

 **UiT** The Arctic University of Norway

Digital medicine and emergent technologies

Gunnar Hartvigsen, professor

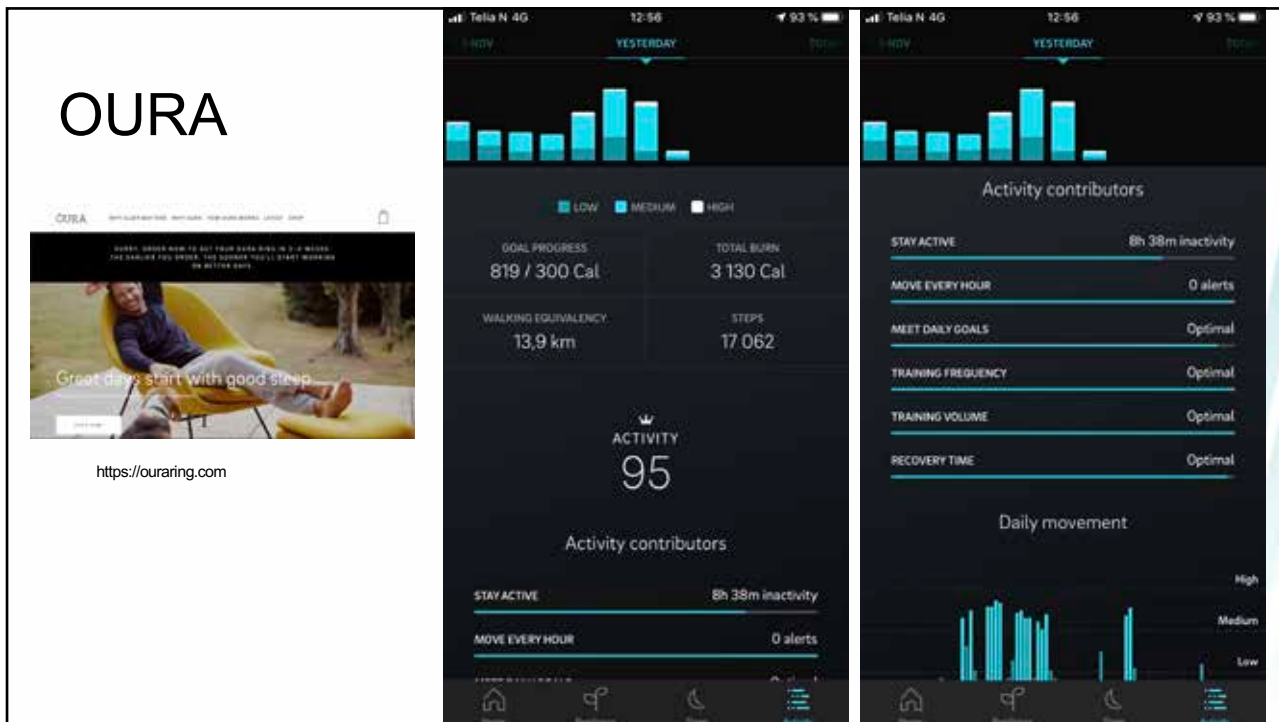
*Department of Computer Science
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Faculty of Health and Sport Sciences
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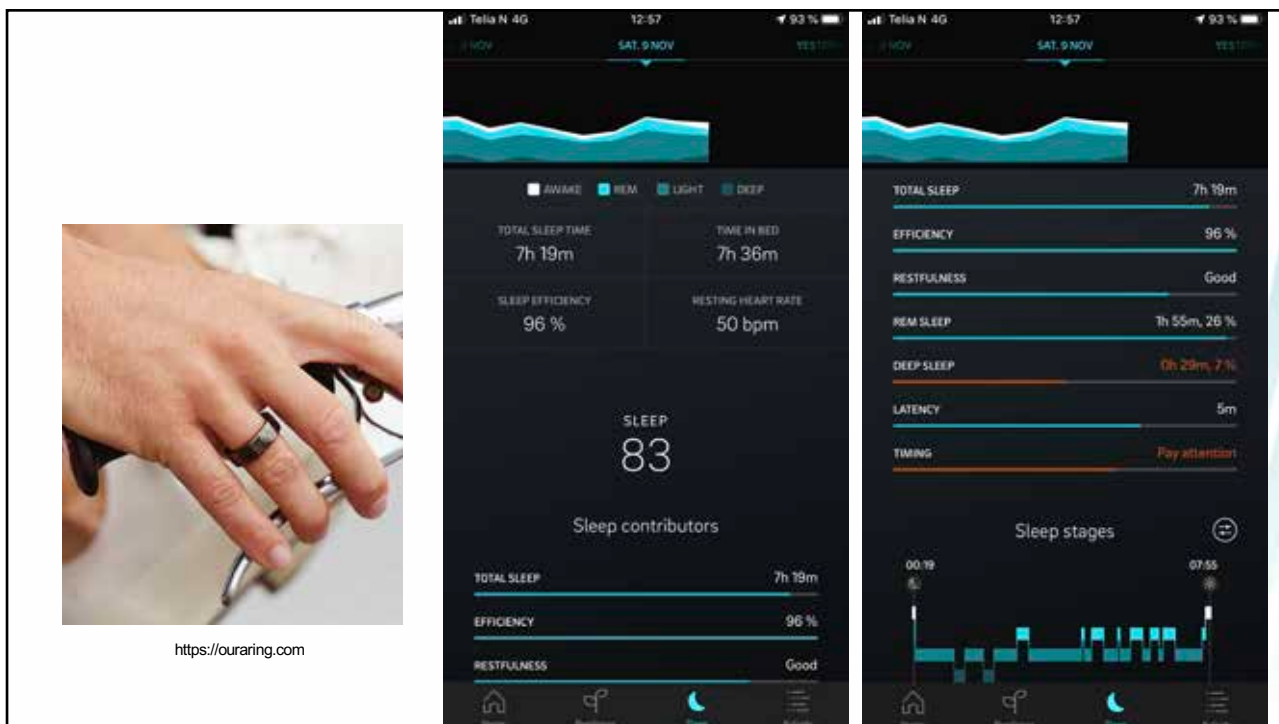
1

I'M PART OF "THE MOVEMENT" MYSELF

2



3



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UiT / THE ARCTIC UNIVERSITY OF NORWAY

SEARCH MENU

The Tromsø Study

Home How to apply for data access Contact

The Tromsø Study

The Tromsø Study was initiated in 1974 in an attempt to help combat the high mortality due to cardiovascular diseases in Norway. This mostly affected men. In the mid-1970s, one in every five Norwegian men died of myocardial infarction before the age of 75, while the situation in Northern Norway was even worse.

