Preface

During the nineteenth and twentieth centuries the art of medicine was advanced, especially with regard to therapeutic interventions. Now the focus has shifted over recent decades, we are able to look deeper and deeper into the micro-cosmos, observing and analyzing molecular structures, such as DNA, and even go beyond this looking at atomic and sub-atomic level, our ability to foresee is growing stronger. While the elders could only treat conditions they could grasp with their hands, digital imaging became the ultimate diagnostic weapon of the twentieth century, making smaller and smaller structural changes recognizable. This allowed faster diagnosis and treatment of diseases. While today prevention is based on early recognition, tomorrow's medical strategies will be based on anticipation. While no man can foresee the future we can learn from the past and apply the lessons learned in the present, thereby enabling the future. Medicine has always been in a creative dialogue right at the interface of art, philosophy and science. The evolution of medicine has always been driven by a combination of soft and hard factors; human factors—such as the reluctance to change, social and societal forces—such as ethics, legislation and economics and technical progress such as the evolution of machines and computers. All of these factors have contributed to the emergence of e-health and m-health in the late twentieth century.

Now, at the beginning of the twenty-first century we find ourselves (almost) ready to individualize health care by not only sequencing individual DNA and tracking down intra-individual changes in real time, but also to turn our newly

gained wisdom into individualized "theragnostic" strategies, which has already started to fundamentally change healthcare and the way it is delivered.

Twentieth century healthcare was driven by statistical averages, which were reflected in values defining normality, the type and dose of medication prescribed, the surgical approach to be chosen, etc., future practice will be turning away from generalization and move towards the definition of individual real-time requirements. Personalized medicine or precision medicine will allow for individualized treatment anywhere, anyhow and at any time.

At the same time, health monitoring and management will become more personal and timely as new technologies will enable individuals to conduct routine health monitoring and management activities on the go using virtualization tools and cyber-physical systems based on Industry 4.0 design principles connecting the physical and the virtual world in real time. However, safety, security and privacy aspects are of utmost importance for Health 4.0 strategies to thrive and unfold their beneficial potential. New network technologies, such as the 5th generation network (5G) will enable ubiquitous access, enhance connectivity and allow the ad hoc orchestration of services, integrating patients, formal and informal carers, social workers and medical practitioners.

Smart algorithms will allow for the monitoring and enhanced management of especially chronic, non-communicable conditions such as asthma, diabetes, multiple sclerosis or cancer. The prime target of these technologies will be to enable lower qualified individuals to conduct the routine tasks of higher qualified individuals and identify patients in need of expert attention or intervention.

Virtualization in the health domain comes with the emergence of next generation mobile network strategies (5G). While the global pick-up rate of e-health and m-health technologies has so far been patchy and behind expectation, new network technologies will provide the missing pieces towards comprehensive care virtualization:

- 100 times more devices to be able to connect
- Reduction of latency times below 5 ms
- Improvement of coverage
- Enhancement of battery life
- Improvement of security, quality of service (QoS) and quality of experience (QoE)
- Enhanced bandwidth
- Enabling the (medical) Internet of Things

The Health 4.0 approach, which is derived from the manufacturing industry's well-known Industry 4.0 concept, will ultimately turn into a win-win situation for all stakeholders as it enhances and facilitates a collective approach towards a manageable future in the light of changing socio-economic conditions. However, Health 4.0 is a chance to turn these socio-economic challenges into economic opportunities given the fact that the average Chinese spending on healthcare is around 5% of the GDP while European spending is around 10% of the GDP and rising. This is only topped by the US economy where around 18% of the GDP is spent on healthcare.

It is thus exciting to see how the move towards virtualization under a Health 4.0 framework may enhance our capability to expect the unexpected and thus enable us to cope with emerging challenges such as the growing concern of resistance to antibiotics, malaria, viral outbreaks and cancer and increase effectiveness and efficiency of care.

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