Healthcare 4.0: An Introduction

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ABSTRACT

The rapid increase in population, rising burden of noncommunicable chronic diseases (such as diabetes and obesity), care costs skyrocketing, and the global shortage of doctors, nurses, and technicians are leading to an increasing demand for resources to support healthcare. These global challenges will seriously affect the healthcare delivery is the US and around the world. The current technological advancements are leading to the emergence of the so-called Health 4.0 revolution. Healthcare 4.0 has the potential to enable new healthcare-related processes (such as home care and personalized treatments) and transform them into services. This paper provides an introduction to the emerging area of Healthcare 4.0 and identify its opportunities, benefits, and challenges.

KEYWORDS: Industry 4.0, Healthcare 4.0, Health 4.0

INRODUCTION

Healthcare plays a major tole in the growth and well-being of any nation. The healthcare industry sector can be divided into four segments [1]: (1) Health care services and facilities; (2) Medical devices, equipment, and hospital supplies manufacturers; (3) Medical insurance, medical services and managed care; (4) Pharmaceuticals.

Healthcare is under tremendous pressure to deliver superior health outcomes, comply with regulations, achieve customer satisfaction, reduce cost of care, ensure patient safety, and handle financial constraints and budget reductions. Some of the challenges are illustrated in Figure 1 [2]. The healthcare industry is in dire need of the improvements that digitalization will bring in terms of saving costs, improved diagnostics, and more effective care. Healthcare 4.0 has the potential to offer realistic solutions to handle these challenges.

FUNDAMENTALS OF INDUSTRY 4.0

The fourth industrial revolution is commonly referred to as Industry 4.0 (or I4.0). The term "Industry 4.0" came from the German term "Industrie 4.0," which was first used in 2011 in a project sponsored by the German government that was meant to promote the computerization of manufacturing.

Industry 4.0 is powered by the technologies originated from manufacturing industries.

These technologies include the Internet of Things (IoT) or Internet of Medical Things' (IoMT), Internet of Services, Industrial Internet of Things (IIoT), big data analytics, artificial intelligence (AI), cloud computing, cyber and physical systems (CPS), robotics, advanced materials, additive manufacturing, machine learning, cybersecurity, and mobile devices. Some of these technologies are shown in Figure 2 [3]. They help create digitized healthcare products and technologies, as well as digitized healthcare services and enterprises.

Industry 4.0 refers to the current trend of automation and mployment of Internet technologies in manufacturing. This includes using machine-to-machine and Internet of things (IoT) deployments to help manufacturers provide increased automation, improved communication and monitoring. This trend of the Industry 4.0 affects most processes, people, and processes throughout the society. Industry 4.0 is an emerging network approach where components, processes, and machines are becoming smart. It enables companies to achieve faster innovation, increase efficiencies, produce customized products of higher quality, and expand the boundaries of innovative, new manufacturing opportunities. Factories will gradually become automated and self-monitoring as the machines are given the ability to communicate with each other and their human co-workers. The major applications of Industry 4.0 are smart factory, manufacturing, smart product, and smart city [4].

CONCEPT OF HEALTHCARE 4.0

The healthcare extension of Industry 4.0 is known as Healthcare 4.0 or Health 4.0 in short. Healthcare 4.0 extends the concept of Industry 4.0 in a scenario where healthcare organization is an integrated center capable of providing the

patient with a personal care service. The scope of Healthcare 4.0 is broad and is characterized by a fusion of technologies across physical, digital, and biological domains. The major technologies that can significantly contribute in realizing the objectives of Healthcare 4.0 include [5]:

➢ **The Internet of Medical Things (IoMT):** This is a healthcare application of IoT technologies and envisions a network of connected devices that sense vital data in real time. It drives the next generation of connected healthcare, with the capability to store and process scalable sensor data (big data) for health care applications. The Internet of Services (IoS) paradigm can connect gadgets intelligently.

➢ **Artificial Intelligence (AI):** In AI, machines are programmed to develop cognitive functions for learning and problem solving. AI uses the power of predictive analytics to accelerate healthcare. It has the ability to sift through large amounts of information. AI-based technology has the potential to assist physicians in diagnosing diseases. Without doubt, AI will drive the healthcare of tomorrow.

➢ **Cybersecurity:** Healthcare is one the most targeted industries when it comes to cyberattacks. This could put patients in danger. Patient records, such as EHRs, are sought after by hackers. It is up to suppliers and the hospitals to work together to deliver security to the patient's identity.

