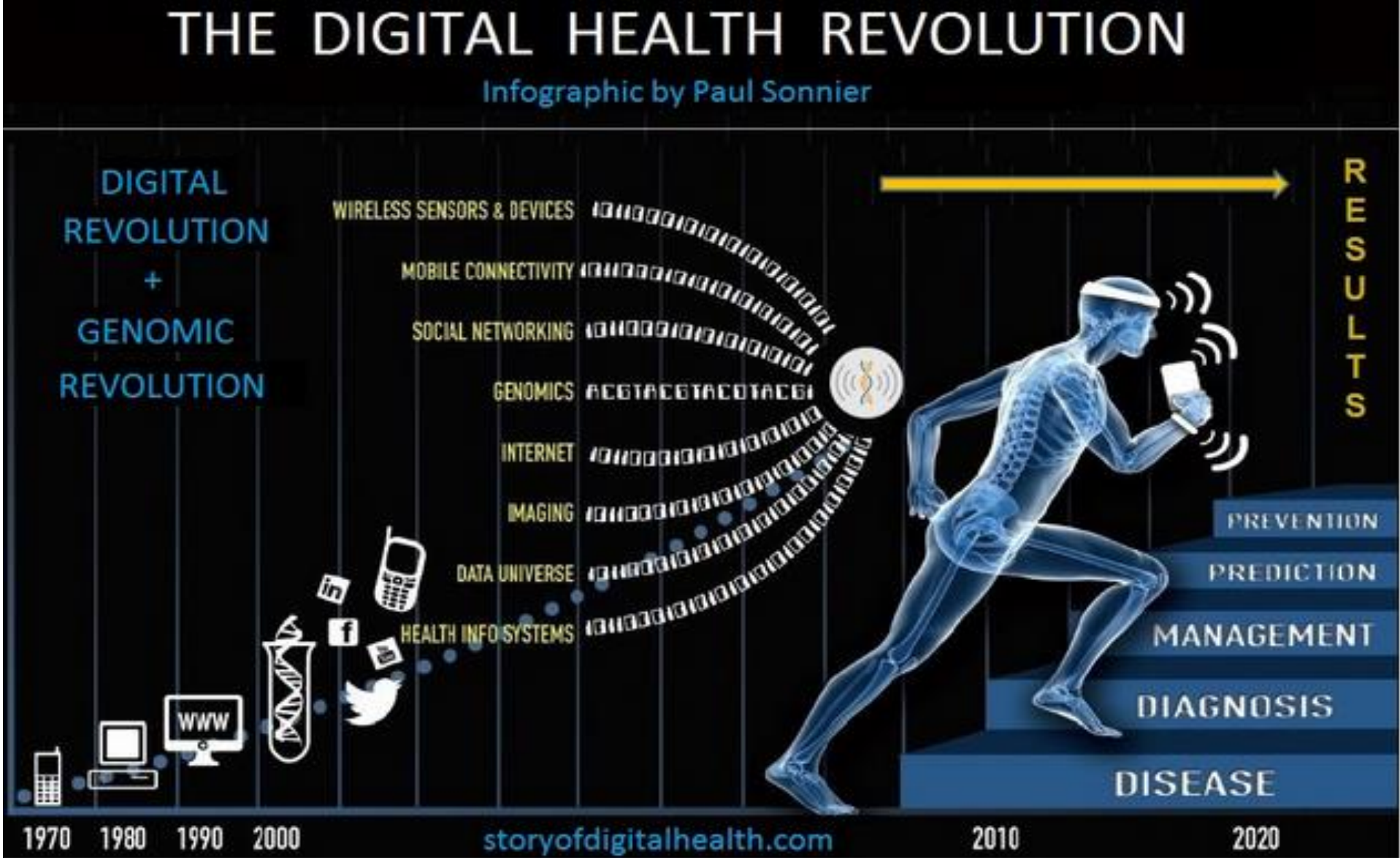
Arrow heat map represents the perceived magnitude of impact on current models of care and, by inference, on the proportion of workforce affected

Big Data and Artificial Intelligence Will Revolutionize our Lives

With the evolution of digital capacity, more and more data is produced and stored in the digital space.

Digital Health - the convergence of the digital and genomic revolutions with health, healthcare, living and society – is rapidely creating new era of human progress

In the future, **many aspects of care will shift closer to the patient's home**, while more specialised care is centralised into national or regional centres.



Digital/ E-health is the convergence of the digital and genetics revolutions with health, healthcare, living and society

(from the Four Wave: Digital health by P Sonnier)

Transforming healthcare through AI and robotics systems

Last decade	Current decade	Next decade
Medical Products	**Medical Platforms**	**Medical Solutions**
Equipment, Hardware, Consumables	Wearable, Big Data, Health Analytics	Robotics, AI, Augmented Reality
		
Differentiation is solely through product innovation. Focused on historic and evidence based-care.	Differentiation by providing services to key stakeholders. Focused on real time outcome based-care.	Differentiation via intelligent solutions for evidence/outcome based health. Focused on preventive care.

Transforming healthcare through artificial intelligence systems

Source: Frost & Sullivan, 'Transforming healthcare through artificial intelligence systems', 2016

The expanding **digital health landscape** includes products such as:

Digital Therapeutics

Digital therapeutics deliver evidence-based therapeutic interventions to patients to prevent, manage, or treat a medical disorder or disease.

Examples provided on page 6.

Mobile Health (mHealth)

Examples include:

Wellness, fitness trackers, and nutrition apps

Consumer health information

Medication adherence apps

Health Information Technology (HIT)

Examples include:

Electronic medical record systems

Electronic prescribing and order entry

Consumer health IT applications

Devices, Sensors, and Wearables

Examples include:

Wearable and wireless devices

Biometric sensors

Diagnostic products

Personalized Healthcare

Examples include:

Patient reported outcomes

Predictive analytics

Clinical decision support

Telehealth

Examples include:

Telemedicine virtual visits

Remote patient monitoring

Remote care programs

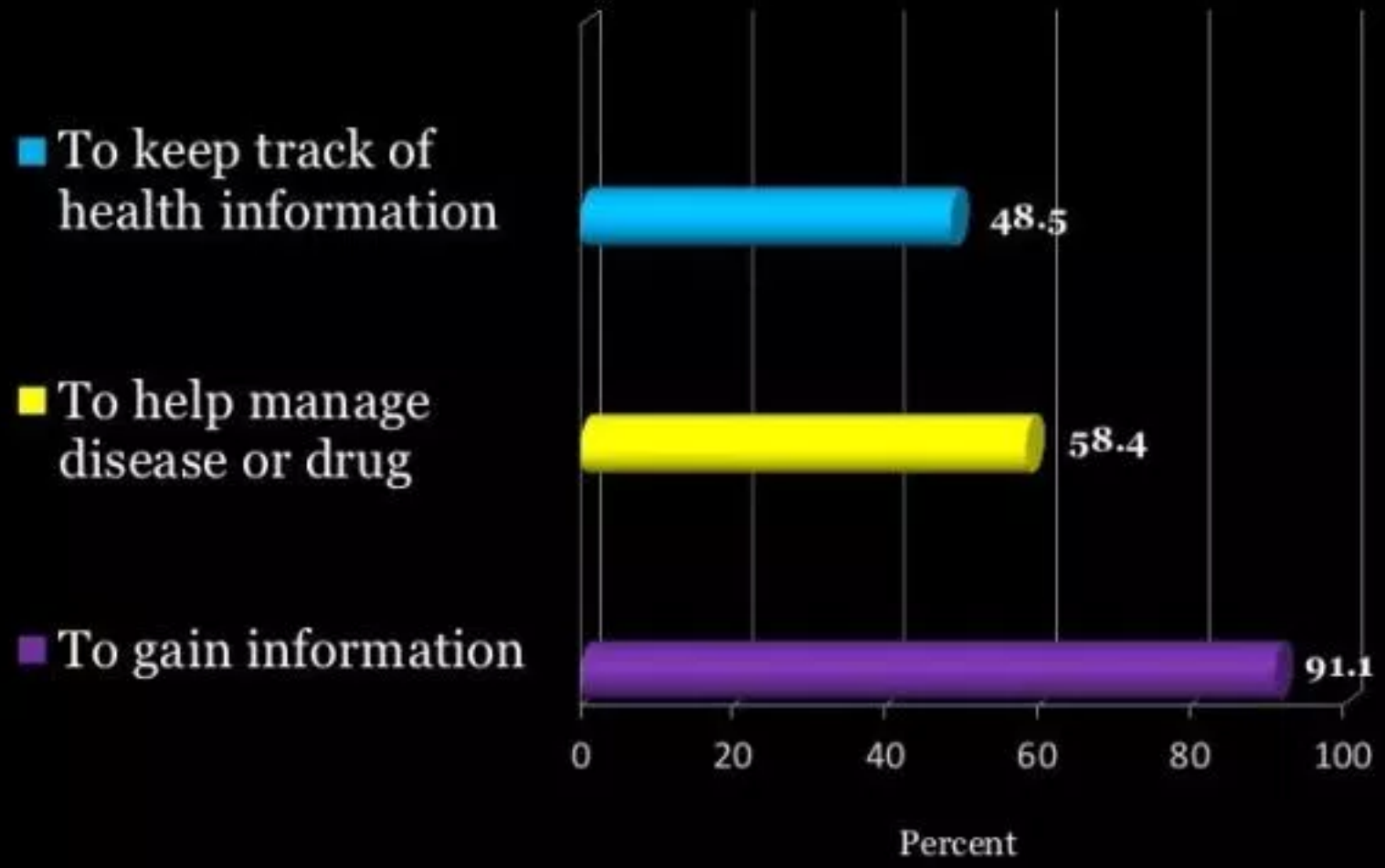
Sources provided on page 14.

The digital health landscape, from the Digital Therapeutics Alliance's new report.

M-Health is a sub segment of e-Health

mHealth is the use of mobile devices and global networks to deliver health services and information