The primary aim of the Tromsø Study was to determine the reasons for the high mortality of cardiovascular disease, and also to develop ways of preventing heart attacks and strokes. The study was gradually expanded to include many other diseases, such as rheumatism, neurological and mental diseases, skin diseases, stomach and bowel-related diseases,

NESSTAR: research database

List of publications

5

LET'S TAKE A STEP BACK

6

Project title

Full flow of Health Data Between Patients and Health Care Systems

7

The primary objective is ...

... to investigate how to integrate and utilize data between all three main actors in health care; the **patients**, the **primary care** and the **secondary care** actors.

8

WHAT IS GOING ON OUT THERE?

9

FORTUNE | Health

The Future of Health According to Health Experts
They're placing big bets on VR and wearables

DAVID RHEW
Chief Medical Officer
Samsung Electronics America

“The business of medicine is inefficient, expensive, and ripe for disruption.”

Prepare for the Digital Health Revolution

By Mukherjee
Apr 20, 2017

10

thebmj

BMJ 2018;360:k6 doi: 10.1136/bmj.k6 (Published 15 January 2018)

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EDITORIALS

Check for updates

Digital healthcare: regulating the revolution

We need an agile and future proof framework that everyone can trust

Rishi Duggal *medical adviser*¹, Ingrid Brindle *patient*², Jessamy Bagenal *senior medical editor*³

¹NHS Digital, London, UK; ²Manchester, UK; ³The Lancet, London, UK

The digital health revolution has arrived. In 2017 the digital health industry was already worth \$25bn (£19bn; €21bn) globally, with the potential to cut healthcare costs by an estimated \$7bn a year in the US alone.¹ Digital health, or e-health, encompasses several distinct technologies including but not limited to: decisional support systems that use algorithms derived through mining clinical datasets, such as the work carried out by Google DeepMind; mobile health apps, or m-health, which can support and monitor healthy behaviours; connected biometric sensors, such as continuous glucose monitoring; consultations via video link (“telemedicine”); and electronic personal health records.

New products come to market quickly—153 000 mobile health apps have been released since 2015, bringing the worldwide total to 320 000.² The sudden influx of technology, combined with a lack of robust governance, has led to distrust among some

example, a new psychiatric drug with inbuilt sensors to record ingestion and track adherence has recently received FDA approval.⁴ Digital innovations will continue to create new and unpredictable ethical and regulatory issues. Regulators will need to maintain a horizon scanning service so they are aware of how digital health evolves and how their regulations must change in response.

In 2017 the Care Quality Commission published their position on regulating digital health in primary care in England.⁵ Although a good first step, the guidance needs improvement in places. For example, digital services can adapt swiftly to user need. It follows that software and services registered for regulation might change before inspection and change again before the regulator reports its findings.

Regulators will need to develop more agile approaches, perhaps involving digital health services to provide updates to maintain

BMJ first published as 10.1136/bmj.k6 on 15 January 2018. Downloaded from <http://www.bmj.com/> on 10 November 2019

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Regulating digital health, while trying to create an environment promoting innovation, is challenging