Other technologies include genetic engineering, synthetic biology, nanotechnology, data science, bioinformatics, the healthcare informatics, the cyber-physical systems, the Internet of things (IoT), robotics, drones, blockchain, cloud computing, 3D printing (additive manufacturing), and the information security. These technologies are shaping the way we treat patients.

APPLICATIONS
Healthcare 4.0 is a disruptive process of transformation of the entire healthcare value chain ranging from medicine, medical equipment production, hospital care, remote care, healthcare logistics to healthy living environment. However, the implementation of Industry 4.0 in healthcare will be a transitional process for the healthcare industry because of the importance in retaining compliance and the need to prove quality systems. The following are common applications of H4.0 [6].

➢ **Personalized Medicine:** This is basically tailoring of disease treatment to a specific person, taking into account their genetic and biological makeup, the environment in which they live. It also identifies what the best sequence of care is for a given patient. Collaboration, coherence, and convergence will make healthcare more predictive, precise, and personalized.

➢ **Smart Manufacturing:** More and more technologies incubated in manufacturing industries driven by Industry 4.0 are being adopted in healthcare industries and services. Medical device manufacturers are facing challenges in terms of price, speed to market, increased product complexity, and more stringent regulatory compliance. The pharmaceutical manufacturing has paid much attention on producing safe and quality products. The manufacturing control of pharmaceutical production should be self-organized and flexible enough

to meet external market's demands. Providers of service and goods need to work together with consumers to ensure their adaptability to smart product characteristics.

➢ **Smart Hospitals:** Many hospitals are still working towards becoming "connected" or smart. The digital revolution is arriving at a hospital near you. Smart hospitals are dictating the way in which they purchase equipment. The demand on hospitals is to make them an integrated center able to provide the patient with a personal care service. Besides improving patient outcomes, leveraging on Healthcare 4.0 will help hospitals address global operational challenges.

Other applications include Intensive Care Unit (ICU), telemedicine, and digitalized surgery (or surgery 4.0).

BENEFITS AND CHALLENGES
Healthcare 4.0 is about capturing the huge amounts of data and putting it to work in applications. It offers medical device manufacturers some benefits. Healthcare 4.0 is a key enabler for high value care. Pharmaceutical industry industries tend to shift from being just medications manufacturers to being healthcare service providers.

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Healthcare 4.0 faces some significant challenges including the reliability and latency issues of high speed data networks, the acceptance of robotics in clinical practice, the human safety issue during human-robot interaction, and the corresponding legal issues. The field of healthcare is burdened with regulatory compliance and strict regulation. Healthcare organizations, governmental agencies, and healthcare professionals need to discuss the challenges involved in implementing healthcare 4.0.

CONCLUSION
The digital age has arrived. Digitalization of healthcare may be denominated as "healthcare 4.0." The digital revolution is arriving at a hospital or clinic near you.

Healthcare 4.0 is a strategic concept derived from the Industry 4.0 concept. Those who ignore the opportunities I4.0 offers will be in serious danger of not being able to compete in the near future as others drive down manufacturing costs. More information on Healthcare 4.0 can be found in the books in [7,8].

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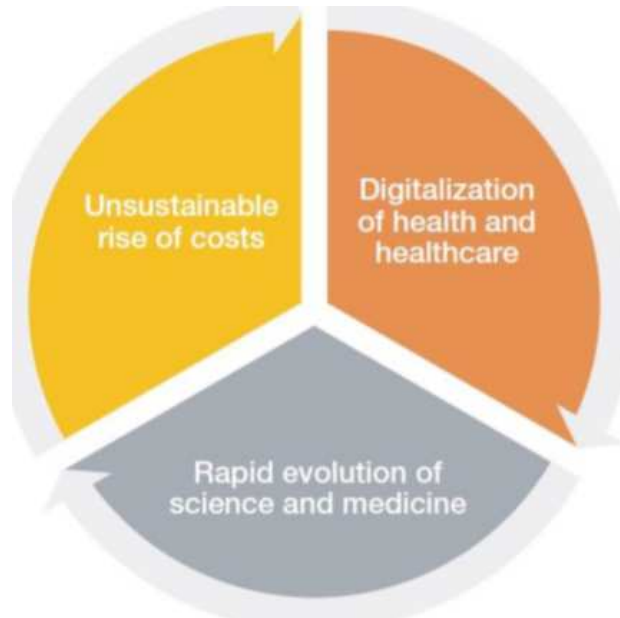
Figure1. Some healthcare challenges [2]

Figure2. Key technologies for Industry 4.0 [3]