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## mHealth as a health system strengthening tool in China

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### ABSTRACT

Over the past 70 years, there was a rapid epidemiological transition in disease burden in China, from infectious disease to non-communicable diseases (NCDs), which requires long-term prevention and management. Rapid growth in mobile phone use, internet connectivity and digital health technology, presents new opportunities for improvement in NCD healthcare delivery and population-based outcomes. Although there were a growing number of research to evaluate the feasibility and effectiveness of the mobile health (mHealth) interventions for NCD management, the extent to which mHealth contributes towards the health system strengthening in China remains unknown. In this paper, we provided a high-level overview of mHealth in China and its role for Chinese health system strengthening. We conclude with several recommendations for the future of mHealth research in China based on existing evidence identified.

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### What is known?

- Non-communicable diseases account for China's largest burden of disease.
- mHealth serves as a promising tool to improve the healthcare delivery for non-communicable diseases.

### What is new?

- A multidisciplinary team, comprising of researchers in the field of behaviour science, health system, health policy, public health, engineering, etc., is required to work together to develop and evaluate the mHealth interventions in real-world health systems.
- Three recommendations are provided for future mHealth research in China through a health system lens.

The disease burden in China has evolved over the past few

decades. China is now confronted with a rising tide of non-communicable diseases (NCDs) in the face of persisting gaps in the delivery of effective care for maternal and child health, and a range of communicable diseases. With the rapid development of mobile communications and network technologies, there is a large potential for mobile health (mHealth) to improve the healthcare delivery for NCDs and the health system capacities. In this paper, we provided a high-level overview of the disease burden and health system in China, and the potential use of mHealth to address the existing health system challenges. We also summarised the findings of a recent completed systematic review on mHealth interventions in China, and finally provided recommendations for future mHealth research through a health system lens.

### 1. Burden of disease in China

In the past few decades, under the circumstances of rapid economic growth, urbanisation, industrialisation and ageing, China has experienced dramatic epidemiological transition from infectious diseases to NCDs. In 2017, the top three causes of disability-adjusted life years were stroke, ischemic heart disease and low back and chronic obstructive pulmonary disease [1]. NCDs caused over 80% of China's total disability-adjusted life years (DALYs) lost and accounted for China's largest burden of disease [2]. Cardiovascular

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disease (CVD), the leading cause of mortality and morbidity, accounted for more than 40% of total deaths in 2018 in China [3]. Hypertension is one of the most important risk factors for CVD. Its prevalence in the population aged over 18 years old in China increased from 18.1% in 2004 to 22.8% in 2010 [4]. It was estimated that 25.2% of the Chinese adults were hypertensive in 2015 [5]. Similarly, the prevalence of diabetes increased two-fold from 5.5% to 11.6% in the ten years from 2001 to 2011 [6–8].

## 2. Health system in China

The health system in China is comprised of three independent but interrelated systems: health financing system, health service delivery system, and health governing system. China has experienced four major rounds of health reforms since mid-1980 [9]. The last round of reform starting from 2009 achieved remarkable results in accomplishing nearly universal insurance coverage, however, many system level challenges remain [9]. First, in governance, health reform is plagued by highly-fragmented responsibilities and lack of coordination between many relevant government agencies. Second, in financing, China's health payment system is dominated by fee-for-service that can create perverse incentives for inappropriate healthcare delivery. Third, the health workforce suffers from problems relating to quantity, quality, and distribution. There is a severe maldistribution of workforce between urban and rural areas. Fourth, in medical products and technology, China's hospitals and providers depend on drug prescription for revenue, which has contributed to severe over-prescription of drugs and inadequate stewardship of antibiotics. Fifth, from an information perspective, China's health information system lacks uniformity and transparency. Lastly, despite a clear hierarchy health governing system, health service delivery is fragmented and distorted with resources and services over-concentrated in tertiary centres, with rudimentary and inadequate primary care. Challenges in the health system structural components interact with each other to increase waste, inefficiency and poor quality of care.

