Editorial
Health Engineering: Convergence Transforming Reactive Medicine to Proactive Healthcare

NONCOMMUNICABLE diseases (NCDs), also known as chronic diseases, continue to be the leading causes of mortality and morbidity in the world. According to the World Health Organization, NCDs kill 41 million people each year, or are 71% of all deaths globally. Cardiovascular diseases account for most NCD deaths (17.9 million annually), followed by cancers (9.0 million), respiratory diseases (3.9 million), and diabetes (1.6 million). These four types of diseases account for over 80% of all premature NCD deaths [1]. Between 2010 and 2050, the proportion of the world's population older than 65 years of age will almost double, and that older than 85 will be 3.5 times as large [2], [3]. Mainly due to the increasing aging population, it is projected that total deaths from NCDs will continue to rise over the next decades if no effective and preventive measures are taken.

NCDs tend to be long and dynamic processes that begin before any symptoms and are the result of a combination of behaviors, lifestyle choices, and environmental, physiological, and genetic factors. Considering the future burden of NCDs and other unmet grand healthcare challenges, various national health policies and strategies have placed emphasis on their prevention and control. For example, the Healthy China 2030 Plan, drafted jointly by over 20 departments, has set a vision for a greater focus on prevention, rather than treatment, and for an expanded health industry through health sciences and technology innovation. It is the first medium in a long-term strategic plan developed at the national level in the health sector over the past 69 years since the founding of China in 1949 [4].

How do we achieve the goal of disease prevention? The seminal report by Sharp and Hockfield, two world-renowned biologists at the Massachusetts Institute of Technology, argue that truly major advances in the fight against NCDs, the diseases of aging, and other pressing health challenges will only come from a novel research strategy—convergence that integrates biomedical knowledge with advanced engineering skills and expertise from life sciences, physical sciences, mathematics, and information technology [5]. Convergence can enhance early diagnosis and early prevention. Sharp and Hockfield pointed out specifically that "catching problems at their outset can save on costly later-stage or last-minute treatment. Wearable smart devices that monitor health and wellness will alert patients and doctors to incipient health issues. Paired with advances in health information technologies that integrate molecular and genomic data, wearable monitors can help prevent disease progression. Meanwhile, algorithms to enable data-driven medical decisions can help doctors use the best available evidence quickly" [5].

Eric Topol, an eminent cardiologist and geneticist, captures the essence of the technical convergence of six major technological advances—smartphones, personal computers, the Internet, electronic devices and biosensors, genetic sequencing, and social networks—that are driving dynamics to precipitate a new era of proactive healthcare [6].

The convergence research model provides a blueprint for addressing society's most pressing health challenges and is leading to a revolutionized healthcare system that enables the *participation* of all people for the early *prediction* and *prevention* of diseases, such that *preemptive* treatment can be delivered to realize *personalized, precision, pervasive*, and *patient-centralized* healthcare, i.e., the paradigm of P8 Health or the p-Health model [7]. P8 Health is proposed based on P4 Medicine (i.e, predictive, preventive, personalized, and participatory), advocated by Leroy Hood, a world visionary scientist, and other pioneers of system medicine in the early 2000s [8], [9]. The major elements of Hood's P4 Medicine have been adopted by a series of reports by the U.S. Institute of Medicine and the National Academy of Sciences.

With visions of P4 Medicine or P8 Health, health engineering (i.e., the applications of engineering principles and convenience approaches to solve problems in health) is emerging as a new interdisciplinary field of research and development. The purpose of health engineering is to develop innovative technologies, systems, and solutions for early detection, early prediction, early prevention, early diagnosis, early intervention, and early treatment of diseases—especially NCDs. Prominent research areas in health engineering include, but are not limited to, unobtrusive biosensing wearable and flexible bioelectronics, miniaturized multimodal tele-imaging, close-loop drug delivery systems, homecare AI/robotics, and health informatics.

It is believed that health engineering with the P8 Health vision and the multiscales integration at the molecular, cell, organ, and system levels would drive the convergence to transform the current reactive medicine to proactive health in the future.

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REFERENCES

[1] "Noncommunicable diseases," World Health Organization, Geneva, Switzerland, 2018. [Online]. Available: http://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases
[2] D. J. Hunter and H. V. Fineberg, "Convergence to common purpose in global health [Editorial]," *New Engl. J. Med.,* vol. 370, pp. 1753–1755, May 2014.
[3] *World Population Prospects: The 2012 Revision*, Dept. Econ. Social Affairs, United Nations, New York, NY, USA, 2017. [Online]. Available: http://esa.un.org/unpd/wpp
[4] "Healthy China," World Health Organization, Geneva, Switzerland. [Online]. Available: http://www.who.int/healthpromotion/conferences/9gchp/healthy-china/en/
[5] P. Sharp and S. Hockfield, "Convergence: The future of health," *Science,* vol. 355, no. 6325, p. 589, Feb. 2017.
[6] E. Topol, *Creative Destruction of Medicine: How the Digital Revolution Will Create Better Health Care*. New York, NY, USA: Basic Books, 2012.
[7] Y. T. Zhang and C. Poon, "Editorial note on bio, medical, and health informatics [Editorial]," *IEEE Trans. Inf. Technol. Biomed.,* vol. 14, no. 3, pp. 543–545, May 2010.
[8] L. Hood *et al.*, "Systems Biology and new technologies enable predictive and preventative medicine," *Science*, vol. 306, no. 5696, pp. 640–643, Oct. 2004.
[9] L. Hood *et al.*, "Revolutionizing medicine in the 21st century through systems approaches," *Biotechnol. J.,* vol. 7, no. 8, pp. 992–1001, Jul. 2012.

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