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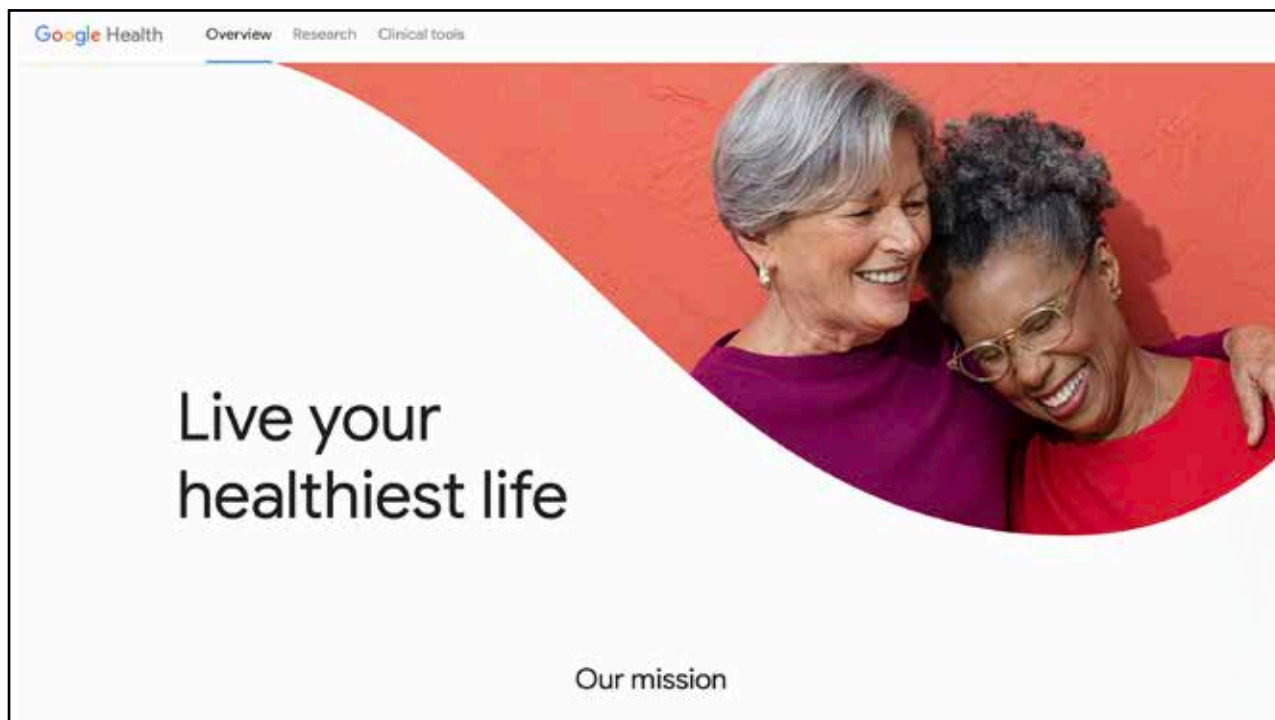
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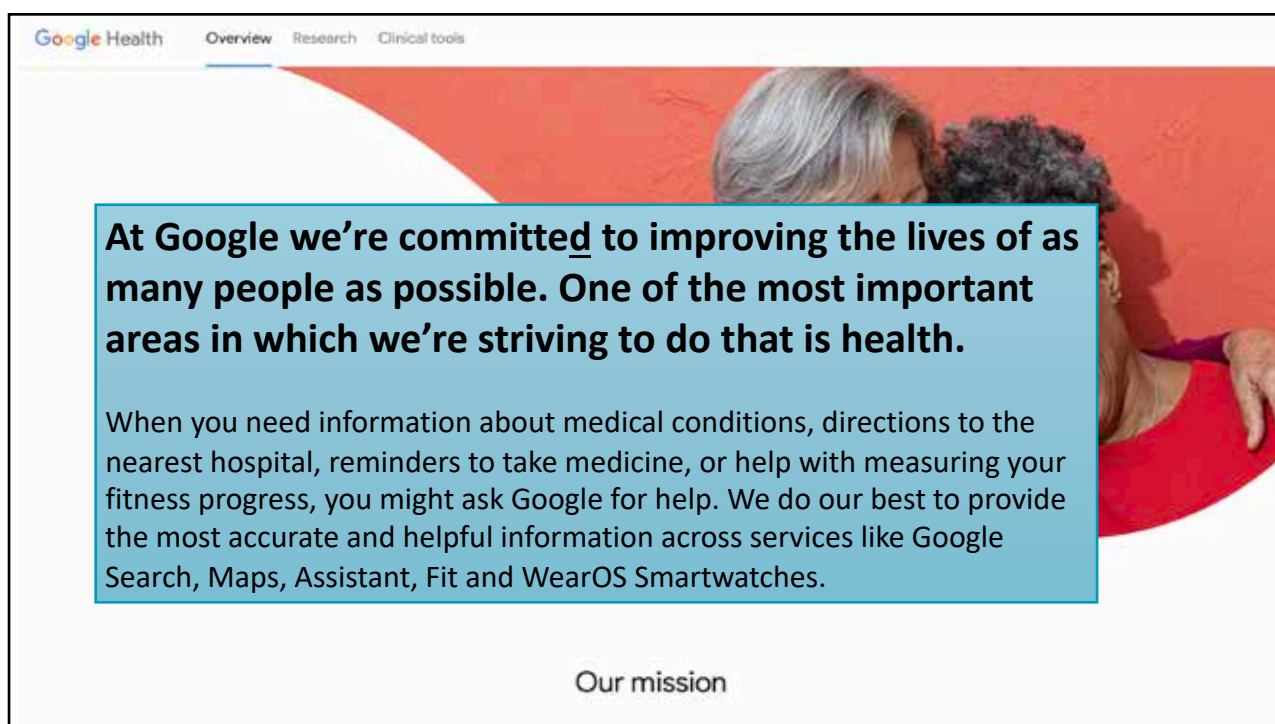
GAF A ARE ON-BOARD!



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18



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Google Health Overview Research Clinical tools

Beyond that, emerging technologies present opportunities to elevate healthcare for everyone. Today we're studying the use of artificial intelligence to assist in **diagnosing** cancer, **predicting** patient outcomes, **preventing** blindness, and much **more**. We're exploring ways to improve patient care, including tools that are already being used by clinicians. And we're partnering with doctors, nurses, and other healthcare professionals to help improve the care patients receive.

the most accurate and helpful information across services like Google Search, Maps, Assistant, Fit and WearOS Smartwatches.

Our mission

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Google Health Overview Research Clinical tools

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“I believe Google is already a health company. It's been in the company's DNA from the start.”

David Feinberg
Head of Google Health

Our mission

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DeepMind

What if solving one

DeepMind | Blog | DeepMind's health team joins Google Health

DeepMind's health team joins Google Health

18 SEP 2018

SHARE

AUTHOR

Dr. Dominic King

Over the last three years, DeepMind has built a team to tackle some of healthcare's most complex problems—developing AI research and mobile tools that are already having a positive impact on patients and care teams. Today, with our healthcare partners, the team is excited to officially join the [Google Health](#) family. Under the leadership of [Dr. David Feinberg](#), and alongside other teams at Google, we'll now be able to tap into global expertise in areas like app development, data security, cloud storage and user design to build products that support care teams and improve patient outcomes.

During my time working in the UK National Health Service (NHS) as a surgeon and researcher, I saw first-hand how technology could help, or hinder, the important work of nurses and doctors. It's remarkable that many frontline clinicians, even in the world's most advanced hospitals, are still reliant on clunky desktop systems and papers that make delivering fast and safe patient care challenging. Thousands of people die in hospitals every year from avoidable conditions like sepsis and acute kidney injury and we believe that better tools could save lives.

most useful that learn very for all.

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Twine Health was acquired by Fitbit, which was acquired by Google

#twinehealth + #fitbit

TWINE HEALTH AND FITBIT JOIN FORCES TO DELIVER BETTER HEALTH BEYOND THE DOCTOR'S OFFICE.

The world's biggest wearables brand meets superior health outcomes.


HEALTH COACHING OPTIMIZED

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MAGAZINE NEWS OPINIONS TOP 30 RESEARCH SUPPLY CHAIN

The Legacy of Apple Health

Does Apple Health present the opportunity to be the company's greatest contribution to mankind or will it falter due to a lack of direction?



Apple Health's Tim Cook sees the segment as having potential to be the firm's greatest contribution to mankind.

