Mobile + Health
= Boosting China’s mHealth Bandwidth

A policy white paper
November 2015
FOREWORD

In the last 30 years, China’s extraordinary evolution has been characterized by enormous challenges and the overcoming of those challenges. Global manufacturing centres and distribution lines preceded the gleaming cities, soaring fly overs, and bullet trains that are associated with today’s modern China.

The hundreds of millions of Chinese people lifted out of poverty by these incredible shifts have seen their lives improved, with opportunities for employment and secure housing, food and expanded education. China’s healthcare has improved as well, but perhaps not quite with the same reach and dynamism. China’s health systems, and its healthcare delivery have lagged.

As China prepares to embark on the 13th 5 Year Plan, there are tremendous opportunities to change this dynamic. To achieve the promise of reforms that harness new technologies, and deliver better lives for China’s people, mHealth offers this.

mHealth has the potential to change healthcare delivery and improve quality of care and patient outcome. By leveraging the telecommunications revolution and the widespread use of smartphones, mobile phones, tablets, and the IT infrastructure already in place, mHealth can bring quality healthcare more effectively, efficiently and with reduced costs. But there are barriers to mHealth. Outdated laws and regulations, fractured authorizing environments, inadequate financial reimbursement models and poorly integrated systems will need to be addressed if the full potential of mHealth is to be achieved.

As an early step in helping Chinese policy makers navigate the mHealth space, the China Center for mHealth Innovation (CCmHI) is proud to release this landscaping report on mHealth in China. The first of two parts, this report provides an overview of mHealth in the Chinese healthcare system, particularly from the perspective of academic endeavour. It is hoped that the analyses and recommendations here can contribute to the formulation of policies and practices by Chinese decision makers and bring about expanded use of effective mHealth solutions.

Many have contributed to this report, and we gratefully acknowledge leadership in writing this report by Prof. Dong (Roman) Xu and Dr. Maoyi Tian, with the assistance of Dr. Puhong Zhang, Ms. Rong Luo, Mr. Jing Zhang, Mr. Shi Chen, and Mr. Dorde Petrovic.

The Chinese people are deservedly proud of China’s great achievements over the last 30 years. China has made tremendous strides in improving their people’s lives. mHealth can offer even more opportunities to improve the lives of the Chinese people by becoming an integral part of better, more affordable and equitable healthcare.

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EXECUTIVE SUMMARY

The advent and increasing ubiquity of mobile telecommunications has been deemed by many to have the potential to revolutionize healthcare delivery globally. In China, rapidly expanding mobile infrastructure and capabilities provide an increasingly appropriate environment to realize some of this potential, with the development of innovations that apply mobile technology to the practice of medicine and public health. Such mobile health (mHealth) innovations may be particularly important as China continues to undergo a rapid epidemiological transition, such that the long-term prevention and management of chronic non-communicable diseases (NCDs) has become an increasingly recognized clinical and public health priority. China recognizes the need to evolve the health system in order to maintain the major population health improvements achieved over the last several decades, as well as confront the new challenges of NCDs. The promise of mHealth to positively influence the health system evolution in this context is enormous.

In this report, we examine the extent to which mHealth is currently contributing towards health system strengthening in China. This examination primarily occurs through the lens of a systematic review of the scientific literature, with an assumption that this sector is the genesis of much mHealth innovation. However we also review government and industry sector involvement, as well as the legal and regulatory framework in which mHealth innovations must currently operate.

The main findings of this review are:

• While the relevant regulatory framework is evolving as mHealth activities grow, several important gaps require urgent reforms.
• mHealth activity is rapidly increasing in government, academic and commercial sectors, with a clear response to the changing burden of disease in China.
• The application of mHealth technologies and practices to the strengthening of existing health systems in China is currently limited.
• More consideration is required around the potential for mHealth to address issues of equity, particularly between rural and urban settings.
• Development and evaluation of mHealth innovations has been insufficient in scope and rigor to generate scalable solutions and provide reliable evidence of their values.

The Chinese government has identified a number of these issues and has expressed commitment to or is already attempting to address some, such as strengthening the regulatory environment that pertains to mHealth. In addition to supporting such changes, we make four recommendations aimed at increasing the likelihood that mHealth innovations can positively impact health outcomes in China and help the Chinese people live better and healthier lives.

CCmHI’s recommendations are to:

• Continue reform of relevant policies and regulations;
• Promote a health systems perspective in guiding and shaping future mHealth innovation and application;
• Address equity gaps through targeted mHealth innovations and ensure more broadly targeted mHealth approaches do not widen equity gaps; and
• Generate appropriate evidence for scalable and sustainable models of care.

