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Letter to the Editor

The Fourth Industrial Revolution and Photobiomodulation

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As we approach a new period of unprecedented development in digital, physical, and biological technology, these three main drivers for the fourth industrial revolution as well as its applications are converging greatly.[1] Great Britain set the scene for the first industrial revolution, which introduced hydraulic and steam machine to factories. The second industrial revolution separated components and attained the assembly of products based on labor division, which accomplished an age of affordable consumer products from mass production. The third industrial revolution introduced successful application of electronic and information technology and the continuous automation of manufacturing process. Today we are standing on the edge of the fourth industrial revolution distinguished from the first three industrial revolutions by the vast application of cyber-physical systems in the manufacturing processes.[2] The fundamental background of the fourth industrial revolution is significant integration of intelligence and networking systems.[3]

The fourth industrial revolution will be seen in all aspects of the society, including technology, production, consumption and business, and it is influencing every aspect of human life while the first three revolutions are characterized by industrial production.[1] The fourth industrial revolution is able to reshape the landscape of healthcare, mobility and education systems worldwide, while influencing the functions and performance of the environmental community and its related institutions.

Global productivity growth from the First Industrial Revolution (1850–1910) and specifically the steam engine is estimated at 0.3%, the Third Industrial Revolution (1993–2007) IT and early robotics around 0.4–0.6%, while it is estimated the Fourth Industrial Revolution (2015–2065) and automation may lead to productivity growth of 0.8–1.4%. The global economy will be able to bounce back with new vitality and lead to significant growth in productivity as a result of the key role players, robotics, artificial intelligence, and machine learning in this important event or era of history. Significant growth and development in digital, physical, and biological systems will occur in this phase of our history.[4]

In less than a hundred years, the life expectancy of people will increase to almost 150 years. Patient self-management will become the norm and hospitals mere casualty units. Emergency medical care vehicles will be 5G-connected and by having access to digitized trauma data, critical care and procedures will be performed in transit. Small, wearable health-monitoring devices will allow early detection of chronic and noncommunicable diseases, including cancer and diabetes. Computer vision is allowing the visually impaired to "see"; dyslexia sufferers to read. Complex surgical procedures that currently are seen by surgeons through holographic robotics will soon be augmented by robots.[5]

Overlapping of technology and healthcare will introduce improved medicines of greater diversity and specificity to sick people, while biological sensors will dramatically improve early detection and diagnosis. Predictive diagnosis will allow preventive measures rather than reactive treatment of symptoms. Artificial intelligence using data will enable medical scientists to instantly access best-case history. Clinical practitioners will no longer need to face the impossible task of keeping up with new developments. Since the focus of healthcare should always remain with the patient and patient-care, individualization of patients and their particular sets of health characteristics, unique in each patient, will become the norm and improve clinical treatment. However, clinicians will never become obsolete but remain essential for detailed diagnosis and care. Sixty percent of deaths worldwide are a result of chronic diseases such as heart disease, cancer, diabetes, stroke, and arthritis, yet most are preventable or reversible with early diagnosis. Noninvasive, small, wearable devices may be able to continuously monitor vital and effectively and promptly register irregularities, which can potentially save millions of lives. Healthcare is a fundamental human right and enormous financial savings can be introduced by a new technology-driven approach that should rechannel funds for an improved broad-based healthcare system.

Photobiomodulation (PBM) is the application of low-intensity laser irradiation to biological tissue with the aim of stimulating cellular processes. Enhancing the activation of biochemical mechanisms induces activation of specific factors that contribute to healing, pain relief, reduction of inflammation, and tissue regeneration. PBM is the term used to describe the mechanistic basis for this phototherapeutic specialty and photobiomodulation therapy (PBMT) as the term for its therapeutic application. Although PBMT was developed and investigated in the 1960s, it is one of the greatest marriages between technology and healthcare and has long been underutilized and underestimated in its contributory role to healthcare in the fourth industrial revolution.

PBM as a therapy is cost effective, especially as a treatment option for cancer (photodynamic therapy), noninvasive, particularly applied for complex diseases of the eye, including

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macular degeneration, diabetic retinopathy, glaucoma, and retinitis pigmentosa, and highly effective for degenerative diseases of the central nervous system such as Alzheimer's and Parkinson's disease. In addition, it is environmentally friendly.[6]

Due to the technological development of light emitting diodes, which is physically able to resemble the same wavelengths, power densities, and fluencies of laser light, the scope of PBM has broadened to allow the average practitioner to use and apply this therapy. It has also enabled home care and self-treatment of the average person suffering from any of the wide variety of diseases and conditions to introduce this modality almost as a household item. Medical implants, prosthetics, and devices, manufactured to replace a missing biological structure, support a damaged biological structure, or enhance an existing biological structure, are man-made devices that are currently used extensively to improve patient care and life expectancy. Imagine millions of microscopic-sized light particles, tuneable and implanted to circulate the human system, detect and hone in on metabolic irregularities in the body, and diagnose, treat, and prevent disease development. Impossible? I believe not.

Considering the vast number of therapeutic applications that PBM offers as treatment for disease as well as the aspect of preventative, diagnostic, and therapeutic advantages, I believe that PBM may well be regarded as one of the most significant factors to contribute to healthcare in the fourth industrial revolution.

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