Sean Fenske, Editor-in-Chief • 09.06.19

Tim Cook hopes that Apple Health represents the firm's "greatest contribution to mankind." A bold aspiration considering how influential on the world the company has been already. Then again, a significant breakthrough in healthcare is ultimately much more beneficial than the iPhone, iTunes, or the

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Tim Cook hopes that «Apple Health represents the firm's "greatest contribution to mankind.»

A bold aspiration considering how influential on the world the company has been already.
(...)
Apple is just one of several tech giants who have entered the healthcare technology space, leveraging different capabilities from the traditional medtech firms to enable prevention, diagnosis, and treatment of a variety of diseases. Their potential to disrupt the industry has often been discussed. To some, these organizations represent serious new competitors to established medtech firms. Others consider them potential partners who bring a much needed skill set to those already quite familiar with operating in the regulatory environment. Regardless of the view one has, these enterprises bring specialized capabilities with them that complement the needs to address the ongoing shift in healthcare (e.g., digital health, patient-focused solutions, artificial intelligence, big data and analytics, etc.).

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NRK
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Søk

The smartwatch saved Toralv

Smartklokken reddet Toralv

Natt til lørdag falt Toralv Østvang (67) hardt i badegulvet alene på Hamar. En knapp halvtime senere fant politiet ham blodig og bevisstløs. De hadde fått beskjed av smartklokken rundt håndledet hans.



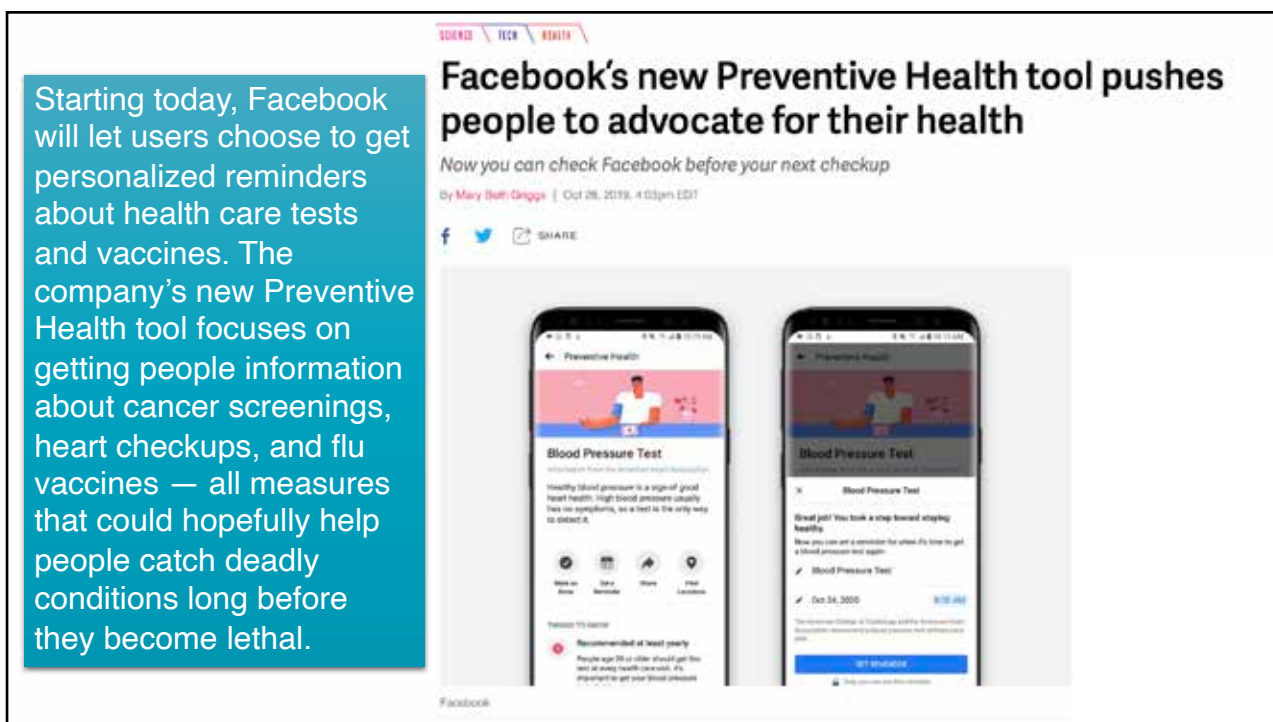
Night to Saturday, Toralv Østvang (67) fell hard in the bathroom floor alone at Hamar. About half an hour later, police found him bloody and unconscious. They had been alarmed by the smartwatch around his wrist.

REDDET AV KLOKKEN: Politiet i Hamar fant en blodig og forslått Toralv Østvang natt til lørdag etter at klokken hans ringte dem.
FOTO: PRIVAT

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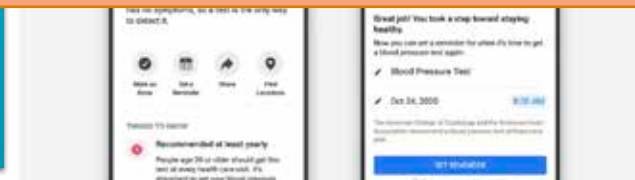


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Starting today, Facebook will let users choose personalized reminders about health care and vaccines. The company's new Preventive Health tool focuses on getting people informed about cancer screenings, heart checkups, and vaccines — all measures that could hopefully help people catch deadly conditions long before they become lethal.

Facebook's new Preventive Health tool pushes

This marks Facebook's second venture into health-related tools. Its other effort, promoting local blood drives, launched in the United States in June after debuting in India in 2017. Overall, both of these tools mark a far more simple entry into the health space than other tech giants have made. Amazon has been getting into online pharmacies and electronic health records, Apple is monitoring your heartbeat, and Google might be trying to buy Fitbit.