This broad overview is the first of a series of policy papers that will subsequently provide a more in-depth understanding of both the promise and reality of the mHealth landscape in China.

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ABOUT CCmHI

The George Institute for Global Health (TGI) at Peking University Health Science Center, through a grant from Qualcomm® Wireless Reach™, established the China Center for mHealth Innovation (CCmHI) in 2014. CCmHI aims to improve community health care in China through the study of affordable, sustainable mHealth solutions. CCmHI focuses on 6 priorities:

• Build Chinese capacity in digital health care development and evaluation, including providing opportunities for student internships and fellowships
• Develop and test mHealth platforms designed to provide community health care workers with evidence-based, personalized guidance about the care of individual patients
• Target the 10 leading causes of premature death and disability in China
• Provide solutions effective in both urban and rural settings
• Assist with integrating mHealth strategies into national and provincial policies and guidelines
• Support the development and expanded use of mHealth technologies globally

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Abbreviations

CCmHI China Center for mHealth Innovation
DALY Disability-adjusted life years
FFS Fee-for-services
LHS Lay Health Supporter
LMIC Low and middle income countries
MCH Maternal and child health
MHA Mental health administrator
MMS Multimedia messaging services
NHFPC National Health and Family Planning Commission
NDRC National Development and Reform Commission
CFDA China Food and Drug Administration
CPC Communist Party of China
MOST Ministry of Science and Technology
MIIT Ministry of Industry and Information Technology
MHRSS Ministry of Human Resource and Social Security
PDA Personal digital assistants
RCT Randomized controlled trials
SMS Short message service
WHO World Health Organization
BACKGROUND

What is mHealth?

Mobile health (mHealth) has been variably defined, including as emerging mobile communications and network technologies for healthcare or medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices.1 2

This paper adopts a narrower focus on products and services utilizing voice and/or data enabled mobile phones and tablets, in order to prioritize personal communication devices that may be secondarily used to improve health outcomes. Such mobile devices may incorporate a range of functionality, including standard voice, short message service (SMS), multimedia messaging services (MMS), web browsing, and applications (apps) on a range of operating systems that may be powered by various sensors.

The potential for mHealth in China

China’s rapid development of mobile infrastructure and the changing disease patterns underpin the tremendous potential for mHealth in China. The proliferation of mHealth initiatives globally has been fueled by the unprecedented uptake of mobile telecommunication networks and devices, including in most rural and many remote regions of the world. China is no exception - Chinese manufactures lead the world in producing low-cost and highly functioning smartphones and mobile phone penetration reached 94.5 per 100 people (Figure 1)3. Cellular signals now cover almost all residential areas from densely populated cities to remote villages, with increasing penetration of 3G and 4G networks (Figure 2)3. Penetration of smartphones has also increased rapidly, expected to reach 90% in urban areas and 32% in rural China by the end of 20154.

Figure 1: Mobile phone-ownership in China by Year

![Graph showing mobile phone ownership in China by year](source: 2014 Communication Industry Statistical Bulletin)

With major advances in public health and an increasingly aging population, the disease burden in China has rapidly evolved over the past
couple of decades (Figure 3). Non-communicable diseases (NCDs) now account for 80% of China’s burden of diseases, with the top 3 causes of premature morbidity and mortality in 2010 being stroke, ischemic heart disease and chronic obstructive pulmonary disease. However, regional health disparities remain, and some parts of China are confronted with a rising tide of NCDs in the face of persisting gaps in the delivery of effective care for maternal and child health, and a range of communicable diseases.

Figure 3: Percentage changes in top 25 causes of Disability Adjusted Life Year Loss in China (1990-2010)

Source: Global Burden of Disease Profile - China

Responding to NCDs requires a paradigm shift of the service model from episodic and institutional care to long-term community-based care, with a high level of coordination required among all stakeholders. The portability and connectivity of mHealth applications make these promising facilitators of this paradigm shift (Box 1).

Box 1: Characterization of mHealth

Unique Features of mHealth

mHealth applications possess several unique features that make them attractive tools to improve health system capacities:

- Portability - the small size allows the mobile device to be freely and conveniently carried almost anywhere;
- Connectivity - the voice and data connection link people and transmit information;
- Expandability - the functional expandability with new apps is almost unlimited and easy as they can be pushed to the device even with no user effort;
- Sensors - miniature and powerful sensors are making mobile devices even more functional than computers as health care aid.

