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Role of Science and Technology in China's Health Sector

Introduction

China, the world's most populous country, achieved enormous improvements in health between 1950 and 1980. In these decades, it's life expectancy almost doubled (rising from 35 to 68 years), and infant mortality dropped (falling from 200 to 34 per 1,000 live births).[1] The vast improvements in health indicators were attributed to government policies emphasizing a focus on prevention rather than cures, and dissemination of health education. Factors like changing hygiene, education, living standards, and culture also contributed.[2] The role of Science and Technology was limited. Vast improvements in health-care were achieved under these conditions as China was recovering from extreme poverty as well as from the chaos of long conflicts, both internally and with Japan.

Although China has seen extensive economic growth ever since it introduced market reforms in 1978, progress in the health-care sector has slowed down. It now faces conditions and health challenges which are very different from those it faced over much of the last century. Science and Technology will now have to play a prominent role, if China is to achieve progress in the health sector.

The central government in Beijing seems to have realized this, and currently the Chinese health sector is going through a period of reform. Healthcare institutions, as well as supporting industries like ICT, pharmaceutical and equipment manufacturing, are playing an ever-increasing role in tackling the various challenges and helping the government in its ambitious plans to achieve equal access to public healthcare for all its citizens by 2020.[5]

The rest of this paper is organized as follows. In part 1, we examine the notable features of health-care in China, and the various challenges China now faces. In part 2, 3 and 4, we investigate the role of

Science and Technology in meeting various health related needs through three important sectors – ICT, pharmaceuticals and medical equipment. In part 5 we look at innovations in organization and policies, which are affecting the healthcare system in China. The last section summarizes how Science, Technology and Innovation are helping tackle the various health challenges and establishing China on a path of extensive health-related progress.

1. Features of Health in China

China currently has a life expectancy at birth of 74.68 years, having risen by about 6.6 years since 1990.[4] Being the most populous country in the world and an economy in transition, it is challenged by uneven economic growth and distribution of wealth. Access to medical services, especially for the rural population, has declined. Despite price regulations, health-care costs have been increasing considerably and are skewed toward outpatient and prescription drug costs. Emergence of black markets, overprovision of profitable high-tech services, and overuse of prescription drugs are some of the reasons behind these escalating costs. A survey of 190,000 urban and rural residents conducted by China's Health Ministry in late 2003 found that 36 percent of patients in cities and 39 percent in the countryside avoided seeing doctors because they were unable to afford medical treatment.[1]

China's strict population control policy, though providing some benefit, has led to gender imbalances and rapid rise in the share of elderly population. Though the health impact of gender imbalances is not entirely clear yet, experts agree that they are likely to be negative.[4] The falling fertility and increased longevity has led to graying population. The proportion of Chinese aged above 65 is projected to reach 20 percent by 2040.[6] The aging population is driving the country's demand for health-care services. Also, not unexpectedly, there has been a major shift to chronic diseases as the major contributor to the burden of disease.

Given these challenges, the government has acknowledged the need for reform and has already put 1.27 billion Chinese - 95% of the country's population - on basic health insurance in the past two years,[8] creating "the largest medical insurance system in the world".[7] The government has invited researchers and scientists to join the effort, and has given (and intends to give) science, technology and innovation a major role to play in the planned 12-year, $130 billion health care revamp.[12]

2. e-Healthcare

The use of Information and Communication Technology (ICT) to fulfill the health related needs of the citizens, health-care providers and government is called e-Healthcare. It is one of the fastest growing sectors in the Chinese healthcare market with compound annual growth rate of 21.2% in the period 2007-2012.[13] China has been focusing on the use of ICT to improve the overall quality of life of its citizens. Several Golden Projects which focus on the use of ICT in different areas like Golden Bridge Project, Golden Card Project, Golden Custom Project, Golden Finance Project, Golden Macro Project, Golden Shield Project, Golden Tax Project and Golden Health Project have been launched by Chinese government. With some of them launched as early as 1985, they indicate the importance Chinese government places on the use of science and technology for the development of the society (Golden Health project was launched in 1995). At the heart of e-Healthcare are the information systems; they can be further classified into three different categories based on their function:

1) Hospital Management Information System (HMIS): These are based on use of ICT for the purpose of enhancing the capabilities of finance and administration system; over 90% of the Chinese hospitals are using HMIS at some level.[13]

2) Hospital Clinical Information System (HCIS): These are used for clinical and diagnostic functions; these are more advanced than HMIS and only 20% of Chinese hospitals are using these systems.[13]

3) Geographical Management Information System (GMIS): These information systems are used for the information sharing functions.

