A Multi-level Technical Infrastructure for Diabetes Chronic Care Management in China

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Abstract

This paper specifies the World Health Organization’s Innovative Care for Chronic Conditions Framework (ICCC) to diabetes prevention and management activities in China via extensive literature review and verification using qualitative data analysis of both primary and secondary data. We utilize the specified ICCC to propose an integrative and interconnected technical architecture that addresses some of the gaps and needs found at the macro, meso, and micro levels. The proposed technical infrastructure creates an integrative framework, where the technical architecture has strategic alignment with all layers of the ICCC. This will help policy makers and technologists facilitate developing a comprehensive infrastructure to address management of chronic conditions in China, as well as providing a catalyst for new initiatives.

1. Introduction

Chronic conditions account for 50% of the global disease burden, and the number continues increasing rapidly [1]. Chronic conditions not only negatively impact people’s health, but also exponentially increase societal health care costs. It is imperative for every country to develop a comprehensive chronic care system to better envision how to prevent and control chronic conditions within its specific socio-political infrastructure.

In the 1990s, Wagner and his colleagues developed an integrated Chronic Care Model (CCM) based on the context of the American healthcare system to provide theory-based organizational and behavioral guidelines to improve chronic illness care (see Figure 1). The CCM includes four important components within the context of the community and health care system: (1) self-management support, (2) delivery system design, (3) decision support, and (4) clinical information systems, to maximize the impact of community and health systems on chronic care. In addition, the CCM also addresses an important concept of patient-provider interaction in chronic care that emphasizes the relationship between informed/active patients and prepared/proactive practice team [2]. This model has been used to design health interventions and programs [3,4], to promote quality improvement [5,6], and to change the practice and organization of care for chronic conditions [7].

In response to the rapid growth of chronic conditions and the urgent need to transform healthcare systems in developing countries, the World Health Organization (WHO) collaborated with health leaders from Africa, Asia, Eastern Europe, and Latin America to examine the relevance and applicability of CCM a national-level perspective. They concluded that the CCM could be used as a basic framework for health policy development and health system redesign. However, it is not a stand-alone, sufficient framework to reflect the context of international chronic care. Therefore, CCM was expanded through the efforts of the group. WHO published an official report presenting the Innovative Care for Chronic Conditions Framework (ICCC) in 2002. The framework, shown in Figure 2, includes three levels of stakeholder structures involved with chronic care: (1) macro (policy), (2) meso (community and health care organization), and (3) micro (patient/family, community partners, and health care team). The ICCC emphasizes different aspects of chronic care than the CCM model. At micro-level, in addition to the interaction between patient and health care teams, the role of community partners is included. At meso-level, the ICCC enhances the importance of “organized and well equipped” health care teams rather than a “decision support” system. Decision support tools are necessary but not sufficient in many developing countries. The ICCC puts strong emphasis on continuity and coordination of health services, which does not address the coordination between primary, secondary, and tertiary health care services that is still problematic in most developing countries. The function of community in prevention and management of chronic conditions was greater detailed and emphasized. In addition, the importance of policy component is overlooked in CCM. ICCC emphasizes that the positive policy environment could effectively reduce the burden of chronic conditions via supporting care.

The underlying premise of the framework is that better outcomes for chronic conditions will occur when policy is aligned with underlying structures, and when the partnership
among patients and families, health care teams, and community partners is well established. The ICCC can be used to identify the strengths, deficiencies and interconnectivity of existing chronic care structures within community, health care organization, and policy. The ICCC specification can, consequently, provide further recommendations for improvement and design of health care systems.

As one of the most prevalent chronic conditions, diabetes is a primary cause of premature death and adult disability worldwide; the death rates are predicted to rise by 25% over the next decade [8]. It is projected that the total number of people with diabetes in the world will grow from 171 million in 2000 to 366 million in 2030 [9]. Moreover, WHO projects that there will be a 170% growth (including 80% of all new cases) in the number of people with diabetes in developing countries by 2025[1]. China poses a major concern. The number of diabetic patients in developing China is estimated to be 42.3 million in 2030, up from 20.8 million in 2000, which places a huge potential impact on the future global burden of diabetes, the health care system in China, and individuals affected [9, 10].