Those features of mHealth allows health care delivery to transcend time and space, and to reach hard-to-reach population.
**Health systems in China**

China has experienced four major rounds of health system reforms since mid-1980s, achieving remarkable results in terms of the Millennium Development Goals and accomplishing near universal insurance coverage. However, many health equity and health system level challenges remain: for instance, while some counties in China have under-five mortality rates similar to those in the most developed nations in 2012, some have similar rates to those recorded in low income countries. Examples of health system level challenges are shown in Box 2. A key question is whether and how mHealth developments in China has and can tackle such health equity and health system challenges, particularly in responding to the rapidly evolving disease burden.

Box 2: Examples of Health System Challenges in China

<table>
<thead>
<tr>
<th>Governance</th>
<th>Fragmented responsibility among governments; lack of coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing</td>
<td>Fee-for-service creating perverse incentives</td>
</tr>
<tr>
<td>Workforce</td>
<td>Insufficient training and maldistribution</td>
</tr>
<tr>
<td>Medical Products</td>
<td>Inappropriate drug prescription and use of diagnostic tests</td>
</tr>
<tr>
<td>Information</td>
<td>Lack of uniformity and transparency</td>
</tr>
<tr>
<td>Delivery</td>
<td>Fragmented with excessive concentration on tertiary centers</td>
</tr>
</tbody>
</table>

Source: authors

**How did we develop this report?**

To understand mHealth and its relation to China’s health system challenges, this paper utilizes an adapted health system framework (Figure 4) to evaluate the current and potential role of mHealth. In this framework, applications of mHealth are categorized into one of the 12 health system strengthening tools in accordance with the functions they have; those 12 tools correspond to and strengthen various health system structural components, often referred to as control knobs; these control knobs work together to achieve the intermediate (access, quality and efficiency of care) and the final goals (health status, financial risk protection and customer satisfaction). The goals have two dimensions: the extent of the realization and equity in terms of the distribution of those outcomes.

Under this interpretative framework, we conducted reviews of:

1. Government policies, regulations, laws, and initiatives related to mHealth through review of official websites of the Ministry of Industry and Information Technology (MIIT), National Health and Family Planning Commission (NHFPC), and Ministry of Science Technology (MOST).

2. Academic activity related to mHealth through a systematic review of literature published in both Chinese and English utilizing the scholarly search engines of PubMed, Embase, Cochrane, Clinical Trials Registry, International Standard Randomized Controlled Trial Number (ISRCTN) registry, Chinese Clinical Trial (CHICTR) registry, and China National Knowledge of Infrastructure (CNKI).

3. Commercial activity related to mHealth through a website search of commercial products, media reports, industry meetings and investment reports. We also identified mHealth apps available on Baidu, Tencent, and 360 in the categories of health and fitness and medical, limited to those with a minimum of 100,000 downloads as of 11 September 2015.

It should be noted that, while we have canvassed a wide range of mHealth information, the focus of this report is on academic activity.

**Figure 4: mHealth-Health System Strengthening Framework**

Source: Adapted from Hsiao’s health system model, the WHO health system framework, and the mHealth tools proposed by Labrique
SUMMARY OF FINDINGS

Government policies, regulations, laws and initiatives

We identified 12 government policies, regulations and laws relating to mHealth (Table 1), as well as five major government mHealth initiatives (Table 2).

