



Digital Health Technologies and Big Data Analytics in Neurodegenerative Diseases

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Abstract

The use of digital technologies and computational approaches play a decisive role in smart, sustainable and inclusive development in health process. Data protection and information security are of the utmost importance to maintain public trust in digital health services. On the other hand for patients, digitization results in higher-level services, easily accessible to actively manage their health and well-being. Simultaneously, through the utilization of big data analytics, early diagnosis and prevention is supported for their benefit. Neurodegenerative diseases are a broad range of pathological conditions in most brain-related disorders that lead to progressive degeneration and/or death of neuronal cells. Computational approaches in neurodegeneration through machine learning techniques can be used for identifying features of importance in high dimensional data and provide constructive models of potential biomarkers, defining a new field of translation research in the new digital era. Based on the epigenetic history for each patient separately as well as the existence of underlying diseases, the presence of digital solutions can form an individualized strategy in terms of the personalized healthcare.

Keywords: Big Data; Digital Technologies; Neurodegenerative Diseases; Biomarkers; Translation Research

Introduction

Digitization puts the health industry in a new era, creating new possibilities for the patient and at the same time reducing costs, opening new horizons in research and development. The digitization of the health sector brings the patient first and foremost into focus, who will acquire the role of «consumer of health services» as they seek control over their health management, and by gaining access to information will multiply their options [1]. The area can be shaped based on the needs and expectations of consumer of health services, who will demand upgraded experiences, with the main characteristics being personalization, comfort, speed and immediacy in the provision of services [2].

The new challenge in healthcare is to combine medical expertise with other expertise in digital technology to deliver new products and services. This means creating medical value for the patient, resulting in improved patient care by healthcare professionals. In developed countries, pharmaceutical companies face significant restrictions on the drugs they produce and make available, both in regulatory compliance and in their budgets [3]. Their interest is therefore increasingly focused on offering products of great added value, not only in treatment, but also in compliance, side effect management and personalized patient monitoring. Healthcare is one of the most important and fastest growing industries in the world. The need for healthcare applications that can comply with the requirements of safety and

compliance of this industry is greater than ever [4]. At the same time, usability is becoming increasingly important in all industries, and healthcare is no exception. For example, virtual reality (VR) technology, such as for pain relief and rehabilitation, is a health technology innovation that is gaining popularity [5]. VR headsets allow the person to be transported to a different world, which can be used for a variety of purposes, including pain relief and rehabilitation as well as on mental health, an important issue that many people struggle with. Applications such as the Headspace, offers guided meditation and mindfulness exercises and has a tracking feature that lets you track your progress over time [6].

Neurodegenerative diseases are incurable and progressive diseases that debilitate the patient, bring about changes in the quality of life of patients and caregivers with the main symptoms being motor and mental disability and are due to the degeneration/death of nerve cell [7]. As a result, they have the progressively worsening disorder of many higher mental functions such as memory, speech, orientation, as well as disturbances in the patient's emotion, mobility and overall functionality. It is worth noting that neurodegenerative processes can differentiate their apoptosis machinery, or even control through signals mechanisms of neuronal death while recent advances in basic knowledge of these diseases have led to a reassessment of pathological processes about new therapeutic approaches, such as pioglitazone for Alzheimer's disease [8].

Neurodegenerative Diseases and Brain Disorders

Neurodegeneration includes a series of diseases that affect the neurons of the brain. Neurons are structural units of the nervous system that includes the brain and spinal cord which do not reproduce or renew themselves, so if they are damaged or die, they cannot be replaced by the body. Typical examples of neurodegenerative diseases are Parkinson's disease, Alzheimer's disease and Huntington's disease [9]. Neurodegenerative diseases are incurable conditions that cause disability and lead to the progressive degeneration and/or death of nerve cells. This development causes problems with movement (ataxia) or mental function (dementia). Globally, the percentage of the population affected by neurodegenerative diseases is constantly increasing which may be due to its increase life expectancy and population growth as these are diseases that they mainly affect elderly people [10].