The purpose of this paper is to first specify the generic ICCC policy and behavioral framework (macro, meso, and micro levels) to diabetes management and prevention activities in China. Our policy and behavioral model drives the development of our proposed technical infrastructure, creating an integrated framework where the technical architecture has strategic alignment with all layers of the ICCC. The technical infrastructure is likely to meet the needs of patients with chronic conditions because these needs were articulated by identifying existing gaps and recognizing current strengths.

The proposed infrastructure works well for all medical conditions and is particular well suited for patients with chronic conditions because of its ability to collect data over time to enable trending and charting the long term process of the chronic condition. The information collected in our application is focused towards diabetic patients because the data is blood sugar level, diet, and weight.

Our model can serve practitioners and researchers. Figure 1. The Chronic Care Model (CCM) (Wagner, 1998)

At the micro level, the innovative use of technology has the potential to improve the overall outcomes for patients with diabetes and other chronic conditions by educating the patients, connecting them with care providers, and networking with other patients with similar chronic conditions. At the meso-level, data collected by patients and shared with health care institutions can provide a greater stream of quality data to improve situations of previously unattainable, imperfect, or sporadic data collection. Data results from studies among hospitals or public institutions can facilitate the direction of macro-level policies and efforts. To maximize the benefit of any technology-based solution, alignment must exist at the macro, meso, and micro levels of the chronic care framework. The macro level policies must promote development of meso layer infrastructure that will provide services to the end-user patients who may use various technologies in self-management. Aligning policy strategy with emerging technology and health care services will create scalable infrastructure supporting management of diabetes to educate and assist patients and care providers.

The first step toward holistic technology-based chronic care applications is to understand the current status of macro, meso, and micro-layer efforts. For example, what infrastructure and services are available to provide connectivity? What devices at the micro level are available to patients and at what cost? Finally, what policies exist that will promote the creation of the physical and service infrastructure to fully realize the benefits of technology-based health care applications?
interested in health care projects and policy. Specifically, the
specified behavioral/policy model can serve to inform
information systems (IS) researchers and practitioners, who
are interested in using technology to analyze and improve
chronic care management (in this case, for China). As with
policy initiatives, IS application may focus on one or multiple
levels. To the best of our knowledge, we are the first to use the
ICCC as a foundation for technical specification in any form.
Thus, our second goal is to propose a technical architecture
that can address gaps at the ICCC macro, meso, and micro
levels, recognizing the potential of integrated systems. An
integrative technical framework will help facilitate a
comprehensive understanding for planning, design, and
tracing the rippling effects of new technological initiatives.

2. Methodology

The ICCC is a generalized framework [11]. The application
of the ICCC to specific countries is still in its early stages, but
shows great promise. For example, Morocco, Russia, and
Rwanda have successfully used the ICCC framework as the
conceptual basis for chronic conditions analysis [12]. In
addition to facilitating internal strategizing and planning for
an individual country, a collective specification of the ICCC
for countries throughout the world will make possible a
global view and comparative analysis of chronic disease
management.

We use the ICCC framework to 1) organize literature and
other secondary data 2) to capture the current state of diabetes
care in China 3) highlight strengths, weaknesses, opportunities, and threats and 4) present results. We also use
the resulting specified ICCC model as a foundation to inspire
the design of an integrative technological system that can
provide potential improvements affecting multiple layers. We
provide our method as an example of how to do such analyses.
To specify the ICCC model for China, multiple methods were
used.

2.1 Literature Review

Article selection was based on the following overall
criteria: (1) the article was related to diabetes control and
prevention in China and (2) the article discussed one of the
specific levels of the diabetes framework - macro-, meso-, and/or micro-level. English-language articles were
identified from the following databases: (1) PubMed, (2)
Cochrane Database of Systematic Reviews, and (3) ProQuest Health Management. Chinese-language articles
were identified from VIP Information (http://www.cqvip.com/), which is one of the largest online
databases in China. It covers not only the field of Medicine
and Health but also Social Science, Natural Science, Economic Management, etc.

