Chapter 5

The Practice of Medicine in the Age of Information Technology

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Additional information is available at the end of the chapter

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Abstract

Regarding the practice of medicine, we have to face the chances and challenges of all aspects of e-Health; however, the term "digitalization" is broader and spanning all aspects. However, the digitalization of medicine offers solutions for pressing problem. We know the factors that lead to excellence in medicine. Without the right amount of experiences based on a solid ground of knowledge, no excellence is achievable. The problem, nowadays, is that due to restriction of working hours, to the goals of life ("life-work-balance") and the restrictions of Generation Y, almost no education in medicine is spanning the needed 10,000 h experiences in practical medicine for excellence. Therefore, we will see the fading of medical excellence, if we could not establish other systems. A solution can be searched in decision-support systems. However, a requirement before is the need of a digitalization of all health data. We surely do not have enough evidences for all aspects of the practice of medicine, the intuition is fading away and therefore, we have to look around for other solutions. Big data generated by the digitalization of all health data could be the problem solver. In combination, IT will help to improve the quality of care.

Keywords: quality, practice of medicine, digitalization, health care, intuition, big data, randomized controlled trial (RCT)

1. Introduction

Nowadays we found a lot of changes of the frame works for all professions. The terms "digitalization," "Internet of Things," "disruption," and "big data" cover some aspects of these changes on different hierarchical levels. Regarding the practice of medicine, we have to face the chances and challenges of all aspects of e-Health; however, the term "digitalization" is broader and spanning all aspects [1]. In the following chapter, I try to highlight some aspects especially in the face of practical medicine.

2. Excellence in the practice of medicine

We know the factors that lead to excellence in medicine. Without the right amount of experiences based on a solid ground of knowledge, no excellence is achievable. However, without knowledge and without the ability for processing the experiences, excellence cannot be found [2]. Therefore, experiences alone are not the key to excellence [3]. It is the combination of genius, knowledge base, and experiences. Simon and Chase have found for master chess player that 10 years of practice are necessary [4]. In that time period, around 50,000 different patterns are stored that are essential for the intuitive part of the game. Ericsson was able to extend these findings to musicians and physicians [2]. For excellence, you must be worked in practice for about 10,000 h.

However, let us have a closer look to excellence in the practice of medicine. Colleagues were asked what makes the difference regarding excellence in their colleagues [5]. They gave four factors:

1. Extensive practical experiences.
2. Master in taking the medical history from patients.
3. Precise and critical integration of all information into the process of diagnosis reasoning.
4. Continuous learning of clinical practice.

In internal medicine, the process of diagnostic reasoning is key to excellence [6]. This process can be divided into two parts:

System 1: Intuition

System 2: Analysis

Both have different properties (**Table 1**). For the doctor in the practice of health care, due to time pressure and the big number of patients and problems a typical doctor has to treat, handle, and solve in short time, the system 1 (intuition) is the only practical way, that is in most part confined to the amount of experiences made before. However, from time to time,

System 1: Intuition	System 2: Analysis
Experimental-induction	Hypothesis-deduction
Rational limitations	Rational unlimited
Heuristic	Normative
Pattern recognition	Robust decisions
Modular ("hard-wired") decisions	Critical-logical thinking
Guidance by pattern recognition	Decision trees
Gut feeling	Logical reasoning

Table 1. Medical decision-making after Croskerry [6].