The HCIS and GMIS generally use Electronic Medical Record [EMR] and Electronic Health Record [EHR] for transferring information using these information systems. The EMR is used for recording the case and patient history electronically and helps in the clinical and diagnostic purposes. The EHR are electronic records that are used to transfer health related information across the different constituents of health care (Hospitals, Health Administration and Medical Insurance Companies).

The ICT is particularly suited for the Chinese government policies in healthcare and Chinese government policies are particularly suited for the ICT. The Chinese government is increasing the number of health care facilities (especially in rural areas), implementing universal healthcare insurance coverage and establishing central procurement and distribution of drugs. These policies can be most easily and efficiently implemented by using Information and Communication Technology in health care. China has about 70% of its population in the rural areas and only 20% of China's medical resources are available to this approximately 900 million rural population.[14] This has resulted in a huge divide in the access of the medical facilities between rural and urban areas, the Chinese government is addressing this problem by developing rural healthcare facilities. The e-healthcare systems like remote clinical and diagnostic facilities are complementing the infrastructure development and allow the rural population to directly use the medical facilities of the urban hospitals. The Enterprise Resource Planning [ERP] software and real time integration of inventories through ICT has the potential to streamline the operations of provincial procurement center for central procurement of the medical supplies and drugs. The Chinese government is also trying to develop hardware infrastructure and standards to standardize EMR and EHR. [15,16]

Table 1: The Medical Information System Statistics (till year 2008) [27]

No.	System Name	Established		Under Construction		No		Total	
		Quantity	%	Quantity	%	Quantity	%	Quantity	%
1	Outpatient & Emergency Inquiry System	169	63.00%	19	6.33%	122	40.67%	300	100%
2	Outpatient & Emergency Registration System	318	88.34%	11	3.01%	39	10.66%	368	100%
3	Outpatient & Emergency Billing & Charging System	398	96.66%	8	1.93%	10	2.42%	414	100%
4	Outpatient & Emergency Pharmacy Management System	393	96.39%	8	1.94%	11	2.67%	412	100%
5	Inpatient Registration/Discharge/Transfer Management System	391	96.37%	7	1.71%	12	2.93%	410	100%
6	Expense Management System	386	94.69%	7	1.72%	16	3.69%	407	100%
7	Bed Management System	360	92.07%	7	1.79%	24	6.14%	391	100%
8	Inpatient Prescription Management System	310	88.67%	11	3.14%	29	8.29%	350	100%
9	Inpatient Pharmacy Management System	364	96.42%	6	1.62%	11	2.98%	371	100%
10	Medication Inventory Management System	392	94.69%	8	1.93%	14	3.38%	414	100%
11	Medication Preparation Management System	183	56.66%	13	4.02%	127	39.32%	323	100%
12	Medication Accounting System	281	77.84%	14	3.88%	66	18.28%	361	100%
13	Nursing Information System	226	69.23%	20	6.16%	80	24.62%	326	100%
14	Medical Records Management System	303	83.47%	16	4.41%	44	12.12%	363	100%
15	Medical Statistics System	274	80.36%	18	5.28%	49	14.37%	341	100%
16	Payroll Management System	201	65.06%	17	5.50%	91	29.46%	309	100%
17	Accounting System	303	83.01%	13	3.56%	49	13.42%	365	100%
18	Economic Accounting System	260	74.50%	15	4.30%	74	21.20%	349	100%
19	Fixed Assets Management System	250	72.46%	30	8.70%	65	18.84%	345	100%
20	Material Management System	266	77.10%	26	7.54%	53	15.36%	345	100%
21	Hospital Office Automation System	82	29.18%	27	9.61%	172	61.21%	281	100%
22	Medical Papers Management System	131	46.79%	12	4.29%	137	48.93%	280	100%
23	Remote Health Service System	89	31.90%	11	3.94%	179	64.16%	279	100%
24	Remote Education System	76	27.68%	10	3.69%	186	68.63%	271	100%
25	Medical Management and Quality Control System	63	20.23%	23	8.78%	186	70.99%	262	100%
26	Regional Health Information System	14	5.67%	15	6.07%	218	88.26%	247	100%