Table 1: Major Government Policies, Regulations and Laws Related to mHealth

<table>
<thead>
<tr>
<th>Title</th>
<th>Issuing Authority</th>
<th>Key Messages related to mHealth</th>
<th>Related System Component</th>
</tr>
</thead>
</table>
| China’s 12th Five-year Plan for Health Development | The State Council | • To strengthen the construction of health information platform.  
• To promote health information sharing.  
• To gradually achieve successful information exchange between health services, public health, drug supply and health management. | Information |
| China’s 12th Five-year Plan for Science and Technology Development | MOST | • To advance technologies for disease screening, healthcare services, Chinese traditional medicine, and physical activities.  
• To pilot regulate the integration of medical information, clinical decision support and personal health information sharing. | Technology Governance |
| Opinions of the CPC Central Committee and the State Council on Deepening the Reform of the Medical and Health Care System | CPC Central Committee and the State Council | • To construct the healthcare information sharing system platform.  
• To facilitate the communications, knowledge sharing and cooperations between community health providers and urban hospitals.  
• To promote the use of telemedicine to remote areas. | Information Service Delivery |
| Seeking Opinions on Multiple-site Physician Practice (Draft) | NHFPC | Physician are allowed to practice at multiple sites | Health Workforce |
| Notification on the Classification of 11 Products by the Food and Drug Administration | CFDA | The following products are not classified as medical device: health management software including pedometer, food tracking device, blood sugar measurement, blood pressure measurement, weight measurement and sleep monitoring | Governance |
| Software as a Medical Device Registration Guideline (Draft) | CFDA | To regulate the registration and monitoring of software as a medical device | Governance |
| Software as a Medical Device Registration Instruction | CFDA | To define The internet Medical and Health Information Services: the provision of medical and health information services to internet users by launching a medical and health institution website or health promotion/disease prevention website or a website including health promotion and disease prevention component.  
• It is not allowed to provide diagnosis and treatment over the website. | Service Delivery |
| Administrative Measures for Internet Medical and Health Information Services | NHFPC | • To define The internet Medical and Health Information Services: the provision of medical and health information services to internet users by launching a medical and health institution website or health promotion/disease prevention website or a website including health promotion and disease prevention component.  
• It is not allowed to provide diagnosis and treatment over the website. | Service Delivery |
| Guideline on Accelerating the Construction of Population Health Information System | NHFPC | • To complete the regulation for health information management.  
• To construct three database: national population health information, electronic medical record and electronic health record.  
• To accelerate the health information integration and sharing.  
• To enhance the security level of health information | Information Governance |
| Several Opinions of the State Council on Promoting Information Consumption and Boosting Domestic Demand | The State Council | • To promote health information development and sharing.  
• To accelerate the construction of the project named information beneficial to people.  
• To complete the regulation of medical management and health information system.  
• To extensively spread the use of electronic health record and electronic medical record.  
• To promote the use of telemedicine for health consultation and health management. | Information |
| Notice of the National Health and Family Planning Commission on Issuing the Measures for the Administration of Population Health Information (for Trial Implementation) | NHFPC | • To regulate the administration of population health information.  
• To promote the interconnection and shared use of population health information.  
• To advance the development of scientific research.  
• This measurement shall apply to such work related to collection, administration, use and safety and privacy protection of the population health information involved in medical, health and family planning service agencies at various levels. | Governance Research Information |
| Guidance for the Protection of Health Industry Information Security Level | NHFPC | • To increase the ability of health industry information security protection.  
• To provide the safeguard for the development of the health information. | Governance Information |
| Decision of the Standing Committee of the National People’s Congress on Strengthening Information Protection on Networks | The State Council | • To protect the network information security.  
• To maintain the lawful rights and interests of citizens, legal persons and other organizations.  
• To safeguard the national security and public interest. | Governance Information |

The government, realizing the potential of mHealth in promoting economy and improving health, have issued its national strategies such as Internet+ and Big Data Development Framework that have broad mHealth implications. There are two strong but seemingly conflicting forces in terms of government policies: one, from the economic sector such as the National Internet+ strategic policy, perceives internet-
based innovations as one of the most important new economic engines, while the other, mainly from the health regulators, are cautious about appropriateness of service delivery via the Internet and express concerns over data safety. Other policies, while not formulated for mHealth, may influence the development of mHealth. For example, recent policies that relax restrictions on private practice such as the regulation on physician multi-site practice may finally allow public physicians to take a second job in the private sector\(^\text{11}\), which is critical for many mHealth providers. We identified five major government initiatives that have a mHealth component (Table 2).

Table 2: Major Government Initiatives related to mHealth

<table>
<thead>
<tr>
<th>Initiative Title</th>
<th>Leading Organisation</th>
<th>Main Objective</th>
<th>Participating Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and Medical Information HuMin Action Plan</td>
<td>NHFPC MHRSS</td>
<td>• To standardize medical information service.</td>
<td>45 large hospitals from 15 provinces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To promote the use of telemedicine.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To develop and complete the monitoring and alerting system for public health and infectious disease.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To facilitate health resource sharing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To develop and complete the national electronic health record and electronic medical record system.</td>
<td></td>
</tr>
<tr>
<td>National 12 5-year Information Project - National Health Information Project</td>
<td>The State Council NHFPC NDRC</td>
<td>• To establish health information sharing platform.</td>
<td>Nationwide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To increase the capacity in telemedicine.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To enhance the health equity.</td>
<td></td>
</tr>
<tr>
<td>National Innovative Medical Device Demonstration Project</td>
<td>MOST NHFPC Local governments</td>
<td>• To construct health information sharing platform between the government, medical institution, and community health service stations.</td>
<td>11 provinces including Chongqing, Guangdong, Sichuan, Liaoning, Jiangsu, Zhejiang and etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To maximize the use of the health resources.</td>
<td></td>
</tr>
<tr>
<td>Regional Collaborative Medical Demonstration Project</td>
<td>MOST</td>
<td>• To increase medical information level.</td>
<td>PLA General Hospital in collaboration with Xiamen City and Dalian City</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To develop innovative health service delivery model</td>
<td></td>
</tr>
<tr>
<td>Hospital Digital Demonstration Project - Pilot</td>
<td>NHFPC</td>
<td></td>
<td>First batch in 20 hospitals</td>
</tr>
</tbody>
</table>

