Gordon G. Liu
Xuezheng Qin *Editors*

Global Health and Development

Low-Carbon Economy and Health Innovation

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Foreword by Huitong Zhao and Yu Sun

Peking University Global Health and Development Forum 2021: *Human Health and Medical Innovation in the Era of Low-Carbon Economy* was successfully held on December 22, 2021, to celebrate the first anniversary of the establishment of the Institute for Global Health and Development of Peking University (GHD). Opinion leaders, experts, and scholars from home and abroad participated in the event online or offline to share insights on the global response toward climate change and pathways to optimization of the human's healthcare system, which is of great concern to the domestic and international communities. There are experts from academia, politics, and non-governmental organizations at home and abroad in the fields of global health, health economics, medical innovation, environmental science, public health, etc., as well as business representatives, teachers, and students of GHD.

The conference was launched with three themes—Healthy Development in the Post-Pandemic Era, Global Health and Low-Carbon Economic Transition, and Medical Innovation for Sustainable Development. Each session was presented with a keynote speech and a roundtable forum session. The participating experts offered advice and suggestions for the construction of a low-carbon society and the development of human health in the post-pandemic era with a sincere attitude, broad vision, profound insights, and detailed discussions. Active discussions and in-depth dialogues were held in a friendly atmosphere, and the scene was brilliant.

Human health is closely related to global climate change. With the consensus on human health issues caused by carbon emissions and global warming, the urgency of the improvement of global health, the enhancement of ecological balance, and the transformation of a low-carbon economy have become increasingly prominent. In response to the COVID-19 pandemic, how to prudently optimize the healthcare system with systematic green and low-carbon perspective so as to improve the population health is the focus of this forum as well as GHD's effort in practice for improving global health.

To achieve the goals of Healthy China Strategy and Carbon Peaking and Carbon Neutrality, the forum aims to discuss the trend of human health development in the post-pandemic era, deeply analyze the relationship between low-carbon development and human health, share the research progress of development in medical innovation, and explore the pathways for the healthcare industry to promote the

transformation of a low-carbon economy. Besides COVID-19, other long-term and arduous challenges to human health, such as major non-communicable diseases and climate change, are deserved to be paid attention to. Most of the participants believed that all fields should work together to take strategic and integrated actions to defend the right to health, increase health benefits, and focus on overcoming common problems faced by human health. In accordance with the requirements of COVID-19 epidemic prevention and control, we should optimize the system and mechanism to fully release the spillover effect in the field of promising medical innovation with high potential for high-quality development. Through the in-depth and pragmatic cooperation and shared responsibility in green and low-carbon economic development, healthcare innovation, and other fields, we can make joint efforts for global environmental protection and global health improvement.

Since 2020, the COVID-19 pandemic has posed a serious threat to human health. Furthermore, it has triggered an unprecedented crisis in various countries' economic growth, social stability, and global governance. The establishment of GHD on December 22, 2020, conformed to the trend. With an international perspective, GHD aims to bring together the forces of economics and management, public health and medicine, international relations and diplomacy, population and environment, data and information, etc., and place global health in the framework of human development. Based on the vision of *One World*,*One Health*, through the research, think-tank service, cultivation of talents, and integration of production and education, GHD is dedicated to exploring the solution to the major issue of human health, promoting China's active participation in global governance, improving the transformation of innovative scientific and technological achievements, building an international and forward-looking innovation-supported platform, providing the public goods that serve for global health and society, assisting the construction of the community of human health, accelerating China's development in the global civilization, and ultimately enhancing the common development and health and well-being of mankind. Since its establishment, GHD has always adhered to a global horizon and first-class standard, fully leveraging its interdisciplinary advantages, forging ahead, expanding cooperation, actively serving people's health and social economy, and efficiently promoting global health and sustainable development.

This forum will provide inspiration and ideas for medical and health innovation and green and low-carbon economic transformation in the post-pandemic era. This book, *Global Health and Development: Low-Carbon Economy and Health Innovation*, is published to further output the wisdom of the forum, enhance academic influence, and contribute to the innovation and development of medicine in a green and low-carbon economy, as well as to commemorate the first anniversary of the establishment of GHD.

Beijing, China

Huitong Zhao
Yu Sun

Foreword by Bernhard Schwartländer

Global Health and Development—The Universality of Health, Science and Innovation

Never before has the concept of planetary health shown to be more palpable, more meaningful, and more relevant: the health of human civilization and the natural systems on which it depends. And never before it has become more clear that despite all the efforts of scientists, policy makers, and politicians, the global community has failed to truly connect the dots and to collectively and decisively act to stop global warming, protect the environment, and to ensure equitable access to health for everybody.

Floods, draught, ice caps, and glaciers melting at record speed are alarming signs of the threat to the natural systems on which human civilization depends. Unhealthy life styles across all regions and cultures of the world are now the leading risk factors for ill health and premature death. Rapid urbanization and cultivation of land for agricultural use fundamentally change the natural habitat of animals—both threatening the biodiversity of the planet, as well as altering the way humans and animals interact with new health risks such as increases in vector borne diseases, threat through new viral diseases in mankind including MERS, SARS, and of course Corona.

All of this and related challenges and opportunities are being discussed in this important book, compiling interventions of top scientists and policy makers, prepared to celebrate the opening of the new center of Global Health and Development at Peking University. It is visionary that the center brings together the faculties of Public Health, Diplomacy, and Health Economics. As the readers of this book engage in the numerous well-presented papers discussing some of the most pressing challenges to human civilization, I would like to highlight some overarching lessons and a vision of how we, as the global [scientific] community, may strive to address these to protect the health of human civilization and the natural systems on which it depends.

Over the past years, the COVID pandemic has highlighted in painful ways, how being interconnected across the globe has allowed an airborne pathogen to race

through all continents, all regions, and countries in multiple waves—in record time. Globalization has been highlighted as a risk, and countries have not only shut their borders. We have seen racism against foreign people in many countries and cultures. We have seen massive inequities in access to life-saving vaccines. And we have seen political blame and accusations—rather than engagement to find solutions together.

There have also been good news of course, and many of these have been described in more detail in this book. The development of COVID vaccines in record time is one of the success stories of modern civilization. With the vision and leadership of the World Health Organization (WHO) and a number of other health-related organizations and players, the "Access to COVID Tools Accelerator" (ACT-A) was created only months after COVID was detected. ACT-A is described in more detail in the chapter of Victor Dzau in this book. The institutions coming together in the ACT-A partnership worked tirelessly to cut time from at every single step from design to development and deployment of vaccines, therapeutics, and diagnostics and to make them available to all parts of the world. In many ways, scientists, foundations, the UN, and policy makers have shown what may be possible if all work towards one goal: protect the health of every human being against one common threat. The genome of the virus was shared within weeks after the unknown disease was described. This allowed the development of diagnostics and their use around the globe. The first vaccines were injected into people within less than one year after the virus causing the unknown pneumonia had been isolated. These are huge milestones for science as well as global health—never seen in history before.

Of course, not everything went according to plan. The fact that in summer 2022 large parts of the population of richer nations have received three or four shots of the vaccine, while the rates in the low income countries in Africa hardly reach 20 percent, is a massive inequity. This is not only inacceptable under moral standards, it also reflects a failure in the global response to COVID, as the virus will come back. Anybody can only be safe if everybody is safe. Subtypes of viruses emerging in one region can threaten success in other parts of the world at any time.

During times of geopolitical tensions and an increasingly fractured world, health and environment may appear as the only common language we have. When it comes to the health of our civilization and health of the natural systems on which we depend, we are all the same. Health—intrinsically linked to natural systems on which we depend—may be the last common language we have. The right to health and life does not differentiate by where you leave, what you do, and what you believe.

In this book, the Department for Global Health and Development has from the outset worked as a connector: bringing together and link leading experts and policy makers from different fields and from around the globe. This opportunity triggers a number of overarching questions on pressing issues toward a healthier human civilization and the natural systems it depends on.

Connecting the Dots

The need for intersectoral action for health was first acknowledged in 1978 in the WHO declaration of Alma-Ata and taken forward in the Ottawa Charter for health promotion with the concept of "healthy public policies" (1986). The Concept of Planetary Health is building on these principles but firmly links health action with the natural environment. While multisectoral action for health has been raised many times, the reality is far from perfect. Coordinating mechanisms are weak and largely ineffective. Funding for research and implementation is mostly sector specific. There are positive examples like the "Healthy cities" movement, as it seems that political commitment can more easily be generated locally, where the impact is more directly felt. But lessons learned need to be scaled up.

There is much science on specific aspects of health and environment, innovation, and digitalization, including in this important book. However, there is much less investment in science on how best to trigger multisectoral action or into prioritization of research to generate the knowledge and shared commitment we need to accelerate planetary health action, where the total is more than the sum of the individual pieces.

Security and Health

Security concerns have become more immediate in our increasingly fractured world. Peace, access to food, threats through diseases, and natural disasters are just few examples how the health of human civilization is threatened. In June 2000, the Security Council of the United Nations for the first time discussed a health issue and unanimously passed the landmark resolution 1308 on AIDS. That triggered unprecedented action in the global fight against the disease. Health-related discussions in the Security Council happened since, mainly around health emergencies such as HIV, Ebola, and of course COVID. We have yet to see a discussion on that level on planetary health—arguably the most profound security challenge of mankind. Much needs to be done to compile the strategic information that speaks to the political powers who also manage the Security Council. This requires specific research, as well as dialogue across countries and cultures, creating consensus in the world of science as a critical base to create political momentum.

The Powers of Digitalization

Digital innovations clearly have transformative potential for all aspects of human life. New tools and applications have the potential to dramatically increase the availability and access to information, diagnostics, and health interventions. They may help to overcome the dramatic shortage of health workers and health inequities and bring

interventions to people. There are numerous exciting examples—and we are only at the beginning of a digital revolution in health.

While progress has been breathtaking in many ways, it often starts with the solution, rather than the overarching question. Many times it is "the digital whizz's" who bring their ideas to health problems or health providers turning to the technical specialists to find solutions for a specific problem. This may lead to uneven or overall ineffective use of capacities toward a greater goal. Specific research and work toward identifying and prioritizing problems that need digital solutions may help to increase overall health outcomes. With other words, we need an overarching agenda and strategy with clear priorities that guide the work to protect the health of human civilization and the natural environments on which it depends.

Epidemics of Fake News

Social media have created new dimensions of information sharing and connecting. Along with this, we have observed an epidemic of fake news. The main platforms invest heavily in differentiating between "real people" and so-called bots that automatically react to triggers to swamp the information space. There is no doubt that such targeted mis-information can lead to false perceptions and mis-understandings. In health, we have seen a dramatic increase in such mis-information over the past years. The intersection between politics and health science has let to a new level of mis-information during the COVID pandemic. For the first time, major social media platforms have started to work with providers of "trusted information" to counter false information with what is scientifically correct and to block false information that may lead to behavior and decisions that are dangerous for the individual or public health. It is important to note that this is not about what information one likes—or not. This is about science. And about what information is scientifically correct—or not. Ultimately, this work has to be led by normative agencies like the World Health Organization. But the science into what triggers false information, how people deal with it, and how decisions are taken will have to go much beyond what the World Health Organization can do alone. This is a new field in research and science—but one with huge challenges and potential.

This book is a powerful demonstration of the vision behind the new department of Global Health and Development at Peking University. The mix of founding disciplines—Global Health, Diplomacy, and Health Economics—cuts a cross relevant disciplines in new ways. While globalization bears risks, the solution to the most pressing issues on the health of the human civilization is global. And globalization in science is a value—and a must—if we are to find the solutions we need. The center may offer a platform for science around the world. A platform that starts with sharing, listening, and understanding. A hub and nucleus for Health Diplomacy with a new

generation of health diplomats. A hub of innovation to address the overarching and most complex challenges to the health of human civilization and the natural systems on which it depends.

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Abbreviations

ACT-A	Access to COVID-19 Tools Accelerator
ACTIV	Accelerating COVID-19 Therapeutic Interventions and Vaccines
AI	Artificial intelligence
AIDS	Acquired immunodeficiency syndrome
AMC	Advance Market Commitment
C19RM	COVID-19 Response Mechanism
CDC	Centers for Disease Control and Prevention
CDD	Africa Centres for Disease Control and Prevention
CEPI	The Coalition for Epidemic Preparedness Innovations
COP	Conference of the Parties
COVAX	COVID-19 Vaccines Global Access
EPR	Extended Producer Responsibility
ETS	Emission Trade System
EUL	Emergency Use Listing
FDA	Food and Drug Administration
GAVI	The Global Alliance for Vaccine Immunization
GHGs	Greenhouse Gases
GMO	Genetically Modified Organism
GPAI	Global Partnership on AI
GPMB	Global Preparedness Monitoring Board
ICLR	International Conference on Learning Representations
ICML	International Conference on Machine Learning
IPTK Bank	Intellectual Property Technology and Knowhow Bank
IVDs	In Vitro Diagnostics
JAE	Joint Admissions Exercise
JE vaccine	Japanese Encephalitis Vaccine
KPIs	Key Performance Indicators
LMICs	Low- and Middle-Income Countries
MMV	Medicines for Malaria Venture
MoU	Memorandum of Understanding
NCD	Noncommunicable Diseases

NeurIPS	Conference and Workshop on Neural Information Processing Systems
NMPA	National Medical Products Administration
NRDL	National Reimbursement Drug List
PICOS	Population, Intervention, Comparison, Outcome, Study Design
PKU-iGHD	Peking University Institute for Global Health and Development
PMC	Pune Municipal Corporation
PV	Photovoltaic
R&D	Research & Development
RDPAC	Pharmaceutical Association Committee
SARS	Severe Acute Respiratory Syndrome
SDGs	Sustainable Development Goals
TB	Tuberculosis
TEDx	Technology, Entertainment, Design
UN	United Nations
UNICEF	The United Nations Children's Fund
VEGF	Vascular endothelial growth factor
WHO	World Health Organization

Introduction

Collaborations and Resilience to Promote Global Health

Gordon G. Liu, Lijing L. Yan, and Ming Xu

Over a hundred years ago in 1918, on September 22, Professor William Welch from John Hopkins University (JHU), also serving as the Lieutenant-Colonel of the United States Army arrived at Camp Devens, 60 kilometers away from Boston. Witnessing firsthand the rasping blue death of hundreds of patients in the morgue, he uttered to Dr. Rufus Cole, then Director of the Hospital of the Rockefeller Institute, who was disturbed and surprised to see Dr. Welch also losing his calm demeanor, at least momentarily, "This must be some new kind of infection or plague," [1]. After leaving the morgue, he made three phone calls, the third one to warn the US Army that the disease would spread quickly to other camps and to order camp hospitals expanded and to impose quarantine measures. What happened later that led to nearly one-third of the global population's infection and the death of millions of people—the 1918 influenza as we now know it, proved this warning came in too late and the effort to contain the spread of the disease too feeble.

Welch's first two calls and his long life and career, however, exemplified the essence of scientific collaborations. He called Harvard pathologist Burt Wolbach and immunologist Oswald Avery at the Rockefeller Hospital to help determine the nature of the disease and to find a cure. In the 1920s, Dr. Welch played significant roles in guiding the effort of the Rockefeller Foundation to establish the first medical

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school in China—Peking Union Medical College—PUMC. The 100th anniversary celebration of the top-ranked PUMC in 2021, though marred by the difficulty in international travels due to the Coronavirus Disease (COVID-19), signifies the long history of US-China collaborations in medicine and public health. In 2022, we are now in the third year of the still rampant pandemic of COVID-19.

Compared to the limited knowledge on plague over a century ago in 1918, it is easy to notice the great progress in medical research that has been advanced since then. For example, while it took scientists over ten years to dispel the prevailing view of a bacterial cause for the 1918 influenza, it only took a few weeks for scientists to identify the coronavirus (SARS-CoV-2) as the definite pathogen for the COVID-19. Thanks to the prompt and open sharing of the sequence of the virus by Chinese scientists in January 2020 and close collaborations within academia and across science, business, and governmental agencies, the development of several types of COVID-19 vaccines took only months not years. The people who suffered and died from the 1918 influenza—estimated to be at least 10 million and could be as high as 50 or 100 million, had no chance of being saved by vaccines or innovative medicines. Thanks to the accelerated modern technology, the role of vaccination alone was estimated to have averted nearly over 20 million deaths globally from December 20 to December 2021 [2].

The flickering light in the open sharing of coronaviral sequence and the successful development of safe and effective vaccines has been dimmed by the trend of de-globalization imposed upon many countries in the world by the pandemic, the geopolitical tensions, and the so-called concern for "national security." Many scientists and businessmen lament that the golden days of close bi-lateral and multi-lateral or global collaborations are a memory of the past without a clear prospect for reality again in the near future. Such sentiments were expressed in the many speeches given at the Peking University Global Health and Development Forum on December 21, 2021 recorded in this book. In response, various solutions and calls for action were made by experts and opinion leaders attending this forum. In this introductory chapter, we offer a focused narrative on the role of collaborations and resilience in promoting global health in this pan-COVID-19 era.

1 Global Health and National Security

The issue concerning global health, especially global health security has never become more significant given the profound changes following the increasing challenges sweeping the globe. In principle, global health security is to minimize the danger and impact of acute public health events that endanger people's health across geographical regions and international boundaries [3]. While there may be no definite answer in how to promote global health security, global collaboration and resilience have been proven to be essential for achieving success and progress in

human history. It is even more true now when the world is at the present crossroads, facing the intertwined challenges of geopolitical and economic crises and the COVID-19 pandemic.

A virus does not need a passport or visa to travel. It knows no national borders. Without fail, emerging infectious diseases such as the severe acute respiratory syndrome (SARS) and COVID-19 bring the inter-connectedness of human fate to the frontline of global affairs and occupy the "Front of Mind" of collective awareness. Paradoxically, such awareness of inter-connectedness often leads to close of national borders or even regional borders within a country as measures to contain the spread of infectious diseases. Compared with previous infectious disease outbreaks, border closures have been more prevalent and longer-lasting, possibly due to the higher transmissibility of the SARS-CoV-2 virus and the lingering pandemic.

While we recognize border closure, social isolation, and quarantine as traditional and effective containment measures for infectious diseases, their prolonged use undoubtedly affects the ordinary order of people's lives and the national economy to a great extent. This line of strategies also does not fully utilize the advancement in low-cost and effective vaccines as the biotechnological weapon to win the war on COVID-19. Winning does not equate eradicating the virus or disease but means minimizing their influence on societies. Border closure with the goal of COVID-19 containment within one's own countries, while understandable and justifiable, is neither sustainable nor effective for global security, not even for national security over the long run.

The dilemma presented by COVID-19 containment measures is only one example of how national security is not a concept in silo. It is influenced by many factors, including threats to global health from widespread infectious diseases and political and military factors. We echo with the World Health Organization that health is a fundamental human right globally. The Constitution of the World Health Organization signed in 1946 and entered into force in 1948, included the following statement, "The health of all peoples is fundamental to the attainment of peace and security and is dependent on the fullest cooperation of individuals and States." We argue that health is one area that can transcend narrow-minded nationalism and achieving global health security is consistent with national security goals. *Without global health security, there is no true national security.*

Currently, there are many health challenges that we need to join forces to address on a global scale. Our shared vulnerability has created a need for collective defenses and shared responsibility in making these defenses work. Such principle underlies the International Health Regulations (2005) that came into force in 2007. The launch of the Global Health Security Agenda (GHSA) in 2014 demonstrated the global effort to strengthen the world's ability to prevent, detect, and respond to infectious disease threats. More than 70 countries have signed onto the GHSA framework. Both GHSA and the IHR aim to elevate political attention and encourage participation, coordination, and collaboration by multiple stakeholders, while leveraging previously existing commitments and multilateral efforts [4]. The global fight against COVID-19 in the past years has called for solidarity and made it more convincing for humankind to become more and better coordinated through commonly shared values.

2 Clarity and Security

We recognize that concerns for national security are real and multi-faceted. However, it is often used to provide a blanket ("cover all") reason for restricting cross-border exchanges and collaborations. No clear rules are set to identify the specific national security interests at risk or ways to ameliorate these potential risks. As such, nearly all kinds of international scientific collaborations have been affected and stalled. To a great extent, the progress and development in human history have never been achieved at no cost of bearing risks, from both natural and human-led factors. As such, we must always consider optimal strategies in dealing with the inevitable trade-offs between cost and benefit of security management while continuing our joint journey for human development. We strongly encourage national governments to clarify which kinds of activities generate threats to national security interests and restrict bans on collaborations to only these activities. If current world politics and tensions render such a clarification impossible as it implies all other activities not listed would be allowed, alternatively, creating a list of activities as receiving the green light for cross-border exchanges and collaborations will be helpful to break the status quo of isolation. *Without clarity, there is no true security.*

3 Safe Data Sharing and Collaborations

Improving data sharing across countries is the key to sustaining health security and making our response to health challenges more effective. A case in point in need of clarification is the rules regarding safe data sharing. For example, clinical trial data on the effectiveness and safety of COVID-19 vaccines are valuable in speeding up vaccine development and marketization. For rare side effects, large sample sizes are required to obtain valid results.

Data sharing and pooled analyses are one way to address this issue. At the present, clinical trials data belong to the sponsors of the trials and are proprietary. Even when means to de-identify individual data are plenty and secure, sharing of these data for the common good is rare if not non-existent. When direct exchanges and sharing of data between two countries or institutions are not feasible due to the lack of mutual trust or standard operating procedures, enlisting the support of trustworthy international organizations such as the World Health Organization or the Rockefeller Foundation may provide one solution. If such breakthroughs in sharing non-confidential data on vaccines can be achieved due to its value in helping mankind to combat COVID-19, we would have a good base for setting up rules in safe sharing of other data on diagnostics, medicine, or technology. As data form the cornerstone of scientific research, *without clear rules for safe data sharing, there is no true international collaborations.*

4 Collaborations and Global Health

It is easy to understand why the COVID-19 pandemic caused by a new virus is a big threat to global health security. Multi-drug resistant bacteria are another example in infectious disease research that if left unaddressed, could cause serious consequences to people in many countries. Global health security is not only affected by infectious diseases, however; other major areas in global health research also require concerted effort globally, as called for by the concept of One Health. For noncommunicable chronic diseases (NCDs) such as diabetes, heart disease, stroke, and cancer or maternal and child health issues that do not appear to have the ability to transmit from person to person or go beyond national borders, they are actually global challenges that have deep-rooted causes in international trade, world hunger and poverty, and gender inequality, to just name a few. To tackle the rising global challenge of NCDs—an important agenda being sidelined by COVID-19, also require sharing of data, mutual learning, and collaborations.

To a larger extent, the COVID-19 pandemic has undermined the progress made on sustainable development. It poses a significant challenge to the full implementation of the 2030 Sustainable Development Goals (SDGs) Agenda as there has been a rise in extreme poverty, inequalities and injustice across the globe [5]. We are witnessing the cascading and interlinked crises, dominated by COVID-19, climate change, and conflicts, which have been creating negative spillovers on many aspects. Following the SDGs as blueprint to achieve universal health coverage, we can take coordinated actions to better strengthen social protection systems, improve public services and invest in health through concerted efforts.

5 Resistance and Collaborations

We face the usual challenges in pre-COVID-19 times. We also face unusual difficulties imposed by the devastating COVID-19 pandemic and by our inability in finding strategies that can both contain the spread of virus and not affect the local, national, and global economy. Taking a historical and long-term view, we do not need to lose hope. Worthy causes won in human history are synonyms with being resistant to hardships. Advancements in science such as COVID-19 vaccines and medicine, adoption of mobile health technology for COVID-19 and NCD management alike, and innovative business models and new ways of living and working through more intensive and effective remote collaborations are not just silver linings in the pandemic but represent real signs of progress.

While we are grieved by the passing of vulnerable fellow citizens, we are also encouraged by resilient people who not only survived the pandemic in 1918 and COVID-19 but work tirelessly to save lives and build resilient healthcare systems. We also call for resilient global health governance that will help us achieve global health security through collaborations. In December 2021, the Peking University Global

Health and Development Forum was successfully held with both Chinese participants and the presence of international leaders and experts via videoconferencing. It is but a small example of resilience in the face of difficulties. *Without resilience, there is no true collaboration and advancement.*

William Welch who died in 1934 was an influential American who left a legacy for connecting the scientific community together across national borders. May our generation and era be remembered in history not only by the COVID-19 pandemic but also by how we are resilient enough to overcome obstacles and remain connected.

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Global Health and Economic Development

Abstract This section is based on the ideas from the participants of Peking University Institute for Global Health and Development (GHD)'s launching ceremony in 2020 and the PKU Global Health and Development Forum 2021, which brought together prominent scholars and experts from China and all over the world to discuss in depth on how to promote global health and economic development in the context of the COVID-19 pandemic.

Health Without Borders

Minghui Ren

I would like to congratulate the establishment of Peking University Institute for Global Health and Development (GHD). GHD's establishment is highly timely. Right now the COVID-19 pandemic is not yet over. Its impact is much more than just in the health arena.

We also see the crisis in the economy, humanitarian, and it has a major impact in globalization and its agenda. Health is a part of politics; it is a political choice. For the past decades, WHO holds the concept that enjoying health is a basic right for everyone. No one should die because of poverty. No family should become poor because of disease. All of us should enjoy equal rights to a full health service, including medicine, vaccines, and other products. Based on such a concept and consensus, the WHO is dedicated to establish a partnership and work with all for health for all to guarantee global health security and to have a good public service for everyone. There is unlimited pursuit of humankind for health, it is part of an important history for human beings. Urbanization actually brings contact of human beings and animals, so we see more risk of animal-source diseases.