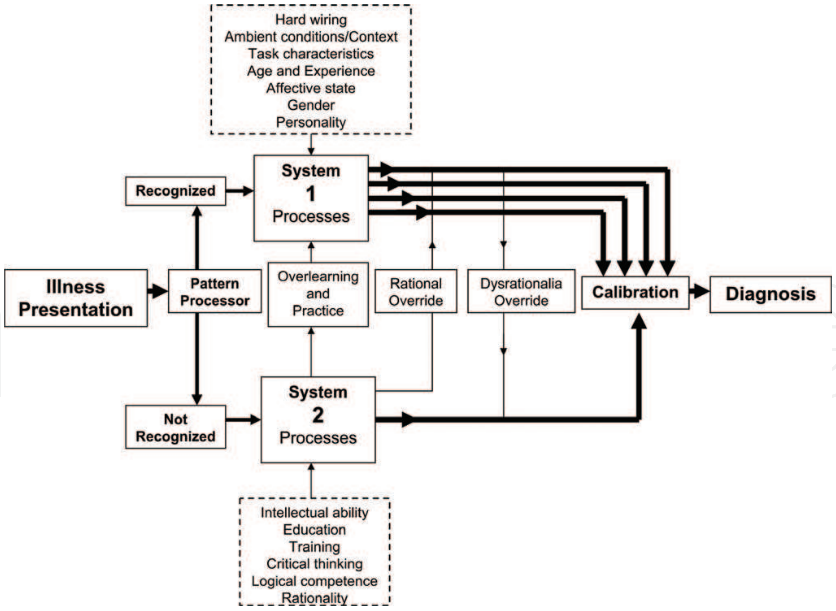

Figure 1. Combination of System 1 and System 2 in diagnostic reasoning [6].

the doctor will face a problem, he cannot solve by intuition, then he has to go to system 2 (analysis), that is time-consuming. Ideal would be an automatic adjustment of both systems in all decision-making during the process of diagnostic reasoning (**Figure 1**).

The problem nowadays is, that due to restriction of working hours, to the goals of life ("life-work-balance") and the restrictions of Generation Y, almost no education in medicine is spanning the mentioned 10,000 h experiences in practical medicine. Therefore, we will see the fading of medical excellence, if we could not establish other systems to replace system 1. The United States was leading in guarantee excellence in medicine by education since the days of Flexner [7]. The base of the excellence, however, was the precise and holistic learning of the medical knowledge base [8]. This is under pressure [9–11].

A solution can be searched in decision-support systems. However, before we need a digitalization of all health data. Electronic patient records are the key to accomplish that task [12]. Since we do not have the holistic solution, interfaces, and standards for that interfaces are highly needed [13, 14]. The analysis of data from the health system, often called "big data," is confined on a solution to those issues. Algorithms should give help in a world of overwhelming information load for the doctor and should release him from the pain of long working hours. This is the promise of big data from the viewpoint of the practitioner.

3. Big data versus randomized controlled trials (RCT)

Measurement of quality in diagnostic reasoning and decision-making is the evidence-based decision, based on precise evidences generated, at best, in randomized controlled trial (RCTs) [15]. RCTs revolutionized medicine and yearly we get the evidences from 40,000 trials [16]. However, we surely do not have enough evidences for all aspects of the practice of medicine,