Note: These initiatives were found by searching the keywords of mHealth from major government websites. Details on the mHealth aspect were not available from the websites.

Applying our health systems framework (Figure 4), we found that most government initiatives targeted electronic medical records and were designed to improve health information systems while there are many red empty cells in Figure 5, indicating limited use of mHealth tools to strengthen the system control knobs. Meanwhile, few government initiatives have been found on the application of mHealth to provide medical services beyond the settings of traditional healthcare facilities.

Figure 5: Health system framework assessment of mHealth – government initiatives

<table>
<thead>
<tr>
<th>mHealth Functionality</th>
<th>Leadership/ Governance</th>
<th>Financing</th>
<th>Payment</th>
<th>Health Workforce</th>
<th>Medicines/ Technologies</th>
<th>Information</th>
<th>Service Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education/behavioral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Sensors/point-of-care devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Registries/vital events tracking</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Data collection and reporting</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Electronic health records</td>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Electronic decision support</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provider to provider communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Provider work planning/scheduling</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Provider training/education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Human resources management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Supply chain management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Financial transactions/incentives</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Note: The numbers in cell indicate the number of projects that belong to the tool in that row and correspond to the control knobs - the health system structural components - in that column.
Academic activity

Over the past 10 years, the number of academic publications relating to health interventions utilizing mHealth approaches has been rising and particularly rapidly increasing over the past 5 years (Figure 6).

Between 2003 and 2014, we identified 69 academic projects relating to an intervention with a mHealth focus, as defined by this report. Only one out of 69 studies was conducted in a rural setting. Approximately 40% of the interventions focused on the management of NCDs (Figure 7).

Despite the increasing adoption of smartphones, the overwhelming majority of academic projects utilize regular mobile phones (Figure 8). Many used simple SMS messaging to educate clients and promote adherence to treatment plans. As the published studies do not necessarily represent the current research activities, it is possible that ongoing projects may involve greater smartphone use.

Applying our health systems framework (Figure 9), we found that for academic projects, three categories of health system tools were most commonly adopted: 1) client education and behavioral change communication; 2) sensors and point of care diagnosis; and 3) Data collection and reporting. We did not identify any mHealth activity for provider work planning/scheduling, to manage human resources, to improve supply chains, or to facilitate financial transactions despite mHealth's great potential in these areas. In Appendix 1, we described in more details the functions of those applications.
The academic studies utilized a range of study design to evaluate mHealth interventions (Figure 10). Only 26% used the most rigorous study design (randomized trial), while 7% of the publications were systematic reviews or non-systematic review of the literature. Over 40% of publications were either case reports or findings of pilot studies. The largest randomized trial included 1992 participants.

A number of mHealth projects that are ongoing are not represented in this report. Appendix 2 summarizes relevant projects supported by the National Natural Science Foundation; these more recently funded projects appear to maintain a focus on client education/behavioral change and sensors/point of care diagnosis.

**Commercial activity**

Our review indicates increasing interest in mHealth in the private sector. Private investment in mHealth has increased significantly in 2014 (Figure 11). On 11 September 2015, we identified 263 apps with more than 100,000 downloads. mHealth-related applications have proliferated, including many apps related to the management of NCDs. The prevailing view of investment reports and industry key opinion leaders (KOL) considered chronic disease management as the most promising area of mHealth development as well. Meanwhile, a few well-developed mHealth apps appear to integrate several sophisticated health strengthening functions (Box 3: case study).