## 3. mHealth

From the 1990s, with the rapid development in information technology and telecommunication, medicine has been benefited immensely. A new term “electronic health (eHealth)” emerged. There are several definitions of eHealth, but the most common used is defined by Eysenbach in 2001: “eHealth is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment of networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology” [10]. During the last decade, increased availability and affordability of the mobile devices, and unprecedented development of mobile technologies and communication systems, have accelerated the deployment of such systems and services into the health sector. This also marked the evolution of eHealth systems from traditional desktop platforms to wireless and mobile configurations. The term mobile health (mHealth), one aspect of the eHealth, was coined by Robert Istepanian in 2005 to denote the use of “emerging mobile communications and network technologies for healthcare” [11]. However, mHealth has been variably defined. The Global Observatory for eHealth at the WHO defined the mHealth as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring device, personal digital assistants (PDAs), and other wireless devices”

based on the findings of the second global survey on eHealth [12]. mHealth often encompasses the functionalities of mobile devices in standard voice, short message service (SMS), multimedia messaging services (MMS), web browsing, and increasingly applications (apps) on Android, iOS, Windows and BlackBerry that may be powered by various sensors.

In an academic context, most systematic reviews have focused on the effectiveness of the stand-alone mHealth interventions [13–16]. There is little evidence to show the extent to which mHealth interventions play a role in strengthening the health system. Labrique et al. proposed an mHealth-health system framework that delineates 12 common tools that mHealth applications can support, in relation to the WHO building blocks of health systems (service delivery, health workforce, health information systems, access to essential medicines, financing, and leadership or governance) [17,18]. Table 1 lists the common mHealth applications, the corresponding descriptions, and examples of mobile phone functions [17].

Peiris et al. adapted this system-oriented approach to examine the role of mHealth in improving health care quality for NCDs in Low- and Middle-income countries (LMICs) [19]. The review found few high-quality studies. Most studies were restricted to patient behaviour change using SMS [19]. In the health system context, there was lack of evidence to guide decisions on policy and practice for NCD reduction in LMICs [19]. The full potential for mHealth will not be realized if mHealth interventions fail to be integrated into existing health system functions [20].

## 4. Potential of mHealth in China

The proliferation of mHealth applications has been fuelled by the unprecedented uptake of mobile phones with ever growing telecommunication infrastructure, and the potential of mobile technology to bring healthcare to hard-to-reach populations, bridging information gaps between providers and consumers, and improving the efficiency of care delivery. Globally, in 2016, seven billion people representing 95% of the world population lived in areas covered by a mobile-cellular network [21]. Mobile-broadband networks (3G or above) reach 84% of the global population [21]. In LMICs, the number of mobile-broadband subscriptions continues to grow at double digit rates [21]. In China, the penetration of mobile phone reached 112.2 phones per 100 people in 2018 [22]. The overall penetration of the mobile phones in 31 provincial-level administrative regions of China in 2018 was high. The largest penetration of the mobile phones (184.7 phones per 100 people) is in Beijing, while Jiangxi province located in the south-eastern part of the country has the smallest number (87.5 phones per 100 people) [22]. There has been a dramatic increase in the penetration of mobile-broadband 4G network from 2015. The total number of mobile-broadband 4G network users reached 1.17 billion in 2018 [22].

As indicated previously, the Chinese health system faces substantial ongoing challenges. The many unique features of mHealth provide enormous opportunities to overcome some of these challenges, and facilitate health service delivery model from institutional care to long-term community-based care in responding the rapidly evolving disease burden.