Figure 1

The government has developed Regional Health Information Networks (RHIN) to manage the information exchange between the different departments, hospitals, medical insurance companies and health administration. As recent as in August 2009, United States Trade and Development Agency (USTDA) awarded a grant to the Sichuan Health Information Centre (SHIC) to design a province-wide universal healthcare system based on an e-healthcare technology platform (probably US is investing in

Chinese e-healthcare for advancement of commercial interest of US e-healthcare companies). Perot Systems Corporation is developing healthcare information system for Changsha. These two are just examples of the efforts by some provinces to develop RHIN, there are many more projects set for implementations in the future. After the break out of Severe Acute Respiratory Syndrome (SARS) in south China the Chinese Centre for Disease Control and Prevention (CDC) has been using the ICT for the purpose of surveillance of infectious diseases. This has resulted in improved response time and pattern recognition of outbreak of a disease. The e-Healthcare also comprises of various other complementary systems like Radio Frequency Identity (RFID), digital imaging and training simulation software. The use of RFID has streamlined the operations of the diagnostic labs where RFID tags are used to mark the patient samples and carry the patient information. The digital imaging allows for the images of various diagnostic tools (X-ray, CT, MRI etc.) to be transferred in a digital format from one place to another reducing the need for transportation of the physical samples. The training simulation software are used in medical educational institutes for training of the medical personal. The Internet has also become an important tool in raising the health awareness of the people as various websites and podcasts have health related information freely available on them.

Figure 2: Doctors in Zhejiang No.2 People Hospital conducting a teleconsultation with a patient and doctors in Shaoxing Hospital using the Golden Health Network (GHN).

3. Pharmaceuticals

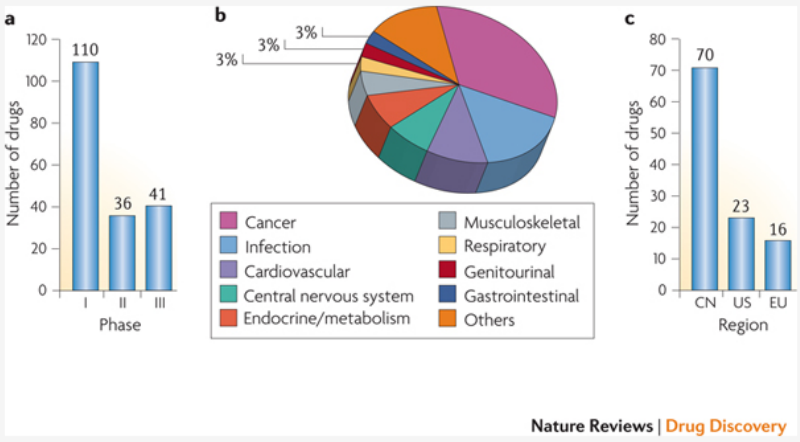
Before the economic reform in 1978, China adopted a three-tiered system to provide healthcare both in rural and urban areas. Changing pattern of diseases, market trends and social strata was followed by growth in medical expenditure. The Chinese government in April 2009 unveiled a 3-year action plan on health-care reform, supported by 850 billion Yuan ($124 billion) to create a universal medical insurance system, establish a national essential drug system, improve grassroots medical care and make a public health service available to its 1.3 billion citizens. According to IMS Health, in 2009 the pharmaceutical market in China increased by 27.9% to reach $31.7 billion and by 2013 is expected to reach $73 billion in annual sales, making China the third largest pharmaceutical market globally.