Also, globalization, rises risk of the pandemic to spread over borders. Chronic, non-communicable disease burden increase has to do with environmental way of life. The deterioration of ecosystems threatens the security of the entire planet. All of these are key challenges for global health, aids, best interpretation of a community of shared future for all. Global health is an important agenda of global development and it requires global cooperation.

Ren Minghui Assistant Director-General of WHO and Assistant Director-General for Universal Health Coverage/Communicable and Noncommunicable Diseases at WHO headquarters.

This article is based on Ren Minghui's remarks at the launching ceremony of Institute for Global Health and Development, Peking University and the Beijing Forum 2020.

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We join hands in fighting COVID-19, our health system, China played an important role and GHD's establishment would be more important to enrich the series and practice of global health and development, WHO has great expectation for our future partnership.

Launching PKU-iGHD Conforms to the Trend

Qide Han

In 2020, the Beijing Forum took place as scheduled and we are here to witness the launching ceremony of the Peking University Institute for Global Health and Development. The idea of the establishment of the Institute was born in the spring when the pandemic was controlled in China and the preparation was officially started on May 4th, which is the anniversary day of the Peking University. Now we are welcoming the birth of a new institute, and that is the GHD. Congratulations. The establishment of GHD is in line and comes at the right time, good place with supportive people.

First of all, the right time. The outbreak of the COVID-19 pandemic in 2020 brought unprecedented impact on people's lives and economic development, and these impacts present both challenges and opportunities. The spread trend of COVID-19, the prevention and control mode and also the vaccine developments are all new challenges we need to face. COVID-19 affected the whole medical system and the impact on the economy and politics is actually highly correlated with the development of whole mankind. The GHD focuses on global health and development, born in 2020, it takes promising trend and will definitely have a bright future.

Now let's take a look at the so-called global health. The global health as a discipline of 20 years' history, it has evolved from tropical medicine, regional medicine, and international health. This emerging discipline has three main features: focusing on cross-border health problems and solutions, emphasizing the combination of public

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health—population and prevention as the main strategy, and clinical methods—individual disease diagnosis and treatment as a key, as well as multidisciplinary and interdisciplinary. With the development of China's economy and the improvement of international influence, China is also playing an increasingly important role in the field of global health. The director Liu Pei Long and his team a few years ago published a paper in the *Lancet* and he pointed out that in terms of knowledge exchange, health assistance, health security, and global health governance, China has made outstanding contributions to the world. How can China perform well to promote people's health, economic and social development in the new uncertainty era around the world, is a worthy research work to do. Therefore, it is also the embodiment of the regional advantages of this new research institute established at Peking University in China.

Finally, let's look at the people. We have Global Health Department at Peking University School of Public Health—a founding member and held the first chairman of Chinese Consortium of Universities for Global Health (CCUGH), established the China Global Health Network with a joint of government, industry, university, and research institute, and made great contributions to the development of China's global health discipline that is obvious to all.

Why we are setting up the Institute for Global Health and Development at Peking University?

This is inseparable from the two features of global health: across multiple disciplines, and focus on both public health and healthcare. At the same time, it also reflects the strategic positioning and courage of the leaders of Peking University.

As for the new institute, it will exert its function of integration of multiple disciplines, for example public health, economics management, international relationships, data science, life science and clinical science, and psychology and so on and so forth. And hopefully the GHD will play a role as a hub and flagship, to the talent advantages in the university and also bring about considerable contributions into scientific research and other related fields.

On the day of the establishment of this institute, I would like to express my sincere gratitude and congratulations to all of you who have worked so hard to prepare for the establishment of GHD and also for those who are unable to attend today's ceremony. I would like to say thank you for your support as well. I am very happy to be the co-chairman of the advisory council of GHD with professor William Hsiao, and we believe that under the leadership of the chairman Zhan Qiming, the Dean Gordon Liu, and other deans, we will scale new heights and achieve brilliant and success and contribute to the cause of global development and human development for China and the world.

China-US Cooperation to Create a Responsible Future

Stephen Orlins

There's great joy in the establishment of this vital institution. But today, I have to say I'm a little sad. Before Larry was president of Harvard, before Victor was dean at Harvard Medical School, before Professor Sachs was a professor, I was a young undergraduate at Harvard. Fifty-one years ago, in my sophomore year, a then young professor opened my eyes to China. He taught me my first course about China, and over these fifty-one years since he taught me that course, he's been my friend, mentor, inspiration, and adviser, and he spoke at Beida many times. Sadly, yesterday morning, Ezra F. Vogel (FU Gaoyi to the Chinese audience) passed away, and it's heartbreaking for us. But I know if he were still around, I would call him before I spoke tonight. He would have told me that what you're doing here is emblematic of what China has become and very much emblematic of what Peking University is, has been, and will be in the twenty-first century. He would have said this is really, really important. And it is essential.

There are so many distinguished friends and colleagues speaking today. It shows just how important this is. It's a testimony to the creation of this global institution. I'm particularly honored to talk with Justin Lin and GAO Fu and be invited by Gordon Liu. All three of those individuals have played an essential role in strengthening the relationship between the National Committee on US-China Relations and Peking University. I don't know Justin Lin if you're still on, but let me tell you a trade secret. In 1986 when you were a Ph.D. candidate at the University of Chicago, we gave you your first job hosting an economic delegation that came from China then and included ZHOU Xiaochuan and many others.

Stephen A. Orlins, President of National Committee on United States—China Relations (New York).

This article is based on Stephen A. Orlins's keynote speech at the launching ceremony of Institute for Global Health and Development, Peking University and the Beijing Forum 2020.

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Ten years ago, Justin, YAO Yang, who is now the Dean of the National School of Development at Peking University, and I started the discussion of the creation of a Track-II economic dialogue. Last week, that dialogue met for the twenty-first time. At this time of difficulty, this dialogue has recommended nonpolitical solutions to some of the difficult economic issues in US-China relations. It has repeatedly proved the value of the Track-II model in improving the lives of Chinese and Americans.

Five years ago, I approached Gordon Liu to discuss the possibility of creating a Track-II dialogue between leading healthcare specialists from both countries. Gordon, as he's so well able to do, saw over the horizon and recruited an outstanding group of specialists from China. The American specialists are led by our former Food and Drug Administration (FDA) head Mark McClellan, who spoke earlier this morning, and on the Chinese side by former vice minister of health, LIU Qian. Because of their vision, this Track-II has contributed to improved healthcare cooperation between the United States and China. There is not a day that goes by that I don't rejoice in the fact that as a non-healthcare specialist, I've participated in cooperation with Peking University that has led to healthier Chinese and American lives. So, I rejoice in creating the Institute for Global Health and Development at Peking University.

Media always asks me if I'm an optimist or a pessimist about the future of US-China relations. If it is Chinese media, I respond, "That depends on what you report and what the Chinese government does. China needs to change some of its policies." If it's American media, I respond, "That depends on what you report and what the American government does. America needs to change some of its policies." I then elaborate by saying that I am an optimist in the long term because the people of each country will determine the future of US-China relations and that a mother in Shanghai and a mother in New York each have the same four fundamental fears. Each fears that climate change will cause the Huangpu River or Hudson River to overflow its banks and flood their homes. Each fears that terrorism will claim their children's or friends' lives as it did in New York on 9/11 or at the Kunming rail station. Each fears that an economic crisis as it did in 2008, or even right now, will deprive their children of a better life. Finally, each fears that a pandemic will sweep away their families. As GAO Fu just said, only cooperation between the United States and China can combat these global threats.

I strongly believe that no matter what the government did, the Chinese and American people would not allow the government to steal the future from their children. I, therefore, did not expect that the deterioration in the US-China relationship would prevent the kind of cooperation that would save lives on both sides of the Pacific. I did not expect that a pandemic that should have drawn us together tore us apart. As we slowly emerge from this pandemic, we've heard everyone talk about the horrible numbers in the United States, but as we appear today, I can only hope that this has been a teaching moment. A moment that the people in China and the people in the United States recognize that only together can we confront the twenty-first century illnesses that will engage both China and America; only together can we face all these global problems.

COVID-19 has been a tragedy, but as Larry Summers said, it won't be the last pandemic and likely won't be the worst. Healthcare and illnesses know no boundaries. If my daughter suffers from cancer, I don't care whether the cure comes from Berlin, Beijing, or Boston. We need to focus on areas where cooperation can improve the health of Americans and Chinese.

We need regulatory harmonization where we align clinical manufacturing and post-market regulation that promotes greater efficiency among companies and government agencies working to bring vaccines and other drugs to market. We need to immediately work together to develop a communication strategy to combat skepticism among some segments of the public, especially in the US, about vaccine safety. As GAO Fu said, we need to increase transparency and access to data that furthers vaccine development and treatment strategy.

The tragedy of COVID-19 has led to healthcare delivery outside of the hospital system, through telemedicine and digital health, for example. We Americans and Chinese need to share these expertise to work together to pave the way for more effective responses. I hope and expect Peking University's School of Health and Development will lead the way. I congratulate you on having the vision to establish this critical global institution at this critical time.

Unlock China's Potential as a Provider of Global Public Goods in Health

Steve Davis

It's inspiring to know that so many of you from government, academia, business, and philanthropy are assembling to focus on the shared vision of strengthening South-South cooperation and development for a better and fairer world.

Since opening our China office in 2007, the Bill & Melinda Gates Foundation has supported China in addressing major domestic health and development challenges and is working with Chinese partners to apply their expertise, experience, and resources for the benefit of the world's poorest people, especially those in sub-Saharan Africa.

Given that China has a proven track record for developing and manufacturing world-class and affordable health products—from vaccines to drugs to contraceptives—we believe China has even greater potential for becoming an influential provider of global public goods. Over the past decade, our foundation has worked with the government, research institutes, regulatory bodies, private sector, and global health partners, including the World Health Organization, to support the development and distribution of many Chinese health products, including helping them obtain WHO Pre-Qualification for use in developing countries, and support the most vulnerable communities in addressing public health challenges. These experiences re-affirm our belief in this opportunity, especially as we see the expanding reach of Chinese public health goods through more robust engagement with international organizations and multilateral mechanisms.

Today, I would like to offer two ideas on how China could leverage its unique position to further its global efforts in supplying affordable, quality health products.

Steve Davis, Former Executive Strategy Adviser and Interim China Country Office Director, Bill & Melinda Gates foundation.

This article is based on Steve Davis's remarks at PKU Global Health and Development Forum 2021.

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First, to maximize the impact and minimize the cost of global goods, it is imperative that we think holistically about whole journey of these products—across the entire value chain from the beginning to end, what activities should be done and what resources must be mobilized in different stages?

Too often, we think only one part of this work—for instance, the research stage or the regulatory stage—and later find challenges or delays because we didn't consider early enough how to address all the critical issues—from testing to prequalification to export commitments to marketing to scaling through partnerships. We encourage our partners to assess and plan for the entire journey, and we support many efforts in the whole value chain.

- Take our work in eliminating malaria as an example. Over the past 60 years, China has reduced malaria cases within its borders from 30 million a year to zero—an incredible achievement that underlines the depth of experience China can bring to this issue. At the Gates Foundation, we work with Chinese and African partners on a wide range of matters across the entire value chain.
  - On the vector control side, we are assisting China to bring high quality, affordable mosquito nets to the global market and tapping into China's Research and Development (R&D) capability to explore the potential of an innovative insecticide from natural compounds.
  - On the treatment side, we support China's becoming one of the primary sources of global procurement of anti-malaria drugs. Its research in the biosynthesis of artemisinin may contribute to the continuous supply of anti-malaria commodities.
  - To increase the quantity and quality of Chinese anti-malaria health products, we are working with Chinese regulatory agencies and the private sector to improve the quality of Chinese antimalarial products and support them in obtaining the WHO pre-qualification to maximize their global impact, or navigate registration, export or procurement policies.
  - On the strategy side, we are supporting Chinese partners' efforts in capacity building of Africa Centres for Disease Control and Prevention (CDD) through pilot projects and further integrating China's innovative, proven methods to strengthen malaria control programs and health systems in African countries.
  - On the implementation side, we are also supporting China in collaborating with other multilateral donors and international platforms such as the Global Fund to sustain effective interventions and scale the impact of such contributions.
- From early-stage R&D and demand-side analysis to manufacturing and policy integration, there is a wide range of stakeholders within the value chain. Applying end-to-end thinking helps us identify partners early for functional solutions at different stages. While the value chain of the global health market is complex, we must use a holistic approach to maximize value at the lowest total cost for our final beneficiaries.

Second, we must accelerate the drive for affordable digital public goods in global health.

- The COVID-19 pandemic has forced healthcare systems worldwide to significantly accelerate the transformation or broader adoption of the digitalization of health care delivery. As co-chair of the World Health Organization's Digital Health Technical Advisory Group, I believe that many future global public goods will be presented in digital products. Technologies such as virtual care, remote monitoring, artificial intelligence, big data analytics, smart wearables, platforms, and tools enabling remote data across the health ecosystem, creating a continuum of care have proven potential to enhance health outcomes. The global health markets need more digital tools and services in those areas.
- And China is well-positioned to be a leader in providing digital global public goods at an affordable cost. Again, to do this effectively, we need to ensure we adopt a holistic approach to the entire digital ecosystem, mainly starting from the demand side, that is from the point of view of what the consumers and communities in the lower and lower middle-income countries need and are asking for, not just pushing products and solutions from the outside.

China has the potential and commitment to becoming an even more critical provider of global public goods in health. This will require increasing investment, innovating new technologies, and improving capabilities across every stage of the products' journeys. And importantly, we need more innovative models for cooperation involving bilateral, trilateral, and multilateral partnerships. This is why I look forward to discussions from this Forum on your collaborative efforts in solution-building and establishing sustainable models of public-private-academic partnerships—and underscore the Gates Foundation's ongoing commitment to work with you on these critical issues.

Five Observations on Impact of the Pandemic

Christopher J. L. Murray

I would like to reflect on five things about how I think COVID-19 will change global health in the coming years.

First, I believe that the way the global community has been thinking about pandemic preparedness will change very substantially. If you think about the joint external evaluation process from WHO and other partners, those scores were not predictive at all of how well countries managed COVID-19. In fact, there is no correlation between those scores and subsequent COVID deaths, at least to-date.

I think as the global community reflects on why what went wrong in the Joint Admissions Exercise (JAE) process and other scores, like the Global Health Security Index, which is also weakly correlated with what happened, that will lead to a very major re-thinking about both monitoring rules of the content of pandemic preparedness.

Second observation. I think we will see an increased focus, maybe perhaps paradoxically, on some of the major non-communicable disease risks: obesity, diet, diabetes, high blood pressure, because what we have learnt during the COVID pandemic is that those risks, when poorly managed in health systems, actually leads to a more vulnerable population. One of the strategies, certainly not the only one, but one of the strategies that I think we will see more discussion of in the coming year or two is how do we help countries better manage those risks and be in a better position if and when there is another pandemic, particularly one that attacks those that are more vulnerable.

Christopher JL Murray, Professor and Chair of Health Metrics Sciences, University of Washington, USA.

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Third observation is that we have seen just as Noncommunicable Diseases (NCD) risks have been a major determinant of how bad COVID has been in each country, we have also seen within each country that COVID has struck at a much higher rate in terms of transmission and to some extent also in terms of death rates amongst those who are most vulnerable, which has put a light, an intense light, on existing inequalities. So, for example, in the United States, although Hispanic populations generally have a mortality advantage in the US compared to non-Hispanic whites, for COVID they have a death rate that is about three times higher. The same is true for Black Americans, the relative risk of death is about three but of course they have a mortality disadvantage compared to non-Hispanic whites. But these relative risks for COVID are much higher than for all courses and again it points to the importance of thinking about and studying in much greater focus, I believe, in the coming years or a reinvigorated focus on understanding inequalities in societies and thinking about policy strategies that could reduce inequalities.

A fourth topic or change that I think will come from COVID will be a much greater interest in places like the institute for global health and development but around the world in understanding the behavior of both government and individuals. So if you think about what has been some of the most important determinants of death and transmission, it has been the action of governments early or even once broad-based community transmission has occurred, the biggest determinant right now as we speak of transmission is the imposition of social distancing mandates by governments, and that is very different across different jurisdictions. I think there will be a lot of interest in why there is already a blossoming of quantitative political science analyses of these, and I expect we'll see much more of this given how powerfully important different types of mandates have been in controlling the transmission.

Likewise, we have seen enormous variation in individuals' behavioral response. Some individuals in society, some societies more than others, people have worn a mask, have avoided contact. Even when you control for many other factors, there is a considerable amount of behavioral response that we don't understand, and that's what economists and other people who study behavior can help provide some key insights I think in the future. Better models, understanding human behavior. Of course the one human behavior that is now front and center is vaccine hesitancy, and we see enormous variation within countries, by educational attainment, by gender, by socioeconomic status, and particularly across countries or even regions within countries in people's willingness to accept a COVID vaccine, and that will probably dominate our considerations around COVID in two or three months from now.

A last reflection on COVID is about the change in the way we think about data. So what COVID has done, in a way that I think very few saw coming, has been this explosion of data provided by the private sector. So everybody who tracks the epidemic right now, who models transmission, is now heavily dependent on data collected by the private sector and less so on data collected by government. The ways in which data have been particularly useful have been, for example, cell phone-based mobility data. Cell phone-based mobility data route to where those phones go to, so you have datasets that were almost unimaginable a year ago where we can count the number of people who have been to a religious ceremony given with about

a one-day lag. How many people have been to a restaurant, to a bar, to a department store, a level of detail with about a 24-hour lag…that seems extraordinary!

Then you combine that with the role that Facebook has been playing surveying people, two million people a week around the world, providing the main source of data for mask use, for behaviors around COVID, for willingness to take a vaccine.

You just have a very different landscape around global data collection with a much more increased role played by the private sector. There will be many issues that will come out of that. I think when people understand how much detail you can purchase publicly—a dataset that will let you track most cell phones or smartphones around the world, it's really quite extraordinary detail. There will be some backlash, I believe, around privacy, but I do think we will see a lot of discussion in the coming years about the role of data that's been collected by the private sector for public health surveillance and a new direction.

We live in very interesting times. I think like a number of speakers have said before, we expect in our modeling that with human infections today, vaccine scale-up, seasonality, that the large Northern Hemisphere epidemics may be coming to very low levels by the Northern Hemispheres summer with no reasonable possibility of a third wave. It's less clear in other parts of the world. But definitely heading, after the next two and a half months into a period where I think the topic will shift to how do you prepare better for the future and what are the broader implications like the economic effects.

Fighting Against the COVID-19: Collaboration, Innovation, and Health in All Policies

Qide Han

The COVID-19 pandemic has been the largest event in global health and has far-reaching impacts much beyond health. The COVID-19 outbreak began in 2019, coincidentally exactly 100 years after the end of the "1918 influenza" in 1919. The "1918 influenza pandemic" infected over 500 million people and killed more than 50 million. The most recent estimates for COVID-19 are over 14 million infections claiming over 3 million lives. There is no doubt that the COVID-19 pandemic has brought many problems and challenges. However, after fighting and co-existing with it for over one year, are we ready to view it in a different light? From a positive angle?

Many of you witnessed the launching of the PKU Institute for Global Health and Development a little over four months ago on December 22 last year, a direct result of the COVID-19 pandemic. As the co-chair of the International Advisory Committee of the Institute, I would like to highlight three points on global health and development issues that are the major topics for today's Forum as well as the central research agenda for the new Institute.

Before COVID-19, the trend of de-globalization or even anti-globalization was on the rise. Virus does not need a passport to travel across borders. Unlike SARS or other epidemic in recent histories, COVID-19 has affected all nations in the world and has a truly GLOBAL impact. Closing national borders, lockdowns, and social distancing have made us feel more isolated. What we took for granted before COVID-19—things like free travel and social gathering, for example, have become a dream that is still hard to achieve for many. But the loss of regular in-person contacts has made

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us more keenly aware of their values—how previous human connections are. The global pandemic has also made it exceedingly clear that the fate of the human race is connected with each other; that collaboration at a global scale is a must for us to fight and win the battle against COVID-19. "Virus has no borders; collaboration has no boundaries." Although certain forms of collaborations are still restricted, innovations and advancement in technology have also helped us to collaborate in new ways. This is why south-south cooperation is a key theme highlighted in today's forum.

My second point is to stress the core common value of human health. It is unfortunate that most people may not realize the value of health until it is too late—when they get sick or older. Nations and societies often behave the same way. The COVID-19 pandemic is like a "bomb," disruptive and devastating, but it is also an alarm bell. It heightens our awareness of the importance of health and how we need to improve our public health and healthcare system to be better-prepared for COVID-19 and other future threats to health. In response, we have seen stronger interests from the younger generation to study health science and global health, and national investments in health facilities and infrastructure. However, these are not enough. What we need is a sustained effort to embed health in all policies as proposed by Chairman XI Jinping, to achieve universal health coverage for all as advocated by the World Health Organization, and to make health promotion a priority for all people, families, communities, societies, and nations.

Finally, I'd like to touch upon the important role of development in promoting human health in general and fighting against COVID-19 in particular. Narrowly defined, it is an economic term, referring to economic development or as in development economics. Development can also go well beyond economic domain, encompassing social, cultural, technological, and other dimensions. Since the outbreak of COVID-19, we have witnessed development and innovations on many fronts. Not only scientific research and publications on COVID-19, but also development of vaccines and vaccination at an unprecedented speed. Not only new products, but also new ways to deliver the products and services. Not only development in how we interact and collaborate with each other, but even how we live, study, and work. Digital health is a good example. I am glad to see many talks today, not only on COVID-19 vaccines but also on digital health today.

Years later, when we look back at 2020–2021, I trust that we will not only see the crisis but also great development in how we courageously overcome the crisis. Even if the pandemic may still be with us for some time to come, human history has taught us one thing: in the long run, development is the central theme that triumphs over death, destruction, and defeat.

Preparing for Pandemic

Victor Dzau

Today I will review COVID-19 global response preparedness, emphasizing two things. First is the report from the Global Preparedness Monitoring Board (GPMB). Second are some important developments regarding countermeasures and vaccines, and how we are trying to meet the global needs and achieve global solidarity.

In 2018, the World Health Organization (WHO) and the World Bank co-convened a new monitoring board called the Global Preparedness Monitoring Board. This was in response to the United Nation (UN) Secretary-General's commission that recommended the need for such a monitoring board after the Ebola crisis. I was very fortunate to serve on the board in fact with Dr. George Gao, Director of the Chinese Center for Disease Control and Prevention. In 2019, the GPMB released its first report, '*A World at Risk: Annual Report on Global Preparedness for Health Emergencies*'.

Importantly, the report says one very real threat is that of a rapidly spreading pandemic due to a lethal respiratory pathogen. And we all know this is very profound and prescient, because although we thought about this risk, nobody thought it would ever happen. Of course, it's happening right now in 2020. In this report we asked for seven urgent actions. Among those actions, we asked for the heads of governments, countries and financing mechanisms to all to work in coordination and collaboration. And of course, not much happened in response.

We now know the COVID 19 pandemic has caused devastation across the world.

This is not just a health threat. In fact, it is an economic crisis. It is an educational crisis. It is a suicide crisis. It is a world crisis.

Victor Dzau, President, US National Academy of Medicine; Chancellor Emeritus, Duke University, USA.

This article is based on Victor Dzau's keynote speech at the launching ceremony of Institute for Global Health and Development, Peking University and the Beijing Forum 2020.

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What are the lessons learned? First, COVID-19 has revealed a collective failure to take pandemic prevention and preparedness and response seriously and prioritize it accordingly. We live in an interconnected world—an infection anywhere is a catastrophe everywhere.

Another important issue we have learned is the human dimension—that is, the importance of leadership and citizenship. We have seen a need for leaders to make decisive and strategic decisions, and to base these decisions on science. Simultaneously, citizens must be encouraged to participate in protecting themselves and each other.

I think what we have also learned is that the current measurements of preparedness are not predictive. Using the Global Health Security Index, the US ranks first in capacity to prepare for epidemics and pandemics. But as you know, we have not fared so well during the COVID-19 pandemic.

Health emergency preparedness requires effective and agile systems. Pandemic preparedness is a common good. We must invest in preparedness globally, because the potential return on investment is immense. No one is safe until all are safe. Global preparedness is not simply the sum of national preparedness, and the world of preparedness is already complex. It needs consolidation and not fragmentation.

A second GPMB report was released in September 2020. We called it *A World in Disorder*. It recommended five different actions: responsible leadership; engaged citizenship; robust global governance of preparedness; strong agile system for health security; sustained investment. An additional overarching recommendation was for cooperative research and development worldwide.

I will review some of the recommendations included in this report. As I mentioned previously, what distinguished successful countries from those who have not coped well with the pandemic is leadership—leadership that makes strong choices based on the science, creates a national strategy, and involves every one of us, as responsible citizens for the public good, to protect ourselves and protect each other.

One major recommendation in this report is global governance of preparedness. We must amend the international health regulations to the World Health Assembly. We must develop mechanisms for assessing multilateral preparedness, and there must be an international framework of governance that is clear and un-complicated.

We must also develop strong agile health security systems for every country. Heads of states can strengthen their national systems through an all of society approach. This type of approach does not only focus on health, economics, or forced dichotomy of health versus economics. This is a one health approach, which builds sufficient public health capacity and a strong public health workforce; strengthens health systems; and puts systems of social protection in place to safeguard the vulnerable members of that population. Importantly, heads of government must strengthen the WHO as an impartial international organization for directing and coordinating pandemic, response and preparedness, with a renewed commitment to a multilateral system.

There are two additional areas I want to emphasize. First is sustained investment. It is crucial that global leaders, along with the UN, the WHO, and international finance institutions, recognize preparedness as a global common good, one that is not at the mercy of political and economic cycles. Nations must ensure that they

have adequate finances for domestic and global investment. There must be a mechanism for sustainable financing of global health security which mobilizes resources at scale, in a timely manner without relying on global development assistance. The research sector, governments, the WHO, international organizations, and the private sector must coordinate effectively, from end to end and from research to development. During health emergencies, there must be a sustainable mechanism to ensure rapid and equitable access to vaccines, therapeutics, diagnostics, and non-pharmaceutical interventions.