The image shows two screenshots of the Facebook Preventive Health tool. The left screenshot displays a 'Need to do' section with icons for 'Get a flu shot', 'Get a tetanus shot', 'Get a COVID-19 test', and 'Get a COVID-19 vaccine'. Below this is a 'Recommended at least yearly' section with a red warning icon and text: 'People age 50 or older should get this test at least once a year. It's important to get your blood pressure checked.' The right screenshot shows a 'Great job! You took a step toward staying healthy.' notification with a checkmark and text: 'Now you can get a reminder for when it's time to get a blood pressure test again.' Below this is a 'Blood Pressure Test' section with a checkmark, the date 'Oct 24, 2020', and a blue 'Get reminder' button.

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The image is a header for a Builtin article. At the top, the Builtin logo is on the left, and navigation links for 'TECH JOBS', 'TECH TOPICS', 'TECH HUBS', and 'FOR EMPLOYERS' are on the right. The main visual is an illustration of a pharmacy with a person at a computer terminal. Below the illustration is a white box with the following text:

HOW AMAZON'S 'HAVEN' VENTURE COULD IMPACT ALL ASPECTS OF THE HEALTHCARE INDUSTRY

The healthcare industry has never experienced anything like Amazon's combination of powerhouse logistics, voice AI expertise and robust data analytics. And the impact could be huge.

September 24, 2019 | Updated: September 25, 2019 | Written by Stephen Gossell

At the bottom of the white box are social media icons for LinkedIn, Facebook, Twitter, and Messenger.

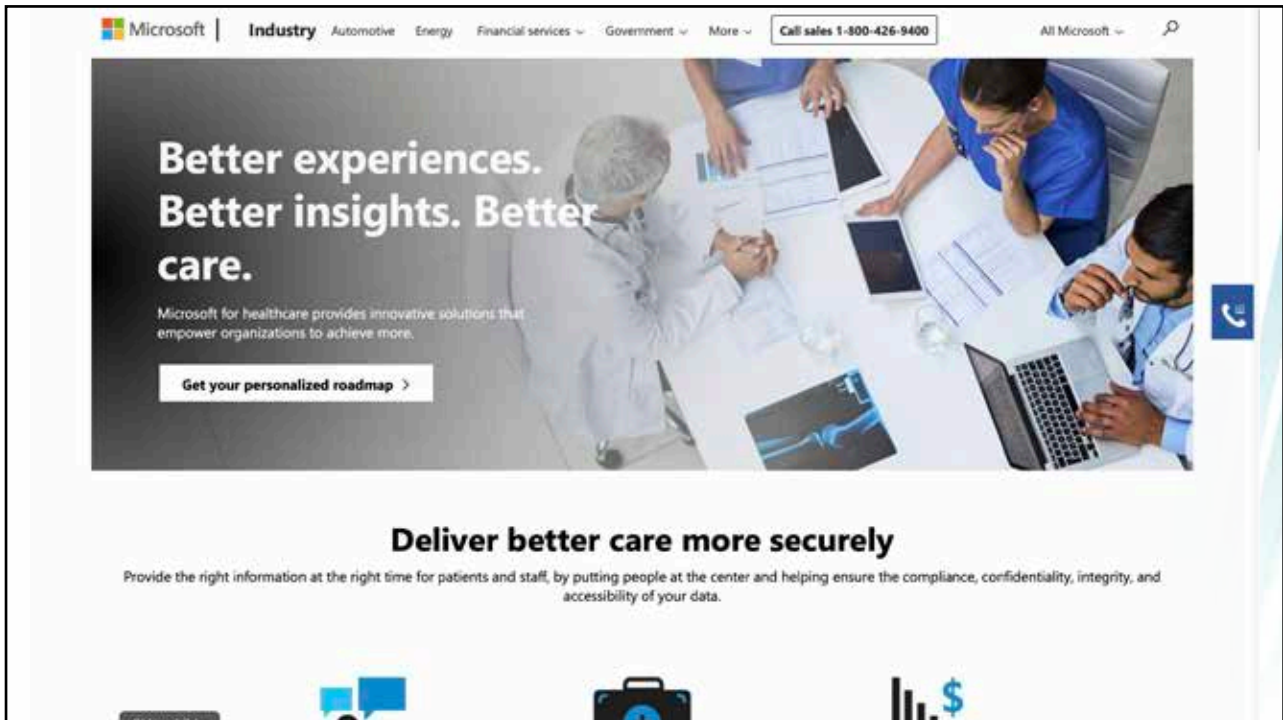
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EVERYBODY WANTS THEIR SHARE OF THE "MARKET"

33

The screenshot shows the IBM Watson Health website. At the top left is the IBM logo. Below it is a navigation menu with links for 'IBM Watson Health', 'Government', 'Provider', 'Life Sciences', and 'Consulting'. On the right side of the header are icons for search, user profile, and a menu. The main content area features a large heading: 'Strategic transformation. Make your data make the difference'. Below this is a paragraph: 'IBM Watson Health applies data-driven analytics, advisory services and advanced technologies such as AI, to deliver actionable insights that can help you free up time to care, identify efficiencies, and improve population health.' A blue 'Contact us' button is positioned below the text. To the right of the text is a black and white photograph of two people in white lab coats, a man and a woman, looking at a screen. Below the main content is a dark horizontal bar with two dropdown menus: 'Choose your focus' and 'News and events'. The lower section of the page is titled 'Helping you extract value from your data'. It contains a paragraph: 'We work with you to cross barriers between health and care systems, to provide actionable insights that help you free up more time to care, to identify efficiencies that can reduce growing costs, and unearth the right intelligence to help you improve the health of people and populations.' Below this paragraph are three large blue numbers: '800', '3,600', and '15,000'. Underneath each number is a short description: 'Supporting over 800 customer', '3,600 of IBM's global patents are', and 'Helping to create meaningful c...'.