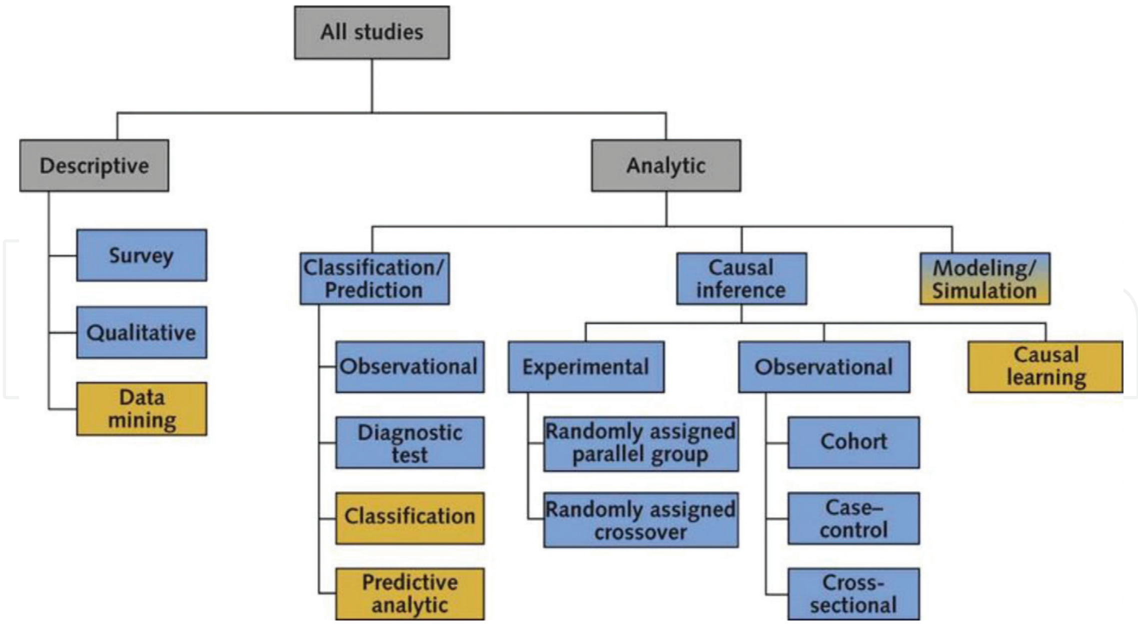

Figure 2. Big data (yellow) and randomized controlled trials (RCT = blue) [17].

the intuition is fading away and therefore, we have to look around for other solutions. Big data could be the problem solver [16]. The combination of RCTs and big data could be key to assure the quality and excellence in medicine in the future (**Figure 2**) [17].

4. Impact of modern machine learning in todays and future medicine practice

Machine learning (ML) technology already has a big impact on today's medical practice. From image classification in radiographs, over epidemic outbreak prediction to genome sequencing, computer algorithms become more and more prominent in modern medicine [18–21]. Projects of major companies like IBM Watson or Google's Deep Mind Health as well as numerous smaller privately and publicly funded research projects are pushing forward to close the gaps between medicine, mathematics, and computer science [22].

For narrow applications with clear regulations, ML algorithms already outperform human capabilities by far and even create new unseen strategies as recently shown by Google's Alpha Go Zero [22]. In this case, a self-trained algorithm mastered the game—more complex than chess—in less than 3 days. Although it has to be mentioned, that the reinforcement learning strategy used in this case might not be suitable in many medical applications, it is an indication of the potential of modern learning algorithms.

A closer look on the technology gives hope, that similar algorithms will not be limited to single and narrow applications, but rather can evolve in order to address the challenges of preserving the knowledge and intuition of experts and improve the quality of RCTs.

The reason for the great potential of machine learning lies in the nature of most of these new algorithms. Regardless whether Random Forests, Support Vector Machine or—most popular

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today—Deep Neural Networks are applied, they generate their functionality by converting the information contained in thousands and even millions or billions of examples into a highly nonlinear mathematical model [23–25]. In some ways, this is similar to the human learning process and hence may be the appropriate tool for conserving human experience in such models.

With medical data becoming increasingly available in a digitalized form, not only by clinical trials but rather from every day medical practice, the databases grow in size and in depth [26]. This provides the possibility for algorithms not only to become more precise in their predictions but also to become more general in a sense that they can include a huge variety of factors in their decision process. Some aspects of a fading in intuition may so be replaceable by recommendation systems not based on thousands of hours of experience but of millions of decisions already made by experts in the past. Of course, so far, humans are still more efficient in their learning capabilities, but the pure scale of data contained in the algorithmic models may overcome this lack in efficiency. Nevertheless, recommendation systems driven by machine learning algorithms are more likely to complement a physician's intuition in the very near future, than to completely surrogate it.

In a similar manner, classical RCTs can benefit from big data. In semi-supervised learning, for example, datasets of known and unknown outcomes are considered. Here one task is to identify corner cases in the data in order to increase the model accuracy most efficiently [27]. Such methods could help to identify suitable candidates for clinical trials to make their results more robust. Another opportunity in this direction is the analysis of already trained models by feature extraction methods, which may generate promising hypotheses for further investigation in RCT. Finally it is to mention, that although RCTs form the scientific backbone of medicine, factors like publication bias and poor reproducibility rates show, that permanent monitoring of standard clinical practice is necessary [28, 29]. The ability of machine learning algorithms to constantly adapt to new situations, they seem to be predestined for such a controlling task.

5. Conclusion

The excellence in the practice of medicine was bonded to long working hours and a relative small knowledge base. Nowadays, the framework for the practice of medicine is protecting the rights of the individual regarding long working hours, however, in combination with the fast growing of the knowledge base, the practice of medicine is under pressure regarding quality and excellence. The big data approach could help find a solution; however, the digitalization of all data used in the practice of medicine before are warranted. In combination, IT will help to improve the quality of care.

Conflict of interest

There is no "conflict of interest" declaration necessary.

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