The initial search of English-language articles identified a
total of 548 citations published between August 1989 and
June 2008. The initial search of Chinese-language articles
identified a total of 335 citations published between August
1989 and June 2008. After deleting duplicates and scanning
titles of the citations and abstracts, a total of 48 articles were
deemed appropriate for the study at hand.

2.2 Web Search

The World Wide Web (WWW) has become more
important and popular within China. According to the
statistics, there was a total of 2.5 hundred million Internet
users in July 2008, and about 69.2% percent of them used
search engines to find their information and target web sites
on the WWW. In addition, 25.4% of Chinese Internet users
visited government websites in 2007 [13]. To augment our
academic literature review with detailed information about
policy, programs, activities, and grass roots effort of diabetes
prevention and control in China, we searched publicly
available information and governmental document websites.
We performed a search of diabetes-related information using
keywords (in Chinese), including “Diabetes,” “Chronic
Diseases,” “Policy,” and “Prevention and Control.” The
most substantial information related to the current study was
found from the following governmental websites: (1) Ministry of Health of the People’s Republic of China
(http://www.moh.gov.cn/2.htm), (2) Chinese Center for
Disease Control and Prevention (http://www.chinacdc.net.cn/n272562/), (3) National Center
for Chronic and Non-communicable Disease Control and
Prevention (http://www.chinancc.com.cn/law/index.asp),
and (4) local Boulevard Block Office.

2.3 Verification: Interviews and Secondary Data

In order to validate data with perspectives from those
involved in the ICCC process and current practice of diabetes
care system in China, we conducted interviews with hospital
and clinic personnel (hospital admin, physicians, nurses,
diabetes educators) in China’s capital, Beijing (both its city
and its outlying rural areas), using the Assessment of Chronic
Illness Care (ACIC) survey [14]. We also used this same
protocol in interviewing five public health academics in
China. To further verification at the micro level, we were able
to review patient focus group transcripts from a study
exploring the potential use of mobile technology to assist
Chinese diabetics with self-management. The focus group
protocol included several questions about sources of diabetes
information, interaction with health care professionals, and
the role of the patient’s family and social network.
3. Results

3.1 Macro-Level

The macro- or policy level of the ICCC has important influences on determining the success or failure of a chronic care system. Policy sets the tone of priority, concern and attention, and also provides enablers or constraints. Table 1 summarizes our findings from literature regarding positive policy efforts at the macro-level.

Table 1: Macro-Level Environment in China

<table>
<thead>
<tr>
<th>Macro-Level Positive Programs and Activities</th>
<th>Health Care Organization Environment in China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provide leadership and advocacy</strong></td>
<td><strong>Meso-Level Existing Programs and Activities</strong></td>
</tr>
<tr>
<td>* National Plan of Prevention and Control of Diet-Related Non-Communicable Diseases</td>
<td>* Comprehensive community management of diabetes</td>
</tr>
<tr>
<td>* Country-Wide Diabetes Intervention</td>
<td>* Network of chronic conditions control based on diabetes and hypertension</td>
</tr>
<tr>
<td>* Health Education Intervention on Patients with Diabetes</td>
<td>* Group management for diabetic patients in hospital and community</td>
</tr>
<tr>
<td>* National Project for Diabetes Management</td>
<td></td>
</tr>
<tr>
<td>* Self-Management Program in Chronic Disease in Beijing</td>
<td></td>
</tr>
<tr>
<td>* United Nations World Diabetes Day-China Action in Beijing</td>
<td></td>
</tr>
<tr>
<td>* The Incentive Project of Dissemination of Health Knowledge (Diabetes) in China</td>
<td></td>
</tr>
<tr>
<td>* Dietary Guidelines for Chinese Residents and the Chinese Pagoda</td>
<td></td>
</tr>
<tr>
<td>* National Plan of Action for Nutrition</td>
<td></td>
</tr>
<tr>
<td><strong>Integrate Policies</strong></td>
<td><strong>Promote continuity and coordination</strong></td>
</tr>
<tr>
<td>* Guideline for Diagnosis and Treatment in Non-Communicable Disease</td>
<td>* Comprehensive community management of diabetes</td>
</tr>
<tr>
<td>* Guideline for Chinese Diabetes Prevention</td>
<td>* Network of chronic conditions control based on diabetes and hypertension</td>
</tr>
<tr>
<td><strong>Promote Consistent Financing</strong></td>
<td>* Group management for diabetic patients in hospital and community</td>
</tr>
<tr>
<td>* Increasing Health Insurance Coverage in Urban (Basic Medical Insurance, BMI) and Rural Areas (New Cooperative Medical Scheme, NCMS)</td>
<td></td>
</tr>
<tr>
<td>* Governmental Grant for Diabetes Research</td>
<td></td>
</tr>
<tr>
<td><strong>Develop and Allocate Human Resources</strong></td>
<td><strong>Encourage quality care through leadership and incentives</strong></td>
</tr>
<tr>
<td>* Workshop of Diabetes Prevention for Health Professionals</td>
<td>Nonexistent</td>
</tr>
<tr>
<td><strong>Supportive Legislative Frameworks</strong></td>
<td><strong>Organize and equip health care teams</strong></td>
</tr>
<tr>
<td>* Bans on Smoking in Schools and Public Place, Tobacco Advertisement via the Mass Media, Sale of Cigarettes to Adolescents.</td>
<td>* Hospitals provide medical education lectures for doctors periodically</td>
</tr>
<tr>
<td>* Physical Activities Promotion</td>
<td>* Most doctors gain special skills and knowledge via self-pursued continuing education</td>
</tr>
<tr>
<td><strong>Strengthen Partnerships</strong></td>
<td>* Bayer Diabetes Houses provides comprehensive diabetes care and the training of community physicians</td>
</tr>
<tr>
<td>* International Meeting on Nutrition and Agriculture</td>
<td></td>
</tr>
<tr>
<td>* Beijing HOPE Project : China Diabetes Education Program, Beijing Diabetes Care and Education to Community Program, and Expanding Improving Diabetes Education and Care in China Program</td>
<td></td>
</tr>
</tbody>
</table>