Countries which have resources have actively mobilized domestic resources to prepare and to respond. With respect to vaccines, diagnostics, and therapeutics, the US has invested heavily into coordinated responses such as Accelerating COVID-19 Therapeutic Interventions and Vaccines (ACTIV) and Operation Warp Speed. To date, we have spent up to $18 billion to acquire vaccines, therapeutics, and diagnostics. China and Russia have also done well in investment and vaccine development.

What happened at the beginning of the pandemic was a lack of a coordinated system that would have allowed the world to come together to coordinate a response to COVID-19 and to coordinate investment into successful pandemic response resources.

In March 2020, the GPMB, led by myself and Jeremy Farrar, called for an injection of $8 billion US of new global funding for the development of vaccines, drugs, and diagnostics. The European Commission, led by President Ursula von der Leyen, hosted a global pledging event which raised $18 billion US in a mere seven weeks. Out of that amount raised, and in parallel to these efforts, was the creation of a coordinated coalition of global health actors known as the Access to COVID-19 Tools Accelerator (ACT-A). ACT-A has supported the fastest, most coordinated, and successful global effort in history to develop tools to fight a disease by deploying tests, treatments, and vaccines.

What is unique in ACT-A is that it brings together multiple agencies and entities globally, which previously worked in silos. Under ACT-A, these entities came together for the first time to work in a coordinated and voluntary fashion. This included the WHO; the Global Alliance for Vaccine Immunization (GAVI); the Coalition for Epidemic Preparedness Innovations (CEPI); Wellcome Trust; UNITAID, the World Bank; the Global Fund; FIND, the global alliance for diagnostics, and others.

ACT-A is overseen by a global council which includes the WHO; the G20 countries and the European Commission; and several other partners. It has a coordination hub and a steering group known as the ACT-A Principals Group, in which I serve. This group is organized into three pillars: vaccine, therapeutics, and diagnostics partnerships, in addition to a cross-cutting whole system connector. This brings together the entire continuum, from research and development, to manufacturing, to procurement, to deployment. For the first time, stakeholders are working together to not only consider what vaccines to invest in, but how to support risk management from procurement to distribution. For example, the vaccine partnership—referred to as the COVID-19 Vaccine Global Access Facility (COVAX)—includes CEPI, the WHO,

and GAVI. The United Nations International Children's Emergency Fund (UNICEF) is involved as a key delivery partner. This is a pillar in which I am particularly active.

What has ACT-A done to date? For vaccines, the goal is to have two billion doses by the end of 2021. Earlier, Dr. Summers said we should have everybody vaccinated by 2022. We have a long way to go until we reach this milestone, but this is an ambitious goal many in ACT-A are working to achieve. For therapeutics, we hope to have 245 million courses by mid-2021. For diagnostics, we hope to have 500 million tests by mid-2021. Since April 2020, until the time of this lecture in December 2020—a mere eight months—we have accomplished a significant amount. This includes securing vaccine candidates and early doses and supporting clinical trials. The first antigen replica diagnostic test has been established and is approved as ready for effective implementation.

We have a long way to go, but when it comes to vaccines, the news is good. Pfizer and Biotech received approval from the United Kingdom and received emergency use authorization in the US in December 2020. Moderna and AstraZeneca approvals are not far behind.

Vaccine development has moved with rapid speed, taking us from sequencing of the virus in January 2020 to creating the vaccine, conducting phase 3 trials, and now to approvals in a mere 10 months. There are also many reasons to celebrate the technology and science used in this process, including advances in RNA, DNA, and viral vectors, among many others.

However, many countries, particularly low-income countries, are not able to secure these vaccines despite the efforts of organizations like GAVI. Many middle-income and even small high-income countries without the resources of China, Russia, the US, have needed to work together to purchase large amounts of vaccine using pooled mechanism. The ACT-A COVAX pillar has been successful in bringing together 190 economies to create a pool of purchase vaccines. Today we have one billion doses secured globally.

Looking forward, we have a long way to go. At the time of this talk, there is still a major financing gap—approximately $28 billion—that would be required if we hope to achieve the full set of ACT-A goals by the end of 2021. The vaccine alone will require another seven to eight billion dollars. This underscores the importance of sustainable financing, particularly in the future—not only to secure the COVID-19 vaccine, but to prepare for pandemics to come.

As we have heard many times today, multilateralism is truly important. We see examples of this today, and we must give credit to China in this regard. At the time of this talk, China is ready to ship 400 million doses to other countries. We need this coordination in the midst of vaccine roll-out to achieve equitable distribution, so that everyone is able to access the vaccine, regardless of socioeconomic status. We also need to ensure public trust in vaccines, and of course, as I said earlier, we must establish a sustainable coordinating framework and financing mechanism for the future.

Vaccines have also created many questions—for example, with regard to safety, because they were authorized and came to market so rapidly. Will people take

the vaccine? If we have limited doses initially, how do we manage allocation? How will we distribute the vaccine and how will we ensure equal access across the globe?

The WHO, one of the leaders of the COVAX initiative, released a two-stage framework for equitable vaccine allocation. Under this framework, the vaccine would go to first health workers, the elderly, and those at high risk. These combined populations account for 20% of the global population. At the time of this talk, the COVAX aspiration is to ensure every country has 20% of vaccines immediately available for 2021. But while it is possible to distribute vaccines, it is particularly challenging to distribute the vaccine in GAVI-eligible, low-income countries to low-income countries. Experience suggests the existence of two separates, disconnected supply chains. One moves vaccine from vaccine supplies to the country, and a second moves vaccines from a country to local. We are facing this at home in the US. How do you get from the central government to state and local jurisdictions? And then, how do we distribute the vaccine to individuals? Storage of mRNA vaccine is limited because the vaccines must be refrigerated—at −70°F for the Pfizer vaccine and at −20°F for the Moderna vaccine. We must also consider the supply chain. The WHO estimates that over 50% of vaccines may be wasted globally on an annual basis because of temperature control, logistics, and shipment-related issues. We also are lacking adequate workforce for true mass vaccination.

Clearly, there is much work to do. In terms of vaccine hesitancy, surveys conducted in the US in 2020 show that 50% of population said they would get vaccinated, but 30% said they would not. About 20–30% were unsure whether they would pursue vaccination. Our population is very hesitant. In a parallel global survey, 70% of respondents reported they were very likely or somewhat likely to get vaccinated. The numbers suggested that almost 90% in China were likely to get vaccinated, but only about 50% in Russia felt similarly. Vaccine hesitancy is widespread. We have populations at home in the US that have historically been exploited and mistreated by the medical community. Because of this, many communities of color don't trust the government. We will need a concerted effort to address hesitancy through educational campaigns, which build trust by providing transparency and honesty about side effects. We must also ensure vaccine safety systems that follow patients after their initial vaccination and any subsequent doses.

As an international community, we have learned so much from the COVID-19 pandemic. It is imperative to have (1) a globally coordinated, end-to-end research and development preparedness and response ecosystem for vaccines, therapeutics, and diagnostics; (2) strategy and coordination in public health intervention—including detection, testing, contact tracing, data reporting, and analysis—and digital innovations at national and global levels; (3) multilateralism to engage all countries to work together to promote global coordination and equitable access; and (4) sustainable financing: long-term, predictable, reliable financing for global pandemic prevention, preparedness, and response.

In summary, COVID-19 has demonstrated the importance of four critical and interconnected dimensions in pandemic response and preparedness. First, responsible leadership. Second, engaged citizenship. Third, agile health security systems.

Fourth, sustained investment. We all must work together. Multilateralism is the essential link, ensuring all components of the broad effort function coherently and effectively at local, national, regional, and global levels. Solidarity is crucial if we hope to achieve equity for all.

I am optimistic. Hopefully, with the incoming US federal administration we will see China and US work together for the greater good of humanity.

Economic Development and Its Impact on Health

Justin Yifu Lin

I would like to talk about economic development, health systems, and their impacts on health.

For health, its purpose is to improve people's well-being and to allow them to have longevity. We know that with economic development, household income will increase, people will have better nutrition and if they are sick they can go to doctors. Under that situation, they will be healthy and can live longer.

According to the World Bank's data, in 2018, in low-income countries, the life expectancy of the people is 63.5 years. For low-medium income countries, their life expectancy is 68.4 years. For upper-middle income countries, their average life expectancy is 75.3 years. For high-income countries, their life expectancy is 80.7 years. Although we know the relationship between economic development and health and life expectancy, the issue is how to promote economic development.

From my study of the new structure of economics, we know that economic development is a process of structural transformation with continuous technological innovation in the existing sectors to improve productivity, and also industry upgrading to relocate resources from lower value-added sectors to higher value-added sectors. By this way, the economy will have better performance and the income of people will increase, resulting in better health and longer life expectancy.

Technology innovation is very important in the transformation of the traditional agriculture. But only in agriculture is not sufficient, because unless a country is well endowed with arable land, otherwise no country can reach middle-income status by agriculture alone.

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This article is based on Justin Yifu Lin's keynote speech at the launching ceremony of Institute for Global Health and Development, Peking University and the Beijing Forum 2020.

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So, when a country is in an agrarian a stage, it is always poor. If a country wants to improve its income, it needs to upgrade to manufacturing sector, and gradually to service sector. I think this is known to almost everyone, but only a few developing countries have been able to industrialize their economy and to move from low income to middle income and further to high income.

From my own studies, if a country wants to be successful in industrialization, the country needs to follow its comparative advantages in the process of development. Because for the ambition to imitate the high-income countries' industries, the intention is good, but in general, because of violation of comparative advantages, firms in those industries are not viable and need to be subsidized with all kinds of government distortions. As a result, their performance will be poor.

For a few successful economies, which catch up the high-income countries, they followed their comparative advantages in their industrialization. When they transformed from the agrarian economy, they started with labor intensive industries which were consist with their comparative advantages. They were competitive and gradually they moved up the industry ladders to more capital-intensive industries.

To develop a country's economy, and especially in the manufacturing sectors, along the line of a country's comparative advantages, two institutions are important: one is to have an effective market system. Only with an effective market system, the factor prices can reflect the relative abundance of factors endowments which determine the comparative advantage of the economy. With competitive markets, the price signals will guide the entrepreneur to adapt the right technology and to go into the right industries which reflect the country's comparative advantages.

At the same time, the comparative advantages only mean the factor costs of production of the industry will be low. To be competitive, the industry also needs to have suitable infrastructure and institutions to reduce transaction costs. The improvement of infrastructure and institutions require government coordination. Therefore, it's essential to follow the comparative advantages of the economy in the development. But to make that happen, both the market and the state are needed. If a country can develop its economy successfully by following its comparative advantages with the supports of market and the state, people in the country will increase income, improve nutrition, and you can have much better health and life expectancy.

At the same time, it's also very important to have a good health system. We can take China as an example. In 1978, before starting the market orientation reform, China was the third poorest country in the world according to the World Bank's data. Its per capita GDP was only 156 US dollars, which was less than one third of the average of sub Saharan African countries. But in 1978, the health measured by life expectancy in China was 65.9 years, while average life expectancy in low income countries was 47.6 years, in lower middle-income countries was 54.2 years, and in upper middle-income countries was 64.4 years. It means the life expectancy in China was 18.3 years higher than low-income countries, 11.7 years higher than lower middle-countries, and 1.5 years higher than the upper middle-income countries. How that was possible? Well, it is because of the good health system in China.

At that time, China had a prevention health system that was set up all over the country. At the nation level, China had the ministry of health; at a county level, China

had county hospitals; at the township level, China had the township health center; and in a village, China had village health clinics. By that, China could prevent pandemics and infectious disease very effectively. If farmers got sick. They could go to village clinics to get treatment. If the clinics could not treat them, then they could go to the hospitals in the township. If the township hospital could not deal with the problems, they could go to the county hospitals. That's one thing.

Secondly, the farmers had the cooperative health system. They pooled money together and if someone got sick, they had the money to go to the clinic or go to the hospital to get treatment.

And the third was the famous Barefoot Doctors. At the village, they had barefoot doctors. Their training was minimal but they were able to take care of simple diseases.

I think with these three systems, China was able to create a kind of miracle. In 1978, China was one of the lowest income countries, but China's performance in terms of health was better than upper middle-income countries. Certainly, this kind of system will not appear spontaneously. The government needs to create and institute them.

Good health is one of the common goals in the world. According to the United Nations' Sustainable Development Goals, good health is the number three goal among 17 goals, which all the countries in the world commit to achieve by 2030. So from the above observation, I think if we want to have good health for the people, first of all we need to have economic development to raise the income of the people, so that when they get sick they have the money to go to the hospital, and they can have good nutrition. To have good economic development, we need to have two institutions working together: one is a market institution, the other one is the state. And to have good health, in addition to raising people's income, it is also essential to make health care available and affordable to the people. If we want to make the health care available and accessible to people, we need to have a government to create the system. Overall, we need the market and the state working together to promote economic development and to provide health care and so on to the people. Then the good health in the Sustainable Development Goals can be achieved.

Those are my observations.

Health Aid Promotes Human Health

Ming Xu

Thank you for giving me the floor to talk about the commodity supply for development assistance and the role of Chinese companies.

As you know, under the Sustainable Development Goals (SDGs), international development aims at improving the lives of individuals, particularly in the low-and middle-income countries (LMICs). In the health field, it is desirable for the people there to be well equipped, to live more equitable lives, and enjoy easier access to those basic commodities, especially essential drugs, and medical services. So this is actually what is stipulated by SDGs.

When talking about the commodity supply for international development programs, I have to say, fighting major infectious diseases like AIDS, TB, malaria, and COVID-19 has become a top priority for many countries, particularly those LMICs. Let's take malaria as an example, just because of the COVID-19 pandemic, the incidence last year increased because there was less care for the vulnerable population. Most deaths happened among young children, especially in sub-Saharan Africa. So this is indeed a very challenging situation we are facing today.

When we talk about the particular market for public procurement, especially the market for development assistance, I try to give you a clear picture of diseases and donors. This is an exceptional market, and I will briefly walk you through it. The development assistance is focused primarily on major infectious diseases, maternal and reproductive health and related fields.

Major purchasers in the development assistant programs include UNICEF, the Global Fund, and other UN agencies. Some foundations, such as Bill and Melinda

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Gates Foundation, are also big contributors to those international development programs. Before the COVID-19 pandemic, the size of the development systems for health was just about $35 billion to $40 billion a year, with an average annual growth rate of roughly 1%.

But just because of COVID-19, the market expanded exponentially, particularly in the past two years. Here's the snapshot of those focused areas. Prevention, diagnosis, treatment, vaccine, nutrition, and family planning are actually the core of this market. There have been some changes in this market due to the outbreak of COVID-19.

Next, I'll talk about the Access to COVID-19 Tools Accelerator (ACT-A) Initiative. ACT-A was launched in April 2020 by WHO and other UN agencies. There are three pillars of ACT-A: vaccine, therapeutic and diagnostic partnership.

Gavi, UNICEF, and WHO are the co-conveners for the vaccine partnership. For the therapeutic partnership, UNITAID, the Global Fund are held responsible for developing deploying new therapeutics, especially in the LMICs. For the diagnostic partnership, the Global Fund is playing a crucial role, especially in deploying those badly needed In-vitro diagnostics (IVDs) for those countries at risk. FIND and WHO are providing support to this particular pillar.

The World Bank and the Global Fund are also responsible for building up the health system connector. Among other things, let's take vaccines as an example, WHO made it very clear that ensuring equitable access and a fair allocation is a priority as the vaccination campaign unfolds at scale.

When we talk about the commodity supply on the part of companies, you have to get your products registered. For ACT-A, there is a particular procedure, EUL (Emergency Use Listing), as part of the WHO approval procedure to cope with emergencies.

The EUL procedure involves a rigorous assessment of quality, safety, and efficacy data to enable early and targeted use of yet to be licensed vaccines, treatments, and diagnostics, to respond to a public health emergency of international concern. So there are three phases for EUL, preparedness phase, emergency phase, and post-listing phase.

So what is the nature, the essence of EUL, and how is the EUL procedure different from pre-qualification? Prequalification is the precondition for a particular product to be purchased by those UN and international agencies, and the procedure of EUL is intended to provide a time-limited listing for unlicensed products in an emergency context when limited data are available but products are not yet to be approved for prequalification. As part of the EUL, the expectation is that the manufacturer will complete the development of the product and submit for licensure and WHO prequalification. Here's a short description of those categories of medicines for WHO prequalification. You know that the primary types of medicines are those products related to HIV/AIDS, malaria, TB, reproductive health, influenza, acute diarrhoea, and neglected tropical diseases, etc.

In addition to that, those APIs for making formulations of these products are also required to apply for WHO prequalification.

This slide shows the prequalified China-made products. So far, there have been 33 Chinese manufacturers, which have already got the prequalification from WHO, with

55 active pharmaceutical ingredients. In terms of vaccines, there are four Chinese manufacturers with seven vaccines prequalified, including the JE vaccine, influenza vaccine, polio vaccine, and HPV vaccine. There are also some IVDs and the vector control products like bed nets. So far, there have been 10 China-made PCR tests and 2 vaccines endorsed by WHO under the EUL procedure. The Global Fund and UNICEF are the major purchases of those WHO prequalified products, including those products granted EUL status.

Before the COVID-19 pandemic, the Global Fund purchased roughly $1.7 billion worth of health products every year. China has become a very important supplier of those essential drugs to the Global Fund. Chinese companies now rank 5th among all the suppliers of those essential products.

Lastly, I just want to bring your attention to some initiatives and arrangements launched or promoted by the UN agencies to facilitate access to those essential medicines in LMICs. Maybe you have known that Pfizer has just signed a voluntary licensing agreement with MPP, Medicine Patent Pool for its COVID-19 oral antiviral treatment candidate.

This is a special mechanism backed by UNITAID in Geneva. The MPP aims to enable affordable production of essential drugs still under patent protection by obtaining volunteering licenses from the patent holders and making these licenses available to generic companies in LMICs. However, these companies can only sell these products in designated countries.

You are not allowed to sell without permission in your own country. So this is a very special feature of this arrangement. MPP has signed agreements with 10 patent holders for 13 HIV antiretroviral, 1 HIV technology platform, 3 hepatitis C direct-acting antivirals, and 1 TB therapeutic.

Another arrangement launched by Gavi is called IPTK Bank (Intellectual Property Technology, and Knowhow Bank). This is an initiative launched by Gavi to enable the early market entry of multiple developing country vaccine manufacturers and to facilitate the rapid rollout of new vaccines in developing countries.

Another mechanism also interesting to companies is called the Product Development Partnership, such as Medicines for Malaria Venture, MMV. This is a public–private partnership to encourage pharmaceutical companies to develop innovative drugs to treat malaria.

To attract more companies to produce generic drugs, tiered pricing has been used a lot, especially in LMICs to improve the access of those essential drugs, particularly in an emergency context. So I think this is high time to think about how we may work together to galvanize more Chinese companies into providing quality-assured and affordable commodities, especially for those international development assistant programs.

Strategies to Improve Access to COVID-19 Vaccines

Somil Nagpal

Explaining the importance of the vaccine distribution, and of the COVAX facility which I will be referring to abundantly during the illustrative case, and I will be starting now.

We have been talking about Indonesia as a case on how our team are trying to do their best in ensuring access to COVID-19 vaccines in emerging economies.

So just a quick reminder of how Asia is feeling in terms of vaccine access, the COVID-19 incidence is still high in Asia. There's some plateauing and some decline in some countries, but it's still high. However, fortunately, there have not been too many deaths in Asian countries. There is successful containment in many countries and it is a delight to see a large gathering of people in person on the other side of the screen. I hope that all countries, including mine, are in that situation soon. We are looking forward to a time when we can all be together in the same room. But there is a lot of credit to be given to the countries that have been able to do successful containment and the presence of all the audience in person in China is an example.

Vaccinations have begun in several countries. There are supply constraints which affect Indonesia as well compared to the two large manufacturers and countries, China and India. Indonesia is still quite modest in terms of its numbers. And of course, the concerns as you can see and variance are quite high. However, Indonesia is doing better than many other countries, many other emerging economies and other lower income countries which may actually need multiple years to complete their vaccinations. And this is something we do need to be concerned about.

So just reading about the first presentation about the fairness of vaccine distribution, this slide illustrates that point that most of the vaccine purchases currently are

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among the high-income countries. We are looking at most of the world's available supply being not distributed very uniformly at this point. And this is how the emerging economies stand and this is how the lower-income stand. And in that context, the COVAX, which has planned to deliver 1.8 billion doses in 2021, is going to be a big contributor to the availability of vaccines across the entire developing world. Other challenges about the availability include the effects from any new strains to timeline for regulatory approvals as new vaccines emerge. The challenges the manufacturers are facing are in terms of availability of raw materials and consumables. There are several months of delay in ordering for these supplies, which manufacturers are very concerned about.

Human resources for scaling up manufacturing are also facing the impact of COVID-19 as the skillset is not that wide. And even if manufacturing capacity in the world is actually quite adequate, the intellectual property, quality and regulatory issues do challenge the coordinated use and availability of vaccines.

In Indonesia, this is a chart that shows the trend in the doses being administered every day starting in January when the president of the country received his vaccination as a demonstration of solidarity with the vaccine campaign. Several other political and social celebrities joined him. The vaccination phase kept improving and actually went further to almost half a million cases per day. But then given the reduced availability of the vaccines, now is back to about half of the peak. This is a concern but this is because of the limitations that have been recently experienced because of the availability of supply. The country hopes that by June or July, the situation will substantially improve and get back the pace needed.

In terms of the rollout plan, Indonesia is vaccinating in phases. The first phase is currently completed. All the health workers in all the provinces of the country were vaccinated between January and February. Since February, they started vaccinating other frontline public service workers and the elderly. And next, you will see the vulnerable population including those with comorbidities starting in June or so. And then later in the year, after these groups are complete, then the rest of the population. So in all, 181.5 million beneficiaries of the entire adult population of the country are being offered free access by the government COVID-19 vaccines. This is one of the largest such efforts for free vaccinations for an emerging economy, having given free access and the time line of one year for vaccinating everyone. It's certainly a very good objective that the country is trying to achieve.

The vaccines that have been deployed in Indonesia are currently Sinovac from China and AstraZeneca, which have come from COVAX. These are the two that have been approved by the national regulator and are currently used. In addition, there will be further supplies from COVAX. It will include multiple vaccines from the COVAX portfolio, which is not yet fully known. But also, additional supplies from AstraZeneca and also from Novavax produced by the Serum Institute of India. The government has also created a private sector employer program where the employers can distribute vaccines free for the employees. And they should use vaccines other than those being used by the national program. And this private sector program places orders for Sinopharm, Sputnik V, and CanSino. We can see a lot of the vaccines that Indonesia has tried to source were based on the earliest availability that could be

available in 2021, so as to not delay the program and to keep it in time for the country to achieve its target of vaccinating everyone by March of next year. And there are a lot of orders and supplies that are not necessarily from the most developed countries, but really coming from China and India in terms of the needs for the country.

I just wanted to draw some parallels and this is my last slide. I will try to keep more time for discussion. But India, as another emerging economy, does not have adequate vaccines for all its domestic needs, and this is compounded by the shortage of the raw materials which are needed from overseas suppliers. These limitations are also affecting global availability of the vaccines, which is affecting the COVAX facility and which is again affecting the AMC countries for COVAX as well. But there are some parallels over its access to vaccines. We can learn from what India has been able to do in terms of access to affordable vaccines. And if there is time, I think we should go deeper today or otherwise in a future setting to see what other lessons from Indian pharmaceutical industry that can be drawn from improving access to vaccines as well.

Gavi's Contribution to Human Health

Li Zhang

For those unfamiliar with Global Alliance for Vaccines and Immunization (GAVI), let me say a few quick words. It began in 2000 as an alliance of the key agencies in global health, including the World Health Organization (WHO), the World Bank, United Nations International Children's Emergency Fund (UNICEF), and the Bill and Melinda Gates foundation, basically in response to acute market failure that made new vaccines unaffordable for low-income countries.

So Gavi's mission is to save children's lives and protect people's health by ensuring that low-income countries can afford vaccines. Vaccines are one of the most successful and cost-effective health investments in history, with more comprehensive benefits that accrue across a lifetime. A recent study by John Hopkins University covering the 93 Gavi supported countries projected that for every dollar spent on immunization, there are 21 dollars saved in healthcare costs, wages, and productivity due to illness and death [1].

When we consider the broader social value of lives saved and people living longer and healthier lives, the return on investment in vaccines is estimated to be 54 dollars for every dollar spent. So that shows how vital investments in vaccines are truly crucial [1].

So now, coming to the Corona Virus Disease 2019 (COVID-19) pandemic, which the WHO formally declared as a global pandemic about a year ago about this time. It has also threatened decades of progress, and as a result, we see that 2020 was the worst global economic contraction in peacetime since the great depression.

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It is also estimated that the direct and indirect impacts of the virus would put between 143 and 163 million more people into poverty by 2021, and reverse critical gains in health, education, and nutrition [2]. Impacts on local and national economies and international trade and travel continue to result in the loss of 375 billion to the global economy a month [3].

It was recognized early that the global community would require one of the biggest and fastest international efforts in a decade to end the pandemic. So at the international community's request, Gavi and our colleagues from WHO are driving a global coordination and financing effort that will accelerate the distribution of COVID-19 vaccines worldwide, also known as the COVID-19 Vaccines Global Access (COVAX) facility [4].