## 5. mHealth systematic review

We therefore conducted a systematic review to characterize current mHealth interventions in China, and identify gaps in mHealth intervention development. The results of the review can be found elsewhere [23]. In brief, the majority of the studies were conducted in an urban setting with only 6 out of 49 were focused

**Table 1**  
Twelve common mHealth applications, descriptions, and examples of mobile phone functions [17].

Common mHealth applications	Descriptions	Examples of mobile phone functions
1 Client education and behaviour change and communication	Consumer-focused strategy to improve people's knowledge and attitudes, and behaviour.	<ul style="list-style-type: none"> <li>• SMS</li> <li>• MMS</li> <li>• IVR</li> <li>• Audio and/or video</li> </ul>
2 Sensors and point-of-care diagnosis	Link mobile phones to an external device for remote monitoring of the consumer.	<ul style="list-style-type: none"> <li>• Camera</li> <li>• External sensors</li> <li>• Accelerometer</li> </ul>
3 Registries and vital events tracking	Facilitate the identification and enumeration for specific services.	<ul style="list-style-type: none"> <li>• SMS</li> <li>• Voice</li> </ul>
4 Data collection and reporting	Move from paper-based systems to near-instantaneous reporting.	<ul style="list-style-type: none"> <li>• Digital form</li> <li>• Digital form</li> <li>• SMS</li> </ul>
5 Electronic health record	Register, access and update the patient records at the point-of-care.	<ul style="list-style-type: none"> <li>• Voice</li> <li>• Digital form</li> </ul>
6 Electronic decision support	Ensure the providers' adherence to defined guideline by incorporating point-of-care decision support tools with automated algorithm instruction.	<ul style="list-style-type: none"> <li>• Mobile web</li> <li>• "apps"</li> </ul>
7 Provider-to-provider communication	Coordinate care and provide expert assistance to health staff, when and where it is needed.	<ul style="list-style-type: none"> <li>• IVR</li> <li>• SMS</li> <li>• MMS</li> </ul>
8 Provider work planning and scheduling	Remind health care workers of upcoming or due/overdue services.	<ul style="list-style-type: none"> <li>• Camera</li> <li>• SMS</li> </ul>
9 Provider training and education	Provide continued training support to frontline and remote providers.	<ul style="list-style-type: none"> <li>• Mobile calendar</li> <li>• SMS</li> <li>• MMS</li> <li>• IVR</li> </ul>
10 Human resource management	Allow supervisors to track and monitor the performance of the community health workers.	<ul style="list-style-type: none"> <li>• Audio and/or video</li> <li>• Mobile web</li> <li>• GPS</li> <li>• SMS</li> </ul>
11 Supply chain management	Track and manage stocks and supplies of essential commodities.	<ul style="list-style-type: none"> <li>• Voice</li> <li>• Mobile web</li> <li>• GPS</li> <li>• Digital form</li> <li>• SMS</li> </ul>
12 Financial transactions and incentives	Pay for health care service, supplies, or drugs via mobile money transfer or banking services.	<ul style="list-style-type: none"> <li>• Mobile money transfer and banking services</li> </ul>

Note: SMS: Short Message Service; MMS: Multimedia Messaging Service; IVR: Interactive Voice Response; app: Applications; GPS: Global Positioning System.

on a rural population. The most common disease focus was non-communicable diseases. There were only less than half of the studies utilised a randomised controlled trial design. Risk of bias for randomised controlled trials was mostly classified as either low or unclear. We applied a health system framework, and found the most use of mHealth application was in client education and behavioural change communication, for example, improving patients' medication adherence. From the health system perspective, most studies targeted service delivery, for example, using SMS for lifestyle modification, with no studies found to improve health financing systems.

## 6. Incomplete regulations

As mHealth is an emerging field in China, many related regulations are inadequate or lack clarity. This includes regulation related to data security and confidentiality, workforce regulation, payment schemes, and service delivery regulation. With potential increasing use of sensors, mobile applications, clinical decision support system and diagnostic tools, the regulatory framework around software as medical device needs to be improved. The Chinese government has launched several policies and regulations relating to mHealth. Notably, National Health Commission has launched the National Standard of Telemedicine Information System in 2016. It is the first time that the national government has specified the scope, functions and system requirement of telemedicine. However, the standard remains vague, with no specific

and measurable indicators to regulate the development, implementation and maintenance of the technology.