Source: www.vcbeat.net
Mobile + Health
= Boosting China’s mHealth Bandwidth

INTERPRETATION OF KEY FINDINGS

In an environment that is increasingly ripe for exploiting mHealth opportunities, our review leads to several conclusions:

• First, while the relevant regulatory framework is evolving as mHealth activity grows, several important gaps requiring urgent reform exist.
• Second, mHealth activity is rapidly increasing in government, academic and commercial sectors, with a clear response to the changing burden of disease in China.
• Third, the application of mHealth to strengthening of existing health systems, which is largely the purview of government and academic programs, is currently limited.
• Fourth, more consideration is required around the potential for mHealth to address issues of equity.
• Finally, development and evaluation of mHealth innovations has been insufficient in scope and rigor to generate scalable solutions and provide reliable evidence of their value.

Regulatory environment

As mHealth is an emerging field in China, many related regulations are currently inadequate or lack clarity. Relevant areas include data privacy, security and confidentiality, service delivery regulation and healthcare price-setting. With likely increasing use of sensors, other diagnostic devices and sophisticated decision support for patient care, the regulatory framework around software as a medical device will demand greater attention. In the current environment, The National Health and Family Planning Commission (NHFPC) currently explicitly forbids diagnostic and treatment activities to be conducted in the virtual space, citing concerns on quality, safety and unregulated price-setting. A stronger regulatory environment around such issues is essential.

Response to changing disease burden

Unsurprisingly, mHealth innovations are responding to the changing burden of diseases in China, as indicated by almost 50% of the academic projects reviewed focusing on NCDs. However, most mHealth interventions focus on single diseases, potentially compounding the inefficiencies that arise from multiple vertical disease programs in the primary care environment. In fact, mHealth has the potential to establish primary care platforms that incorporate management products and services for multiple conditions; such opportunities currently remain unrealized.

Health system strengthening

Based on our review, China’s published academic projects and government initiatives in mHealth currently provide limited opportunities for health system strengthening. We identified innovations that primarily addressed only two of the 12 health system strengthening tools described in our framework (Figure 4). In addition, most innovations focused on supporting a single specific tool, while the potential for low-cost integrated mHealth tool to strengthen health systems is likely to be particularly important. For example, a village health worker with limited training could be supported by an integrated mobile system providing

• a health record to extract past encounters and record new information;
• an electronic decision support system that enables evidence-based practice such as a checklist for examination;
• a provider-to-provider communication platform that may allow real-time consultation or appropriate triage;
• a provider work planning and schedule system to allowing prioritizing of patients for preventive services and follow-up of chronic conditions;
• a quality management system where work performance and quality indicators can be tracked and acted upon;
• a supply chain management tool that monitors and responds to changes in resource utilization; and
• a mobile financial transaction system for circumstances where provider and consumer incentives may be utilized. Furthermore, health systems can be most effectively strengthened only when those mHealth tools actually improve the overall functions of those health system control knobs (e.g. governance, financing, payment, human resources, and health service delivery).
context, but not ‘rolled out’ due to a variety of technical, practical, economic and often institutional and political barriers. The relatively new term pilotitis has been coined to represent the dissatisfaction from donors and governments about isolated mHealth interventions that are successful in one health system. Indeed, the field of mHealth globally is plagued by ubiquitous small scale pilots, to the extent that the term pilotitis has provided such evidence. Research outcomes are largely limited to low quality, small scale and often excessively controlled experimentation, and scaled by the health system and is ultimately sustainable. Our review suggests that current mHealth research activity in China rarely provides such evidence. Research outcomes are largely limited to low quality, small scale and often excessively controlled experimentation, which provides little understanding of the likely true impact of an intervention with large-scale real-world implementation within complex health systems. Indeed, the field of mHealth globally is plagued by ubiquitous small scale pilots, to the extent that the term pilotitis has been coined to represent the dissatisfaction from donors and governments about isolated mHealth interventions that are successful in one context, but not ‘rolled out’ due to a variety of technical, practical, economic and often institutional and political barriers. The relatively new field of implementation science is currently limited in China, and expanding capacity and commitment to obtaining robust and appropriate evidence in relation to mHealth innovations will be crucial to realizing its potential. This will require multidisciplinary approaches to both the development and evaluation of mHealth interventions.

### Equity in healthcare access

Equitable access to quality services is an important dimension of effective health systems. In the private sector, mHealth applications clearly target the urban clientele, particularly exploiting the penetration of smartphones in these communities. From a public health perspective, the vast rural population in China warrants greater attention. While mHealth has great potential to expand access and increase quality of care to rural populations, unless this is strategically addressed, a widening of the digital divide may in fact increase inequitable healthcare access. Similar considerations are relevant to other disadvantaged subgroups of the population.