So COVAX is under the vaccine pillar of the access to COVID-19 tools accelerator which is known as the Act-accelerator, which is a global collaboration that brings together scientists, businesses, donors, global health organizations to speed up an end to the pandemic through the support of vaccines, therapeutics and also diagnostics. The COVAX facility, it's an international procurement mechanism designed to maximize the country's access to COVID-19 vaccines as quickly, fairly, and safely as possible.

With more than 119 economies now involved in the COVAX facility, including China, the COVAX facility covers more than 90% of the global population [5].

So, the facility proves participants' buying power and allows the government to benefit from a larger portfolio of promising vaccine candidates with a bigger market to provide security of demands.

As we know, in regular times, from vaccine R&D to procurement, to manufacturing, and then to procurement, it can take ages to reach people. So, the facility is basically about the acceleration of that. Early vaccine markets would be characterized by far greater demand than supply, therefore, driving up the cost and preventing low and lower-middle-income countries from being able to access the COVID-19 vaccine. Gavi has also coordinated the development and implementation of the COVAX advance market commitment (AMC) [6].

It's a financing instrument that supports the participation of 92 low and lower-middle-income economies through support, both public and private contributions as well. The initial objective of the facility is to provide enough vaccines to protect the high-risk and vulnerable population and frontline health workers that are necessary to end the acute phase of the pandemic.

The Allocation of the vaccines to the different countries is guided by the WHO allocation guidelines to achieve the objective of the COVAX facility, which has currently assembled a broad portfolio of vaccine candidates and also vaccines.

As of April 2021, we have secured deals with six vaccine manufacturers and have more to come. We are now able to deliver 1.3 billion doses by the end of 2021 to AMC countries and extend coverage for exercising options on another 500 million doses [7].

COVAX is delivering on its commitment with Ghana and Cote d'Ivoire, which became the first countries to administer COVAX-supported vaccines on the first of March 2020, which is just 83 days after the first dose was administered in wealthy

nations in the UK [7]. As of April 2021, COVAX has shipped more than 39 million COVID vaccines to 113 economies across the world, with more than 65% of all low and lower-middle-income countries having already received their first delivery of these vaccines [8].

The supply from the first allocation round is anticipated to cover an average of 2.5% of the AMC population by May [7]. This is enormous progress, we are only partway there, and inequalities remain in the rollout of COVID-19 vaccines.

So higher income countries, it's ahead in the race to vaccinate their populations. However, given the rising number of variants, the progress achieved by higher-income countries will remain in jeopardy as long as the COVID-19 virus threats other parts of the world.

The latest study shows that if the world's wealthiest nations are fully vaccinated while the developing countries are half vaccinated, it could drive down the global economy by about 9.2 trillion U.S. dollars, and almost half of that, which is about 4.5 trillion U.S. dollars, would be incurred in the wealthiest nations [9].

It shows that vaccine quality is really at the heart of what we're trying to do with economic recovery. So continuous improvements will help shape the way how Gavi and COVAX work with partners. We recognize that the only way to adequately respond to the challenge of COVID-19, particularly given the onset of variants, is to achieve global vaccination coverage as quickly as possible.

As one of the biggest and fastest international in a decade, the COVAX facility will be a testament of how global organizations come together and devise a new model of working. We are incredibly grateful for the contributions and support provided by both the public and private sectors to help this initiative come to fruition. As recently as last week, we just launched the COVAX AMC investment case, which presented a 2 billion funding gap to support the delivery of a total of 1.8 billion doses to AMC countries by the end of 2021 and to end the acute phase of the pandemic [10].

This success of the facility will not just determine how quickly we end this current crisis but also help us prepare for the next pandemic because there will be the next one. The emergence of novel viruses of pandemic potential is an evolutionary certainty.

The global challenges we face today can only be solved through solidarity and international cooperation. As my colleagues have shown, no one is safe until everyone is safe. So, with that, thank you very much, and I definitely look forward to hearing from other colleagues about their work.

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Chronic Non-communicable Diseases Deserves More Attention

Youfa Wang

The infectious disease has been talked about a lot since the Corona Virus Disease 2019 (COVID-19) pandemic occurred. We should be confident that the infectious disease is much easier to contain than noncommunicable diseases (NCDs). With successful vaccines and other successful measures, we will be able to overcome such infectious diseases. NCDs have been a major challenge to human health worldwide.

We are facing serious challenges of NCDs globally and in many countries, including China, as one example. On the one hand, it is a good example and, on the other hand, it's a poor example. I will share with you about some of the issues we have in China and the potential future, lessons that China can contribute to the world in terms of the serious challenges we're facing.

The prevalence of NCDs including such as diabetes, some types of cancer and obesity is very high and the awareness and management rates in general are low, especially in low and medium income countries including China. For example, many of the chronic disease patients, such as type 2 diabetes patients, even do not know they have the disease. These patients do not take the treatment, and the patients taking the treatment cannot manage their condition. In general, in many low-income countries, including middle income countries like China, only about one-third of people with NCD are aware of their diseases and take the needed measures to control them. All of these are huge challenges.

NCDs kills about 41 million people each year, accounting for about 70% of all deaths globally. Each year more than 15 million people die from NCD between the ages of 30–69 years, which is premature deaths. About 85% of these premature deaths occur in low- and middle-income countries. In China, NCD deaths accounted

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for more than 80% of the total deaths. About 80% of all NCD deaths are in low- and middle-income countries. That's why many low- and middle-income countries are facing such a double burden: infectious disease and chronic disease.

Fortunately, we do know many of the factors that contributed to NCD that include tobacco use, physical inactivity, harmful use of alcohol and poor diets. Take tobacco use as one example, even though the harm of tobacco is clearly understood, many countries including China are not successful in controlling tobacco use. NCDs threaten the progress towards the 2030 Agenda Sustainable Development Goals (SDGs). The costs of NCDs treatment, combined with loss of income, force millions of people into poverty annually.

Critical actions are needed from government and individuals to manage NCD. Many of such NCD intervention efforts need policy and also need the support of individuals. If we cannot take such successful actions, we will not be able to achieve the global target of a 25% reduction in the risk of premature mortality from NCD by 2025, and the SDG target of a one-third reduction in premature deaths from NCD by 2030. So investing in better management of NCD is critical. NCD management includes a number of actions such as detection, screening for the patients, and providing them with the successful treatment and also such palliative care.

International collaboration is important to fight the NCD epidemic. And China can play important roles in such collaborations, including sharing some of the lessons we learned in the past several decades. However, China has seen a very rapid increase in chronic diseases as the most recent data reported in December, 2020 in the national NCD report. The report indicated that many of the main chronic diseases and the related risk behaviors such as poor diets had been steadily increasing. Also, at this moment in China, more than 50% of adults are obese or overweight.

About two decades ago, many people thought that malnutrition was the major challenge for countries like China. That is not true, and not anymore. At present China is becoming the country with the largest number of people with overweight and obesity. Even among children, about 20% of them are overweight or obese.

Obesity is just one indicator of many poor behavior and the environmental factors for poor health. The World Health Organization (WHO) and the United Nations have put a lot of effort and attention into fighting the NCD epidemic, and have taken a number of actions including producing a series of important reports. The "Global Noncommunicable Disease Action Plan 2013–2020" was released in 2013 by WHO setting up nine global targets for NCD control by 2020.

However, now we fail in achieving these goals such as lowering the prevalence of type 2 diabetes and obesity to a limited level. With the ongoing COVID-19 pandemic, we are facing even more challenges than before to fight the NCD epidemic. Many of the measures taken to fight COVID-19 would facilitate physical inactivity and poor diets, which may put more people at risk of NCDs, especially those suffering from obesity and cardiovascular diseases. In addition, the global aging, the more rapidly increasing aging puts additional challenges.

Taking obesity as an example of the NCDs, there are 40% of adults who are obese worldwide. In China, based on the new national NCD report released in December 2021, more than 50% of adults and 20% of children are obese. In 2019, we published

this *China Obesity Prevention and Control Bluebook* as one effort that China is taking to face the epidemic. The projections indicated that 61.5% of Chinese adults will be overweight and obese by the year 2030 if there is no effective approach taken. This is because of the changing food environment and changing behaviors on diet and physical activity.

The WHO has recommended countries to take effective approaches to fight this growing obesity epidemic, especially to provide a supportive environment and communities for desirable lifestyles including healthy diets and adequate physical activity to fight NCDs. Many of such actions need strong government commitment and support and engagement of individuals. China can try to provide a good potential example for the world with the *Healthy China 2030 Initiative* and also the *National Nutrition Plan.* For example, "Reduce intake of salt, cooking oil and sugar" is one of the key clear messages taken by China, and have made some good progress thus far.

Our team published a 246-page comprehensive report entitled "China Blue Paper on Obesity Prevention and Control" and a paper entitled "Prevention and control of obesity in China" in Lancet Global Health in 2019. We proposed the following policy recommendations for China: (1) Make the government responsible and enhance cross-sector collaboration. This includes integrating obesity prevention and control into government mandates and the day-to-day work of relevant government agencies and authorities, improving and completing the nutrition policy system, and fostering the training of nutritional experts and professionals. (2) Make better use of health professionals' institutions to promote large-scale, population-level educational programs and campaigns, to provide individual-level counselling and guidance on obesity prevention, control, and treatment, to implement 360°, multilevel, multi-component, and multisector prevention and intervention programs and related research, and to develop and improving surveillance systems at national and local levels. (3) Engage families and individuals in obesity prevention and control by making individuals accountable for their health. (4) Improve the obesogenic environments.

This is one of the papers we published regarding the global health with an example of some recommendations we made for China to take to fight the growing obesity epidemic.

There is another example of an international collaboration project that my team got funded in 2011 when I worked as a professor at the John Hopkins University. The NIH in the U.S. invested more than 16 million US dollars to support this international collaboration project to fight obesity and NCDs. In the future, we are hoping that countries like the United States will continue to commit to such international efforts. As part of this program we have an ongoing research project in China.

In 2011, we received more than two million US dollars to support this project in China to fight the obesity epidemic, named "Multilevel Systems-oriented Childhood Obesity Study in China". The aim was to study the interplay, impact and feedback loops of the built, social, economic, environmental and policy factors, and their changes on individual children and their families' decisions, eating, physical

activity, and adiposity outcomes. Also, this project aimed to study why some individuals/families may respond differently to the environments and how they may affect their environments (i.e., feedback loops)—Explore potential intervention options. This project used unique rich longitudinal data, novel statistical analysis and systems models.

Moreover, our team has been trying to develop a large new program which includes the effort targeted at the local, regional, and global to fight the NCD epidemic. This program is based on a strong theory like system science and will use big data.

Low-Carbon Economy and Human Health

Abstract As low-carbon emissions have become the common goal of the global community, it is of significant importance for China's healthcare system and the international healthcare system to make joint efforts to develop an optimized pathway where the human health benefits could be improved. This section investigates the relationships between the health sector and the low-carbon economy. It offers the innovative insights, such as the technology or framework, for industry, government departments, and institutions to take action.

Human Health and Medical Innovation in the Era of Low-Carbon Economy

Qide Han

Distinguished guests, Ladies and gentlemen, I am glad to see old and new friends here as well as many participants online. The theme of this year's forum is "Human Health and Medical Innovation in the Era of Low-Carbon Economy."

As we speak, the human world is still fighting against the new wave of the pandemic. But in the meantime, we are also facing many other challenges, some of which are much tougher to deal with in the long run, including major non-communicable diseases and climate change. Fortunately or not, many of the leading disease conditions and environmental issues are closely interacted, offering us great opportunities to search for more cost-effective solutions when conducting strategic actions holistically. For example, when assessing the costs and benefits of switching a fossil-fuel power station to a solar photovoltaic (PV) power plant, the action equation may be solved with very different optimal choices with or without including the health gains. Likewise, investing in a healthy city project may be more worthwhile with a much cleaner landscape when considering its contributions to the goal of low carbon transition.

In particular, we actually know quite a lot from the literature on how human health can be influenced substantially by global warming and air pollution in particular. For example, based on a recent study by Harvard scientists and collaborators in 2021, as high as 8 million people died in 2018 from fossil fuel pollution, which was responsible for about 1 in 5 deaths worldwide. Numerous studies also suggest that human health is very much impacted by climate change through channels such

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as extreme temperature, leading to a huge burden of illness worldwide. Meanwhile, plenty of studies have shown that turning into a low-carbon economy would generate tremendous health co-benefits by reducing fossil fuel use and relying more on cleaner production. Therefore, in this regard, rich research evidence is available to support a broad consensus on how important and worthwhile it is to pursue actions for low-carbon transitions. But the real question remains as "how" to do it, calling for increased efforts for technological innovation and political commitments, both domestically and globally.

From the health perspective, however, research evidence is relatively scant regarding how health reform and system development can contribute to low carbon transitions. Interestingly, some insights and encouraging messages may be obtained from recent changes in China's health policy settings. For brainstorming, let me share a few observations. As you may be aware, in 2016, when launching the 13th five-year plan, the "Healthy China 2030 Blueprint" was initiated as a top national development strategy. Following the Blueprint, a well-scheduled roadmap of Healthy China Action Plans has been made, including the national promotion of Health Knowledge, Healthy Diet, Healthy Exercise, and Smoking Control. Presumably, if all these goals are achieved as scheduled in time, the low-carbon contributions would be noticeable but not quantified yet because all these action plans would be essentially associated with decarbonization in nature.

Another important aspect is the healthcare system reform that may help reduce a great deal of carbon emissions on its way forward. Following the Reform policy settings, two areas are particularly important with great potential for emission reductions, one of which is pharmaceutical policy reform, involving changes in R&D, manufacturing, distribution, prescribing, and appropriate utilization. For illustration, based on some research, the pharmaceutical industry alone is even more emission-intensive than the automotive industry. Public hospital reform is another major reform component. As indicated in a 2019 paper in Lancet Planetary Health, public hospitals are responsible for over 48% of total emissions by the Chinese healthcare system, offering great opportunities for emission reduction if considered as an additional goal in the hospital reform efforts.

Because of time limitation, I can only highlight some of those crude observations above, hope to trigger more thoughtful responses, insights, and perhaps some sound policy advice by the following distinguished speakers, and the audience at large.

Once again, I think this Forum picks a very right topic to address at the right time and in the right place here at the Peking University, where we remain strongly committed to improving global health and human development through scientific inquiry and knowledge sharing worldwide. *In closing,* I wish the Forum a great success and all of you a pleasant and productive day.

Bio-industrials and the Green Transition

Kasim Kutay

In my view, the green transition will not happen at the pace or the cost desired if we do not harness the power of biotechnology. As everybody in the audience knows, we are in a golden era of biotech innovation. What we've seen over the last six or seven years in terms of biotech innovation is nothing short of staggering. I can give many examples, but perhaps the best one of late is the innovations associated with applying mRNA and the successful use of that technology for vaccines against COVID. Ten years ago, mRNA was nothing but a moonshot, but today it is a reality. And I can give numerous other examples of how much progress and how many drug approvals and new healthcare developments have taken the place of late. So we understand the impact of this biotech innovation on human health. What is less understood is the effect of this incredible innovation on industrial solutions.

I believe that the world needs a bio-industrial future. Bio-industrials will help us act on climate change by reducing waste, increasing the use of sustainable materials and feeding growing populations. At the same time, from a company perspective, they can help you win customers as consumers focus on sustainability, and they help firms meet new and growing sustainability regulations.

I came across this recent example of the power of bio-industrials. I will use it to illustrate the growth in new applications of bio-industrial technology. Every year in India, farmers torch millions of acres to prepare the fields for next year's harvest and crop. But today, there is an alternative; rather than doing all this burning, there is a new spray-in development using an enzyme that breaks down stalk stubble into fertilizer, with benefits to the soil and atmosphere.

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This article is based on Kasim Kutay's keynote speech at the PKU Global Health and Development Forum 2021.

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I just gave you an example from agriculture; let me give you some other examples of how bio-industrials are working today. On the left, I'm using an example of biobased fibers for things like apparel. So a perfect example of that is the German-based AM Silk, a manufacturer of recombinant bacterial silk; silk is one of the most durable, natural materials, as many of you will know. And silk can be used not only in apparel, but the company is, among other things, in discussions with certain airplane manufacturers to explore the use of silk in airplane wings. Another example is a bag that MycoWorks is developing with Hermes, the French luxury goods manufacturer. But it's not made from leather, although it looks and feels like leather. It is made from mycelium fungus. There's no killing of animals. There's no need for cattle from which you derive your leather, and, therefore, less agricultural land, less carbon footprint, less methane, etc. And on the right, and this is an incredible innovation; building materials made with bacterial processing. The company is called Biomason, based in the US, that uses bacteria to produce bricks essentially. It's the same microorganisms used in the production of coral reefs and applied industrially, the results are highly durable bricks. And of course, as we all know, building materials, such as cement, are one of the most significant contributors to carbon pollution.

Now just to put things into perspective, I believe we can do a lot more. But even if we did just a little bit, the numbers are pretty staggering. So what if, for example, 10% of the world's annual proteins were replaced with alternative proteins. We would have 700 million tons of CO_2 avoided and 900,000 million km^2 squared of agricultural land saved. That's about equivalent to 50% of the EU's agricultural area. Enzymes in detergents have been around for decades and are highly successful. But unfortunately, a lot of detergents don't use enough enzymes and still use chemicals.

If detergents were all bio-based, five million tons of fossil-based chemicals would be avoided. Another way of looking at it would be to prevent 10 tons of chemicals from being poured down the drain every minute. It's staggering numbers. We're all familiar with biofuels; we're all familiar with the use of micro-organisms to turn starch into biofuel. And if 3% of all liquid transport fuels were bio-based, 300 million tons of CO_2 would be avoided. That's equivalent to 125 million cars off the road. I use these examples because none of these are farfetched or require change that cannot be executed over the next decade.

So in light of that, Novo Holdings is building a portfolio to accelerate this transition. We do this because we've been involved in bio-industrials for many years now, for decades since our founding. And that is because of our shareholding in Novozymes, a world leader in the production of enzymatic bio-industrial solutions. And given this knowledge and network that we have from Novozymes and later on from our shareholding in Christian Hansen, we are now expanding into other areas. We have invested in all the companies you see in Fig. 1. If we look at the need for more sustainable agriculture, we have companies like Vestaron, which use biopesticide. So that is an enzymatic-based pesticide that helps avoid chemical pesticides. We have companies that supply alternative proteins to feed the world sustainably.

Finally, waste, where today we can take industrial off-take gases like carbon, and convert those and recycle them. A perfect example is LanzaTech, which uses bacteria

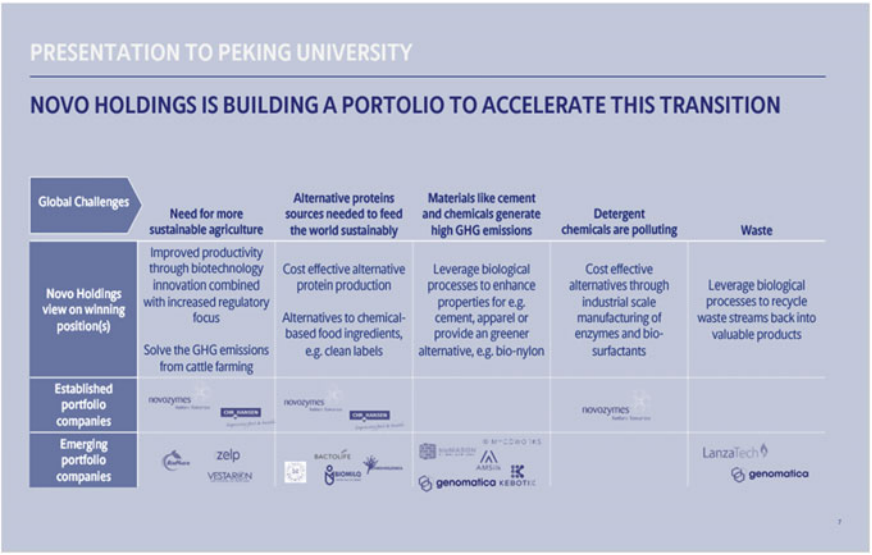

Fig. 1 Portfolio being built by Novo Holdings

to take industrial off-take gas to produce jet fuel. And some planes have already been powered using LanzaTech's jet fuel in combination, of course, with fossil fuels.

There are issues facing the greater adoption of bio-industrials. One is the scaling challenge, as I call it. A lot of these small companies find it very difficult to scale production to a level where that production becomes cheap enough and competitive with the fossil fuel alternatives. That is a considerable challenge. So if you look at the big companies like Novozymes or Christian Hansen, then the economics of biosolutions become viable. But the scaling is very challenging initially.

It is also challenging for those companies to scale to maintain the stability of the quality of the microorganisms they're trying to produce. We will gradually work and develop and overcome those challenges with time. But it is a serious one. The other big challenge is the regulatory pathways. And whether we're talking about Europe or China, the US, and other jurisdictions, there are regulatory pathways that frankly have not kept up with the developments on the biotechnology side. And those pathways are still, in many instances, archaic and arcane and do not allow the approval of bio-industrial solutions to take place at the speed we need. Very often, multiple agencies need to be involved in regulatory approval for anything relating to genetic research or Genetically Modified Organism (GMO). And I will give you an example in Europe, where bio-industrial products can take up to seven to eight years to receive approval, versus in the US, for example, where we're talking about two to three years. So, a lot of regulatory hurdles to overcome on a global basis, but I would urge all policymakers, all those that are focused on hastening the green transition, to focus on simplifying and speeding regulatory pathways to realize the goal of having bio-industrials play a more important role in decarbonizing our planet.

Systems Approach to Health and Innovation: Towards a Low-Carbon Economy

Gauden Galea

In 2018, the World Health Organization (WHO) Western Pacific Regional Committee Meeting decided four key thematic priorities in a policy document called "For the Future": health security, NCDs and aging, climate change and environmental health, and reducing inequity and reaching the unreached.

Indeed, the member states did prioritize on climate change and environmental health with a focus on all the issues that have been discussed here in the context of a low carbon economy, and put that within a systems approach. This systems approach refers to environmental and human health being part of a complex adaptive systems, but also refers to the systems of healthcare delivery and their impact on the climate and the climate crisis. If one looks at the sustainable development goals (Fig. 1) and looks at them from this perspective, we are concerned within the Sustainable Development Goal number three, that aiming for good health and wellbeing. And you relate that to each of the other sustainable development goals. The connection between them, the edges between each of those pairs of nodes in the figure on this slide is a major link with the environment. Either a major contributor to environmental health or a major danger to environmental health. In the context of the United Nations Climate Change Conference (COP26), the WHO convened many organizations and academics and made a special health argument for climate change. And I will summarize the action components within the "For the Future" framework and within those health arguments.

In these times, we must start with the pandemic and end with it. We need to commit to a healthy recovery. We need to align climate and health goals. We need to support a fossil-free recovery. We need to prepare for the next pandemic, which may

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Fig. 1 The Sustainable Development Goals (SDGs) centred on Goal 3: Global Health and Wellbeing

even be starting now. The danger of a pandemic remains with us, and it is not just dealing with the one we have now but always being ready for Disease X, the next pandemic. We need to adopt multi-sectoral approaches with health in all policies. And we need on an immediate basis to commit to vaccine equity.

Our health is not negotiable. As we discuss all these solutions, we need to keep the overall aim in mind. We need to close the 1.5° gap in order to stay alive. This is a step change in ambition, and each country must, as China has done, submit ambitious, healthy climate plans. We need to scale up finance for those vulnerable countries that need to tackle the climate and the health crisis. We need to step up our plans and funding for adaptation and resilience.

There are multiple opportunities for addressing and taking advantage of co-benefits between climate, human health, and animal health, with ecological considerations. The very concept of "One Health" is founded on co-benefits. We must maximize and measure the health co-benefits of climate action at all levels of government, thus honoring every person's right to health, recognizing that the current and future generations have a right to a safe, clean, healthy, and sustainable environment. And in doing so, we need to continue to invest in the science that strengthens the case for co-benefits and develops as we have seen solutions for connecting the benefits to the climate and the benefits to human health. At the same time, we need to build health resilience to the climate risks. This involves a process of regular assessment. The WHO has tools that can assist member states to regularly conduct these vulnerabilities and adapt health vulnerability and adaptation assessments. We need to develop and implement evidence-based adaptation plans for health, and we need to strengthen the climate resilience and environmental sustainability of health systems and facilities.

Jodi Sherman's presentation on this theme has been very impressive and convincing. We need to address the energy systems in ways that protect and improve our climate. We need to phase out polluting fossil fuels. We need to ensure that people in urban and rural environments have access to clean air, adopt WHO's air quality guidelines, do all necessary to adhere to those guidelines, and provide the people of this world with air that is breathable of the highest quality. In doing so, we need to invest in clean solutions for household energy. We have billions of people in the world who do not have clean heating, lighting, and cooking solutions. And at the same time, as we create energy systems in the developed world that is increasingly sustainable, we also need to consider those billions who do not yet have energy security in their household. We need to adapt our food systems to reduce their considerable emissions. As part of the health systems approach, we need to power the health sector with clean energy. And we need to find a just transition for those workers and communities who will be affected by this shift in the industry by providing support, training, and opportunities for those who will be transitioning out of the fossil fuel sector.

Our cities are increasingly attracting large parts of the population. Cities already are home to more than half of the world's population. And within those cities, multiple opportunities exist for reimagining our urban environments, transport systems, and mobility. We need to phase out the internal combustion engine and reduce private car use. We need to prioritize walking, cycling, and public transport, and we need to create people-centered cities, not least using the zoning and virtual systems that can create communities within communities, reducing the need for mobility, taking advantage of everything from telecommunications to the modern digital solutions that we are seeing and discussed at this meeting. We have heard the appeal both from academia and the private sector today that we should be using nature as the foundation for our health. And this includes several actions. We need to halt the destruction of nature, preserve biodiversity and carbon-rich ecosystems, halt the depredation of virgin forests, for example, protect and restore ecosystems. We need to recognize

that there are deep interconnections between human, animal, and ecosystem health, and we need to promote nature-based solutions.