## 7. An integrated health system solution

Most current mHealth interventions are limited to standalone, single-focus tools. Ideal integrated mHealth interventions would interact with key health system structural components, including governance and leadership, finance and payment, workforce, medical technology, information, and service delivery (Fig. 1). For example, an integrated mHealth intervention provided to a village doctor in the primary care setting could:

- At the governance and leadership level, monitor village doctor's performance and track the quality indicators;
- At the finance and payment level, provide service fees and incentives to the village doctor, possibly benchmarked to performance;
- At the workforce level, deliver standardised village doctor training, as well as coordinate and allocate available workforce;
- At the medical technology level, offer electronic decision support system to facilitate evidence-based practice;
- At the information level, record, update, and share patients' medical information governed by relevant regulations;
- At the service delivery level, refer patients to higher level healthcare institutions when necessary.

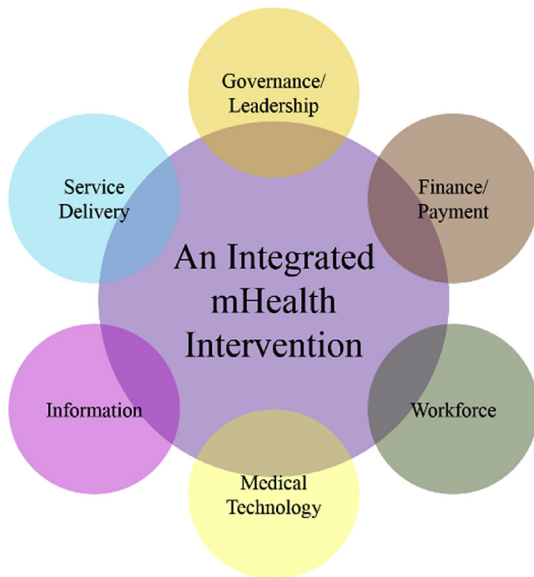


Fig. 1. An integrated mHealth intervention.

Of course, mHealth can only be a facilitator to addressing some of the barriers to the delivery of equitable, affordable effective and safe healthcare, but conceptualising this within a broad health systems framework is crucial to realising any such potential.

## 8. Lack of robust evidence

The fundamental indicators of a successful mHealth intervention are improvement of health outcomes, in a manner that is acceptable and affordable to end users, as well as scalable and sustainable from a payer perspective. However, in the current academic context, attempts to produce such evidence are rare. Even if there is pilot evidence, the research outcomes are small scale and of poor quality. There is also little understanding of the impact of the mHealth intervention in large-scale real-world implementation within complex health systems. Implementation science is a new area in China. It is not sufficient to understand if the mHealth intervention is effective. It is also crucial to understand why it works, how it works, for whom does it work, and in which context. This requires a multidisciplinary team, comprising of researchers in the field of behaviour science, health system, health policy, public health, engineering, etc., to work together to develop and evaluate the mHealth interventions in real-world health systems.

## 9. Recommendations

To summaries, a few recommendations are outlined to support academia, the public sector and industry to maximise the potential for mHealth innovations to strengthen health systems, which could ultimately improve the health outcomes of hundreds of millions of people in China, and billions around the world. 1) All sectors should focus on developing mHealth interventions as system strengthening tools that can be effective within complex environments; this will require interdisciplinary and cross-sectoral partnerships. 2) Academics should rigorously evaluate such innovations using robust implementation science methodologies. 3) Governments and the public sector should strengthen the mHealth regulatory environment, by establishing and enforcing standards for software as medical device, data privacy, security and confidentiality, multi-site physician practice, and health system integration.

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## CRedit authorship contribution statement

**Maoyi Tian:** Conceptualization, Funding acquisition, Writing - original draft; **Xinyi Zhang:** Writing - review & editing; **Jing Zhang:** Writing - review & editing.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijnss.2020.07.001>.