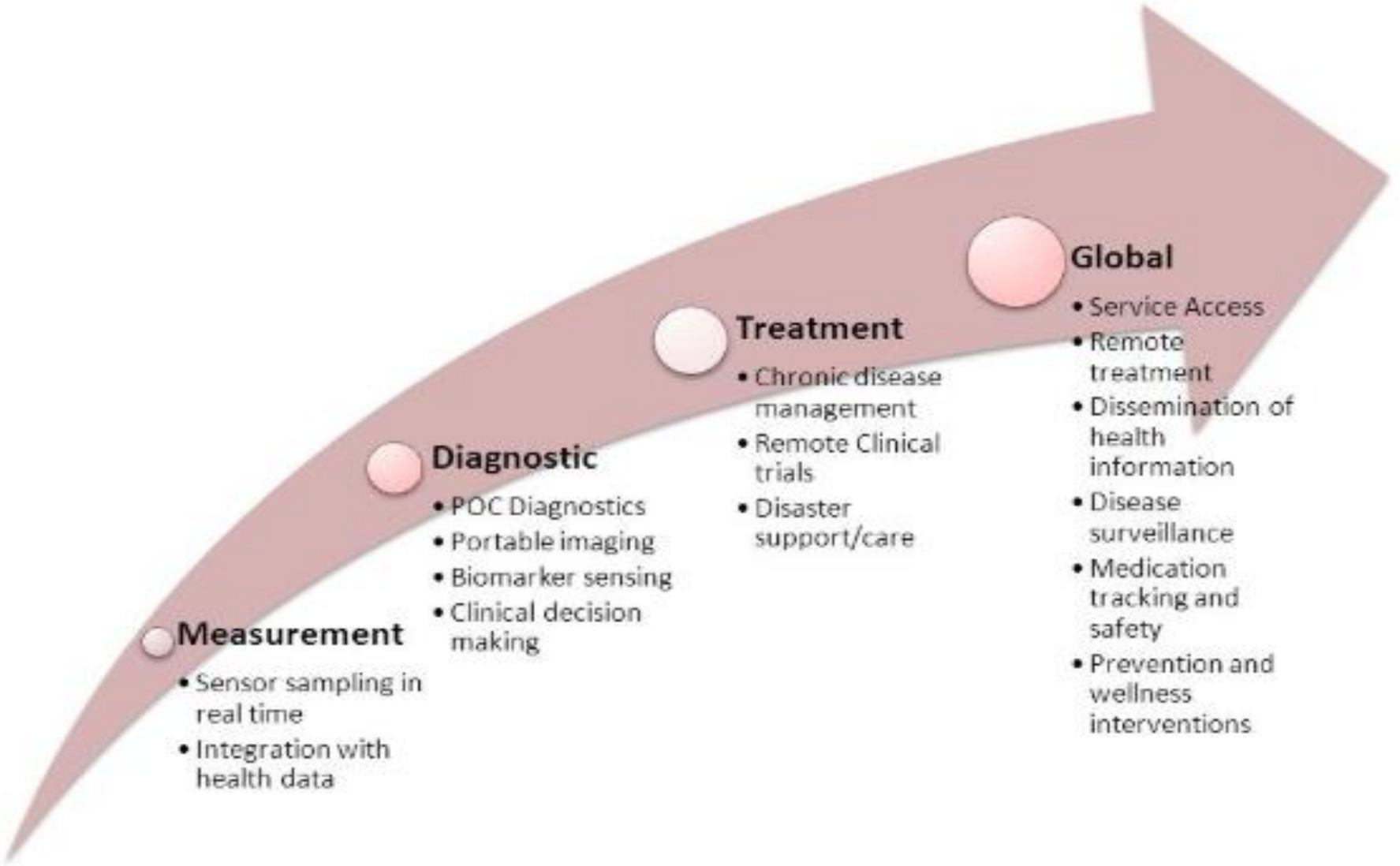
Consumers want to use health apps

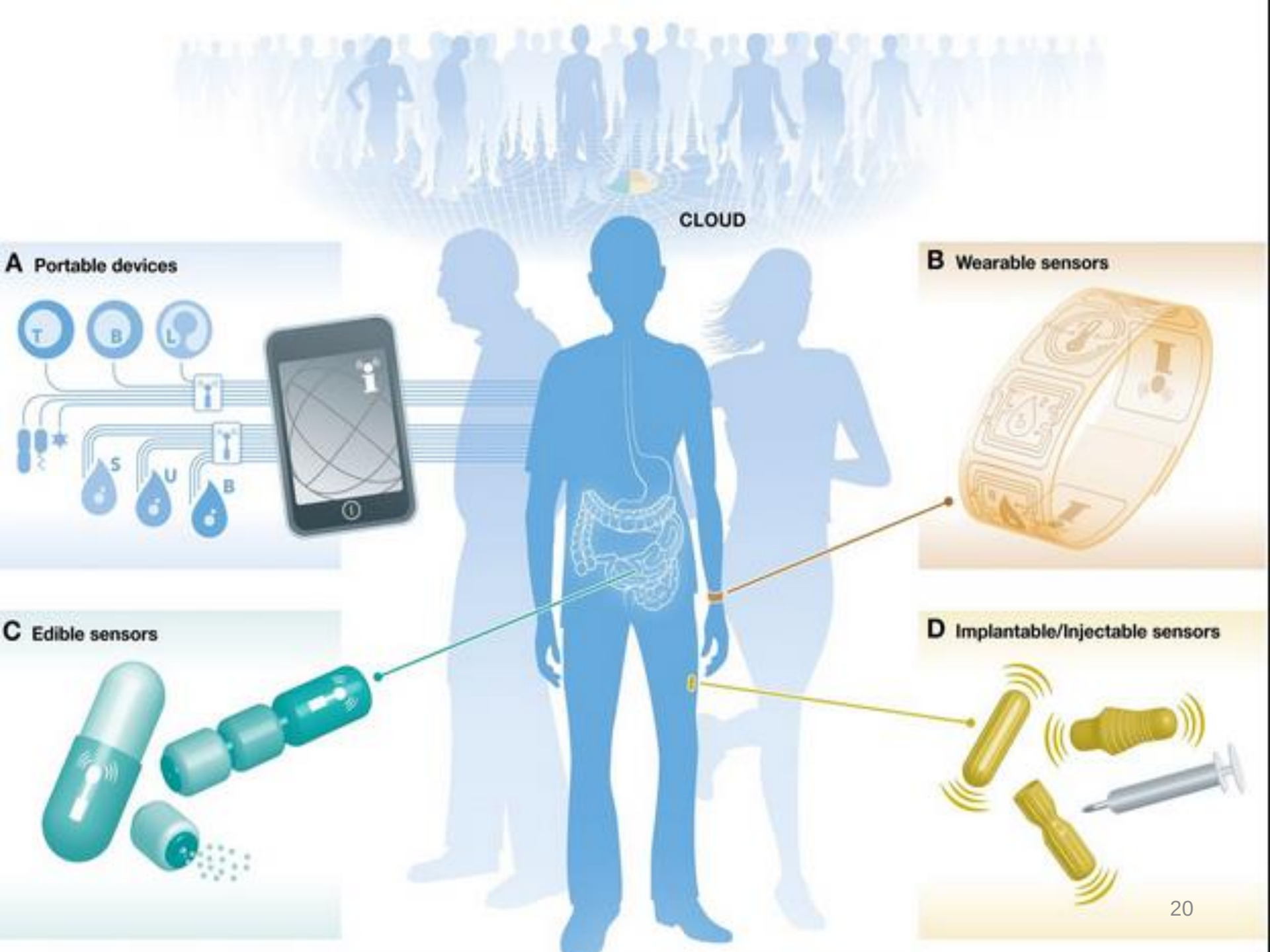


The emerging field of m-Health

Through progressively miniaturized and increasingly powerful mobile computing capabilities,
individuals are becoming increasingly capable of monitoring, tracking and transmitting health metrics continuously and in real time