We have heard a discussion at this meeting, which I can only reinforce of the circular economy. We need to look at an important component in sustainability and that is resilient food systems. I think of food in terms of food quality, food security, and food safety. And the agricultural, industrial, and trade practices that guarantee security, quality, and safety of the food have great impact on the environment. We need to nourish our future by improving access to sustainable and affordable diets. Removing harmful agricultural subsidies, supporting a just agricultural transition away from unsuitable farming practices that damage the environment and risk human health, mainstreaming biodiversity for nutrition and health. We need to look at the way we finance all this our health systems, food systems, and energy, and change our, or at least address our financing in a transition towards what is increasingly being called a wellbeing economy. We need to stop funding pollution and end harmful subsidies for fossil fuels domestically in each country and in our development assistance programs abroad.

We need to close the health financing gap for environmental health programs. Within the health sector, this refers not only to the health financing gap between richer and poorer countries, but also to financing gaps between, or at least financing imbalances between the high-tech hospital-based systems that we see in so many countries in favor of more community-based primary care, such as was mentioned by Mark McClellan earlier on. Like we do in medicine, we have a do-no-harm policy for public finance. We need to prevent investments in unsustainable and polluting activities that can threaten communities' wellbeing. And many nations are vulnerable and feeling the effects of climate change. Not least in our region, the climate crisis is affecting very strongly and already very dramatically the member states in the Pacific. We need to provide financial and debt relief to those countries facing the impact of the climate crisis and that are at the forefront. And we need to both prepare a population of healthcare professionals that are aware of these issues and listen to them and work with them, prescribe and implement urgent climate action.

This basically means that we need to be looking at the curriculum of development for the health workforce. We need to update them to take issues of co-benefits of "One Health" and a health systems approach. We need to bring climate action into the healthcare sector. We need to enable health professional advocacy and use the energy of the young upcoming generation of health professionals to help protect the health of future generations. Within these very brief few minutes, I am shoehorning a large amount of actions. If we look at each of them and the connections between them, we see that the health risks and the health systems and health services are parts of large complex adaptive systems. And therefore, whatever area of important action and prevention or care that we look at within the health sector, we see deep connections between that and the environment.

Here is an illustration on tobacco and its environmental health impacts. Many tend to think of smoking as a behavioral or personal health concern, but indeed it is very much also an environmental concern. It is a health concern in terms of policies such as pricing and marketing that facilitate or encourage smoking or tobacco use. It is also

an environmental concern, looking at the supply side, including the way that tobacco-growing affects the livelihoods of the farmers and the impact it has on the land. These are all parts of the unsustainability of the tobacco industry, even at the production and the supply side. I've already spoken, and other speakers at this meeting have also talked about the food system's impact on the entire sustainability spectrum. Our meat production has an impact on greenhouse gas emissions. Our agriculture impacts land use and its sustainability on the using of scarce water resources. Everything is connected in complex systems. And others have spoken in detail about the impact of the health sector itself. Our buildings and our healthcare facilities have a very direct impact on emissions, on using of disposables, and unsustainable investments and behaviors.

And in this illustration, the panoply of actions that are needed to make our health systems walk the talk and adopt national environmental sustainability policies, ranging from sustain procurement to utilizing innovative models of care, such as shifting to primary healthcare and using more telemedicine as opposed to the highly resource intensive high-tech care, that is in the centers, so-called centers of excellence, the disease palaces that are our hospitals. Hoping that this very rapid overview of the interaction between our health systems' sustainability and the One Health principles, the co-benefits that lie between them, and a focus on the core actions that we need to be taking with urgency. I hope you have at least tied together many of the threads that other speakers have so eloquently presented.

Climate Change and the Health Effects of Carbon Neutrality in China

Peng Gong

We can see that climate has had a deep impact on China over the past 20 years or so. In 2015, we published a paper in Lancet trying to establish a systematic view of how climate change is impacting health. Some intermediate factors eventually drive into the health aspects. This paper has been widely used as a reference for people to study the impact of climate on human health.

Since the systematic review, we set up a monitoring system and begin to do comprehensive evaluation on an annual basis by gradually expanding the international participation in the world. Then in 2020, we also published our first China report. Compared to the global report, the China report is more focused with provincial granularity. So it is a more detailed analysis of China's situation. We established a team in China to do this. This year, a couple of months ago, we also published the second report on China's climate change and health.

The China Lancet Countdown report has almost 90 experts and it is examining 25 indicators of China. The first China report in 2020 systematically looked at climate change and health. The report is divided into (1) climate change impact, exposure and vulnerability, (2) adaptation planning and resilience for health, (3) mitigation actions and health co-benefits, (4) the economic aspects and financial aspects that we could use to address climate change issues to improve health, and lastly, (5) the public and political engagement. So we divide our authorship into five groups to work together, to do systematic studies.

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The new 2021 China report has some key messages. First, China has made important progress in addressing many aspects of the health risks of climate change. But there is still room for improvement. China's health risks from climate change are increasing. So we need timely intervention. Addressing extreme weather events is a compulsory course for every department and every person. China's risks from climate change are increasing, as exemplified by heatwave-related mortality, factorial capacity increase that increases the transmission risk of various kinds of diseases, including Dengue, and wildfire exposure are increased. On the other hand, the effort of adaptation has made China more resistant or resilient to drought and flood. So there are some positive adaptation aspects.

Another message is that each individual province in China faces unique climate health risks. We cannot apply the same set of rules and procedures to address health impacts from climate change. For example, in Beijing, the population affected by floods has been increasing and factorial capacity has been growing very rapidly, while in Guangdong there are more health risks. Particularly, the heatwave-related mortality in Guangdong has increased 24.5 times so as several other aspects for the time. We also can find that China has made great efforts in promoting the carbon peaking and also carbon neutrality goals and increasing the clean energy investment, and steadily increasing the carbon intensity of the energy system. Low carbon investment still increased for the past year. But there is room for improvement. For example, last year we have increased the carbon emission and most of the cities are having particulate matter 2.5 (PM2.5) concentrations higher than the World Health Organization (WHO) guidelines standards.

On the adaptation side, China is making all sorts of progress. All of the 30 provinces reported that they have completed or were developing provincial health adaptation plans. But some improvements need to be made. For example, there is no standalone national health adaptation plan, and the assessment and adaptation planning process is absent in the majority of the provinces. So we made four policy proposals or recommendations. One is to provide systematic thinking in the related department and strengthen multi-departmental collaboration. The second is to do an additional assessment of the health impact of climate change and make a national and regional specific adaptation plan. The third is to strengthen China's climate mitigation actions. And the fourth is to increase awareness of the linkages between climate change and health at all levels.

The Lancet Countdown report specifically targets on China's progress up to 2030s. How does carbon mitigation affect health? So this chart shows that a majority of the effort has been paid to outdoor air pollution and study their impact on the health.

Actually, there are different carbon neutrality pathways on the health aspect. If we choose to reduce positive emissions by using renewable energy, we will gain tremendously due to the reduced carbon emission for the health aspect, but the cost is very high and it is a huge transition pressure.

On the other hand, if we choose only to use increased and active emission by increasing carbon sinks and carbon sequestration, not to mention that the technology is not readily applicable in many aspects, but also, the remaining heavy carbon emission sectors would cause high health damage. So we need to balance both. We

need to develop ways to assess along the different pathways and seek an optimal solution.

So we developed a model. It incorporates scenario setting and also carbon neutrality scenarios. It integrates three aspects in the modeling effort, and eventually to help us to evaluate the health co-benefit and the economic cost, and involved in it different strategies of carbon emission mitigation, and also negative emissions.

As some initial test of the model and trying to answer optimality issues, we realize that the carbon neutrality goal, no matter which pathway we use, is going to have a significant health benefit. For example, if we only use the carbon negative emission approach, by 2060, we will be able to achieve a life expectancy increase of 0.88 years. If we use clean energy and renewable energy path, we will gain 2.8 years. This is a very worthwhile message that politicians and decision-makers should consider.

Medical Innovation and Carbon Reduction Strategies

Guido D. Giacconi

I would like to provide my considerations and contribution for facilitating what China and Europe should do, could do, or must do in this period with unprecedented challenges of the pandemic and fighting climate change. I don't want to repeat what my distinguished predecessors have already talked about, very inspiring speeches finding my full alignment. Instead, I'd like to outline the issues about global health and low-carbon economic transition.

My impression is that the more the global leaders talk about decarbonization, the more they miss the focus of what's the challenge. From my standpoint, the challenge is to keep the increase of the planet's temperature under possibly 1.5 degrees versus the pre-industrial era levels. And now, unfortunately, the 26th Conference of the Parties (COP26) outcome already stated that the challenge is to keep it under 2 degrees. If the temperature over the next 20 years increases 2 degrees, it could bring unprecedented, uncontrollable, and unexpected consequences from the economic, social, and biodiversity standpoint.

The challenge is not local but rather global. Green House Gases (GHGs) don't have passports, and Climate Change will hit with no political discretion. China, Europe, and the United States (US) have the highest share of greenhouse gases emission, not only carbon dioxide (CO_2); that's why they also have the biggest responsibility for fighting climate change. With different footprints, China represents 27% of greenhouse gas emissions on a global scale while Europe represents 6%, even though their Gross Domestic Product (GDP) are generally comparable. This implies that Europe is advanced in containing greenhouse gas emissions, and its practices,

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models, technologies, and regulations could help China accelerate the pace towards *Carbon Peaking and Neutrality*.[1]

How could it be done? We already talked about analyzing the healthcare systems; in the meantime, there should be common wisdom that it cannot be done if it's not through a holistic and systemic approach, where technology is only playing a partial and, paradoxically, not decisive role. If the technology is not embedded and harmonized in a global design and an effective design, technology alone doesn't work, and in some cases, it could be even worse. For example, in China, the carbon footprint of electric vehicles is worse than vehicles fueled by natural gas. Why? Because in China, more than 75% of electricity is produced by coal fire plants, while, for example, in Denmark, 95% of the energy is produced from renewable sources. This means that every new electrical vehicle in China worsens the carbon footprint while in Denmark, it improves. Therefore, technologies and solutions, including simple and basic technologies like electric vehicles, must be properly localized and tailored to local conditions. We can find many other "mislocalization" cases without considering local conditions.

Let's now talk about the healthcare system, which is often discussed based on the cost-based economic and financial levers and mainly on the cost related to labor. Typically, the effectiveness of the healthcare system is measured by the quality of the system's outcomes, especially the quality of human health evaluated by certain Key Performance Indicators (KPIs) such as the average life expectancy or capability to treat diseases vs. the total cost to be borne to maintain the system itself. But for the first time in human history, not only in the healthcare system, since the launch of the first Emission Trade System (ETS) and accelerated by Europe's pledge to become carbon neutral by 2050 and China by 2060, the game changers in global economic models came into the stage, i.e., CO_2/GHGs. Until the confirmed awareness of GHGs role in global warming and climate change, economic values of goods were largely based on the cost of human labor, and human labor was in history and is the fundamental asset regulating economic models. Current and future monetization of emissions have introduced a new asset we might call "negative", i.e., the stock of entities' emissions reduces the entities "value", on top of the carbon trading and ETS mechanisms or taxation systems. The greenhouse gases are a negative asset and a negative commodity playing a decisive role in forthcoming economic models. Nevertheless, we still have not found a way to properly assess and quantify this asset's negative value (ETS is only one of the possible ways).

In any case, the pledges major economies took for achieving carbon neutrality, whenever it happens, imply a radical change in economic models, including healthcare systems whose carbon footprint is significant on the global scale and will increase

[1] Carbon Peaking and Neutrality: the annual carbon dioxide emissions of a certain region or industry reach the highest value in history, and then go through a plateau period and enter a process of continuous decline, the peak target includes the peak year and peak. Carbon neutrality refers to the calculation of the total amount of greenhouse gas emissions directly or indirectly generated by enterprises, groups or individuals within a certain period of time, and through afforestation, energy conservation and emission reduction, etc., to offset their own carbon dioxide emissions and achieve carbon dioxide "zero emissions".

with the forthcoming economic development. Hence, the healthcare system's carbon footprint must be taken into consideration and must be valued or used as a lever for improving not only the quality of services but also how the services are produced and provided and how much greenhouse gases they directly or indirectly produce. The healthcare systems must and will be intertwined with climate change dynamics, both with a direct dynamic through healthcare systems emissions and indirectly from the climate change that puts healthcare systems under stress due to the negative impact on human health in multiple ways.

The direct negative impact on human health of climate change has already been discussed. It's worth noting that the healthcare system's carbon footprint has been calculated as about 4% of global greenhouse gases. In some countries like the United States, it can be close to 10%, while it's less than 4% in other countries. There is a correlation between the healthcare system's carbon footprint and GDP per capita, and this would bring a risky "Catch-22": Climate change will hit human health, and the human health worsening will further stress the healthcare system. The further stressed healthcare system will increase its carbon footprint with a negative impact on human beings and plant health. We must cut this perversion in a way that has been discussed and is going to be discussed.

I won't go into further detail on how climate change impacts human health, but I want to propose the methodologies that have already been applied in other industrial sectors, which are from the greenhouse protocol and now have also been piloted in the healthcare system. First of all, the definition of the boundary in the healthcare system needs to be assessed before designing a pathway towards carbon neutrality: it's an extremely complex exercise. On average, 70% of the healthcare system's carbon footprint comes from hospitals, but this varies from country to country and is highly dependent on the healthcare system design in that specific country. In China, it's very high because of its centralized healthcare system design. In countries like those in West and North Europe, this impact is lower with the distributed healthcare system. But in any case, the hospital design, down to the quality of service and the number of average treatment days per disease, will have a direct impact on the emissions generated by hospitals themselves.

What China and Europe could do to facilitate the acceleration of fighting climate change and carbon neutrality in the healthcare systems? Both Europe and China have taken a peak and neutrality with specific pledges; there is apparently no way of return on that. Now the challenge is how to make it, what the priorities are, and how it can be done. Europe can leverage its know-how to support China in fighting climate change and accelerating carbon neutrality. Unfortunately, we still see confusion in properly tackling carbon neutrality, but the priority now is to make pledges to be followed by actions. Europe with the Green Deal has already done, and China with the *One Plus Ten* policy has launched it. The two economies must sit together, overcome global tensions, and establish comprehensive discussions.

In3act, a European business strategy advisory company with energy as one of the focus sectors in China, is very concerned about the possibility and progress of how China is sticking to its commitments to achieve a carbon peak by 2030 and carbon neutrality by 2060.

For doing that, the focus should be put not only on energy but rather on global economic models, their openness and transparency, and, for healthcare, on the combination of models and quality of services in a holistic way.

So, again, what should be done is to approach the problem in a holistic way also with the support for the social changes that are happening in China and Europe, with the aging population that would stress the healthcare system even more. The healthcare system needs to prioritize understanding how to reduce its carbon footprint to avoid further stress shortly.

We have identified priorities in China and Europe. Also, as Vice President of the European Union Chamber of Commerce in China, I am trying to facilitate a continuous and long-term dialogue for the sake of bringing into China all the experience, competences, technologies, and solutions we developed in Europe over the past decades, not only in how to tackle energy transition but also for designing an effective and efficient, effective, transparent and open healthcare system, keen to make European players to proactively contribute, with a very low carbon footprint in a long term perspective for the sake of human being and planet health.

AI and Climate Change: Opportunities, Challenges, and Recommendations

David Rolnick

I will be talking about how artificial intelligence (AI) can play a role in climate action. I'll discuss opportunities for AI in this space, broader considerations and challenges, and policy recommendations for enabling the impactful and responsible use of AI to help tackle climate change.

Before we dive in, it may be helpful to give some context on what AI is Artificial intelligence refers to any computer algorithm that makes predictions, recommendations, or decisions based on a defined set of objectives. Within that overall framework, certain AI algorithms are known as "machine learning", a term that some of you may have heard because machine learning has become extremely popular and effective in recent years, with applications from the automatic translation to self-driving cars. In a machine learning algorithm, the exact computation that the computer performs isn't specified in advance but instead it's "learned" by the algorithm by identifying patterns within data, generally large amounts of data. The algorithm can then use these patterns to make predictions on new data. Most of the AI techniques we consider here will fall under the heading of machine learning.

It's worth understanding, at a high level, what some of the strengths and weaknesses of machine learning algorithms are. They are good at performing a wide array of simple tasks quickly and automatically, for example, scaling up repetitive activities like labeling images. They can pick out subtle patterns from large datasets that humans might not be able to. And they're able to optimize complicated systems, like industrial machines with many possible controls, to maximize efficiency or minimize cost. However, since they rely on data, machine learning algorithms are also prone

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to failure if the data are inaccurate. If the data that an algorithm is given is biased, then the algorithm can perpetuate that bias. Moreover, machine learning typically finds correlation, not causation—it's generally unable to solve problems requiring broader conceptual understanding or creativity. And these algorithms can also be inapplicable for problems where it's necessary to "show one's work"—often, the answer appears without much explanation of why it is accurate or how confident the algorithm is in that answer.

With those strengths and weaknesses in mind, let's turn to how AI can be relevant to climate action. A large team of experts across many fields and I wrote a report detailing key opportunities and leverage points for AI both in climate change mitigation (reducing greenhouse gas emissions) and adaptation (responding to the effects of climate change). I'll summarize some of the takeaways here, but if you're interested in more details, I do encourage you to check out the full report, or (if you'd prefer a shorter version instead of the whole hundred pages) we have interactive summaries of the information available online, which you can search through by application area or by subfield of AI.

There are opportunities for AI to help advance climate action across many sectors—from electricity systems to transportation, land use, and disaster response. Across all of these, there are four key roles that AI can play.

First, AI can distill large amounts of raw data into actionable information by scaling up labels that humans could provide more laboriously. For example, AI can analyze satellite imagery to track greenhouse gas emissions, update coastal elevation maps to identify communities at risk from sea-level rise or filter large databases of corporate financial disclosures to find climate-relevant information.

Second, AI can improve predictions by learning from past data to predict what will happen in the future. For example, AI can provide forecasts of electricity demand to help balance power grids or predict the supply of electricity when it comes from renewable sources like solar and wind that can change from minute to minute. AI is also being used to predict agricultural yield as extreme weather threatens food security.

Third, AI methods can optimize a complex system with many variables that can be controlled simultaneously. For example, AI algorithms can reduce the energy needed to heat and cool a building or optimize freight transportation schedules to reduce inefficiency or increase robustness.

Finally, AI can accelerate scientific modeling and discovery, often by blending known physical laws with approximations learned from data. For example, AI can speed up the discovery of new materials for batteries or catalysts by learning from past experiments and suggesting promising candidate materials to try out in new experiments. AI can also quickly approximate physics simulations used in climate modeling or energy-efficient building design, which can otherwise be extremely slow to run.

All four functions for AI—distilling data, improving predictions, optimizing complex systems, and accelerating modeling and discovery—cut across sectors. And it's worth noting that all of these example applications I've given are already being developed or deployed.

Importantly, in all of these applications that we've discussed, the role of AI is to support existing work in climate action. AI is not a silver bullet—it's only one of the many tools we need in climate action, and it's not applicable everywhere. It should never replace or distract from other actions needed to fight climate change. Some of the most impactful (and interesting) applications aren't flashy. For instance, detecting failures in railroad systems doesn't receive as much press as self-driving cars, but it's probably more beneficial from a climate perspective.

It's also worth noting that, while cutting-edge AI can be helpful in some cases, in other cases, simpler methods from AI or data science may be enough—one shouldn't leap to using the fanciest technology when a simpler tool will do the job. In addition, AI will optimize for the objective that it's given, and it isn't a replacement for framing the problem carefully—in fact, it's straightforward to use AI to get the wrong answer fast if you've asked it the wrong question.

To avoid pitfalls, it's essential to develop partnerships between AI experts and the stakeholders who will be using the AI and who understand the problem to it's being applied to. This is important to ensure that the algorithm is solving the right problem and that it incorporates domain-specific knowledge. It's also essential to consider the pathway to impact and plan ahead to make sure that any deployment considerations are built into the design right from the start.

Equity considerations are also fundamentally important in AI-for-climate—including who is building solutions, what problems are prioritized, and how these problems are worked on. Empowering a diverse and global set of stakeholders is essential to ensure that technologies are owned by the people affected by them, rather than reinforcing existing power imbalances across countries and institutions. Related to the question of who is the question of what is being worked on, since problem priorities often reflect existing inequities within AI and technology. For instance, AI to fight wildfires (which is a key problem in North America, Europe, and Australia) tends to receive more attention and funding than AI to fight locusts (which affect East Africa, the Middle East, and southern Asia), even though both problems are extremely important and are exacerbated by climate change. And how projects are worked on is also important. Data imbalances between regions or communities within a region can mean AI solutions are only applicable to a subset of the population or that algorithms are most effective within data-rich areas. Ideally, AI-for-climate will serve to improve equity, but this takes active work—both at the policy level and at the project design and management level.

Finally, the impacts of AI depend on how we use it, and some applications of AI are definitely making climate change worse. For example, AI-based recommender systems used in advertising are designed to increase consumption. AI is also being used extensively to accelerate the discovery and extraction of fossil fuels.

I'm now going to turn to a report that we recently released for the Global Partnership on AI (GPAI), a coalition of countries working to support AI-related priorities and foster international cooperation. In this report, we provide detailed recommendations for actions that governments can take to foster the impactful and responsible use of AI in the context of climate change. These include recommendations in the

areas of data and digital infrastructure, research and innovation funding, and deployment and systems integration. We also discuss how AI can have negative impacts on the climate—through its applications and via computation and hardware—and what we can do about it. Cutting across these areas is the need to adopt a responsible AI lens, build capacity among many societal players, set up frameworks for impact assessment, and foster international collaboration.

We make 48 concrete policy recommendations in this report, illustrated with case studies from the private and public sectors. I'll provide some highlights. First, there's an urgent need for data on many climate-relevant problems. Data may be siloed in private entities without the existence of data-sharing structures—even when data-sharing could be to the benefit of all stakeholders. Data may also be scattered across multiple sources and structured inconsistently without standards to enable interoperability. We recommend the creation of data task forces in climate-relevant sectors to identify priorities and work with industry and researchers to develop healthy data ecosystems that enable beneficial work while preserving IP and privacy.

Funding for research and innovation in AI-for-climate can often fall between the cracks. AI funding usually focuses on novel methodologies that improve performance on standardized benchmark datasets. These kinds of pure innovations are important, but they should be complemented by impact-driven funding opportunities that enable projects in AI that help society in mitigating or adapting to climate change, with success being measured by how useful the algorithms are in practice.

To be helpful, innovations in AI-for-climate have to make their way from development to deployment at scale. This requires collaboration between researchers and practitioners in the relevant sectors and incorporating relevant deployment considerations. For example, stakeholders such as electrical grid operators may need guarantees of robustness and safety before using any new technology, given the critical nature of grid infrastructure and how serious any failures would be. We recommend the creation of cross-sectoral innovation centers bringing stakeholders together to partner in addressing challenges and incubating solutions.

Private and public sector entities often don't have the expertise in AI and digital technologies necessary to understand where AI is and is not relevant or how best to deploy it. This can lead either to failures to use technologies where they could be helpful or, conversely, to techno solutionism and over-optimism about what AI can and should do. For both these reasons, it's important to build capacity and literacy in AI. We recommend both upskilling programs—training people already in the relevant organizations—and secondment programs, where AI experts are embedded within these organizations to strengthen communication and cross-sector expertise.

All of the applications of AI that we've highlighted here require care in development and deployment with respect to considerations such as fairness and accountability—best practices should be established across relevant sectors. Participatory design is also crucial to ensure that new technologies are shaped and owned by the communities they're meant to benefit.

Finally, we encourage policymakers to consider the potential positive and negative climate impacts in shaping the development of new technology—for example, by incorporating climate considerations into the framing of "high risk" use cases. Often,

initial choices and incentives can greatly change the impact of new technology. For example, designing autonomous vehicles focusing on personal cars will make driving easier, people may drive more, and global carbon emissions may increase. On the other hand, incentivizing self-driving technology focused on vehicle sharing and public transportation could help decrease carbon emissions. The effects of new technology are not pre-determined—they are up to us, and both implicit and explicit choices are meaningful.

Both of these reports (*Tackling Climate Change with Machine Learning* and *the Global Partnership on AI Climate Change and AI Repor*t) were projects involving Climate Change AI, an organization of which I am a co-founder and chair, alongside Priya Donti of Carnegie Mellon University in the US and Lynn Kaack of the Hertie School in Germany. Climate Change AI is an international non-profit focused on catalyzing impactful work at the intersection of climate change and AI. We offer opportunities for partnership and collaboration across a network of thousands of experts worldwide, spanning research, industry, and policy. We advise stakeholders in the public and private sectors and produce reports and other informational content. We provide resources such as grant programs, courses, and discussion platforms. And we run knowledge-sharing events drawing thousands of attendees from across the world, for example, at the AI conferences Conference and Workshop on Neural Information Processing Systems (NeurIPS), International Conference on Machine Learning (ICML), and International Conference on Learning Representations (ICLR), via Technology, Entertainment, Design (TEDx), and at the UN Climate Change Conference (the COP). If you're interested in learning more about this space, I encourage you to check out the additional resources at Climate Change AI.

Japan's Low-Carbon Society and Public Health

Jinjun Xue

Today, I'm going to share with you my experience, both in China and Japan about the low carbon society. And I will use a case of Japan to talk about the low carbon society and the public health because Japan and China are neighbors, and we can learn from each other. I will talk of five major issues including some indexes of public health in Japan, low carbon society plans in Japan, the public health system and facility in Japan, the Japanese model of epidemic prevention, and finally, some enlightenments from the Japanese experience to other countries, especially to China.