## References

- [1] Institute for Health Metrics and Evaluation. Global burden of disease profile: China. <http://www.healthdata.org/china>. [Accessed 30 May 2017].
- [2] World Health Organization. NCD China profile. [http://www.who.int/nmh/countries/chn\\_en.pdf](http://www.who.int/nmh/countries/chn_en.pdf). [Accessed 30 May 2017].
- [3] Commission NH. China health statistical yearbook 2019. Beijing: Peking Union Medical College Press; 2019.
- [4] China Center for Disease Control and Prevention. NCD surveillance data system. <http://123.57.244.45:8898/chartdata1/>. [Accessed 30 May 2017].
- [5] National Health and Family Planning Commission. China health and family planning statistical yearbook 2015. Beijing: Peking Union Medical College Press; 2015.
- [6] Chan JC, Malik V, Jia W, Kadowaki T, Yajnik CS, Yoon K-H, et al. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. *JAMA* 2009;301(20):2129–40.
- [7] Gu D, Reynolds K, Duan X, Xin X, Chen J, Wu X, et al. Prevalence of diabetes and impaired fasting glucose in the Chinese adult population: international collaborative study of cardiovascular disease in asia (InterASIA). *Diabetologia* 2003;46(9):1190–8.
- [8] Xu Y, Wang L, He J, Bi Y, Li M, Wang T, et al. Prevalence and control of diabetes in Chinese adults. *JAMA* 2013;310(9):948–59.
- [9] Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *Lancet* 2012;379(9818):833–42.
- [10] Eysenbach G. What is e-health? *J Med Internet Res* 2001;3(2). e20.
- [11] Istepanian R, Laxminarayan S, Pattichis CS. M-health. Springer; 2006.
- [12] Kay M, Santos J, Takane M. mHealth: new horizons for health through mobile technologies. *World Health Organization* 2011;3:66–71.
- [13] Beratarrechea A, Moyano D, Irazola V, Rubinstein A. mHealth interventions to counter noncommunicable diseases in developing countries: still an uncertain promise. *Cardiol Clin* 2017;35(1):13–30.
- [14] Free C, Phillips G, Felix L, Galli L, Patel V, Edwards P. The effectiveness of M-health technologies for improving health and health services: a systematic review protocol. *BMC Res Notes* 2010;3(1):250.
- [15] Free C, Phillips G, Galli L, Watson L, Lambert F, Edwards P, et al. The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. *PLoS Med* 2013;10(1). e1001362.
- [16] Free C, Phillips G, Watson L, Galli L, Felix L, Edwards P, et al. The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis. *PLoS Med* 2013;10(1). e1001363.
- [17] Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. *Glob Health: Science and Practice* 2013;1(2):160–71.
- [18] World Health Organization. Monitoring the building blocks of health systems. 2010.
- [19] Peiris D, Praveen D, Johnson C, Mogulluru K. Use of mHealth systems and tools for non-communicable diseases in low-and middle-income countries: a systematic review. *Journal of cardiovascular translational research* 2014;7(8):677–91.
- [20] Michael P, Batavia H, Kaonga N, Searle S, Kwan A, Goldberger A, et al. Barriers and gaps affecting mHealth in low and middle income countries: policy white paper. Earth Institute: Columbia university; 2010. Center for global health and economic development (CGHED): with mHealth alliance.
- [21] International Telecommunication Union. ICT facts and figures 2016. Geneva: International Telecommunication Union; 2016.
- [22] Ministry of industry and information technology of the people's Republic of China. 2018 Communication Industry Statistical Bulletin; 2018.
- [23] Tian M, Zhang J, Luo R, Chen S, Petrovic D, Redfern J, et al. mHealth interventions for health system strengthening in China: a systematic review. *JMIR Mhealth Uhealth* 2017;5(3):e32.