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The image shows a screenshot of a Microsoft website for the healthcare industry. At the top, there is a navigation bar with the Microsoft logo, the word "Industry", and several industry categories: Automotive, Energy, Financial services, Government, and More. A "Call sales 1-800-426-9400" button is also present. The main content area features a large photograph of healthcare professionals in a meeting. Overlaid on the left side of the photo is the text: "Better experiences. Better insights. Better care." Below this, a smaller line of text reads: "Microsoft for healthcare provides innovative solutions that empower organizations to achieve more." A button labeled "Get your personalized roadmap >" is positioned below the text. To the right of the photo, there is a blue telephone icon. Below the main image, the heading "Deliver better care more securely" is displayed, followed by a sub-headline: "Provide the right information at the right time for patients and staff, by putting people at the center and helping ensure the compliance, confidentiality, integrity, and accessibility of your data." At the bottom of the page, there are several small icons representing healthcare and technology: a stethoscope, a laptop, a briefcase, and a bar chart with a dollar sign.

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**MORE
ATTENTION AND
RESEARCH
PUBLICATIONS**

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of the
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Home / Magazine Archive / September 2014 (Vol. 57, No. 9) / The New Digital Medicine / Abstract

NEWS

The New Digital Medicine

By Gregory Mone
Communications of the ACM, September 2014, Vol. 57 No. 9, Pages 18-20
10.1145/2641227
Comments

VIEW AS: SHARE:



The average person sees his or her physician for about an hour each year. At our annual checkups, doctors and nurses check our blood pressure, heart rate, and other vital signs, and from those brief snapshots they attempt to determine our overall health. Until recently, monitoring these metrics outside the office, and over long stretches of time, would have been neither affordable nor efficient. Today, however, the average person carries a versatile medical gadget on them at all times.

"A smartphone has become a medical device of the highest potential," says Sreeram Ramakrishnan, manager of Insights-driven Wellness Services with IBM's Health Informatics group. "The type of sensors that have already evolved are clearly establishing that there's no technological limit. You could capture almost anything you want."

The Owlet Smart Sock wirelessly transmits a child's health data to a parent's smartphone via Bluetooth 4.0.
Credit: Owletcare.com

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NEWS

ACM Transactions on Computing for Healthcare (HEALTH) is a multi-disciplinary journal for the publication of high-quality original research papers, survey papers, and challenge papers that have scientific and technological results pertaining to how computing is improving healthcare. This journal is multidisciplinary, intersecting CS, ECE, mechanical engineering, bio-medical engineering, behavioral and social science, psychology, and the health field, in general. All submissions must show evidence of their contributions to the computing field as informed by healthcare. We do not publish papers on large pilot studies, diseases, or other medical assessments/results that do not have novel computing research results. Datasets and other artifacts needed to support reproducibility of results are highly encouraged. Proposals for special issues are encouraged.

SOCIAL MEDIA

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NHS, UK



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The Topol Review

«Genomics, digital medicine and AI will have a major impact on patient care in the future. A number of emerging technologies, including low-cost sequencing technology, telemedicine, **smartphone apps, biosensors for remote diagnosis and monitoring**, speech recognition and automated image interpretation, will be particularly important for the healthcare workforce.»




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The Top

«Genomics, digital medicine and AI will have a major impact on care in the future. Emerging technologies such as low-cost sequencing, telemedicine, smart wearables, biosensors for remote monitoring, speed of diagnosis, automated image interpretation will be particularly important for the healthcare workforce»

5.0 Digital medicine

New digital technologies have the potential to transform how the NHS delivers care in the decades to come, for example, through faster and more reliable diagnosis of infectious diseases, empowerment of patients to monitor and manage their long-term conditions, promotion of health and wellbeing through personalised apps, and the delivery of care outside of traditional healthcare settings through remote monitoring.



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45

(3.1) Top technology descriptions

Smartphone apps

The app allows patients to:

- **check their symptoms** using NHS 111 online and/or the symptom checker on the NHS website;
- **book and manage their appointments** at their GP practice;
- **order repeat prescriptions**
- securely **view their GP medical record**;
- register as an organ donor; and
- choose whether the NHS uses their data for research and planning

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(3.1) Top technology descriptions

Sensors and wearables for diagnostics and remote monitoring

Today an estimated **70-80% of all clinical decisions rely on the result of a test**, typically performed in a centralised NHS pathology lab.

Advances in sensors and wearables are already beginning to **bring diagnostics and monitoring ever closer to the patient**, including on hospital wards, out-patient clinics, A&E, GP surgeries, pharmacies and in the home.

48

(3.1) Top technology descriptions

Point-of-care and self-tests

Advances in sensors harnessing ultra-sensitive bionano-technologies will transform the rapid diagnosis of disease at the point-of care, and could result in earlier diagnosis, faster access to treatment, improved antimicrobial stewardship, better health outcomes and disease prevention.

49

(3.1) Top technology descriptions

Sensors for self-monitoring

Self-monitoring and self-management have been the cornerstone of Type 1 diabetes management for three decades, since the first finger-prick blood glucose meters became widely available in the 1980s.

The advent of Bluetooth-enabled glucometers linked to smartphones has **made self-management easier to integrate into the activities of daily life.**

50

(3.1) Top technology descriptions

Wearables for remote vital-sign monitoring

There is an **increasing acceptance of the use of wearable sensors** (including the in-built cameras and accelerometers of smartphones) to track vital signs, such as heart rate and abnormal rhythms, respiratory rate, blood oxygen saturation and blood pressure.

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(3.1) Top technology descriptions

Video cameras for patient monitoring

Hospitals and care homes in which frail and elderly patients with cognitive impairment are being cared for usually have video cameras installed in patients' rooms.

Computer vision and machine learning algorithms to analyse video data streams can transform the care of these patients, both through early detection of adverse events such as falls and through presenting objective reports of activity and health data to help healthcare professionals proactively plan care.

52

(3.1) Top technology descriptions

Remote monitoring

The sharing of patient-generated data with the healthcare workforce enables remote monitoring, but this **needs to be integrated within clinical pathways**.

As digital technologies become more prevalent, there is a risk that a deluge **of automatically transmitted data will overwhelm healthcare professionals**.

The application of AI to generate patient summaries may provide a clinically useful solution to this problem.

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Digital technologies have transformed most sectors which affect our daily lives, from communications to transport, banking and entertainment, but not yet healthcare. This is now changing as electronic patient records and online services, as well as wearables, smartphones and apps, are beginning to have a positive impact on the NHS and its workforce.”