R&D and innovation: Chinese government is coming up with numerous policies to encourage drug innovation. The introduction of drug policy reform incorporated cross subsidization of pharmacy services through price regulation so as to benefit truly needy and uninsured patients. Also, China's 11th 5-year plan (2006 to 2010) aims to encourage holistic technology development & R&D capacity together with owning the intellectual property rights of the newly produced drugs. One of the integral parts of this plan was the national 'New Drug Creation and Development program', launched in 2008 to provide 6.6 billion Yuan (US$960 million) to accelerate domestic drug R&D.

Currently China has about 3,500 drug companies, which have drug development and production process improvement as its key focus areas. Biotech companies are major drivers of China's R&D. Their research is essentially small molecule-based and macro compound-based drugs. Expenditure of these

pharmaceutical companies accounts for 3–5% of their sales revenues on R&D. Government funding at state-owned research institutes and top-tier research universities has been a chief contributor to promote research especially in areas such as basic medical research, lead discovery and optimization, therapeutic areas and preclinical research. Global Health R&D Center of China (GHRC) is the first Chinese not-for-profit Product Development Partnership (PDP), an acclaimed organization with developing cutting –edge treatments for public health diseases including tuberculosis, malaria, and HIV/AIDS as its key objectives. China's continually evolving pharmaceutical industry is tapping into its domestic Traditional Chinese Medicine (TCM) knowledge by estimating and identifying TCM active ingredients based on scientific principles and utilizing all this to strengthening the protection of intellectual property(IP) and fostering innovative therapies examined through clinical testing.

Characteristics of novel investigational drugs in China.



a | Number of drugs in each phase of clinical trials. **b** | Indications of these drugs. **c** | Patent protection of these drugs. Some drugs have patent protection not only in China (CN), but also in the United States (US) or the European Union (EU). Data were collected by the end of 2010 from websites of the Chinese State Food and Drug Administration (SFDA) and the Center for Drug Evaluation of the SFDA, the Chinese State Intellectual Property Office, the US Patent and Trademark Office, the European Patent Office and company press releases.

Figure 3

International Technology Transfer:

With the help of technology transfer, production and availability of health products has become possible in developing countries along with promotion of economic and social development. R&D- based pharmaceutical companies in collaboration with partner companies are developing medicines and vaccines for markets of developing countries. This approach has a lot of positive effect on health of recipient country's citizens.

Provision of access to innovative medical services and specialized knowledge and skills also inclusive of clinical and laboratory practices serves as important determinants in improving public health of recipient countries. Health capacity can be build through methods ranging from imparting education and training and management skills. Additionally, quality of local production and investment of foreign pharmaceutical companies can be incremented by establishment of joint ventures.

Emerging biotechnology trends

China is on its way of acquiring a very prominent position in biotech industry worldwide. The recent advancement that has arisen is chiefly due to valuable policy changes, cutting labor costs and increased government and private funding that has been crucial elements in bringing a radical change in this sector. Government support for organizations and institutions embarking on R&D project is largely responsible for bolstering the progress of this sector. Biotechnology has pivotal contributions in S&T development of a country.

Shanghai United Cell Biotech had developed the only tablet formulation of cholera vaccine. Two novel gene-therapy products developed by Chinese firms—Shenzhen SiBiono GeneTech's Gendicine, a recombinant human adenovirus-p53, and Shanghai Sunway Biotech's Oncorine, a genetically modified oncolytic adenovirus—received State Food and Drug Administration (SFDA) regulatory approval for treatment of head and neck cancer in China in 2003 and 2005, respectively. Other firms are also developing innovative treatments for malaria, TB, and HIV.

China is the only country in the world where gene therapy is developed and licensed by the SFDA (State Food and Drug Administration) and is in practice since 2004. A considerable number of Chinese companies are operating in the field of human and animal stem cells. China has collaborated with several organizations in the development of vaccines with some of them working on working on an oral HIV vaccine and novel vaccines against Japanese Encephalitis,

SARS and pandemic avian influenza. Generation of innovative products in areas such as gene therapy and regenerative medicine is one of the chief concerns for China whereas its developing countries counterparts have process innovations at its focal point.