### Robust and appropriate evidence

Any healthcare innovation will not realize its potential unless it actually improves health outcomes, addresses an actual and perceived need, is acceptable to the target population of consumers, healthcare providers and/or healthcare administrators, is affordable, is likely to be adopted and scaled by the health system and is ultimately sustainable. Our review suggests that current mHealth research activity in China rarely provides such evidence. Research outcomes are largely limited to low quality, small scale and often excessively controlled experimentation, which provides little understanding of the likely true impact of an intervention with large-scale real-world implementation within complex health systems. Indeed, the field of mHealth globally is plagued by ubiquitous small scale pilots, to the extent that the term pilotitis has been coined to represent the dissatisfaction from donors and governments about isolated mHealth interventions that are successful in one context, but not ‘rolled out’ due to a variety of technical, practical, economic and often institutional and political barriers. The relatively new field of implementation science is currently limited in China, and expanding capacity and commitment to obtaining robust and appropriate evidence in relation to mHealth innovations will be crucial to realizing its potential. This will require multidisciplinary approaches to both the development and evaluation of mHealth interventions.
KEY RECOMMENDATIONS

The challenges in developing and implementing effective mHealth solutions in China are not unique. It is important to learn from global health experience, including from research and program implementation in both developed and developing economies. It is crucial to both avoid re-inventing the wheel, and learn from failure in other settings. In addition, we outline some key policy recommendations to enable China to start to realize some of the enormous potential that mHealth holds to strengthen the health system and improve health outcomes.

Strengthen the mHealth regulatory environment

• Establish and enforce key industry software standards.
• Clarify and strengthen regulations around data privacy, security and confidentiality.
• Establish a regulatory framework for software as a medical device to ensure quality and safety.

Promote a health systems perspective to mHealth innovation

• Incentivize the development and evaluation of mHealth innovations that take a broader whole of system approach through multidisciplinary partnerships.
• Promote and incentivize innovation through public-private partnerships.
• Create an enabling environment through accelerated health system reform. This includes implementing healthcare financing models that would facilitate mHealth supported services, especially for long-term preventive care, as well as a focus on restructuring and integration, with a particular emphasis on strengthening primary care.

Address equity gaps

• Incentivize a greater focus on developing low-cost mHealth innovations particularly focused on improving services for disadvantaged populations, including but not limited to rural populations.
• Ensure evaluation and monitoring of equity-related outcomes with scale up of mHealth innovations.

Generate appropriate evidence

• Increase research funding for appropriate development and large-scale rigorous real world evaluation of mHealth innovations focused on health system strengthening.
• Promote and develop capacity in implementation science.

CONCLUSIONS

The rapidly changing environment of healthcare needs and provision in China provides many challenges; mHealth has a potentially transformative role in addressing some of these challenges. This potential can only be realized with a strategic approach to developing and implementing mHealth innovations to strengthen health systems, backed by high quality evidence of the benefits and value of such approaches. CCmHI is committed to engaging in partnerships with government, academia and industry to generate new ideas and providing the evidence policy-makers need to make investments where the impact will be greatest. We look forward to being part of this exciting journey forward.
APPENDICES

Appendix 1: mHealth as Health System Tools - A summary account of academic projects

Client education and behavior change communication
Client education and behavioral change communication is by far the most used mHealth innovations among the studies we assessed. mHealth technology provides a minimally-invasive, low cost, reliable, fast and convenient way of communicating with patients and clients. We identified 13 randomized controlled studies with generally positive results in relation to directly or indirectly promoting health of the recipient. SMS was the most common mHealth implementation strategy, mainly used to:

- Prevent H1N1 in Shanghai, reduce suicides in Wuhan, promote best practice in infant feeding in Shanghai; control tobacco use in Shanghai.
- Remind recipients to adhere to treatment plans or medications such as those in pediatric cataract treatment in Guangzhou, allergic rhinitis in Beijing, weight control in Beijing, and attendance to a health promotion center in Hangzhou.

Information about content of SMS messaging was sparse. The unusual preponderance of positive results in the published literature does raise some suspicion of publication bias (i.e. lower probability of negative studies being published).

