

A Decade of Scientific and Technological Innovation at Chinese Academy of Medical Sciences & Peking Union Medical College: Retrospect and Prospect

Taolian Yang¹, Hua Zhong², Wei Wang^{1*}, Jianwei Wang^{3*}

¹Administration Office of Science and Technology Projects, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing 100730, China

²Institute of Medical Information, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing 100020, China

³Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing 100730, China

ABSTRACT

Focusing on the reform initiatives of Chinese Academy of Medical Sciences (CAMS) & Peking Union Medical College (PUMC) in medical scientific and technological innovation from perspectives of deepening the reform and optimizing the ecosystem of science and technology innovation, this article summarizes the highlights of CAMS & PUMC's efforts in safeguarding people's health and promoting the Healthy China 2030 strategy through scientific and technological innovation in the fields including basic research, disease prevention and treatment, and medical technology in the past ten years. These achievements embody the endeavors and responsibility of CAMS & PUMC in realizing self-reliance and self-improvement of Chinese medical science and technology and highlight its contributions to the development of medical science and technology of China.

Key words: Chinese Academy of Medical Sciences; Peking Union Medical College; medical health; scientific and technological innovation; ten years

Since the 18th National Congress of the Communist Party of China (CPC), under the strong leadership of CPC, China's medical science and technology innovation has entered a period of rapid development in the past decade. As the top medical research and education institution in China, Chinese Academy of Medical Sciences (CAMS) & Peking Union Medical College (PUMC) has always taken the responsibility of leading the development of medical science and technology innovation in China and safeguarding the people's health. Focusing on the unmet health needs of the people and taking medical health science and technol-

ogy innovation as the starting point, CAMS & PUMC has thoroughly implemented the "Healthy China 2030" and innovation-driven development strategies, and actively fulfilled the mission of the "national team" of medicine and health. Since 2012, CAMS & PUMC has made great progress in the innovation of medical science and technology, which well contribute to the construction of a healthy China.

DEEPENING THE REFORM OF SCIENCE AND TECHNOLOGY SYSTEM TO ESTABLISH AN INNOVATION ECOSYSTEM

Strengthening strategic planning

As a bridgehead of the reform of the medical science and technology system in China, CAMS & PUMC actively promotes the transformation of science and technology management functions. Based on the major health needs of the country, CAMS & PUMC strengthens the strategic planning of scientific re-

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*Corresponding authors: Wei Wang, E-mail: wangwei@cams.cn; Jianwei Wang, E-mail: wangjw28@163.com

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search. First, the layout of scientific research projects in CAMS & PUMC focuses on the integrated research on prevention and treatment of the major diseases, shared mechanisms of the key health problems, core biomedical technologies, capacity-building in public health, and construction of strategic science and technology resource systems. Second, CAMS & PUMC promotes the construction of the resource system, including the North campus, Tianjin base, Suzhou base, and other strategic science and technology forces, aiming to build the core platforms of national laboratories in the field of life science and health care. Finally, CAMS & PUMC implements a scientific research management mode that is led by landmark achievements and oriented by major tasks. With the adoption of a principal investigator (PI) responsibility system, this mode empowers the PIs to employ staff members and choose scientific research paths upon their own decisions.

Strengthening talent cultivation and employment

By combining the deployment of scientific research tasks with the whole-course growth of high-level talents, CAMS & PUMC actively recruits and retains both leading research talents and outstanding young researchers by implementing scientific research through major collaborative projects and innovative cultivation projects, which have formed some high-level talent teams with reasonable structures. CAMS & PUMC has actively organized the recommendation of national talent research projects. Since 2012, 21 researchers have received funding from the National Outstanding Young Scientists Foundation and 29 have received funding from the National Excellent Young Scientists Foundation, which ensured the availability of a core scientific and technological research team securing Chinese people's health. With the support of national authorities, CAMS & PUMC has consecutively held the National Forum of Young Scientists in Medicine and Health for 14 times since 1987, offering an important communication platform for outstanding young Chinese scientists sharing their knowledge and insights on major issues related to health and diseases, which play active roles in cultivating youth researchers for the country.

Optimizing the use of funds

The continuous and stable financial investment in medical research provides important support to promote

the sustainable development of medical science and technology. The national investment in scientific research at CAMS & PUMC in 2022 has increased nearly five times compared with that in 2012. CAMS & PUMC launched the CAMS Innovation Project for Medical Sciences in 2016 and upgraded its implementation in 2021. A hierarchical project management mechanism led by CAMS & PUMC and participated by grant holding institutions has been established. It highlights collaborative innovation and improves the overall operational efficiency. In addition, CAMS & PUMC has successively implemented a series of project administration modes including "support by the post", "bottom-up", and "unveiling the list of PIs", which is characterized by sustainable support and moderate competition and has remarkably mobilized the enthusiasm of scientific researchers in their careers.