Continuum of mHealth tools



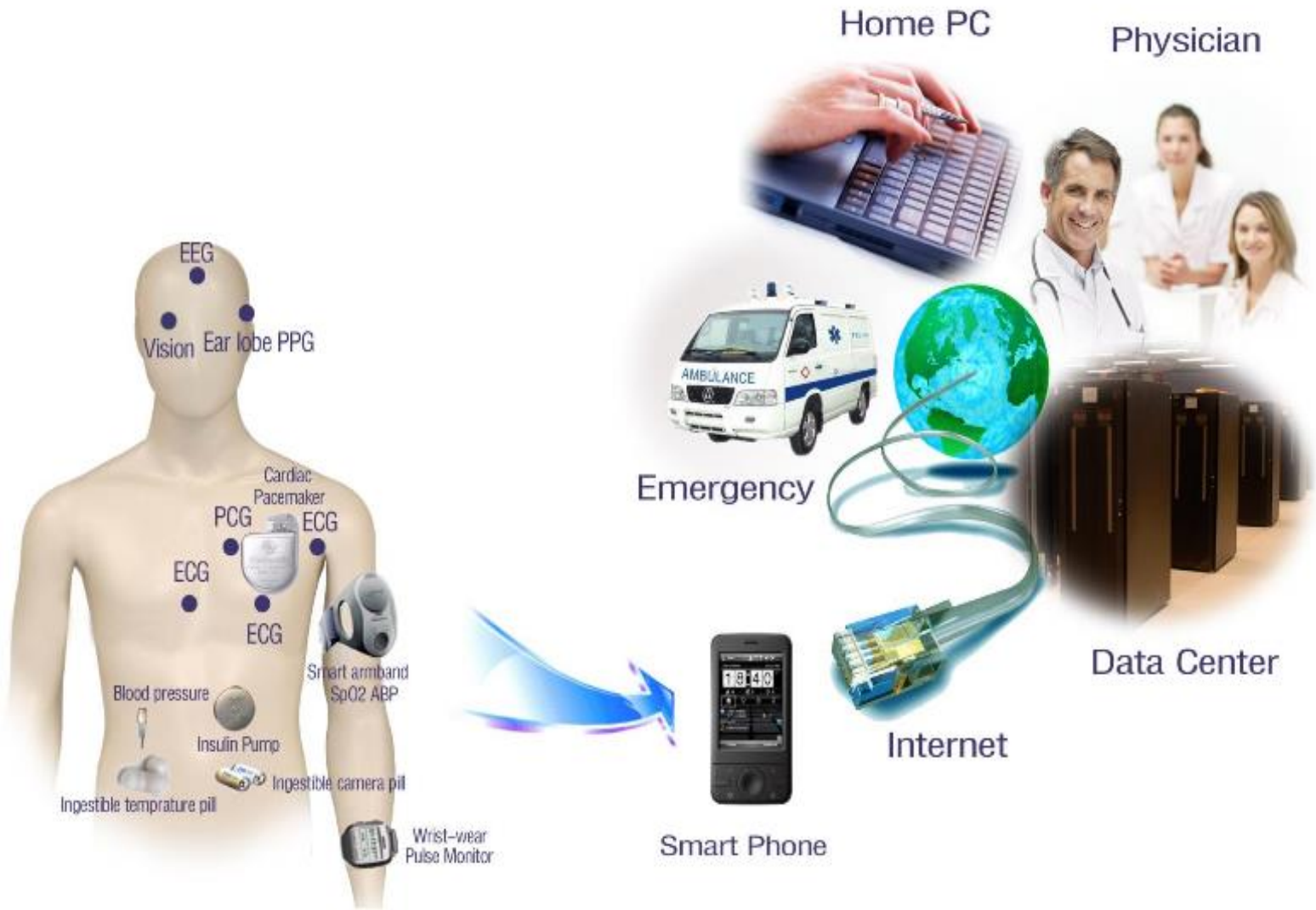

CLOUD
A Portable devices
T
B
L
S
U
B
B Wearable sensors
C Edible sensors
D Implantable/Injectable sensors

Top 10 Remote Patient Monitoring Companies for Hospitals

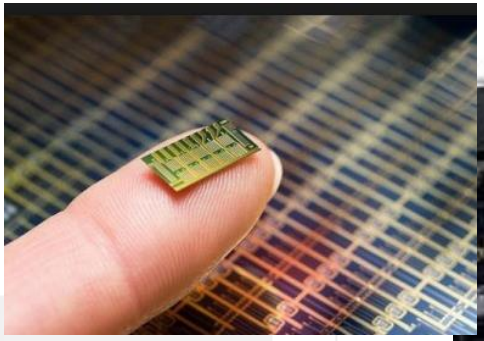
The top remote patient monitoring platforms by vendors offer hospitals advanced chronic disease management features and capabilities.

Source: Thinkstock

Remote Patient Monitoring



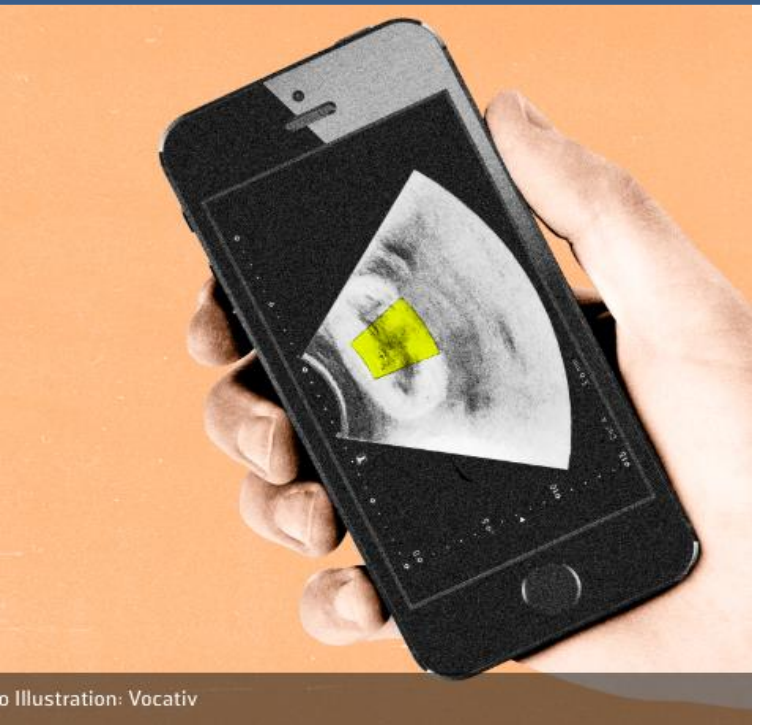
Oxygen Saturation



Oxygen saturation/pulse measured simultaneously with blood pressure, using an Masimo iSpO2 placed on the left ring finger

Doctor Uses His Phone To Diagnose Own Kidney Stone

Smartphone ultrasound technology could someday be the norm in medicine



- **Dr. Eric Topol, a cardiologist and advocate of mobile health technology**,

had an unexpected chance to demonstrate his ideas recently: he used his smartphone and a mobile ultrasound device to diagnose his own kidney stone at home.

UK Goes All In on Remote Patient Monitoring

The NHS launches seven digital health 'test beds' designed to help millions live at home while accessing real-time care support.

7.3.3 Smartphone apps (Example 2 in Figure 1 – Chapter 3): GDm-Health app

Conventional gestational diabetes mellitus (GDM) monitoring involves the use of a paper diary and fortnightly visits to a hospital clinic. The GDm-Health app facilitates self-monitoring and tracking of the progression of diabetes by specialist midwives remotely. The app provides secure communication between women and their healthcare team and potentially reduces the need for clinic visits at the same frequency. Women using the app have been shown to improve their blood glucose control and require fewer clinic visits.[129,130]

There are approximately

80,000

women with GDM in the UK

Users of the GDm-Health app require up to

two fewer clinic visits on average during their pregnancy[131]

Annually, this equates to a maximum of

160,000 outpatient appointments

40,000 hours of outpatient clinic time

20 consultant diabetologists time back for clinical care

From E Topol report

7.3.6 Automated image interpretation (Example 7 in Figure 1 – Chapter 3): Diagnostic support in Radiology

Automatic image interpretation using deep learning for the automated detection of breast cancer has been described as a use case in Chapter 3. The aim is to improve the accuracy of screening while benefiting the workforce by eliminating the need for a second reader of the mammography scans.[140]

Radiologists conservatively spend at least

60%

of their time reviewing images.[141]

Eliminating the need for a second reader represents a

30%

reduction in the time spent reviewing mammograms.

If we assume that what has been achieved with mammography can also be applied to a large extent to other medical images reviewed by radiologists, **AI methods such as deep learning have the potential to reduce the time radiologists spend reviewing images by**

20%[141]

Each year there are approximately

41 million

medical images taken and read by the UK NHS workforce of

4,204

radiologists.[142, 143]

Annually, the potential impact of AI technologies on diagnostic radiology equates to the equivalent of approximately