Professor Lionel Tarassenko

54

“

Digital te...
affect our...
banking a...
changing...
well as w...
a positive...
impact on the NHS and its workforce.

Professor Lionel Tarassenko

5.2 Healthcare professionals

Almost all areas of the workforce over the next 20 years will be affected by the adoption of digital technologies within the NHS and will need to be trained accordingly. **At the heart of digital transformation is the opportunity to improve the quality and efficiency of interactions between patients, healthcare professionals and the healthcare system.**

To achieve this ambition requires substantial investment in the training of healthcare professionals, as well as the creation of new roles in data science, data security, ethics, human factors and implementation science. Investment in current staff should enable them to develop specialist digital skills, including the commissioning of digital technologies through continuous professional development (CPD), sabbaticals and secondments (DM3).

55

The next 20 years

The convergence and complementarity of the three major technologies – genomics, sensors and AI – will enable the development of virtual medical coaches

Inputs

- Social, behavioral
- Genomics and -omic layers
- Biosensors
- Immune system
- Gut microbiome
- Anatome
- Environmental
- Physical activity, sleep, nutrition
- Medication, alcohol, drugs
- Labs, plasma DNA, RNA
- Family history
- Communication, speech
- Cognition, state of mind
- All medical history
- World's medical literature, continually updated

Algorithms

Output

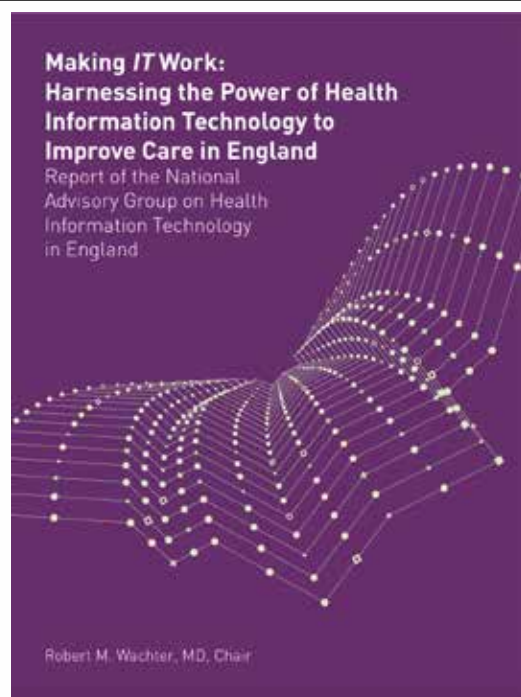
Virtual health guidance

Figure 2: The virtual medical coach model with multi-modal data inputs and algorithms to provide individualised guidance.¹⁰⁵

60

The Wachter Report

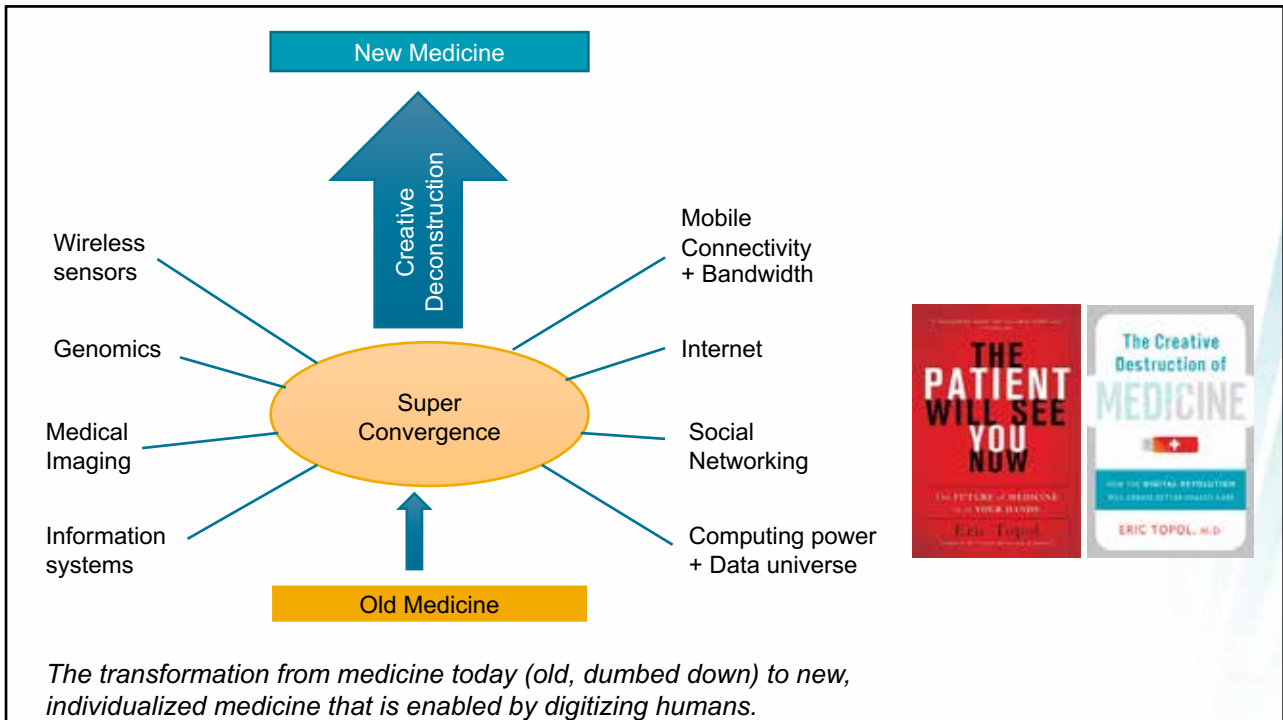
“To those who wonder whether the NHS can afford an ambitious effort to digitise in today’s environment of austerity and a myriad of ongoing challenges, we believe the answer is clear: **the one thing that NHS cannot afford to do is to remain a largely non-digital system. It is time to get on with IT.”**



