BIG DATA IS CHANGING MEDICINE

"Health is too precious to be left to the medical profession alone"

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ABSTRACT

Within this short essay, we provide an overview of the development of "big data" and its possible influence on medical practice. In particular, we explore the underlying technology and demonstrate with practical examples how big data will sooner or later lead to the dissolution of economic consulting and treatment monopoly of classical medicine.

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I.   INTRODUCTION

To understand the extent and importance of global electronic data exchange, as it is termed by "big data", one needs to pay attention to the past and present of the internet. Since the launch of the world-wide web exactly 40 years ago (by linking four military computers in a very spartan network at that time), a development has taken place that equates to the invention of electricity.

Today, more than 340 million domains (addresses in the word-wide net) are available to the user worldwide with more than 500 endings (.com, .de, .info, etc.). The full implications of these developments only become clear by realizing that of the approximately 7.6 billion people worldwide, more than 55% already have access to this information system.[3] Even more impressive is the prevalence of mobile phones with approximately 66% of the global population having access to a cell- or smartphone; trend rising with an average double-digit percentage gain every year. One explanation might be the fact that emerging economies with lacking infrastructure, unlike industrialized countries, often skip household cable connections and directly provide wireless smartphones instead. As a consequence, also in these countries, a permanent availability of people of about 80% can be realized in the up-coming years.
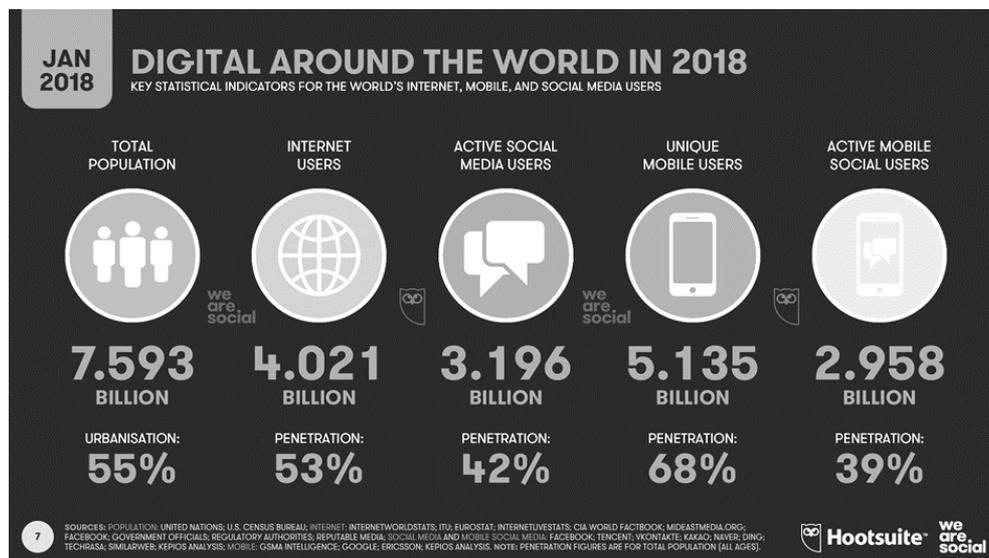

Fig. 1: Digital around the world in 2018[4]

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[3]   WeAreSocial, *Global Digital Report 2018*, (Apr. 19, 2019, 01:00 PM), https://wearesocial.com/blog/2018/01/global-digital-report-2018.

[4]   WeAreSocial, *Global Digital Report 2018*, (Apr. 19, 2019, 01:00 PM), https://wearesocial.com/blog/2018/01/global-digital-report-2018.

II. DEVELOPMENT OF THE TECHNOLOGY

Precondition for the transmission and processing of relevant amounts of data are fast and inexpensive computers as well as the provision of sufficient storage capacity with fast access times.