China's transition period in biotech sector is substantiated by low-cost trainable talent and workforce in R&D, continued support for basic and applied research, beneficial policies and tax treatment backed by China's entrepreneurial culture. With the stimulating growth of government funding in biotech and a growing indigenous pool of skilled workers spurring pharmaceutical innovations along with trained Chinese entrepreneurs in life science sector, the prospects for future growth of biotechnology seems promising.

Summary:

With the unprecedented success of drug production, innovative and patented novel molecular entities and new biologics, improved laboratory practices, manufacturing and clinical practice standards has

promoted the growth of establishing R&D and innovation-based pharmaceutical sector. Local health problems have been a primary contributor in inducing shifts in pattern of research conducted in China. Also, the health care reform introduced in 2009 that provided basic medical coverage and aimed at advancement of health infrastructure and healthcare delivery has also upgraded pharmaceutical industry. Unification of pharmaceutical distribution and biotechnology are one of the chief focus areas of 12th five-year plan. In the coming decades, China has the right potential to become a powerhouse in pharmaceutical domain. The country is anticipated to play a considerable role in the invention , testing and regulation of drugs.

4. Medical Devices:

Health Care Institution Focus	No. of Institutions	Major Medical Devices to be Purchased
County Hospital	2,000	CT, X-ray, type-B ultrasonic, endoscope, EKG, blood gas analyzer, birthing monitor, aurigo therapeutic equipment, ophthalmologic operation microscope, auto biochemistry analyzer, globulimeter, urine analyzer, ambulance
TCM Hospital		In addition to county hospital list, TCM therapeutic equipment, physiotherapy equipment, TCM production equipment
Health Care Center	29,000	X-ray, type-B ultrasonic, electrocardiograph, biochemistry analyzer, gastric lavage machine, disinfector, shadowless lamp, operation table, anesthesia apparatus, gynecological examination equipment, globulimeter, urine analyzer, ambulance

Source: Jinyuan Security Analysis

Major medical device updates in selected types of health care institutions invested in by the Chinese government.

The Chinese government has allocated USD 250 million to subsidize purchase of medical equipment in rural and western China. The development and boom of China's semi urban and second tier cities is also driving the demand in this sector. Thus, it will play a crucial role in meeting the country's growing healthcare needs.

While the investment in rural hospitals and clinics is driving the demand for low and midrange equipment, the Chinese government is encouraging "indigenous innovation" at the same time by favoring local firms in tendering and procurement procedures.

Medical Device R&D and Foreign Collaboration

A large population, relaxed regulatory control and high acceptance of new technologies makes China a very suitable location for medical device R&D. Western companies such as Philips, Siemens, and GE often partner with Chinese firms to conduct clinical trials or to launch new products in China, and then seek regulatory approval and commercialization there. Data gathered in China is then used for U.S. or European regulatory applications.

For example, in 2004, Siemens established a JV, Siemens Mindit Magnetic Resonance Ltd. (SMMR), with a leading Chinese MRI manufacturer, Mindit. The JV is part of the implementation of Siemens' integrated magnetic resonance strategy. Since then, SMMR has provided almost all of Siemens' MRI supplies worldwide. Located in Shenzhen High-Tech Industrial Park, SMMR specializes in the production of MRI systems and hosts Siemens' MRI Center of Excellence. It is one of the three MRI bases outside of Siemens Healthcare in Erlangen, Germany, that offers R&D, manufacturing, sales, technical support, and comprehensive services.[10,25]

Another examples is a joint venture GE formed with a locally listed company, Shinva in 2000. Based in Shandong, the JV specializes in R&D and manufacturing of X-ray devices and related components. The JV

is prospering by leveraging GE's advanced technology and brand image, and by using Shinva's extensive distribution network and local operational experience and skills. [10]

All this has led to China emerging as a global manufacturing base for low- to mid-end medical devices.