The first is some major indexes of public health in Japan. As you may know already that Japan is a country with a very high life expectancy. The latest statistics show that in 2021, the Japanese women's life expectancy is about 87.74 years old, while for men, a little shorter, 84.64 years old. The reason why Japan has one of the highest longevity rates are related to the air quality, environment, lifestyle, and many little things that I will elaborate on later. Currently, the world is still suffering from the Corona Virus Disease 2019 (COVID-9) pandemic, especially in the United States and European countries. Japan has suffered a lot from last year to the earlier this year, but by later this year, Japan controlled the pandemic successfully. It is beyond our understanding at this time Data yesterday (Dec. 21) shows that there were only 170 new cases of infection in Japan. Tokyo, a large city with a population of 20 million, had only 30 new cases of infection yesterday.[1] We are currently looking

[1] However, from mid of January 2022, the fifth wave of the epidemic in Japan has intensified, and the number of new infections has gradually increased, and stricter epidemic prevention measures such as restricting gatherings and catering business hours have to be implemented again.

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at the reasons behind this. What we have known is Japan has a looser approach to control the pandemic, with self-discipline and limited freedom, but people can still go out to do something like shopping or having a drink with friends.

Professor Gong Peng and other professors talked a lot about the relationship between air pollution and death rate, using the case of China in particular, and many papers on this have been published in the Lancet. In the case of Japan, relevant studies show that Japan has very low death rate from air pollution (PM2.5).

Then we talk about a hot topic, carbon emission peak and carbon neutrality. We know that China promised to get the carbon emission peak in 2030 and the carbon neutrality in 2060. While Japan has passed its peak in 2013 already and from now on, Japan has roughly 30 years to reach its new target of carbon neutrality.

The second part is low-carbon society plans in Japan. On the issue of carbon emissions, as we know, the British government was the first to introduce the concept of "Low Carbon Economy",[2] while in 2011 the Japanese government launched the "Low Carbon Society"[3] initiative, which covers all aspects of society, including land use, nature environment, transportation, industry and business, residence life, etc. In 2015, the Japanese government issued another plan, the Hydrogen Society Plan. Hydrogen power is thought the power of the future without any carbon emissions. Companies, especially Toyota, are promoting this new advanced energy technology. This year, the Japanese government announced another plan called the Decarbonized Society Plan. As the data shows (Fig. 1), Japan has been successful in dealing with the carbon emission and passed its carbon peak in 2013, while China and India have a hard task to accomplish from now on.

The third part is Japan's experiences of public health, which I will elaborate with some examples. Actually, Japan now has a cleaner and better environment than that in the past. In the 1960s, when Japan was experiencing rapid economic growth, it also suffered severely from the Four Big Pollution Diseases, especially Yokkaichi Disease or Cough, caused by environment pollution. Since then, Japan has changed its development strategy and gave the first priority to environment protection. In late 1960 and early 1970, Japan made many legislations and policies to improve the environment.

Among these policies, one important step was the oversea industrial transformation in the late 1960s. Prof. Akamatsu initiated a very famous theory named Flying Geese Paradigm to explain this process of industrial structural transformation that made Japan lead among Asian countries in terms of economic development. In 1970s, Japan transferred many industries with high pollution, high carbon emission and high

[2] A low-carbon economy simply means one whose power needs are derived not primarily from carbon-intensive sources such as fossil fuels but from 'cleaner' or less carbon-intensive energy sources, such as wind, solar and hydroelectric power. Other forms of clean energy include, for example, wave power and geothermal which are technically feasible but less common than wind or solar. Biofuels can play a role, but I see them as fuel substitutes rather than a clean technology.

[3] The basic idea of low carbon society is to cut down all carbon dioxide emissions without endangering any developing needs. Based on this the ultimate aim is to enable the society to produce only the amount carbon dioxide which can be absorbed by nature. In that way, society would be carbon neutral.

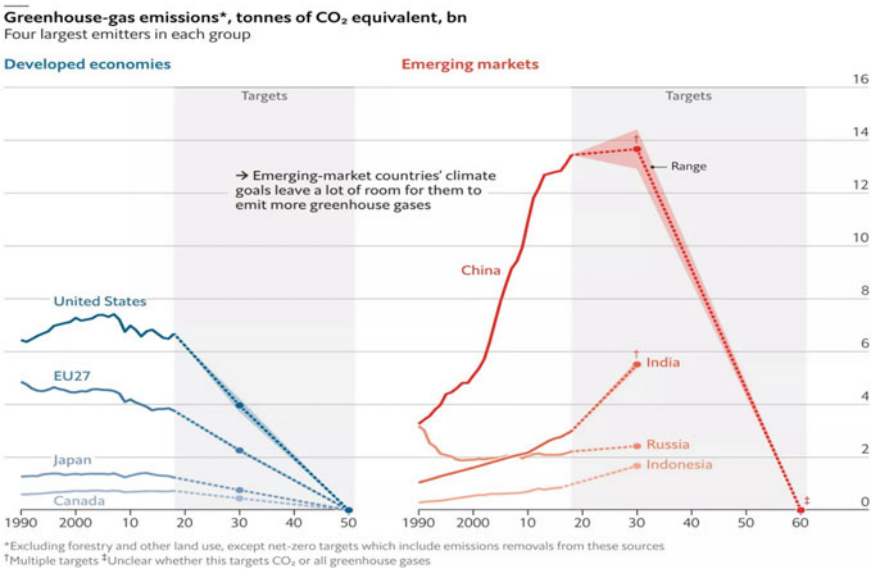

Fig. 1 Greenhouse-gas emissions, tonners of CO_2[4]

energy consumption to other countries. Of course, this kind of industry was beneficial to those countries, such as China by promoting their economic growth, but also created some issues such as environment pollution and carbon linkage.

There are many things that made Japan's environment better and induced it to be a beautiful country. One of these things is the industrial structure change. In Japan, the service sector is the largest share of GDP. The share of manufacturing in Japan is relatively small while agriculture has the smallest share below 10%. In contrast, China has a relatively larger share of manufacturing in GDP, which results in more carbon emissions.

In terms of low-carbon transportation, Tokyo Subway System is the most complex and efficient underground transportation system in the world, which has led to a significant reduction in the use of private cars and thus lower carbon emissions.

As for public facilities, one example is Japan's toilet revolution which brought technological innovations that have led to a well-known clean toilet environment Especially the water wash toilet prevented millions of people from Infectious disease and contributed to the public health.

Regarding the Japanese healthcare system, which called Medial Hospital System, it has one of the highest ratios of hospital beds and medical doctors (per 1000 people) (Fig. 2). There are three types of hospitals in Japan. One is large hospitals, such as The University of Tokyo Hospital, Nagoya University Hospital. They treat major illnesses and do not treat minor illness such as colds, which could be treated at a

[4] Source: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions.

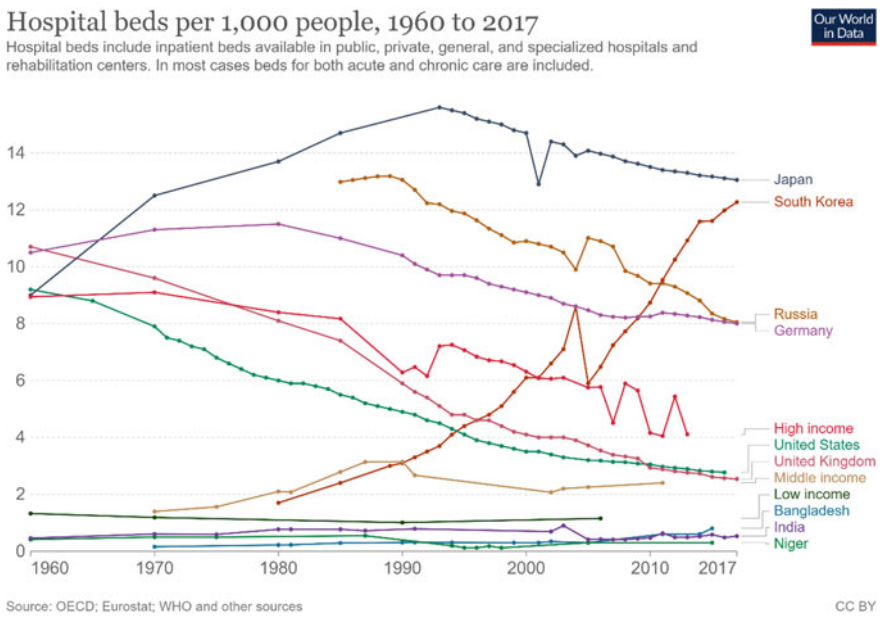

Fig. 2 Hospital bed ratios of selected countries

small clinic. The third type of hospitals treats the type of illnesses that fall between major illnesses and minor illness.

This kind of functional division of hospitals, reduces the burden on large hospitals. In contrast to Beijing and Xi'an, I went to the hospital with a cold and then it was very crowded, and the waiting time was really long. The reason is that there are not enough small clinics to treat minor illnesses like the flu that many people may get. In addition, medical equipment in Japan is very advanced such as computed tomography (CT) machines, magnetic resonance imaging (MRI) scaner, etc. Such high-tech medical equipment can help doctors detect patients' diseases earlier and start treatment earlier, which is closely related to public health as well as longevity.

Let's look at Japanese food. The Japanese food such as Sushi, Tofu, Natto, Soba, is not only delicious, but also low-carbon. This diet structure has contributed a lot to public health.

The fourth part is about the Japanese model of epidemic prevention. The Japanese model has both the government dominance of East Asian authoritarianism and the democracy and freedom of Western capitalism. Mask wearing habit has protected lots of lives during this pandemic. In many countries, this is politicized, but in Japan no one would argue the necessity of wearing a mask. Also, unlike other countries, Japan does not greet with a kiss, hug or handshake, but simply with a bow, which avoids physical touch and thus protects people from being infected by the virus.

The final part is about enlightenments from the Japanese experience. First, it's about decoupling GDP with CO_2. Compared to the year of 1990, Japan achieved

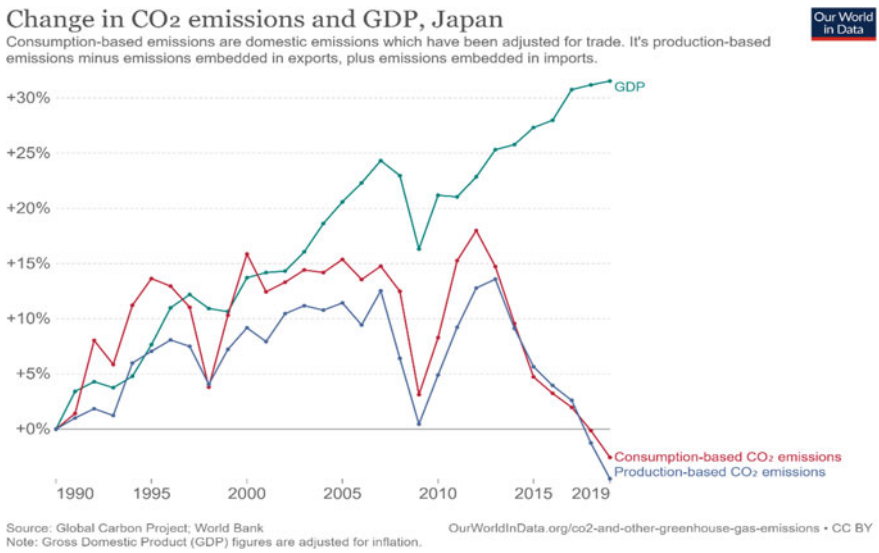

Fig. 3 GDP decoupling with CO_2 emissions

GDP growth (take 1990 as 100) with a rapid reduction in consumption-based and production-based CO_2 emissions (Fig. 3). China will also pursue this process in the future to decouple its economic growth from carbon emissions.

The second is technological innovation. In recent days, scholars, government leaders and politicians mainly focusing on carbon mitigation on policies but ignoring the importance of technological innovation to achieve carbon neutrality. According to Japanese experience, technological progress plays a crucial role in reducing carbon emissions. In addition, according to the statistics of GDP per unit of energy use, Japan has a relatively higher carbon energy productivity than China (Fig. 4). China has a lot of room to improve its technology, to reduce carbon emission and improve the energy efficiency.

Japan has 28 Nobel Prize winners, six of them are from Nagoya University. These professors are not only doing scientific research, but also doing innovations. For example, Professor Hiroshi Amano is one of the innovators of Light Emitting Diode (LED) light and now is conducting research on the new materials for future energy. This type of products can help to reduce carbon emissions while improving people's standard of living.

Finally, as we know, health involves many aspects, such as nutrition, lifestyle, environment, hygiene, diet, friends, healthcare, sleep, stress management, sports, and exercise. As Professor Gong Peng said, health also includes mental health. This concepts is gaining popularity in both Japan and China. Just as Japan used to learn a lot from China in the past, we should learn from each other and have closer collaborations. Hopefully some of Japan's experiences can be used to help China build a low-carbon society and achieve carbon neutrality.

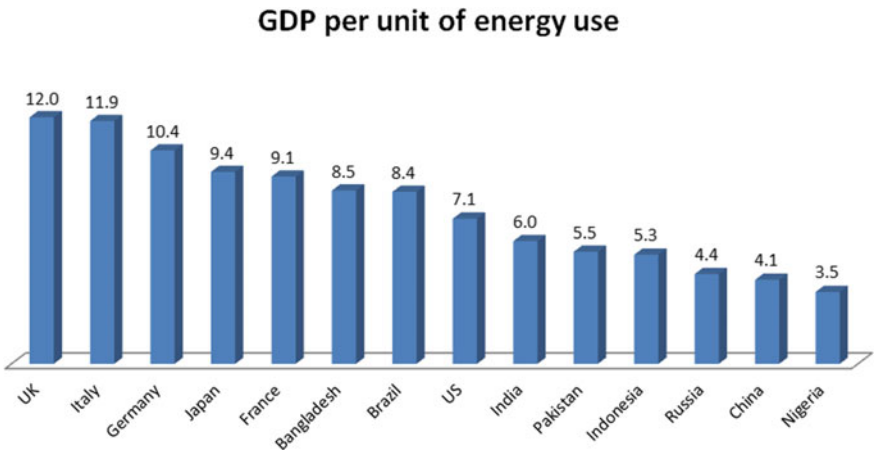

Fig. 4 Energy productivity (GDP output of per unit energy use)[5]

[5] Source: https://en.wikipedia.org/wiki/Energy_intensity#/media/File:GDP_per_unit_of_energy_use.png.

Sustainable Development of Pharmaceuticals in China

Pius S. Hornstein

Climate change represents one of the greatest challenges of our times and has enormous impact on our lives and health. The World Trade Health Organization estimated that between 2030 and 2050, the climate change could cause 250,000 deaths each year.[1] To minimize the consequences of global warming, the United Nations calls for carbon neutrality as the solution to counterbalance the build-up of greenhouse gas emissions in our atmosphere.[2] And we recognize that China has made some major commitments to carbon neutrality as a key pillar of our ecological civilization construction, aiming to keep carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060; Chairman Xi specifically called for emissions per unit of GDP to be reduced by 65% by 2030.[3] This is an important ambition. Deeply rooted in China for 40 years, Sanofi as a local multinational is strongly committed to the health and wellbeing of the Chinese people. We are taking the initiative of minimizing the impact of our activities on the environment while developing and delivering life-saving medicines and vaccines, and introducing many new innovations into China.

In 2015, we said we were set to make a commitment after the COP 21and the Paris Agreement to reach carbon neutrality by 2050. Now, recognizing the immense challenge we face, we have completely revised our goals, and just announced that we plan to achieve carbon neutrality by 2030, 20 years ahead of our initial plan. We

[1] Resource: World Health Organization, 2021.

[2] Resource: United Nations environment programme, 2019.

[3] Resource: Xinhua Net, 2021.

Pius S. Hornstein, the Country Lead at Sanofi Greater China.

This article is based on Pius S. Hornstein's keynote speech at the PKU Global Health and Development Forum 2021.

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are pushing the limits to achieve net zero defined by clear standards by 2050 as part of our commitment to protecting and improving lives worldwide and in China.

So how are we going to achieve that? We have developed a very comprehensive roadmap, which encompasses our innovative healthcare solutions, our way of doing business, our operations, our whole value chain on how we research, develop and manufacture products, but also very importantly the employee mindset and behaviors.

Firstly, let us look at environmental aspects related to our products. We continue to explore how the product impacts the environment and take special care to ensure that our products are developed, used and disposed in a most responsible manner across the whole value chain. From research, packaging, production, and also plant management, we invest great effort to minimize impact. We are constantly expanding our knowledge of the environment and effects of our product ingredients on the environment. To date, we have done an assessment of 60 compounds worldwide which represents a starting point, and by 2050, we want to have assessed all our best-selling products and big block processes across the world to reduce impact.

Secondly, Sanofi is strongly committed to minimizing the potential environmental impact of our operations, meaning from how we maximize renewable energy, and manage infrastructure and waste. For example, solar power in our manufacturing sites effectively reduces carbon CO2 emissions and helps to achieve our carbon neutrality targets by 2030.

Thirdly, a key part of our activities is to mobilize our employees and their relatives and families to change mindset and behaviors, and make a positive impact on the society. We have accelerated our efforts on cultivating our new green ways of working. We launched the "*Planet Mobilization*" Initiative as a key program at Sanofi to practice our commitment to sustainability, deeply ingrained in our ways of working. We are also implementing dedicated initiatives, such as volunteering paperless campaigns. We are opening new brainstorming channels together with our employees, collecting ideas from the grassroots to best understand which small steps and major initiatives we can envision across the company and across the life we are living. Moving forward as a digitally leading company, we will continue to amplify influence digitally through launching a Green Day app, as well as promoting our digital interaction with healthcare professionals, our live broadcast channel called SanofiTube, connecting with our employees and the ecosystem in China. We are very proud of really trying to mobilize all our 8000 employees in China to make a difference on the lives of millions of patients.

To conclude, this is not just a Sanofi-driven effort. The Research and Development (R&D)-based Pharmaceutical Association Committee (RDPAC) and its member companies, as well as our entire society, all play a key role in achieving sustainable development of pharmaceuticals in China. A joint effort is needed. We really want to make a call to action to deliver our green ambitions in China, together with the government, together with the industry associations: It is time that we come together as a team to construct a clean ecosystem that rewards innovation for sustainability. We believe that regulators actually could help by encouraging and accelerating the approval process for innovative green technology. Payers could leave a critical mark

eventually by developing proven systems that truly recognize and reward companies for the efforts they put into the green production design process. Hence not only Sanofi, but all companies can sustainably contribute to a healthier and more ecological life in China. And finally, we believe that policymakers will also work together with us. That can help us set a framework of rules that are fair for companies consistently living their green commitment and contributing to a green economy of China.

Together we can make this happen. Aside from providing great medicines for people, we also would like to minimize the impact on our ecosystem and to be a true partner to the government and the ecosystem for having a greener and healthier environment.

One Health and Low-Carbon Development towards Innovation-Driven Sustainable Future

Pavol Dobrocky

As we all know, the world we are living in today is facing significant challenges with issues like climate change, environmental pollution, and the COVID pandemic wreaking havoc on global health. Each year, an estimated 5million people die from extreme weather and a further 8.7 million deaths are associated with air pollution.

In this context, China's adoption of "Healthy China 2030" and "Dual Carbon Goals" initiatives not only demonstrates China's commitment to sustainable development, but also brings us greater confidence that we can tackle these global challenges together.

As a leading German biopharmaceutical company with a 27-year history in China, Boehringer Ingelheim is very honored to participate in this progress and share our experience. Particular attention is paid to three pillars, namely More health, More Green and More Potential, highlighted by the "Sustainable Development—for Generations" strategy.

1 Operationalize One Health Approach to Achieve "More Health" for People and Animals

Let's start with the first pillar: One Health approach and More Health for people and animals. The lives of humans and animals are interconnected in profound and complex ways. Over 75% of the emerging human infectious diseases are zoonotic, transmitted from animals to humans. Therefore, rather than focusing on human

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or animal health independently, we should understand health in a holistic view, addressing the health needs of both humans and animals, as well as their shared environment. That is what we mean by "One Health" approach.

At BI, we firmly embrace this concept and work ceaselessly over the past 136 years to improve both the health of humans and animals. In terms of human health, BI has developed novel therapies to help millions of patients suffering from respiratory diseases, oncology, cardiometabolic diseases and central nervous system disorders. Regarding animal health, BI has become the second-largest animal health business in the world since 2017 and ranks no.1 for swine, pet parasiticides and horses.

Beyond building on our strengths in these two areas, we aim to drive meaningful impact and deliver more health benefits by creating synergies and exploring unified scientific platforms.

2 Embrace Low-Carbon Development to Realize "More Green" for Planet

Now, let's move to the second pillar: low carbon development and More Green for the planet. Considering the 50 billion tons of greenhouse gas emissions per year, the decarbonization of industry has become increasingly imperative. Our pharmaceutical industry, as a critical development pillar, should take the responsibility and embed low-carbon development into the entire value chain.

At BI, we are committed to achieving carbon neutrality in operations by 2030 and in comprehensive value chain by 2040, and various actions have already been taken. For example, BI China launched BE GREEN program 10 years ago and has been optimizing our energy structure and building up photovoltaic power stations ever since. This year in 2021, BI China has cumulatively reduced carbon emissions by approximately 2000 metric tons and has become the 1st pharmaceutical company to be certified with the Waste Zero Landfill Management System.

3 Capitalize Innovation to Create "More Potential" for Healthy and Sustainable Communities

The third pillar, harnessing the value of innovation, offers More Potential for healthy sustainability. This is the most important one for communities in my personal opinion. Innovation could provide enduring impetus for public health, economic upgrading and sustainable development. With a corporate vision of delivering "Value through Innovation", BI has integrated innovative efforts throughout the entire lifecycle of our business.

In early-stage drug discovery, we supplement our in-house expertise by cooperating with academic institutions and other companies to co-develop scientific innovations. Integrating Research Beyond Borders, business development and licensing and venture capital, we dedicated to providing one-stop innovation collaboration solutions for innovators in China and Asia.

In clinical development, by including China in all early phases of global clinical trials, we have become the first multinational pharmaceutical company to transform this aspiration into reality. More importantly, through collaboration with our strategic hospital partners in China, we aim to accelerate new drug development to ultimately benefits Chinese patients.

On the commercial aspect, BI is the first international service provider of biopharmaceutical contract development and manufacturing solutions in China, providing Chinese biopharmaceutical companies with entire production chain from DNA to Fill and Finish by leveraging our global network.

Moreover, BI is actively adopting the latest digital technologies and solutions across the chain. For example, we have established the "BI X" digital lab in China to explore disruptive solutions for digital healthcare.

In one of our focus therapeutic areas—stroke care, we brought in an innovative disease management approach called "Total Stroke Solution" and already established one and preparing a second German gold-standard stroke rehabilitation center in China. This innovative health solution provides management of the whole patient journey, covering prevention, disease education, testing, first aid, diagnosis, treatment, and rehabilitation.

4 Policy Suggestions for the Health Innovation Ecosystem Upgrade

All these innovation efforts that BI has made wouldn't have been possible without the healthy and evolving innovation ecosystem in China. Since entering China in 1994, BI is excited to have contributed to and benefit from the development of China's healthcare innovation ecosystem. We sincerely look forward to seeing its continuous improvement in the following two aspects.

First, "protecting innovation". We believe that a robust intellectual property (IP) protection system is the cornerstone for innovation. In addition to an established legislative and regulatory framework, stronger enforcement and more coordinated interagency efforts are even more critical. It has also become more vital for China to benchmark its IP protection system with international standards, which will protect not only the foreign players in China but also Chinese companies in expanding their business into the global markets.

Second, "rewarding innovation". We believe it is critical to strike a balance between the patient accessibility and the funding for innovation. As China moves forward to improve the accessibility and affordability of universal healthcare, it

is expected to optimize the mechanism and strengthen the industry's incentive for further investment in innovation in China.

5 Sustainable Development at Our Heart

As a family-owned company, we took a long-term and holistic perspective, establishing long-term growth goals. BI will stand ready to improve human and animal health in China and work closely with all stakeholders across the sector to continue this momentum. Together in partnership, we could deliver innovative health solutions faster and better, and create a healthier, greener, and more sustainable future for generations to come.

Global Actions to Reduce Marine Plastics

Yongmei Zhou

Since its commercialization after the Second World War, plastics has become a ubiquitous material in our lives due to its attractive features of durability, light weight, flexibility and low cost. However, unmanaged plastic waste has caused an ecological, human health and economic disaster. Marine animals ingest plastic and microplastic or trapped by abandoned nets. Our health is harmed by the plastic that enters our bodies through the food chain and the worsening sanitation conditions in cities and countryside alike. Fishery and tourism are directly affected.

According to the Breaking the Plastic Wave study by Pew Charitable Trust and Systemiq published in 2020, if we continue the current trend, the annual flow of plastic waste into the ocean will have increased from 11 million tons in 2016 to 29 million tons by 2040. What does "29 million tons" mean? Imagine the entire coastline of the world, and then imagine for each meter of coastline 50 kg of plastic waste will be going into the ocean every year by 2040. That is a future we need to avert.

Marine plastics has no national boundaries, but we can prioritize progress in countries and industries that contribute the most to this global problem. In terms of geographic distribution of plastic leakage into the ocean, middle-income developing countries with large coastal populations and low capacity for solid waste management rank on top, namely China, Indonesia, the Philippines Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, Bangladesh [1]. Reducing the use of single-use plastic packaging, improving the collection, recycling and managed disposal of plastic waste in these countries is key to reducing marine plastics.