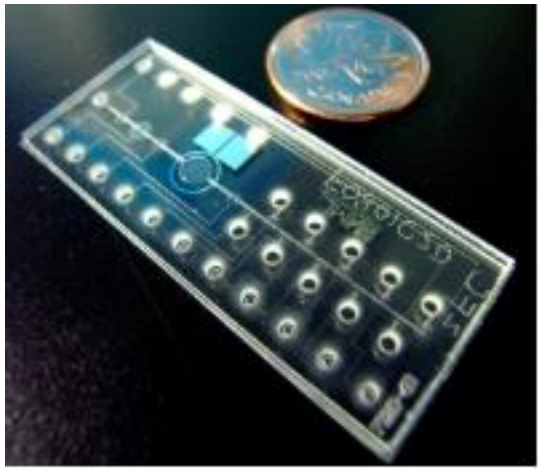
8.2 million
images

890,000
hours of radiologist time

500
radiologists' time back for clinical care

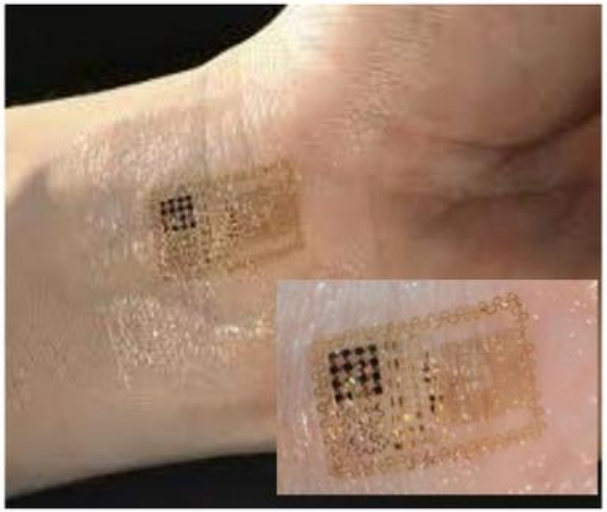
From E Topol report

Lab-on-a-chip (LOC)



- **A Lab-on-a-chip (LOC)** is a device that incorporates one or several laboratory functions on a single integrated circuit whose size varies from few millimeters to limited square centimeters to achieve automation and throughput screening process.
- **LOC devices** can hold up to a small amount of fluid having volume less than Pico liters.
- **LOC integrate** microfluidic, nanosensors, microelectrics, biochemistry, and electronic components onto the same chip
- **LOC devices** allow laboratory synthesis or chemical analysis on a very small scale that have recently shown significant benefits and potential for a wide range of applications such as **genomic research, proteomics research, analytical chemistry, environmental monitoring, the point of care diagnostics, and biohazards detection**.

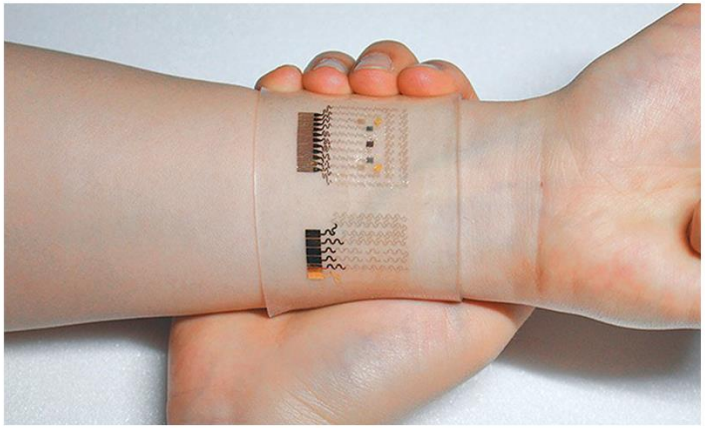
A Lab-on-skin: Biosensors tattoos



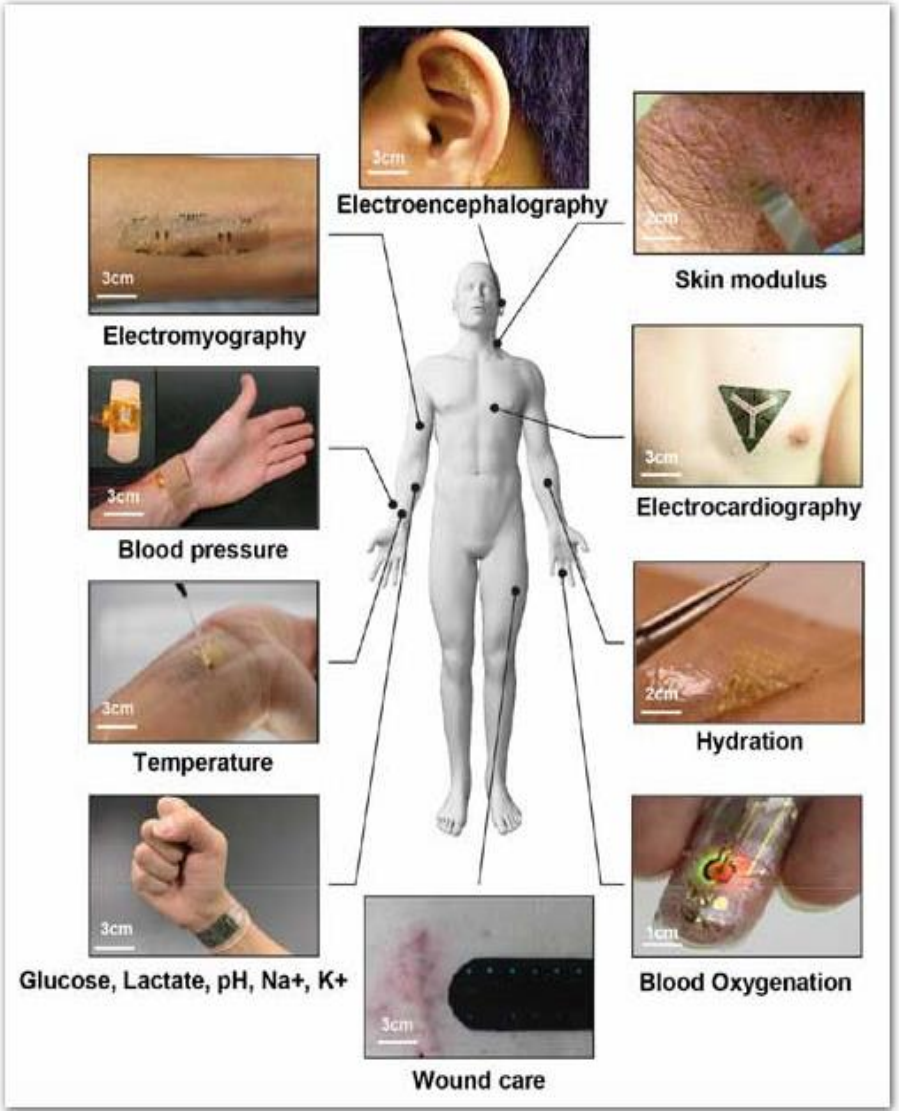
Medical or non-medical devices can be applied to the skin permanently or non-permanently for measuring biological functions like heart-rate, temperature, etc.