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THE NEW DIGITAL MEDICINE

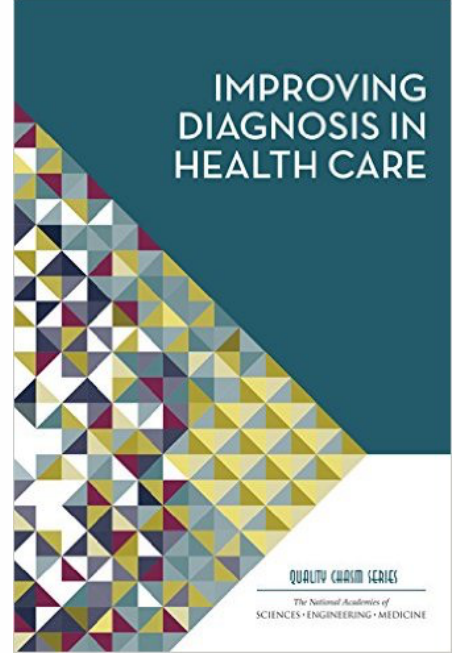
64



66

The next big goal in health care

67

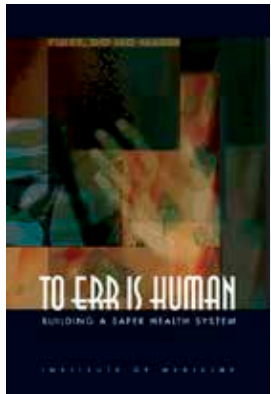


IMPROVING
DIAGNOSIS IN
HEALTH CARE

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450 pages (2015)

Improving Diagnosis in Health Care exposes a critical type of error in health care—diagnostic error—that has received relatively little attention since the release of *To Err Is Human*.



TO ERR IS HUMAN
BUILDING A SAFER HEALTH SYSTEM
INSTITUTE OF MEDICINE

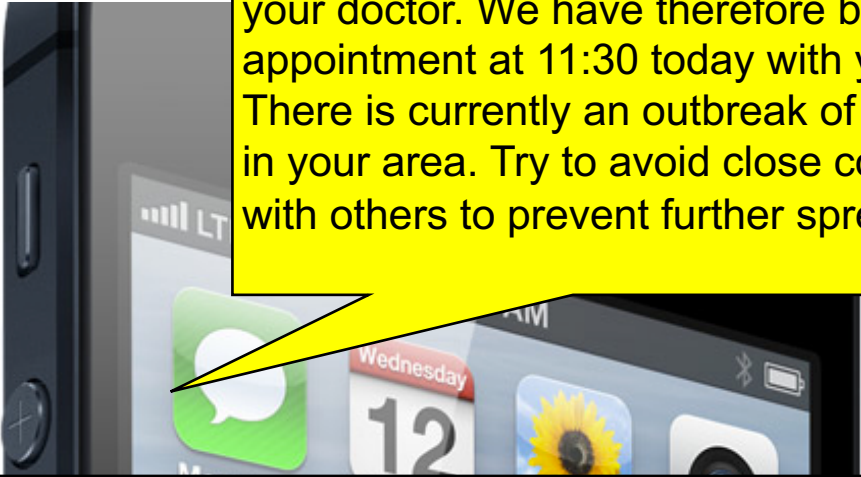
287 pages (2000)

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**AN EXAMPLE
FROM OUR
OWN RESEARCH**

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The combination of sensor-based and syndromic monitoring



You have an infection. Please contact your doctor. We have therefore booked an appointment at 11:30 today with your GP. There is currently an outbreak of influenza in your area. Try to avoid close contact with others to prevent further spread.

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MOBILE HEALTH

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11 surprising mobile health statistics

March 20, 2019 in [mHealth](#)



Mobile health may seem like old news, but smartphone use for health and fitness is still growing fast in 2019. There are more mobile device users and mHealth apps than ever before. Most smartphone owners have downloaded an mHealth app and nearly every physician brings a smartphone to work. In this world of healthcare on-the-go, here are 11 mHealth statistics that will surprise you.

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mHealth is increasingly accessible

- 81 percent of American adults have a smartphone
- There are now 318,000 mHealth apps available in major app stores
- Over 60 percent of people have downloaded an mHealth app

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Smartphones enable healthcare

- Most smartphone users have used their device to gather health-related information
- 90 percent of physicians already use smartphones at work
- Two-thirds of the largest US hospitals offer mobile health apps

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Patient engagement is often mobile

- 43 percent of millennials prefer to access patient portals from their smartphone
- 74 percent of patients say using mobile apps wearables and other mHealth tools helps them cope with and manage their conditions

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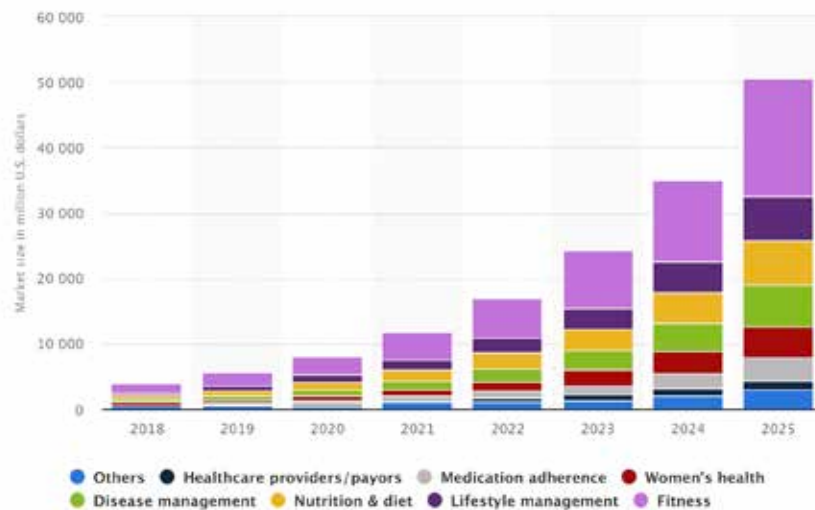
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mHealth creates value and revenue

- 85 percent of health insurance companies think mHealth creates value
- The biggest cost saving benefit from mHealth apps
- The global mHealth app market is growing fast

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Mobile health apps market forecast in the United States from 2018 to 2025, by type (in million U.S. dollars)

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