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This article is based on Zhou Yongmei's keynote speech at the PKU Global Health and Development Forum 2021.

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But investing in solid waste management alone is not enough. Globally, the speed of building waste management infrastructure and delivering services is far outpaced by the growth of plastic production and waste. Currently, two billion people do not have waste collection services. Municipal governments around the world are already overwhelmed by the amount of solid waste (esp. plastic waste) they have to manage. After China banned the import of recyclables and waste in 2018 and subsequent bans of other Southeast Asian countries, municipal governments in developed countries that used to export the problem now have to find domestic solutions.

Policies need to provide incentives for producers to reduce virgin plastic production and adopt designs and business models that help us build a circular economy. What does it mean concretely?

Our first priority should be flexible packaging (bags, films, pouches, etc.) and multi-layer and multi-material plastics (sachets, diapers, beverage cartons, etc.). Among all the plastic types, they are the most susceptible to leakage. Even though they account for 59% of plastic production, they contribute to 80% of plastic leakage [2]. Policies need to stimulate innovations by the fast-moving consumer goods and retail businesses in the way they design and package products.

In 2019, Unilever made a commitment that by 2025 it will (a) halve the amount of virgin plastic used in its packaging and achieve an absolute reduction of more than 100,000 tons in plastic use; (b) help collect and process more plastic packaging than it sells; (c) ensure that 100% of its plastic packaging is designed to be fully reusable, recyclable or compostable; (d) increase the use of post-consumer recycled plastic material in its packaging to at least 25%. Hard targets generate innovations in material choice, product packaging design, a new reuse and refill business model.

Widespread innovations are needed. Government can stimulate such innovations by making companies bear the environmental cost of their products. Since early 1990's, countries in Europe and North America have adopted a policy strategy called Extended Producer Responsibility (EPR).[1]

Originally coined by Thomas Lindhqvist in 1990, EPR extends the responsibilities of the manufacturer of a product to the entire lifecycle of the product and especially for the take-back, recycling and final disposal of the product.

EPR implementation started in Germany in 1991 when it adopted the Packaging Ordinance. Firms pay annual license fees to an industry consortium, which manages a separate waste management stream for their products. Variable fees are assessed based on material type and weight. Members use a Green Dot label on their products to indicate they have contributed to the cost of collecting and processing waste. Germany achieved 3% annual reduction in packaging between 1991 and 1997, as compared to 2–4% annual increase prior to the ordinance. EPR has since spread to other European countries and beyond. EPR legislations differ across countries and local governments within a country, and efforts are underway to harmonize the EPR framework in order to reduce compliance cost for business.

[1] In the field of waste management, extended producer responsibility (EPR) is a strategy to add all of the environmental costs associated with a product throughout the product life cycle to the market price of that product.

Developing countries also need to make polluters pay, whether they are the businesses with the most environmentally damaging products or consumers who generate a lot of waste.

Beyond the lessons we learn from developed countries, what can the developing countries learn from each other that is directly relevant for their context of rapid urbanization and overwhelming challenge of managing solid waste? Solid waste management costs about 19% of municipal budget in low-income countries, 11% in middle-income countries, and 4% in high-income countries [3]. A capital-intensive approach is often neither feasible nor desirable in the context of revenue-poor municipal governments. Many developing countries have a sizable informal sector of waste pickers who are turning waste into economic livelihood. It is estimated that 60% of global recycling is done by 11 million waste pickers around the world. South-south learning can study how to incorporate the role of waste-pickers into policy and program design. For example, how to support waste picker cooperatives and facilitate their access to predictable sources of waste as well as buyers of recyclables and protecting these workers from workplace hazards.

A public–private partnership between the Pune Municipal Corporation (PMC) in India and a waste picker cooperative called SWaCH[2] demonstrates a win–win partnership. In 2008, SWaCH signed a MoU[3] with PMC to collect source-separated waste from households, businesses and institutions, charging them user fees, sorting them in the sheds provided by PMC, depositing the waste at designated collection points, and selling recyclables and keeping the revenue. Covering 60% of the areas in the city and more than half a million households, this arrangement saved the PMC $7.9 million a year and diverted 9% of waste to recycling.

While plastic waste is predominantly an urban issue in developed countries, most developing countries are facing the plastic waste challenge in rural areas as well. 45% of today's leakage is from rural areas. With a large clientele with low income and limited cash flow, producers of fast-moving consumer goods sell their products in small single-use plastic packaging, which is often found littering in nature after use. South-south dialogues can facilitate learning about inducing behavioral change in this context and establishing affordable infrastructure for collection, recycling and disposal in less densely populated areas.

China needs to do more as the largest emitter of plastic waste into the ocean, the largest plastic producer and a large trading partner. Whether we like it or not, a global movement such as the Break Free from Plastic Movement[4] is building. Our

[2] SWaCH is India's first wholly-owned cooperative of self-employed waste collectors and other urban poor. It is an autonomous enterprise that provides front-end waste management services to the citizens of Pune.

[3] A memorandum of understanding (MoU) is a type of agreement between two (bilateral) or more (multilateral) parties. It expresses a convergence of will between the parties, indicating an intended common line of action.

[4] The Break Free from Plastic Movement is a global movement envisioning a future free from plastic pollution. Since its launch in 2016, more than 11,000 organizations and individual supporters from across the world have joined the movement to demand massive reductions in single-use plastics and to push for lasting solutions to the plastic pollution crisis.

trading partners in Europe and North America will ask our export companies to adopt greener design and packaging. The current wave of city-level effort in sorting and recycling waste is a good start. And we need to go beyond administrative measures such as ban and experiment with a variety of policy instruments such as tax, charges, tradable permits. We need EPR for the packaging industry and green innovations by businesses.

As research and teaching universities, we can build global research and learning networks to accelerate global progress and to nurture the next generation of leaders.

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Medical Innovation and Digital Health

Abstract PKU Global Health and Development Forum 2021: *Digital Health and Access to Medicine* was successfully held on April 25, 2021. The objective of this forum is to explore new strategies for international cooperation in response to the COVID-19 epidemic, and to share research achievements in digital health and medical innovation.

This section emphasizes the importance and urgency of the usage of the innovative and digital approach to address global health issues in healthcare and other fields related. The inspired speeches by distinguished guests attending the forum reflect the needs of incorporating the digital health and innovative medical strategies to provide the pathways for the development of economy, environment and healthcare.

Digital Health: A Powerful Tool for a Healthier World

Tedros Adhanom Ghebreyesus

The COVID-19 pandemic has highlighted the inequalities and inequities in our health systems.

At the same time, we have also seen the power of digital technologies to improve health care delivery and help us take on these global threats.

They have been used to screen populations, track people who have been infected, and monitor the flow and supply of critical health resources.

Digital technologies can be used to strengthen primary health care and prevent the spread of resurgent or new diseases.

South-South cooperation can be an important factor in facilitating equitable access of digital technologies to low- and middle-income countries.

But while digital technology holds great promise, in the end it is only a tool. It is up to us to use it wisely.

We must address the disparity in access, quality, and safe use of digital health technologies in low-income and underserved communities, while preserving the privacy, safety, and integrity of individual health data.

WHO's Global Strategy on Digital Health is designed to help countries adopt these 21st-century tools as part of their journey towards universal health coverage, while strengthening governance and data protection.

With the proper oversight and regulatory guidance, digital health can be a powerful tool for building a healthier, safer, and fairer world.

Tedros Adhanom Ghebreyesus, WHO Director-General.

This article is based on Tedros Adhanom Ghebreyesus's remarks at the PKU Global Health and Development Forum 2021.

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The Global Fund's Action in Strengthening the Health System

Peter Sands

I would like to acknowledge the efforts of those Chinese companies who have jointly explored digital solutions together with the Global Fund in the context of COVID-19. As an international organization created to accelerate the end of AIDS, tuberculosis, and malaria, the Global Fund[1] mobilizes and invests more than 4 billion dollars a year to support programs run by local experts in more than 120 countries.

In partnership with governments, civil society, technical agencies, the private sector and the people affected by the diseases, we are challenging barriers and embracing innovation to fight these diseases. The COVID-19 pandemic has taken a heavy toll on our economies, health, and society. It's threatening to destroy decades of progress in the fight against poverty, inequality, and deadly diseases like HIV, tuberculosis (TB), and malaria. Since early last year, the global Fund has responded swiftly to the pandemic through our COVID-19 response mechanism, known as C19RM; we have provided low- and middle-income countries with critical tests, treatments, and medical supplies, adapted life-saving HIV, TB and malaria programs, and reinforced fragile systems for health.

In 2020, we mobilized and deployed a billion dollars through C19RM, and this year, we are deploying at least 3.7 billion dollars. The Global Fund is a founding partner of the ACT Accelerator, the global collaboration to ensure the accelerated launch and equitable deployment of tools to fight COVID-19 in which China is one

[1] The Global Fund is an international financing and partnership organization that aims to "attract, leverage and invest additional resources to end the epidemics of HIV/AIDS, tuberculosis and malaria to support attainment of the Sustainable Development Goals established by the United Nations".

Peter Sands, Executive Director, Global Fund.

This article is based on Peter Sands's remarks at the PKU Global Health and Development Forum 2021.

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of the market shapers. The Global Fund plays an essential role in the partnership, co-leading the diagnostics pillar as well as the health systems connector and the supply of the workstream of a therapeutics pillar.

The pandemic has underscored the need for a digital revolution in healthcare delivery and shown how fundamental it is. Real-time data is crucial to managing the COVID-19 pandemic. Countries already behind in health information systems and data management have been flying blind. We need a massive and rampant change in managing health information and data aggregation.

The Global Fund recognizes the critical role that data and digital health can play in the fight against diseases. Last year, we announced several high-level partnerships with technology companies, including Microsoft, Master Card, Google, etc. We are, together with partners, developing a digital health platform to support African countries in their efforts to accelerate and transform their digital capabilities.

We aim to develop and provide best-in-class solutions, access to co-financing, and collective expertise and knowledge. We know countries need more funds to build their digital capabilities and better solutions, more technical support, and building paths to spend that money well. We have already seen how our partners like Microsoft and Master Card support Rwanda in developing standards for data integration, a fundamental building block for digital health transformation in the country. We have also seen AI and machine learning techniques applied against TB, malaria, and COVID-19 to provide decision-makers with rapid and comprehensive data analytics. All of this is enormously promising and signals the potential impact.

The Global Fund is committed to building a strategic and forward-looking partnership with China. It's high time for the Global Fund to join hands with the private sector in China to address the challenge of major infectious diseases, strengthen the health system across developing countries and reinforce global health security. We know, of course, the deep and broad technology and expertise that exist in China and greater participation of Chinese companies in these areas of common interest will make a big difference.

Opening the Door to Digital Health

Liz Ashall Payne

ORCHA[1] stands for the Organization for the Review of Care and Health Applications. The mission of ORCHA is not to review and improve digital health, but to deliver high quality digital health tools to people and patients. To achieve the mission, the first question is which digital health tools are of high quality. Therefore, I will introduce the work we have been leading on a global scale and share with some of the lessons.

Before I do that, I would like to start by setting the scene. You may be surprised to know that we currently have access to over 375,000 digital health apps. When I use the word app, I'm talking about apps that you can find in the app stores, but that also includes web-based solutions. Globally, 5 million people download one of these solutions every day. That has increased by 25% since COVID. Thus, what we have been seeing is that more people are really interested in how digital health can help their health or to help them with the health condition they may be living with.

It is also interesting to note the way in which our healthcare professional communities are also engaging with digital health. More than 80% of healthcare professionals are already using many medical apps on their smartphones and more than 40% believe that these tools could reduce the number of visits to the doctor's office. Surprisingly, over 90% of healthcare professionals believe these tools could improve the health outcomes of their patients. Currently, there are more smartphones on the planet than there are toilets and toothbrushes. The landscape reveals that many people are already

[1] The Organisation for the Review of Health and Care Apps (ORCHA) delivers a systematic approach to assessing, accrediting, deploying and embedding digital health technologies into clinical services and pathways.

Liz Ashall-Payne, Co-founder and CEO, ORCHA.

This article is based on Liz Ashall-Payne's keynote speech at the PKU Global Health and Development Forum 2021.

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using solutions that healthcare professionals believe could help their patients, and our organization have brought the infrastructure.

Then the question arises, why have we not yet regulated and embraced this opportunity? There are four major barriers to the adoption of digital health apps. The first major barrier is awareness, people, patients, and healthcare professionals are not aware of the opportunity that exists. At present, approximately 6000 digital health apps are available to support people with dementia, and around 20,000 are available for mental health. However, awareness amongst the population and healthcare professionals remains low, and unfortunately, the current training of healthcare professionals does not include the world of digital health.

Once people have built up an awareness of digital health solutions, the next barrier is access. Where do people go to find these tools? Probably an app store. If the word *dementia* is typed in the Apple app store on the phone, only two or three results appear, and it is difficult to access more options.

The ultimate barrier is trust if the user does find the tool. How can people trust this tool? How will the app deal with the data collected? Is the data stored securely? Is it clinically assured and ethical? Will it meet the personal preference needs? Unfortunately, trust is not warranted. The research by ORCHA has found that only 20% of digital health tools meet the quality criteria that were expected before either wanting to use it or recommending it to patients.

The fourth major barrier is ongoing governance. Assuming a clinician deploys solutions for patients, what happens if the solutions change? What if solutions change in an unsafe way? Digital health is changing all the time, presenting benefits as well as risks. How can we ensure that future risks are managed and governed? Those are the four main barriers that have really prevented us from utilizing the opportunity of digital health on a global scale. Then, how does ORCHA overcome these barriers?

It all starts with trust. Trust is the biggest barrier to our adoption of digital health. How do we overcome this barrier and how do we build trust in a system? There are a lot of regulations and standards in the world of digital health, but the regulatory landscape regarding digital health is a real puzzle (Fig. 1) because not all the regulations and standards are relevant to all the four segments, including data privacy, security, clinical assurance, and user experience. Some of the regulations relate to data privacy, some to data security, some to clinical assurance, and some to user experience.

The next challenge of this regulation puzzle is that new regulations are emerging all the time in these different areas. Then, the third challenge is, as not all digital health tools are the same, which of these regulations should be applied to which tools? Some digital health tools are basic, but some are highly complex, built on clinical algorithms and interpreted in clinical systems. Therefore, it varies which regulations meet the needs of which products. This is a real challenge. Globally, digital health frameworks have been created mainly at national levels. The frameworks for digital health are trying to make sense of this regulatory puzzle and create assessment frameworks or questions to evaluate products and assure products of compliance with these standards and regulations.

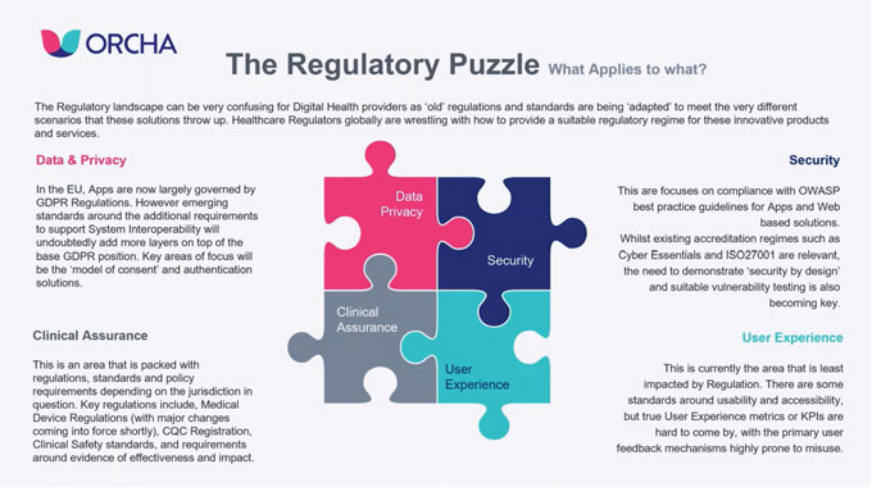

Fig. 1 The regulatory puzzle: what applies to what?

A lot of duplicated efforts may exist in these digital application assessment frameworks. ORCHA works globally to coordinate the baseline review assessment or the foundation review assessment. We have taken different duplicated standards and assessment questions on a global scale and pulled them into a foundational baseline review process. This is the ORCHA baseline review process (Fig. 2), a robust process. It involves over 350 questions covering each of these four areas mentioned above. The beauty of it is that it is proportionate. We only ask relevant questions about the product that is being processed, and it is repeatable. This is important because the process is not just a snapshot of the view. This system is still a manual system, but it uses technology to support the process, and enables the review of every update and change of products. We also work with the developer to advise them on areas they may need to update and change to meet any regulatory requirements.

The work we are doing is based on the ORCHA baseline review. In the structure of the work, ORCHA's baseline assessment is at the bottom and the work carried out in different countries is at the vertical line.

The first one, we worked with GGZ/Mind (de Nederlandse ggz) on the project in the Netherlands and they were able to use all the work we have taken on the ORCHA baseline assessments. We, on their behalf, added additional questions and user experience to get approval in the Netherlands. In the five nations of the Nordic, they had different questions to ask in the review process, and we ran the answers through our system. We also had Israel, National Health Service (NHS) in the EU, International Organization for Standardization (ISO), Health Navigator Charitable Trust[2] in New Zealand. We also operate in other regions, such as Canada and America. This allows

[2] Health Navigator Charitable Trust is a company based in New Zealand and its vision and mission is for all New Zealanders to have free access to independent and reliable health information and resources to help prevent disease and minimize the impact of ongoing health conditions.

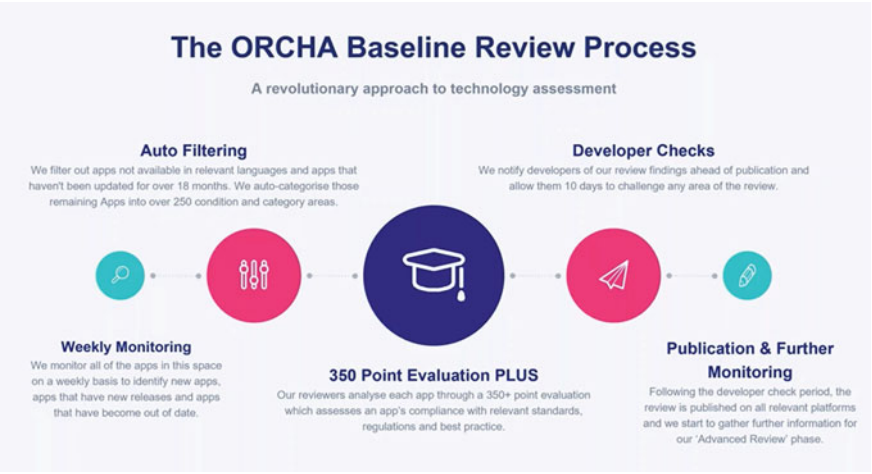

Fig. 2 The ORCHA baseline review process: a revolutionary approach technology assessment

different regions to learn from each other in the process. We have processed 13,000 digital health solutions through that ORCHA baseline assessment. We maintain a review of these products every time they are updated or changed, and then we need to add a few additional questions for specific jurisdictions. This means that the whole world can collectively learn from each other, and leverage the work that each other is doing.

Discerning good products is only the first step in truly helping patients become digitally able. Therefore, once we know which tools are safe and high quality that can be trusted, the next thing we need to do is simply tell people which ones are good. ORCHA has been working nationally, regionally, locally, or organizationally to create digital health app stores or digital health app libraries. These digital health libraries are promoted to specific communities of interest. Some of our libraries are focused on dementia, some others on adult mental health, and some others on long-term conditions. We work with these regions, nations, or organizations, to promote these libraries to people, so that people, communities, and patients know where to go to find a trusted solution. The libraries are equipped with highly configured and sophisticated search engines, which enable people not only to search for and find high-quality products, but also to filter them according to personal preferences and needs, for example, age, technological preferences, whether the individual has a hearing impairment or a visual impairment, what the individual wants from the project, etc.

In addition to these digital health libraries, we work with healthcare professionals who have touchpoints with the patients. The people who are interested in digital health are the truly activated communities. How do we activate those communities who are less activated to use digital health? The best way to activate people to use these tools and get the most benefit from these tools is to have trusted healthcare professionals

recommend the tools to communities. We work with healthcare professionals, train them, and enable them to use these libraries as a formula. Doctors are very used to using formulas to prescribe medication. This is now becoming a digital health formulary approach where doctors, nurses, and therapists, can search for and find the right product for their patients and recommend it to them by a text message, directly to the patient's phone.

Data suggests a conversion rate of around 71%. Approximately 71% of all people who receive the recommendation for a digital health tool via their healthcare professional will convert it and download it. This is not that dissimilar to the conversion rates of drug prescriptions. It means that people are able to access a high-quality digital health tool. It also means that because the back end is continuously re-reviewing and ensuring the quality of an ongoing basis, if we find a future fault with a product, we can do a recall, and that final barrier of governance and ongoing risk management are resolved.

It has been fascinating to look at the data behind the hundreds and hundreds of digital health libraries. We have been able to track what people have been searching for, for example, retrievals during the period of Coronavirus. This data is just a snapshot from March to December of 2020. In March, from the beginning of the pandemic, we saw a huge increase in the number of people and healthcare professionals searching for tools around respiratory conditions in COVID. That rapidly moved into a huge increase in mental health and then in the latter end of the year, towards diet and fitness.

It is fascinating just to observe the trends. I think what COVID has really given us is a real accelerator. As I have mentioned in the beginning, the number of people using digital health has increased by 25% to help themselves through the COVID crisis. Across the digital health libraries, we have seen a massive increase in people visiting and downloading tools. Referrals to patients by healthcare professionals have increased by 6500%. This means that our healthcare system is now much more ready to embrace the world of digital health and the opportunity of high-quality digital health.

Lastly, in order to really support the digital patients, we have to think about three key things. We must build trust in digital health, and that is why the review and robust review comes in. The second thing we must do is activate our populations and patients through our trusted partners, our healthcare professionals. We must enable strong governance and risk management, and use the data that comes out of digital health to feed the next steps.

Intelligent Medical Robots Empower Doctors and Patients

Qiong Ouyang

Today, I want to share with you how intelligent medical robots can empower doctors and patients, improve diagnostic accuracy and enhance medical capabilities.

After two years of rapid development, artificial intelligence has changed the way we interact with machines. Conversational interaction with robots is becoming the next outlet, and chatbots will also become an important tool for this revolution. In recent years, with the rapid development of artificial intelligence and machine learning, chatbots are infiltrating into various fields.

According to Gartner's 2020 technology maturity curve, chatbot penetration has grown from 5–20% in 2019 to 50% in 2020, becoming one of the major business communication tools. As it further lands and achieves more results, the popularity of chatbots will continue to grow in the future.

As an enterprise with advanced AI/big data technology and professional medical technology, it has been committed to helping doctors and patients build an intelligent medical robot. By analyzing the online communication information between doctors and patients and exploring the unmet treatment needs of patients, the robot can truly realize the patient-centered drug promotion model, and drive accurate patient management.

At present, the biggest challenge of intelligent medical robots is how to achieve the efficient production of medical content. We use data to restore the logical structure and create a digitalization in the structure of medical content, so as to improve the accuracy and output efficiency of medical content.

Now let me introduce this intelligent medical robot for you, please. This robot can help users find the medical information that they want through multi-library and

Ouyang Qiong, CEO of Hangzhou Firestone Technology.

This article is based on Ouyang Qiong's comments at Peking University Global Health and Development Forum 2021.

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cross-library retrieval. And also, cutting-edge information for users via this robot can be updated in real time through its automated retrieval. In addition, Intelligent medical cloud's efficient PICOS[1] retrieval strategy can help users use tags to quickly retrieve content. What's more, it's useful for the generation of new medical evidence through multi-dimensional medical content mining.

At present, there are more than 4 million doctors in China who need to continue to learn. And medicines play an important role in knowledge support and medical inquiry services. In the past, pharmaceutical companies needed to set up and operate call center. But now pharmaceutical companies only need to use developed medical robots to achieve medical information transmission at lower costs and higher efficiency.

After three years of exploration, we have partnered with more than 50 of the world's leading pharmaceutical companies to help them improve the efficiency of content preparation and medical inquiries.

Dr. Eye is our collaborative project with Novartis, a new generation of intelligent medical question-and-answer robots that focus on anti-VEGF therapy[2] and related fields of fundus oculi disease. By empowering real-time professional medical responses through dialogue, Dr. Eye can provide more than 10,000 registered healthcare professionals with 24*7 services.

We believe that our intelligent medical robot can truly empower doctors and patients. It can not only provide better care for patients, but also improve diagnostic accuracy and treatment effect and ultimately improve the accessibility of medications.

[1] PICOS principles: P refers to a specific population or clinical problem. I refers to an intervention or exposure factor. C represents a control measure or another intervention that can be used for comparison. O represents outcome, which is the treatment effect of the intervention. S represents the study design protocol.

[2] Anti-vascular endothelial growth factor (VEGF) therapy has been unanimously recommended as the mainstream treatment for neo-vascular fundus disease by authoritative guidelines at home and abroad.

Science Will Win: The Global Fight Against COVID

Angela Hwang

As we continue to live through unprecedented times, it is both a privilege and great responsibility for us to serve patients around the world. Today, I would like to share some insights with you from Pfizer's journey over the last 22 months. During this vital time, we have supported global efforts to combat the COVID-19 pandemic and have learned many lessons along the way. It is a story we are very proud of, a story about the power of science and the power of partnership.

From the beginning of the pandemic, two things were abundantly clear to us. We knew that safe and effective vaccines and treatments would be pivotal to defeating the coronavirus… and we knew that no one company, vaccine or treatment would be enough on its own.