This Wearable Patch Detects Stress Hormone in Sweat

By **Sam Draper** - 27. November 2018

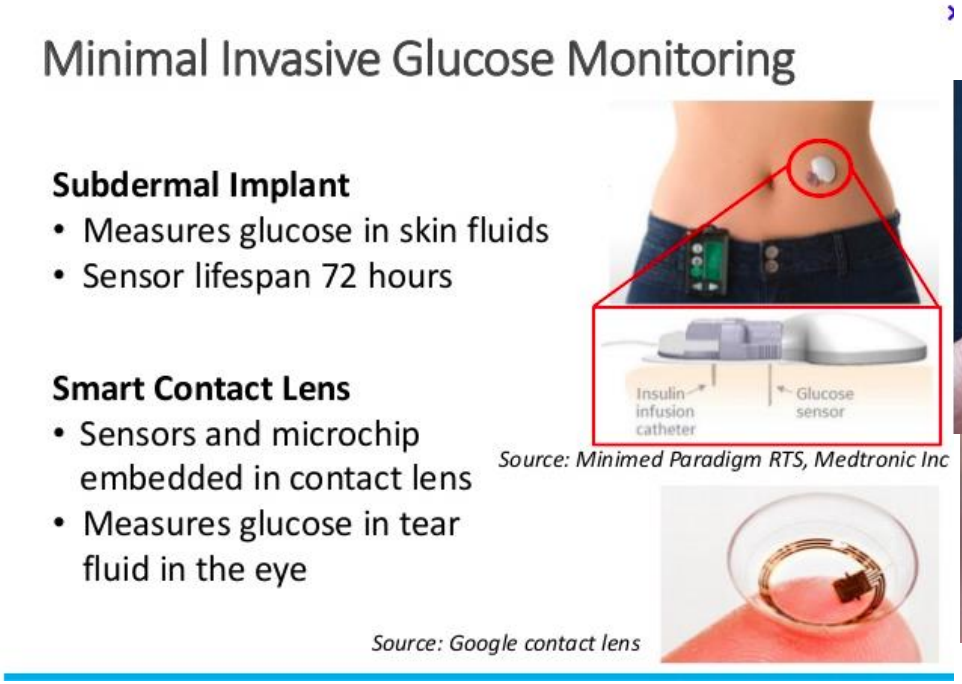


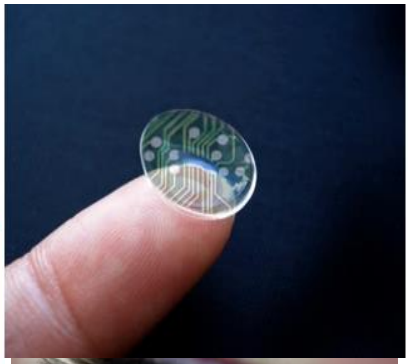
Stress affects us in numerous ways. Affecting blood pressure and metabolism to immune response and memory, stress can lead to the development of chronic diseases.



Sensors for self-monitoring:

Glucose monitoring: still a timely topic





New patents suggest Apple wants to teach your Watch to smell, which could lead to noninvasive blood glucose sensing

The two sensors could also be used to detect pollution or carbon monoxide, or help prevent exacerbation of respiratory conditions.

By **Jonah Comstock** | April 08, 2019

SHARE Share 105

Reality Check for Google's Nanoparticle Health Tests

Google will face big challenges developing a nanotechnology-based test for cancer and other diseases.

By Kevin Bullis on October 31, 2014

This week Google described its ambitious plan to use magnetic nanoparticles circulating through the blood to detect and report back on signs of cancer or an impending heart attack. Some nanotechnology experts, however, have responded by asking whether Google's project is more science fiction than medical reality.

"It's very exciting that a company with Google's financial firepower is taking on this big challenge," says Chad Mirkin, who directs the International Institute for Nanotechnology at Northwestern University. But he says that what Google has described is "an intent to do something, not a discovery or a pathway to get there." At this point, he says, the technology is speculative: it's basically "a good Star Trek episode."

The main problem facing the search giant will be biology. Google intends to produce a nanoparticle pill that you can swallow. From there the nanoparticles would somehow get into the bloodstream, something Mirkin says requires "a big leap of faith." Once in the bloodstream, they're supposed to circulate, find their way to targets such as cancer cells, and then be collected for measurements. A magnet held near superficial blood vessels on the wrist, for example, could concentrate the nanoparticles in one place. Google did not say how it would measure a signal from the nanoparticles.

How nanoparticles could detect the disease early

Nanoparticles are tiny; more than 2,000 could fit inside a red blood cell

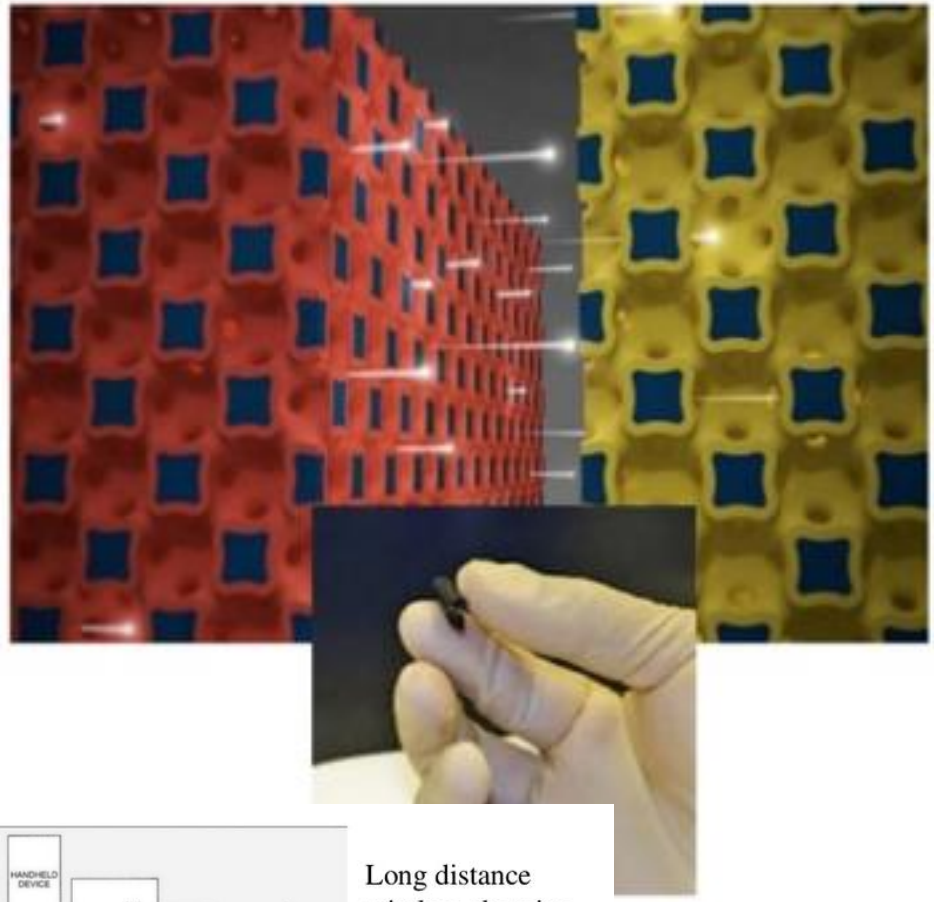
Nanoparticles circulate in the bloodstream and attach to certain cells, including cancer cells

A device worn outside the body can detect the nanoparticles and provide useful information to doctors