Quality Improvements and Consolidation

The central government puts medical device quality and safety issues high in its priority. The Anhui Food & Drug Administration conducted a province-wide quality inspection of the medical device supply chain in 2008, involving 14 manufacturers, 77 distributors and three service providers.

In addition to assessments at the provincial level, the SFDA also conducted a statewide inspection of 30,700 pharmaceutical and medical device distributors in the first half of 2007. A total of 1,202 distributor licenses and 481 Good Supply Practice (GSP) certification licenses were confiscated. The results prompted the government to adopt more stringent actions on quality and safety issues. In 2008, the Standards of Inspection and Evaluation for Good Manufacturing Practice Certification were revised. The revision incorporated new rules on personnel qualification, production process, quality control and validation documentation. As a result, the quality bar has risen much higher, forcing many manufacturers and distributors to exit the industry.

The Chinese government is also imposing regulations and offering financial incentives to accelerate consolidation of medical device companies to enhance safety and industry sustainability. For example, the government sometimes allows reputable companies that produce high-quality medical devices to sell their products at higher prices. Moreover, the government offers R&D subsidies and other incentives to larger health care firms, and is urging state-owned conglomerates with healthcare-related businesses to consolidate. [5]

Innovation and Leapfrogging

The local demand and consumption, government policies and investment, a favorable R&D environment has led to a bright culture of local innovation, which will benefit China's health sector in the long term.

For example, the old approach with sutures (for closing wounds) was to make disposable ones and sell lots of them. But Chinese firms have undercut Western rivals by developing reusable ones. Another example lies in the market for heart where, MicroPort, a Chinese upstart, came out with products that were 40% cheaper, and now owns 70% of the Chinese market. Firms are now leapfrogging to the latest technologies, such as miniaturization, mobile communications and advanced materials – e.g. Brivo - a locally developed line of MRI and CT scanners.[25]

It has been noted by various observers that the chief benefit in China for innovation is not only access not to cheap labor and a favorable market, but also "a culture of frugality".[25]

5. Reforms and Innovations in Organization and Distribution

The government plans to use provincial bidding centers as intermediaries between individual hospitals and suppliers of pharmaceutical and equipment. Such centralization will lead to an efficient cost-effective way of purchasing large volumes of medicines and devices, while at the same time solving problems of corruption and over prescription by unsupervised hospitals. This will also lead to more competitiveness in the market among manufacturers and distributors. Such reforms in the public tendering and distribution procedure will ameliorate two major problems that the health sector of many countries face : distorted payment systems and a lack of proper competition.

Science, Technology and Innovation: Role and the Level of Impact

To meet the challenges noted in Section 2 and to set itself on a path of rapid health-related progress, the following are some of the key areas that should be high on the priority list:

1. Improve accessibility
2. Reduce the cost of medical services and pharmaceuticals
3. Promote efficient practices and reduce inefficient ones (corruption, over-prescription and overuse etc.)
4. Improve Health Education and Dissemination of Information

Science and Technology is to play a central role in meeting these above objectives. As we have seen, the Chinese government has already recognized this and is giving increasing importance to areas like e-Healthcare, pharmaceuticals and medical equipment, besides its extensive insurance policies.

The use of Information and Communication Technology in Healthcare (e-Healthcare) has contributed to the improvement in health by making the healthcare related services more accessible, improving the ease of exchange of health related information and by using information to improve the efficiency & real-time integration of various processes. They will make health care much more portable, precise and efficient. It will also improve access, and ease exchange and dissemination of information. Innovations in medical equipment and pharmaceuticals, along with ICTs will make it easier to treat and monitor expensive chronic diseases that last for years.[19] Together, prominence in these areas will help bring down the costs of healthcare services for the poor and middle-income citizens.

Conclusion

China, though having made impressive improvements in health in the earlier period, had declined in this area in the last three decades. Given the conditions and challenges that China now faces extensive use

of science and technology is needed for achieving further progress. We have seen that the government is already employing science and technology to meet these challenges through at least three areas, and the future thus looks bright for China's Health sector.

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