That is why, in March 2020, just days after the WHO declared the COVID-19 outbreak a global pandemic, Pfizer announced a comprehensive Five-Point Plan that called for unprecedented collaboration across the biotechnology ecosystem to combat the virus. Specifically, we committed to:

- Marshaling our experts to accelerate the discovery and development of vaccines and treatments;
- Sharing our scientific tools and insights with the broader scientific community;
- Sharing our development and regulatory expertise with smaller biotechs;
- Offering our manufacturing capabilities to support other companies fighting COVID-19;
- Building a cross-industry rapid response team to prepare for future health crises.

Angela Hwang, Group President, Pfizer Biopharmaceuticals Group.

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We also set ourselves a bold goal: to develop and deliver, in record time, a COVID-19 vaccine. For Pfizer, there was no more powerful example of delivering on our purpose, which is creating breakthroughs that change patients' lives. So, to help humanity during this crisis, we were prepared to harness all the might of our science, manufacturing, and go-to-market expertise.

Close to two years later, I am extremely proud of the progress we have made by working together. We have a breakthrough vaccine, developed, and delivered to the world in record time. And, from our close coordination with regulators on vaccine development to our collaboration with health systems on vaccine distribution, this has been a real joint effort between industry and government. Not a day has gone by that I have not spoken to multiple officials about the vaccine. To date, Pfizer has delivered 2.25 billion vaccines to 163 countries and territories in every region of the world.[1] I know I speak for all my colleagues when I say that this is an accomplishment we will never forget.

But even with all this behind us, we know there is more to do. There are still people in the world we have not reached. And that is why collaboration remains as important as ever. To that end, Pfizer has pledged 2 billion doses to low- and middle-income economies through 2022, which will be provided through partnerships with international organizations like COVAX and through direct supply agreements with governments. We have also partnered with South Africa's Biovac and Brazil's Eurofarma to manufacture the Pfizer-BioNTech COVID-19 vaccine exclusively for the 55 member states that make up the African Union and Latin America, respectively. I can assure you that we will continue to be relentless in our pursuit to help end this pandemic, for everyone, everywhere.

The power of collaboration is not the only lesson we have learned over the last 22 months. Internally, we have found better ways of working. As a team, we've learned to dream bigger, appreciate out-of-the-box thinking, liberate ourselves from bureaucracy, and be decisive. All of these behaviors are replicable and can help move our programs along faster than ever before. We have held to the belief that if we could achieve the impossible once, we can do it again for other products for which the patient need is also high. Ultimately, our goal is to bring 25 breakthrough medicines or vaccines to patients by 2025. That means advancing our most promising programs as quickly as possible, while maintaining our focus on quality and patient safety.

I am proud that we already have proof of this with the work we've done around PAXLOVID, our investigational oral antiviral candidate for the treatment of COVID-19. Last month, Pfizer announced positive results from an interim analysis of our Phase 2/3 trial of PAXLOVID. The data suggested that PAXLOVID has the potential to save lives, reduce the severity of COVID-19 infections, and eliminate up to 9 out of 10 hospitalizations. Pfizer has submitted this data as part of a regulatory submission to the U.S. Food and Drug Administration for emergency use authorization. If approved, we also hope to make this breakthrough available as soon as possible to patients

[1] As of December 2021.

around the world, including patients in China, subject to local regulatory approval.[2] A treatment like PAXLOVID could provide another tool to supplement the Chinese Government's strong, effective campaign to prevent the spread of COVID-19.

Our progress with PAXLOVID was possible because we leveraged lessons from our vaccine team's experience in 2020. It reflects our new 'lightspeed way of working,' which we hope to bring to life across even more areas of our pipeline. All in all, our experience with the COVID-19 vaccine program will remain an example that permeates throughout our company of what good looks like.

The last—and arguably most important—lesson we have learned, is how critical it is to have a strong and sustainable innovation ecosystem in place, including an enabling policy environment, to support the creation of breakthrough medicines and vaccines.

The achievements we have made these last 22 months have only been possible because of years of research and collaboration that came beforehand. Let us not forget that we had a head start on the development of our COVID-19 vaccine because Pfizer and BioNTech had been in partnership since 2018 to develop an mRNA vaccine for seasonal flu. That experience gave us the confidence to pivot quickly and place a big bet on our ability to create a COVID-19 vaccine using the same technology. In short, our success today is the product of years and years of investment, experimentation, failures, and refinements by the biopharma industry.

Coming to the policy environment... on average, it can cost as much as $2.6 billion to develop a single new medicine and take about 10–15 years to move it from bench to bedside. The risks are huge. Companies like ours can justify this investment only when the policy environment around us is strong and when there are reasonable expectations for a return on investment. Key components of a strong pro-innovation policy environment include:

- A strong and stable intellectual property system that is aligned with international best practice
- A regulatory system that supports global simultaneous development
- A transparent and predictable pricing and reimbursement system that supports access and innovation.

This is why we have we strongly supported China's recent efforts to build a stronger health innovation ecosystem, one that values and incentivizes innovation. We look forward to continuing to collaborate with your government to further strengthen these reforms.

In closing, let me share one final observation. In recent years, our industry has created many important medical breakthroughs—from therapies for HIV to gene therapies that are leading to cure-like outcomes. This has been possible only because we have all worked together. And that remains true for our efforts to combat COVID-19. This novel virus affects everyone. It does not care about race, ethnicity, age or

[2] The U.S. Food and Drug Administration issued an emergency use authorization for PAXLOVID in December 2021. China's NMPA subsequently granted PAXLOVID conditional regulatory approval in February 2022.

gender. It does not care about your personal ambitions or where you live. So, to defeat it, we must continue to reach across boundaries and borders, and work together.

We are confident that science will help us win this battle. And, if we stand together, there is no health challenge we cannot overcome.

Global Innovation and Healthy China 2030

Jean-Christophe Pointeau

Over the past 20 years, R&D-Based Pharmaceutical Association Committee (RDPAC) and its members have been privileged to witness firsthand China's remarkable economic and social transformation. This transformation has been underpinned by the Chinese government's substantial investment in the health and wellbeing of its people. In the past decade alone, the Chinese government has *doubled* its investment in health. We have seen significant improvements across the board—in public health, healthcare services, medical security and access to medicine. Most recently, these efforts have been guided by the *Healthy China 2030* blueprint, which places health at the heart of policy making.

The impact of this investment, and of the government's commitment to health and wellbeing, has been staggering. At the turn of the century, less than one in three Chinese people had access to health insurance. Today, China has achieved near-universal health coverage. Life expectancy, at 77.3 years, is now very similar to that of developed nations; infant and infectious disease mortality rates have plummeted; and survival rates for malignant tumors have risen by 10% points compared to a decade ago. I am particularly proud of the role innovative drugs and new therapies have played in supporting these remarkable achievements.

Of course, as our world changes, so do the health needs of our populations. China's health system, like many others in the world, is under increasing pressure—from an expanding middle class, ageing population, shifting burden of disease, and, of course, a global pandemic.

This means that if we are to achieve the bold *Healthy China 2030* vision, we all need to step up and dig deeper. Everyone has a role to play, including RDPAC and its

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members. In fact, research estimates that innovation in the pharmaceutical industry could help reduce China's disease burden by up to 55% by 2040. Yes, you heard me correctly, 55%! I would like to walk you through how RDPAC and its members plan to make this estimate a reality.

Let me start with prevention. Prevention is a core component of the *Healthy China 2030* vision, and one that the innovative pharmaceutical industry is committed to supporting. In today's world, I cannot think of a more important innovation in disease prevention than industry's efforts to deliver COVID-19 vaccines in record time. RDPAC and its members are also committed to collaborating broadly to support other disease prevention efforts. We do this by promoting health literacy, continuing medical education, encouraging early screening and creating management solutions for chronic disease across China.

RDPAC and its members are also committed to bringing new, innovative medicines to China to help patients live longer and healthier lives. Over the past five years alone, international pharmaceutical companies introduced over 150 new, innovative drugs to China—many of which targeted unmet need in the oncology space.

Of course, we know that accelerating medical innovation to address unmet need will only get us so far. We must be able to get our innovative medicines and vaccines to patients that need them.

That is why RDPAC strongly supports China's recent efforts to expand access to healthcare, including to innovative medicines and vaccines. Let me give you three examples of government reforms that have really started to make a difference in this area.

- First, NMPA[1] has worked hard to accelerate the drug review and approval process and align its regulatory framework with international standards. Because of these reforms, for example, Chinese breast cancer patients were able to access Pfizer's first-in-class therapy, Ibrance, two years earlier than originally planned.
- Second, the Chinese government is supporting efforts to improve affordability and reduce out-of-pocket costs for patients. Last year, for example, the government announced the introduction of a more dynamic NRDL[2] listing system and confirmed its intention to support the development and uptake of commercial health insurance.
- Third, the Chinese government has made several important commitments to strengthen the IP system, including by introducing patent term adjustments and a patent linkage system.

But there is still more to do. Developing innovative medicines and vaccines is a complex, multi-year and resource-intensive process. It can take 10-plus years and

[1] National Medical Products Administration (NMPA) is responsible for the registration of drugs, cosmetics, medical devices and the implementation of supervision and management.

[2] The National Reimbursement Drug List (NRDL) is a list of drugs that are authorized for reimbursement by a central government agency. The government will only reimburse some costs if the drug is not that expensive. If a drug is produced at an expensive price, it will most likely not be included on the reimbursement list.

billions of dollars to take an idea from bench to bedside, with many failures along the way.

For biopharmaceutical companies to deepen their investment in innovation in China, they need to know that their investment will be rewarded. That is why an environment that values and incentivizes innovation is key to supporting access to medicines and medical products, year after year. Integral elements of this ecosystem include:

- A transparent and predictable pricing and reimbursement system that supports access and innovation
- A regulatory system that supports global simultaneous development
- A strong and stable intellectual property system that is aligned with international best practice.

We look forward to continuing to collaborate with the government to support these and other health reform efforts. I am confident that, by working together, we can help China realize the *Healthy China 2030* vision.

Digital-First Value Based Care for Sustainable Health Services

Mobasher Butt

Sustainable healthcare that helps achieve a low carbon economy is critical to all our futures and, of course, for all of those who will follow us, and the time to act is now. Today, I will briefly introduce how we have re-imagined healthcare at Babylon and how we provide the people we serve with a digital-first value-based care approach for sustainable healthcare services.

So I'd like to start by focusing on our mission. As you can see here, it's a simple but bold mission that is making healthcare accessible and affordable for everyone on earth. And while this is our public-facing mission, we also have several other missions. And one of those, for example, is making Babylon the best place in the world for our employees to work in, but also we are on a mission to make healthcare sustainable.

So I'd like to give you some fast facts about Babylon if you don't know too much about the company. We started the company about seven years ago as a small company based in the United Kingdom, but we've grown considerably in the last seven years. We now cover more than 24 million people globally in 16 different countries. We now help a patient every five seconds and deliver millions of virtual consultations, or what you might know is telemedicine, as well as millions of AI interactions globally. We have around 2000 employees, and I'm delighted to share that we became a publicly listed company earlier this year.

In our experience, creating sustainable healthcare relies not only on our efforts but also on the efforts of our partners. And here, you can see some of the partners that we work with around the world, and many of these also share our commitment to creating sustainable health systems. And these partners, as you can see here,

Mobasher Butt, Global Medical Vice President, Babylon Health.

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include large insurers, provider groups, governments, academic institutions, and large donor organizations. Now here, you can see how we have redesigned healthcare. Traditionally, many healthcare has been delivered in physical bricks and mortar structures. But when we designed our healthcare service, we wanted to turn this around completely. And what we've been able to deliver most of the care that people need through our AI services.

Of course, we can't always deal with people's health issues through AI services. So, the next level of care is our virtual services. So, this is where we can connect a patient to one of our doctors remotely through a video consultation. And we know that from delivering millions of these consultations worldwide, around nine out of 10 cases can be resolved entirely through this virtual approach. Of course, there will always be a need to have physical services, and we're not trying to replace those or replace doctors, but trying to support the pressure that health systems face around the world. And through adopting this AI first digital first approach, we've been able to actually remove the need for a lot of the physical structures that exist. So again, contributing towards reducing the environmental costs that come with the delivery of healthcare, through physical structures, via providing care where the patient is, often in their own home or at a place of work, wherever they happen to be. And so, this is our re-imagined model of healthcare.

You can see also here that we focus heavily on prevention. And this is also apparent in my next slide. So you can see here that these are our two health loops. One is our sick loop, and one is our health loop. On the left is our health loop. We're trying to keep everyone in this health loop for as long as possible. So how do we do that? We interact with our patients proactively. We reach out to them, gather data, and use that data to provide insights to the patient, helping them understand more about their health and what kind of risks they may be at if they don't take any action.

Once we've helped them identify their status, we help them set goals and actions. And then, we work with them by assigning care teams to support those patients, who then help the patients to achieve their goals and actions by giving them a clear plan. And then we help them by monitoring them. And, importantly, rewarding them to ensure that they stay motivated. If at any stage, we notice that there's any abnormality, we move the patient from the health loop into the sick loop, and you can see that on the right-hand side. The sick loop aims to intervene as quickly as possible to stop a problem from becoming more severe and costly or requiring hospital care. And instead, by intervening early, we can often deal with this problem in a primary care setting by providing the right expertise, the proper treatment protocol the first time, and quickly trying to rehabilitate that patient and get them back into the health loop, where we'd like them to stay.

As you can see, this is our approach to ensuring that we're creating a very sustainable system by using data to do this. At the core of all of our services is our artificial intelligence. When we set up the company, we quickly realized that if we were going to have any chance of achieving our very bold mission of making healthcare affordable and accessible to everyone, we had to get smart about how we used technology. And to do that, we invested heavily in developing our AI solutions. But the best way to think about this is, we've tried to recreate the equivalent of a human doctor's brain,

but instead, a digital version of that, which we call the Babylon AI brain. And so this Babylon AI brain can perform some of the functions in the same way as a doctor would.

So you can think about how, when a doctor is trained, we have to go through medical school, learn, and build our knowledge. That knowledge allows us to then reason and makes decisions. We can use our perception to treat patients and provide them with the best care and make predictions about their care. And this is what the AI brain is trying to replicate.

As I highlighted earlier, we focus on the preventative approach because we believe that that's the best way to create sustainable healthcare. And how do we do that? We start by onboarding the patient into our system. And this is important because this is where the healthcare journey starts. And so we need to make that an optimal experience as possible. We then assess the patient, and we carry out a health assessment that allows us to use the data to risk stratify that patient. Once we have risk stratified the patient, we can determine what care they need. We assign them to a care team. The care team is multidisciplinary. It includes doctors and other healthcare professionals, such as nutritionists and behavioral health specialists, etc.

The care team helps to set a care plan for the patient. This includes a set of clear goals and actions, and we then help the patient achieve their goals and actions by monitoring them, providing coaching, and rewarding them. Now, of course, from time to time, people will become sick. So as I mentioned before, we try to detect any sign of illness as quickly as possible by monitoring them continuously. Then we try to intervene as soon as possible upon detecting any abnormality. When someone needs any healthcare service, they can contact their health assistant. This is someone available to them 24 h a day, seven days a week, and the role of this health assistant is to act almost in the same way as you can imagine, a concierge service and helping that patient navigate every aspect of their healthcare journey.

Patients can also use our AI symptom checker if they have any symptoms. So this empowers them because it's like having a doctor in your pocket. The AI will guide them through a series of questions, just like a doctor would. And then they're able to receive information about where they need to seek care and what kind of conditions might be causing their symptoms. Should they need to speak to a doctor, we have our virtual consultation service. This is also available 24 h a day. And when necessary, we can also connect the patient to a specialist and make sure that we perfectly match the needs of this patient to be the most appropriate specialist, ensuring that they get the optimum care the first time around. While we don't provide hospital care ourselves, we work with partners who do this. However, we provide the patient with very intensive support before going to the hospital. Importantly, we offer them support throughout the postoperative period when they leave the hospital. They're able to have daily check-ins with the nurse through the app, and they're able to upload photographs such as of their wound. The nurse is then able to monitor them and ensures they're not developing any sign of infection or any complications again so that if we detect any of those things, we can act quickly and ensure that this does not become a more difficult problem to solve or a more costly problem to solve.

And again, trying to reduce the need for the person to be readmitted to a physical structure, such as a hospital, helps with a sustainable approach.

As I mentioned to you, one of the key advantages of our services is the AI brain, which sits at the core of all these services. And the AI brain can integrate all of the services to provide a very personalized approach to each of the patients we serve. And all of their data is stored in what we call the health graph. So the health graph is very similar to a medical record but a much richer data source. So it's not just the interactions when the patient sees a doctor, but also all of the interactions they have with other things like the AI monitoring their health metrics through wearables. Every interaction is recorded within their health graph. And then, we're able to apply machine learning techniques to make inferences about that data and provide them with a much more personalized care service.

This type of approach to healthcare, in other words, a sustainable approach, can achieve the same level of excellence that we have seen in some of the best examples of healthcare in the traditional context. And we feel that it is, and here you can see some of the success that we've demonstrated in some of the countries in which we operate. So you can see a very diverse range of countries here. You've got the US, the UK, and Rwanda. Very, very different in terms of their settings and economic profile and the type of patients we serve in these settings. But you can see that patients appreciate this kind of sustainable approach, and you can see very high satisfaction levels in all the settings.

When it comes to clinical quality, this is critical for us. There's no point in having a sustainable service unless you're also able to provide consistently high-quality care. And we assess the quality of our care internally through a comprehensive audit program, but the care is also evaluated externally through external regulators. And you can see some of the comments, the commendation we received from the care quality commission, the regulator in the UK, in the center of the screen.

And finally, so for care to be sustainable, of course, it needs to be affordable. And you can see some of the significant cost savings that we've been able to make by using this approach. And these cost savings tend to happen downstream in terms of hospital care costs. So, by servicing our patients early upstream in primary care, we can shift a lot of the costs away from more expensive secondary care. You can see that results in quite significant cost savings, allowing the service to be very sustainable.

Exploring Sustainable Development of Medical Insurance Industry to Help Multi-layered Medical Insurance System

Xiaodong Zhang

It is a great honor to have the opportunity to share with everyone how MediTrust Health contributes to the construction of a national multi-level medical security system. As more and more innovative medical and pharmaceutical products from all over the world continue to be launched in mainland China, who will pay for such innovations in China in the future? Whether it is MediTrust Health or the entire healthcare industry, this is a hot topic that deserves attention.

First, China's payment structure is fundamentally different from the rest of the world. China's basic medical insurance is still a very foundational expenditure. In China, the government accounts for 50% of medical expenditures. But in China, a large proportion is actually non-government expenditure. In the United States, the main portion is borne by commercial health insurance. In China, non-government expenditures are mainly paid by the people themselves. Commercial health insurance is still in the early stage of development.

From another point of view, as the aging of the population in China increases, by 2025, total medical and health expenditures are expected to account for 7.6% of GDP. The annual growth rate will remain high, especially since the outbreak of the pandemic. Raised attention to health has further promoted the continuous increase in the proportion of China's future overall medical and health expenditures.

Regarding China's basic medical insurance, in November 2021, there was a crucial event: that is, negotiations on the catalog of medicines covered by national medical insurance system. In fact, China's national basic medical insurance has done a very good job. The overall coverage rate is now 97%, and will almost reach 100% in the

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This article is based on Zhang Xiaodong's keynote speech at the PKU Global Health and Development Forum 2021.

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next few years. However, the "plate" of the national medical insurance fund will still confront substantial payment pressure.

You may also see in the news media or relevant government statistical reports that, on the one hand, the growth rate of the overall medical insurance fund has begun to be lower than the growth rate of the entire medical insurance payouts. Especially in regions where the economy is relatively underdeveloped, the pressure on medical insurance funds is very high. On the other hand, due to the influence of pandemic over the past two years, the National Healthcare Security Bureau has also contributed a large amount of funding for the treatment of the pandemic, including related vaccines and nucleic acid testing. Therefore, it is expected that by 2025, although the overall medical insurance will continue to grow, the proportion of medical insurance in overall medical health expenditures will decline from the current 50% to about 45%.

It is also worth mentioning that the supply-side reform of China's medical and pharmaceutical industries has accelerated significantly in the past few years, achieving explosive development. Take anti-tumor and immunomodulatory treatments as an example. In the past few years, there have been more than 600 domestic drug R&D pipelines. I believe that China is currently the world's most popular market for innovative drugs and innovative medical care, both in R&D and in the terminal market.

However, in the process of communicating with various relevant pharmaceutical companies, we also found that the core challenge at present is the question of who will pay for innovative drugs in the future. On the one hand, people in China still pay more attention to the basic coverage of national medical insurance. In the past few years, the national medical insurance has successively included many innovative medicines on the list of covered drugs.

However, we have also seen the contradictions among the needs of the ordinary people, medical needs, and the scale of medical insurance. We have also seen, in addition to oncology drugs, there are more and more innovative drugs, including drugs for the treatment of rare diseases. We also hope that in addition to medical insurance, different levels of proportions can cover access to medicines.

On the payment side, we have seen a major change in the market over the past few years. At present, commercial health insurance coverage in China is still very limited. Commercial health insurance contributes less than 5% of the overall medical payments. Nationwide, in addition to basic medical insurance, personal expenses are still a huge economic burden for ordinary people.

By 2025, we expect that commercial health insurance will account for approximately 15% of medical and health expenditures, and the annual growth rate will reach nearly 20% in the future. Especially in the past few years, a wide variety of commercial health insurance has become ubiquitous, providing a comprehensive means of supplementing medical expenditures.

Take the very popular "Huimin Bao" as an example from the past few years. The substantial development of Huimin Bao has only occurred in the past two years or so. There are currently more than 100 types of Huimin Bao covering more than 100 cities in China. With the support of local medical insurance bureaus, together with local banking and insurance regulatory bureaus and insurance companies, they have

launched products that are quite beneficial to the people. The general price ranges from tens of yuan to one or two hundred yuan.

The core point of "Huimin Bao" is to include some innovative medical devices, drugs, and innovative therapies that are not included in the medical insurance catalog in the Huimin Bao guarantee. With this guarantee, more and more people will be able to enjoy Huimin Bao in the future. It can also greatly reduce the burden of medical insurance in the future.

We predict that by 2025, the number of people in China with commercial health insurance will reach more than 800 million, and the premiums will exceed 2 trillion yuan. With the continuous development of commercial health insurance, we are also pleased to see that the National Healthcare Security Administration is making efforts to improve the multi-level medical insurance system. We hope that with the continuous development of health insurance, personal out-of-pocket expenses can be greatly reduced in the future. We also hope that at the same time, the payment pressure on national basic medical insurance can be reduced.

MediTrust Health is currently the industry-leading patient welfare management and medical health service platform. We have three main platforms:

First, iCare Health is a service platform that fully serves C-end patients. In the past year, over one million patients have been served through our platform. The total amount paid to pharmaceutical companies, medical services, and advanced equipment products through our platform has exceeded 10 billion yuan, and the total cost savings for patients has exceeded 1.5 billion yuan. Our platform focuses on helping ordinary people reduce the payment pressure, while offering them prompt access to China's innovative drugs and medical services.

While serving C-end patients, we also have empowered two industries. First, we empowered the pharmaceutical industry. For instance, take our iCare Health platform. In the past few years, we have established in-depth cooperation with most of China's foreign-funded multinational pharmaceutical companies and innovative local pharmaceutical companies.

Our coverage of drugs is close to 70%, and is basically the same for innovative drugs newly launched in China in the past few years. At the same time, iCare Insurance also empowers the entire insurance industry. China's health insurance industry has developed very rapidly in the past few years. China's health insurance industry provides digital infrastructure to build a "claims + payment" medical and drug service network for insurance companies. Through infrastructure construction, it provides infrastructure for over 70 insurance companies in China.

Furthermore, on the pharmaceutical company side, in the past few years, we have provided one-stop innovative payment solutions for pharmaceutical companies, and have achieved in-depth cooperation with many pharmaceutical companies.

This has been especially popular in recent years. For example, innovative pharmaceutical companies such as FOSUN Kite and JW Therapeutics, which have CAR-T therapy[1] drugs in China, are our long-term cooperative customers. And we are also

[1] Chimeric Antigen Receptor T-Cell (CAR-T) therapy is a new type of precision targeted therapy for tumor treatment and has achieved good results in clinical cancer treatment through optimization

very pleased to see that, with our innovative payment solutions and the depth cooperation with pharmaceutical companies, more and more pharmaceutical companies, have got core customers after bringing new drugs into the market, whether they are originally innovative payment or commercial health insurance customers. For example, one or two weeks after the CAR-T therapy drug was launched last year, commercial insurance companies paid more than 1.2 million RMB in medical expenses for patients through our service network, which greatly helped patients reduce their medical burden. This also provides a more diversified, innovative access scheme for pharmaceutical companies.

Finally, on the insurance end, we have also continued to lead the innovation of health insurance. From the relatively simple provision of health insurance for oncology drugs, we have gradually expanded coverage in three dimensions, from healthy people to suboptimal people, and to people with pre-existing diseases. A comprehensive line of health insurance products has taken shape, covering domains of illness ranging from tumors to more disease areas, and from medicines to more medical services. The health insurance products we support have covered more than 50 million people over the past year.

We just mentioned products like Huimin Bao. In fact, it is estimated that 80 million people in China were covered by various types of Huimin Bao in the year 2021. MediTrust Health has served 50 million of them. Take the very successful Huimin Bao in Shanghai and Beijing as examples. Together, these two cities have more than 10 million people participating in the insurance. To a certain extent, with large-scale Huimin Bao coverage, we have assisted in solving the substantial problems of accessibility to innovative medical care and innovative medicine that are not yet covered by basic medical insurance.

in recent years. It is a promising new tumor immunotherapy method that can be precise, rapid, efficient, and potentially curative.

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