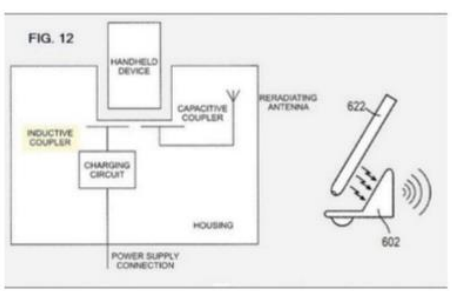
Source: Google

Nano flexible batteries

from A Fou



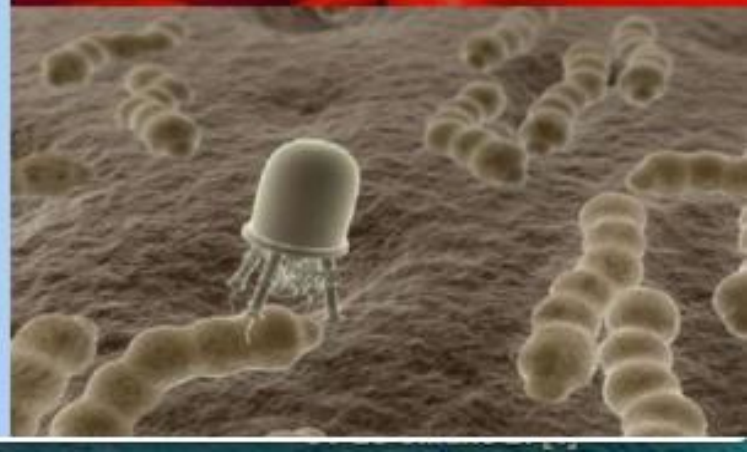
Nano-scale batteries that hold enormous charge and can be charged nearly instantly will power the tiniest devices, even ones that can be implanted or injected.



Long distance wireless charging will keep every electronic component constantly charged

Robotic medical nanodevices controlled by wireless technology

- Nano-robotics, although having many applications in other areas, have the most useful and variety of uses in medical fields.
- Potential applications include early **diagnosis** and **targeted drug delivery** for cancer, **biomedical instrumentation**, **surgery**, **pharmacokinetics**, **monitoring** of diabetes, and health care.
- Future medical nanotechnology expected to employ nanorobots injected into the patient to perform treatment on a cellular level.



The emerging field of m-Health

from Steven R Steinhubl et al. Sci Transl Med. 2015 Apr 15; 7(283)

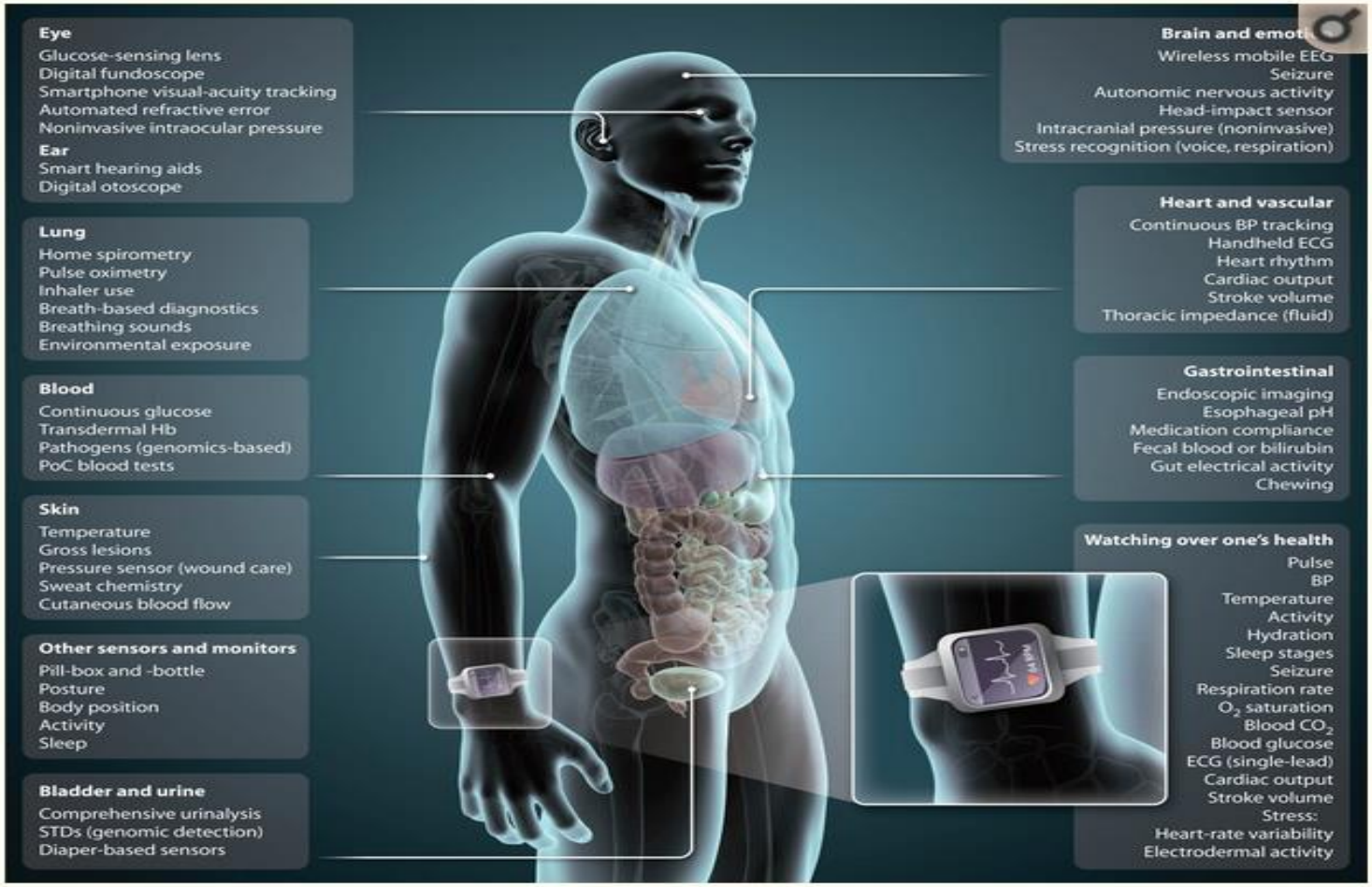


Fig. 1

Sensing a shift in health care. Shown are bodywide measurements by mHealth technologies that are available to health care providers and patients to aid in the tracking, diagnosis, or management of various physiological processes and disease conditions. **(Inset) Watching over one's health.** Multiple developers have reported that the listed physiological parameters are measurable with sensors in a wrist-worn device. BP, blood pressure; Hb, hemoglobin; STDs, sexually transmitted diseases.

https://mhealthintelligence.com/topic/mhealth-apps-software

Articles

Chronic Pain Study Focuses on mHealth Tracking, Care Management

April 03, 2019 by Eric Wicklund
A national research project focused on people living with chronic pain has found that more than 80 percent are using mHealth tools to monitor their activity. This, in turn, could lead to newer and better digital therapeutic programs for...