Improving the research ecosystem

In response to the national science and technology evaluation policy, CAMS & PUMC has been dedicated to establishing a medical research project evaluation system orientated by categorized evaluation and representative achievements evaluation. In the past few years, CAMS & PUMC has developed and annually released the Science and Technology Evaluation Metrics (STEM) of Chinese hospitals and medical colleges^[1]. Start from 2020, CAMS & PUMC annually released the *China's Important Medical Advancement* and *China's Major Medical Achievements in the 21st Century* to the public. These incentive mechanisms have effectively promoted the development of high-level medical innovations in China.

CAMS & PUMC attaches great importance to research ethics. Regarding the episode of the first Chinese gene edited twin babies in 2018, experts on behalf of CAMS & PUMC declared a clear and firm position in *The Lancet* against any clinical operation of human embryo genome editing without scientific evaluation, and called on "the highest scientific and ethical standards to ensure the safe translation of scientific advances to human health benefit"^[2]. CAMS & PUMC has systematically promoted research integrity in terms of policy development, evaluation and system construction, awareness-raising, supervision and regulation, case handling, and self-inspection, along with the optimized mechanisms of scientific research integrity tracking and public opinion monitoring. Furthermore, the research integrity is linked with performance

appraisals of faculties and affiliated institutions. These efforts have effectively created a clean and upright scientific research environment.

FOSTERING SCIENCE AND TECHNOLOGY INNOVATIONS TO SUPPORT THE HEALTHY CHINA INITIAL

The overall science and technology innovation capability improved dramatically

The past decade has seen dramatic improvements in the overall scientific and technological capabilities of CAMS & PUMC, as measured by the quality and quantity of research output. According to the data retrieved from Web of Science, in the past ten years, faculties from CAMS & PUMC have published 206 papers on the world's top journals, including *Nature*, *Science*, *Cell*, *JAMA*, *NEJM*, *The Lancet*, and *BMJ*, as the first author or corresponding author, increasing by 9 times than in the previous decade; there have been 2,258 invention patents granted, increasing by 4.1 times; there have been 557 clinical research trails initiated with CAMS & PUMC as principal institute, increasing by nearly 5 times. Since 2012, CAMS & PUMC has received 3,800 grants from national science and technology programs with financial support of nearly 5.9 billion yuan in total. As the first completing institute, CAMS & PUMC has been granted by the State Council 12 National Awards of Science and Technology Progress (two first prize, 10 second prize) and three National Awards of Natural Science (second prize). Seven achievements from CAMS & PUMC were presented at the National Exhibition of the "13th Five-Year" Science and Technology Innovation Achievements.

Basic research builds the foundation of innovation in medicine

In the field of fundamental medicine, researchers at CAMS & PUMC have conducted series studies on mechanisms of viral immune escape, replication, inflammation resolution, pathways of host cell resistance to viral infection, and anti-bacterial innate immune recognition framework and have updated the mechanisms of natural immunity and inflammation regulation^[3-10], elucidated new mechanisms of tumor immunity^[11,12], revealed new mechanisms of hematopoietic stem cell development, differentiation, and regulation^[13-15], and mapped the somatic cell mutations in normal tissues^[16]. These research findings laid solid theoretical foundations for understanding the pathogenesis of specific diseases.

China's solutions for disease prevention and control support the Healthy China initial

CAMS & PUMC has proposed China's solutions for the diagnosis and treatment of a variety of diseases. Scientists from CAMS & PUMC have constructed a risk prediction model for atherosclerotic cardiovascular disease and the first polygenic risk score model for coronary heart disease in China^[17,18], established a systolic blood pressure control target for elderly patients with hypertension^[19], confirmed the association between PM_{2.5} level and increased risk of ratio^[20], pioneered the construction of an evidence-based medical model for the clinical application of coronary physiology techniques using quantitative flow ratio^[21], revealed the prevalence and risk factors of small airway dysfunction in Chinese adults^[22], analyzed the incidence and risk factors of cancers in Chinese and developed guidelines of screening, early diagnosis, and treatment^[23-25], demonstrated that high-risk human papillomavirus testing is more suitable for primary screening of cervical cancer in China^[26], and established and promoted the treatment system for female pelvic floor dysfunctional diseases^[27]. Achievements as above have effectively improved clinical diagnosis and treatment of relevant diseases in China. In the pandemic of coronavirus disease 2019 (COVID-19), CAMS & PUMC has efficiently organized scientific and technological studies to devote in systematic investigation, and have achieved a series of accomplishments in pathogen identification, epidemiology, transmission routes, animal modeling, pathogenic mechanism, clinical treatment, and drug and vaccine development, thus has supported the global and national fighting against the COVID-19 pandemic.

Biomedical innovations contribute to the development of emerging pharmaceutical industry

Advances in the research and development of biomedical products by researchers at CAMS & PUMC included: 1) completing the first clinical trial on implantable artificial heart in China; 2) Carrimycin (the first self-developed anti-infection drug using synthetic biology technology in China) and Mulberry Twig Alkaloids Tablets (an independently innovative drug for diabetes) were awarded the Category I national certificate of New Drug; 3) development of enterovirus 71 vaccine for preventing severe hand-foot-mouth disease^[28,29]; 4) development of a lipopeptide HIV-1/2 fusion inhibitor with highly potent antiviral activity^[30]; 5) the industri-

alization of the key technology system of polyethylene glycol-conjugated recombinant protein drugs provides the society with innovative drugs with safety and efficacy, controllable quality, and good patient compliance^[31]; 6) the key technology for the comprehensive development of a large variety of traditional medicinal herb, *Panax notoginseng*, has been applied in industrial production^[32].