Sensors and point-of-care diagnosis
Modern smartphones provide impressive capacity to incorporate other technologies, including digital imaging and a range of sensors. This provides particular promise with respect to remote point-of-care diagnosis. We identified and evaluated three innovations in this category-use by ophthalmologists to facilitate real-time slit lamp-eye examination in Hangzhou, by orthopedists to measure the Cobb Angle for scoliosis in Nanjing, and by scientists to assist decoding platform for signal-enhanced mutation detection in Beijing. The tele-ophthalmology project using iPhones for real-time slit-lamp eye examination is noteworthy example of health system strengthening, representing a convenient, inexpensive and portable tool to increase access to specialist services.

Registries, data collection and vital event tracking
Prompt and accurate health system response hinges on reliable and timely data collection and reporting. After the SARS outbreak, China has implemented many primary care and public health reporting systems such as the Residents Health File and various chronic disease management and follow-up systems. The recording and reporting burden on grassroots health workers are onerous. We examined and identified five mHealth innovations that can potentially provide agile, clean, standardized, and shareable data for critical decision making. These include: The Chinese Center for Disease Control and Prevention used a mobile phone-based system for infectious disease surveillance in the aftermath of earthquake in Wenchuan; using the GPS and data capability of mobile phones, Chang Zhou Center for Disease Control and Prevention constructed a platform that automatically sends SMS alerts to fishermen into marshlands of different schistosomiasis endemic levels and collect real time schistosoma japonicum monitoring information; researchers from Tsinghua University experimented a miniaturized total health examination system launched on a mobile phone platform for quick physical examination and reporting; Applications of mHealth have also been found in remotely measuring micturition, recording beverage consumption, and data collecting of infant feeding practices in rural China.

Provider training and education
Shortage and variable quality of health human resources is a substantial challenge for China, particularly in rural areas. Most rural healthcare workers receive limited initial and continuing medical training. We identified only one mHealth innovation in provider education: in a cluster randomized study conducted by Lanzhou University, comparing continuous text messaging based-learning with a traditional one-day training workshop, the SMS-based intervention was more effective and cost-effective in increasing both knowledge and actual practice among the healthcare workers. A more recent study conducted by The George Institute, China and published subsequent to our review showed simple mobile phone delivered decision support improved prescription of appropriate blood pressure lowering treatment by village doctors and blood pressure levels among people with high cardiovascular disease risk in a rural community.35

Electronic health records
In 2009 China launched its Residents Health Record initiative nationwide. The program however has been plagued by many challenges relating to the highly fragmented health system, inadequate digitization technology and insufficient human resources for record maintenance. The advent of mHealth has redefined the landscape of health information management systems in other LMICs, allowing field workers to access and contribute to longitudinal health records utilizing mobile devices. We only identified one study that piloted an integrated community health information system in Beijing, which is tangential to the role of role of mHealth in strengthening health records.
## Appendix 2: National Science Fund supported mHealth Projects

<table>
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<th>Title</th>
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<th>Granted Institution</th>
<th>Principal Investigator</th>
<th>Amount of Grant (10,000 RMB)</th>
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<td>A study to evaluate the reliability of mHealth service data based on the body network</td>
<td>61170212</td>
<td>Tsinghua University</td>
<td>Bin Xu</td>
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<td>Real-time monitoring of body sensor network based equestrian therapy and its evaluation method</td>
<td>61473058</td>
<td>Dalian Institute of Technology</td>
<td>Zhelong Wang</td>
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<td>A feasibility and effectiveness study to enhance HIV/AIDS patients self-management using mHealth tools</td>
<td>71573290</td>
<td>Sun Yat-sen University</td>
<td>Yan Guo</td>
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<td>mHealth user adoption model based on perceived value and trust</td>
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<td>Huazhong University of Science and Technology</td>
<td>Chaohua Deng</td>
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<td>Coronary heart disease patients behavior model and developing management plan using mHealth tools</td>
<td>71573181</td>
<td>Capital Medical University</td>
<td>Ying Wu</td>
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<td>Interventional study on unintentional injuries among pre-school children using mHealth solution</td>
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<td>Central South University</td>
<td>Guoqing Hu</td>
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<td>Using big data for individual mHealth management</td>
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<td>Peking University</td>
<td>Jianbo Lei</td>
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<td>An evidence study for breast cancer patients self-management using mHealth tools</td>
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<td>The Second Military Medical University</td>
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<td>Development and evaluation of mobile application based anticoagulation management model</td>
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<td>Guizhou People’s Hospital</td>
<td>Yetao Li</td>
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<td>Precise response method for mobile based medical imaging</td>
<td>81560296</td>
<td>KunMing Institute of Technology</td>
<td>Lijun Liu</td>
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REFERENCES