Wisconsin Health System Puts mHealth to Work for Chronic Care Management

April 01, 2019 by Eric Wicklund
A Wisconsin health system is using an mHealth platform to give patients with chronic conditions a better idea of how medication management should work. The connected care platform will also give doctors an opportunity to boost outcomes...

Researchers Test an mHealth Wearable That IDs Cancer Cells in Blood

April 01, 2019 by Eric Wicklund
Researchers in Michigan are working on an mHealth wearable that could help doctors identify cancer with more accuracy than a biopsy. The device, which attaches to the arm and filters live cancer cells from blood cycled from a vein...

mHealth Helps Young Arthritis Patients Communicate Their Care Needs

March 27, 2019 by Eric Wicklund
Researchers at the University of Minnesota are touting an mHealth app that not only helps young patients living with arthritis to access healthcare resources, but also allows them to communicate better with their parents and doctors on...

National Study to Train mHealth on College Depression, Anxiety

March 26, 2019 by Eric Wicklund
Roughly 8,000 students from 20 colleges and universities across the country will be taking part in a research study to test the effectiveness of an mHealth platform for treating clinical depression, anxiety and eating disorders. The...

Arizona MD Creates mHealth App for Pregnant Women Dealing With SUD

March 25, 2019 by Eric Wicklund
A University of Arizona physician is modifying an mHealth platform to give new and expecting mothers a digital

6 notes on Apple's health strategy so far democratizing health information

- 1. **Apple kicked off its healthcare projects in the consumer wellness space when it debuted the Apple Watch**, HealthKit platform and Health app a few years ago. These tools were focused on helping users track their exercise, diet and other lifestyle metrics.

- 2. Shortly after, the company launched CareKit, a software framework to help developers create **health-focused products for the iPhone** — such as products that help iPhone **users connect with medical professionals**.

- 3. Apple has built out its **smartwatch into what some might call a medical device**. Most recently, it equipped the watch with an **electrocardiogram feature that passively monitors wearers' heart rhythms for abnormalities**.

- 4. By integrating patients' health records in the iPhone's Health app, the company has made it easier for patients **to share their health data with physicians**, and vice versa.
- .
- 5. Apple has been in talks **with insurers to subsidize the Apple Watch to Medicare Advantage enrollees ,** Apple reportedly hired Jason Oberfest, CEO of a medication management app called Mango Health, which is aimed at people who are **on a complex drug regime**. »

- 6. Apple has repeatedly emphasized the **importance of privacy and security of customers' data.** Data privacy is of particular concern in healthcare, given the sensitive nature of patient data and stringent industry regulations.

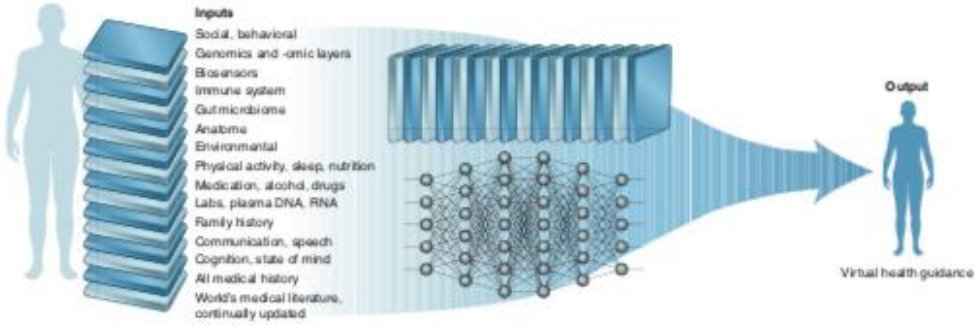
eHealth/m-Health as major disruptive elements

- In the future, « the **health data will be continuously monitored and streamed** to personal data clouds **alerting the individual or health care professionals** at early signs of illnesses or pathological conditions **in real time,** opening the possibility to a **preventive medicine** prior to the onset of disease. »

Humans Plus Artificial Intelligence In Healthcare Will Mean Better Outcomes

The virtual medical coach model with multimodal data inputs and algorithms to provide individual guidance

- **Within the next 2 decades**, we will access genomic, anatomical and physiological information, as well as social, behavioural and environmental data.
- **The fusion of genomics, digital medicine, AI and robotics** will enable staff working within an ethical and legal framework to deliver a more holistic approach to personalised healthcare and disease prevention.
- **With wider use of genome sequencing**, we are likely to be able to predict which antibiotics are suitable for particular infections. Prescribing decisions will be made according to the patient's or pathogen's genetic sequence.
- The convergence and complementarity of the three major technologies – **genomics, sensors and AI** – will enable the development of **virtual medical coaches**



SCIENCES LE VIRTUEL, AVENIR DE LA MÉDECINE?

Les avatars imaginés par le projet Health UE réuniraient toutes les données personnelles de chaque individu pour un suivi médical plus efficace. L'idée fait son chemin.

Un double de soi-même sous forme virtuelle, pour mieux gérer sa santé et se soigner plus efficacement.
Image: Health EU

Health EU – Human avatars to prevent and cure diseases

Imagine a revolution in personalized healthcare and disease prevention system in Europe, based on human avatars of healthy individuals and patients for the prevention, interception and cure of disease.

Prof. Alexander M. M. Eggermont – Project Coordinator
Gustave Roussy and Université Paris-Sud, France

A revolution in human model development is now possible with Health EU by leveraging data from omics analyses, medical and imaging data, environmental and life style big data that are continuously updated by a multitude of biosensors at an unprecedented scale. With these complex data sets, first of their kind(s) human avatars will be built that can be personalised and used to prevent and cure each one's own disease(s). Health EU will exploit most advanced organ-on-chip, smart nanosensor technologies and nanomedicine techniques to realise, validate and use such personalized human avatars in order to create a revolution in healthcare.

In summary

The future of healthcare is **connected**, **patient centered**, **mobile** and **social.**

- **The patient must be considered to be at the centre** when assessing and implementing any new technologies.
- **There is remarkable potential for digital healthcare technologies** to improve accuracy of diagnoses and treatments, the efficiency of care, and workflow for healthcare professionals, but implementation must only be carried out when there has been robust clinical validation.
- P**atients who are willing to take greater charge of their care using digital tools and algorithms will be empowered,** but this should always be an opt-in choice for them.
- A marked improvement in the **patient-clinician-medical biologist relationship is possible,** owing to the gift of time delivered by the introduction of these technologies.
- **The new medicine as envisioned will require extensive education and training of the clinician workforce** and the public, with cultivation of a **cross-disciplinary approach** that includes data scientists, computer scientists, engineers, bioinformaticians, in addition to the traditional mix ofmedical biologists, pharmacists, nurses and doctor.

How Do The Finest Minds Imagine Our Future?
A.I. genomic,sensors,robotics, and augmented realities. Technology shows that our possibilities are endless,

but still, do we know in what world we will end up in the next decades to come?

THANK YOU !