Medical key resource platforms ensure the support of science and technology

CAMS & PUMC has built a medicinal plant resource bank with the most complete system, the largest storage capacity and the strongest preservation ability in the world; constructed and established the animal models system of major human infectious diseases; established and applied a novel and practical technical system based on metagenomics for screening and identification of pathogens combination; developed China's first underlying data collection standard for clinical trials that conforms to international standards and Chinese characteristics. The achievements as above can build steady fundament of scientific data, enable orderly flow of the underlying data, and enhance the strategic guarantee capability.

Efficient and systematic organization of research on coronavirus disease 2019 (COVID-19) to support national epidemic prevention and control

CAMS & PUMC has been actively committed to the prevention, diagnosis, control, treatment, and rehabilitation of COVID-19 and has provided Chinese intelligence to the world in fighting against the pandemic of the disease. At the earliest instance researchers at CAMS & PUMC discovered the new coronavirus and obtain its full genome sequence, confirming it as the pathogen of the pneumonia outbreak of unknown origin in Wuhan^[33], sharing the first batch of strain sequences to the world on behalf of China. CAMS & PUMC developed five diagnostic reagents approved for marketing, in which the nucleic acid detection reagent was recommended by WHO for emergency use; carried out the earliest clinical study on the COVID-19, issuing warnings of the outbreak to the world^[34]; for the first demonstrated that SARS-CoV-2 can be transmitted through high concentrations of aerosols, conjunctiva, and cold chain transport^[35], providing a scientific basis for characterization and prevention of the disease; conducted in-depth researches in cooperation with other

institutions on China's self-developed drug Azvudine, which has been approved conditionally by the National Medical Products Administration for marketing as the first small-molecule anti-COVID-19 drug; developed an inactivated COVID-19 vaccine, which was approved for emergency use; completed and published the first clinical trials with highest evidence level evaluating the antiviral effect of lopinavir-ritonavir and remdesivir^[36]; for the first in the world elucidated the clinical characteristics, long-term health effects, and therapeutic efficacy using plasma of recovering COVID-19 patients^[37-38] and revealed the change patterns of serum antibodies in COVID-19 patients^[39], providing an important basis for clinical therapeutic protocols; established the first animal model of COVID-19 infection, which were used for the evaluation of more than 80% of studies on vaccines; innovatively proposed the idea of the "Fangcang shelter hospital", which was adopted by the Chinese government and have played key roles in controlling the COVID-19 outbreak at critical moment^[40]. The innovative model of "Fangcang shelter hospitals" has been also adopted by the international community in fighting against COVID-19 pandemic.

FUTURE PROSPECTS

As China has begun a new journey toward the second centenary goal of building a modern socialist country in all respects, CAMS & PUMC will continue to adhere to its mission and vision to meet the major national needs by optimizing the organization of scientific researches, innovating the implementation mechanisms, strengthening the construction of talents team, maturing the governance systems, and building steady cornerstone for development. With safeguarding the people's health in all aspects and all life course as the ultimate goal, CAMS & PUMC will make every effort to achieve the self-reliance and self-improvement of medical science and technology in China and continuously contribute to the construction of a healthy China.

Conflict of interest

The authors declared no potential conflict of interest.

Author contribution

Wang JW designed and supervised the research; Wang W revised manuscript; Zhong H collected the data; Yang TL analyzed the data and wrote the manuscript. All authors approved the final version of this article.

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专栏：一切为了人民健康——我们这十年
特别报道

中国医学科学院北京协和医学院科技创新十年回眸

杨涛莲¹，钟华²，王卫^{1*}，王健伟^{3*}

¹ 中国医学科学院 北京协和医学院科技管理处，北京 100730，中国

² 中国医学科学院北京协和医学院 医学信息研究所，北京 100020，中国

³ 中国医学科学院 北京协和医学院，北京 100730，中国

摘要

本文从深化科技体制改革、优化科技创新生态方面重点梳理了中国医学科学院北京协和医学院（以下简称“院校”）在医学健康科技创新发展中的改革举措，初步总结了院校近十年来通过科技创新守护人民健康、推进健康中国战略的亮点工作，主要展示了其在基础研究、疾病防治、医药技术等领域科技创新成果。这些科技成果的取得凸显了院校为实现医学科技自立自强、全面推进健康中国建设提供重要支撑，为我国医学科技事业发展做出重要贡献。

关键词：中国医学科学院北京协和医学院；医学健康；科技创新；十年

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*** 通讯作者：**王卫 wangwei@cams.cn；王健伟 wangjw28@163.com