In addition to the normal functioning of the nervous system, neuroscience also examines neurological, psychiatric or neurodevelopmental-neurodegenerative brain disorders. It is customary, however, to practically have a separation

between neuroscience and neurobiology - mainly on a practical and not always on a scientific level - aiming each field at the well- and poorly written counterparts of the functional and structural elements referred to in the Central Nervous System [11,12]. By extension, neuroscience focuses on clarifying and positively enhancing the functions and structures of neuronal systems, while neurobiology, on the other hand, mainly deals with the biological nature of these systems. Neurodegenerative diseases are characterized by progressive decline of the brain function, therefore, with a significant reduction in the patients' quality of life and their family. Among the main mechanisms related to neurodegeneration protein aggregation and degradation, oxidative stress and mitochondrial dysfunction are included. Moreover, these diseases have a physical, mental and social impact, and this impact extends beyond the obvious features of the symptoms of the disease [13].

Perspectives on Digital Technology in Neurodegenerative Diseases

Genetic and environmental factors play an important role in appearance of neurodegenerative diseases while various studies have confirmed that the environmental toxins are one of the major contributing factors in the development of neurodegenerative disorders such as excessive exposure to pesticides or heavy metals [14]. There is no complete therapy for neurodegenerative diseases, but some treatments that exist for these diseases try to reduce their symptoms and to maintain patients' quality of life usually by using drugs for control of symptoms [15]. This means that the prevention of the occurrence of these diseases acquires great need. If, however, the appearance of the disease cannot be avoided, it is important to make the diagnosis as soon as possible, so that there is room for even a partial reversal slowing the progression of the disease. Even when there are genetic factors that predispose to such a disease, lifestyle factors can affect it gene expression and thus suppress or reverse the mechanisms that lead to inflammation and degeneration.

Before diagnosis, computational approaches using feature selection algorithms and data acquisition are able to classify the population of produced biomarkers into groups with a degree of risk for a disease with emphasis on precision medicine [16]. The first stage can involve the introduction of new data mining technologies offering incredible possibilities for processing data in order to draw conclusions that cannot be executed with traditional database methods. Through this process, biomarkers can be correlated with each other and lead to the creation of decision trees through which the importance of each biomarker is proven [17].

The role of digital technology in neurodegenerative diseases is crucial. Digital health refers to service delivery

tools and services that use and integrate information and communication technologies to improve prevention, diagnosis, treatment, monitoring and management of health-related issues [18]. At the core of such a design is the systematic and strategic exploitation of real health-related data. The use of primary and secondary health data can reduce the time and cost of hospitalization, absence from work, prevent the onset of other diseases and contribute to more and better years of life. These data are included in the broader context of the category of big data based on their volume, their sources and management capabilities. The digitization of health contributes to better and more accurate diagnoses in patients with neurodegeneration as well as in the administration of more appropriate treatment after data analyses, at improvement and acceleration of clinical trials but also in the creation of documentation knowledge, skills and competences for health professionals [19]. Also, these processes help to offer effective and quality services to vulnerable groups of elderly people as well as in the organization and exercise of the work of professionals (digital archives, tools for detecting/assessing needs and malfunctions) in neurological clinics. Summarizing, digital solutions being developed in health today will define the future of medicine. Digital health solutions focus on prevention, early diagnosis and monitoring of disease as well as on education and guidance, assistance with treatment adherence, care coordination and remote monitoring. In the context of neurodegenerative disease, these processes can develop health applications for mobile devices, compatible with the conditions of development of new treatments, with specialized solutions that will satisfy the needs of patients, health care providers and all health professionals.

Conclusion

The potential benefits of integrating the analysis and utilization of big data into the digital health ecosystem are multidimensional. The introduction of digital health services, including remote data collection, surveillance, monitoring and human resource development, shows the potential for wider service development. It should be noticed here the existed ethical and methodological challenges based on these processes and the specific guidelines for analyses of these neurodegenerative patients datasets with full respect for patients' personal data to ensure the corresponding quality of conclusions? Focusing on neurodegenerative diseases and patients, digitization and computational processes can contribute to the planning of their activities, while assisting important also in matters of education and scientific training. In clinical field, early diagnosis and individualized treatment could lead to effective treatment of neurodegenerative diseases and limited side effects, improving the quality of life. Focusing on the health system, as the number of people living with neurodegenerative disorders has increased

worldwide and the enhanced costs are becoming a major health policy issue, new possibilities for rational planning of patients' treatment can lead to economies of scale, reducing unnecessary costs and saving resources.

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