A. Computer Speed

Precondition for adequate data processing is computer speed, which is measured in terms of the number of floating point operations per second (flops). The first computers started with two operations / second (2 flops) in 1941 (computer Zuse Z3, Germany). However, the current record was achieved by an United States supercomputer "Summit" in the Oak Ridge National Laboratory with an output of 200 petaflops (200 quadrillion calculations / second).[5]

B. Data Storage

In addition to a high computing power for the processing of stored data, affordable storage media is required. While in 2003, a gigabyte of hard drive space was about 1.25 euros, this price has dropped to well below 4 cents per gigabyte today with a further decreasing trend. The way and access have changed dramatically in recent decades. First, the floppy disk with 400 kilobyte memory capability was the measure of all things. However, in later years floppy disks and Magneto-Optical (MO) disks, rotating storage devices, magnetic tapes as well as digital storage media (SSD flash memories) took turns. To what extent mass storage devices might be based on biological foundations (proteins or bacteria) in the future, is the subject of current research.
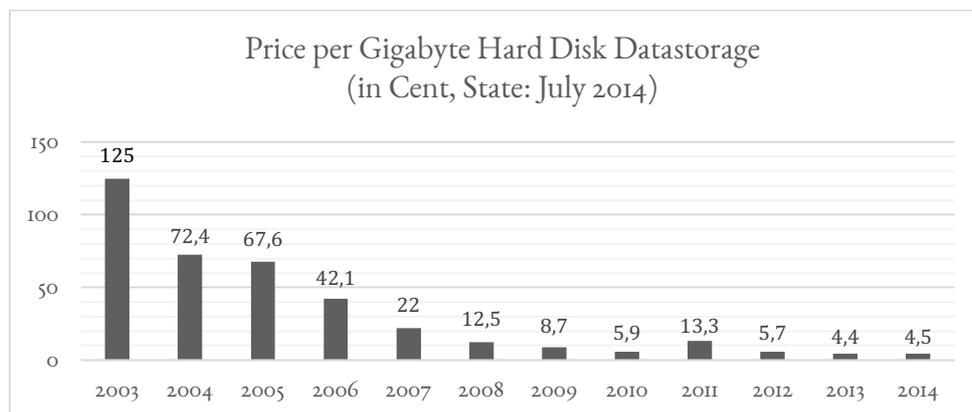

Fig. 2: Dramatic price decline in hard disk storage[6]

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[5] *Summit - America's newest and smartest computer*, (Apr. 19, 2019, 01:00 PM), https://www.olcf.ornl.gov/summit/.

[6] Mathias Brandt, *Dramatischer Preisverfall bei Festplattenspeichern*, STATISTA (Apr. 24, 2019, 11:10 AM), https://de.statista.com/infografik/2544/entwicklung-preis-pro-gigabyte-festplattenspeicher/

C. Transmission Speed

For a save and fast forwarding of data, wireless transmission of information over almost arbitrarily large distances is required. Also here, technology has made great achievements in recent decades: Following the transmission standard for mobile phones 3 G with 100 msec., 4 G with 30 msec., soon there will be a 5 G network with a transmission time of 1 msec., meaning that almost real-time will be reached.[7]
The computing power of the mainframes achieved in recent years, but also the development of smaller powerful computers with increasingly cheaper mass storage, have led to a rapid spread of the Internet and the possible use of smartphones worldwide.

III. E-HEALTH AND CLASSIC MEDICINE

A Measuring instruments for everyone

The ubiquity availability of smartphones, with which one can not only make phone calls, take pictures, play games or watch films, has led to the development of a large number of independent programs on the smartphone. In particular, programs for personal monitoring of body functions - detected by sensors on the back of fitness trackers or wristwatches - are popular. Therefore, a variety of apps, with which data of the own body can be gathered and evaluated, use the smartphone as a temporary storage "of the collected data".[8]

In the small I-cell program, parameters such as pulse rate, body temperature, number of steps, distance traveled, oxygen saturation, skin conductivity, blood pressure, weight, resting periods, sleep / exercise, blood sugar, etc are then available to the user for personal evaluation. Most recently, handy chromatographs, similar to the tricorder ("Bones" from the series "*Starship Enterprise*" already had such a device) show possible ways of further advancement to capture additional data of people.

B Test results for everyone

Besides capturing a variety of data around our body, it would be impressive to be able to extract parameters from our blood and add it to the data potpourri. In this regard, an American company (Theranos) accompanied with an US-department store chain, in fact, had developed a 4-hour analysis service for the most important 20 blood parameters using only one single drop of blood. Results then were made available to the sender via Internet.

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7   Kenichi Yamada & Kim Jaewon, *Fast but patchy: Trying South Korea's new 5G service*, NIKKEI ASIAN REVIEW (2019), (Apr. 24, 2019, 11:23 AM), https://asia.nikkei.com/Spotlight/5G-networks/Fast-but-patchy-Trying-South-Korea-s-new-5G-service.

8   *iHealth*, (Apr. 19, 2019, 01:00 PM), https://ihealthlabs.eu/de/.

Although this service has been withdrawn from the market, it reflects how further analysis- and advisory-offers might be developing.[9]

C. Analysis of genetic material for everyone

Another example represent individual gene analyses, as provided by the company 23 and Me, which make gene analyses available to everyone.[10] Using oral mucosal smear, within 14 days, the company prepares a list for different disease probabilities costing the individual less than $150 – this, of course, works via Internet.

D. Linking of data for everyone

While first, collected data were only available to the individual "smartphone owner", it is now possible to further process individual personal data collected by the smartphone without any problems. Large capacity computers that are able to store large numbers of individual medical histories (for example, the IBM project "Watson", the TK project "Ada", etc.) have been in use for years.

IV.   ALL FOR ONE, INSTEAD OF ONE FOR ALL

Until a few years ago, it was common in medical research to conduct experiments and obtain observations from one or few individuals and then to transfer those results to a large group of potential affected people. Not least due to almost infinite storage options and the high computing power, it is now possible to record data of all patients and to generate treatment recommendations that are based on analyses of multiple correspondences of individual patients. This paradigm shift in the diagnosis and treatment of rare diseases is the precondition for so-called "individual tumour therapies" and, at the same time, the basis to develop individual tumour-specific vaccines / therapy options.

V.   INDIVIDUAL USE

The importance of data collection for the individual assessment of health risks can be easily demonstrated by examples:

By knowing the weight development of a person within 24 hours, the drinking, sleeping and micturition behaviour, combined with the conductivity of the body surface as well as the body weight, the risk for the diagnosis of diabetes mellitus can be easily "calculated". This example may outline the options for generating specific diagnoses through merging of individual data. The development and practical evaluation of large amounts of collected data will be the subject of modern sales models of international corporations.

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9   Matthew Herper, *From $4.5 Billion To Nothing: Forbes Revises Estimated Net Worth Of Theranos Founder Elizabeth Holmes*, FORBES (June 21, 2016).

10   *23andMe*, (Apr. 19, 2019, 01:00 PM), https://www.23andme.com/.

Latest tests with the movement scanners in smartphones shows the possibility of early detection of Morbus Parkinson by analysing walking characteristics in patients suffering from this disease.

"Big data" as well is able to detect early symptoms of heartbeat problems as an early signal of incoming heart attack using the data of the smartphone...

Another example of new data processing options by "deep learning" with the use of neuronal networks is face recognition, which already is in use and far superior when compared to humans in the quality of results. The further development of "artificial intelligence" via Deep Learning and new technologies such as the use of neuronal networks for data processing will reveal to what extent the trained physician will withstand the attack by big data.

VI.   THE MEDICAL MONOPOLY FALLS

The worldwide growing desire for medical care is facing a relative shortage in medical availability. Especially in the so-called "industrial countries", demographic change with an increase of complex diseases due to the aging population leads to a lack - and therefore prize increase - of doctors. As a consequence, the limited medical capacity in the conventional sense has been the driving force for a large amount of developers to identify diseases and to calculate the individual's risk by comparing symptoms and individual parameters within large amounts of data. "Doctor Google" will increasingly take on a serious advisory role and, at best, complement, at worst, replace, the classic domain of the experienced doctor - the differential diagnosis.

With already 10% of the gross national product for the health market, this will create a great impulse to break the medical monopoly:

"Health is too precious to be left to the medical profession alone".

VII.   SUMMARY

The collection and linking of medical parameters and their interpretation is a new and prospering economic sector due to multiple options of complex data processing. However, this will sooner or later lead to the dissolution of economic consulting and treatment monopoly of classical medicine.

Using the smartphone as local data storage, the app as a data collector, and communication with large databases and correspondingly available mainframe capacities will result in the provision of complex differential diagnostic tools. Whether medical standards will be improved or only revealed to a broad marketing remains open.

At any rate, big data will significantly change the differential diagnostic practice and have a lasting effect not only on medicine, but will equally change other non-empirical sciences; for example case law.