**Deficiencies**

1. Not many national policies, plans, and legislation for diabetes prevention and control
2. No financing incentives for health care professionals and providers to implement diabetes care
3. Insufficient training and continuing education of diabetes care for health professionals
4. Weak links between governmental health and non-health sectors, and community groups.

3.2 Meso-Level

3.2.1. Health Care Organization. The hospital system has played a significant role in delivering health care services in China. Given the different administrative levels in China, hospitals are mainly organized as Provincial level, Municipal level, County level, and District level [15]. In urban areas, health services are delivered from a three-tier network composed of street clinics, district hospitals, and municipal (city) hospitals. With the introduction of the Chinese Urban Health Reform System, community health service centers (CHSC) have also played an important role in delivering several key functions in disease prevention and control, health education, family planning, medical treatment service, and community rehabilitation in urban areas [16]. In rural areas, village clinics, township health centers, and county hospitals are responsible for delivering health services [17]. Table 2 summarizes our findings from literature regarding positive policy efforts at the meso-level.

Table 2: Health Care Organization Environment in China

<table>
<thead>
<tr>
<th>Meso-Level Existing Programs and Activities</th>
<th>Deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Promote continuity and coordination</strong></td>
<td><strong>Deficiencies</strong></td>
</tr>
<tr>
<td>* Comprehensive community management of diabetes</td>
<td>1. Diabetes care and services are not well coordinated across different levels (i.e. first-, second-, and third-tier) hospitals and between health care providers and community groups</td>
</tr>
<tr>
<td>* Network of chronic conditions control based on diabetes and hypertension</td>
<td>2. Insufficient hospital/clinic initiated follow-ups on diabetics</td>
</tr>
<tr>
<td>* Group management for diabetic patients in hospital and community</td>
<td>3. Lack of clear support and sponsorship for improving the care of diabetes in health care organizations</td>
</tr>
<tr>
<td><strong>Encourage quality care through leadership and incentives</strong></td>
<td>4. Diabetes care practice is not usually formed by established guidelines</td>
</tr>
<tr>
<td>Nonexistent</td>
<td>5. Information system is not well developed</td>
</tr>
<tr>
<td><strong>Organize and equip health care teams</strong></td>
<td><strong>Deficiencies</strong></td>
</tr>
<tr>
<td>* Hospitals provide medical education lectures for doctors periodically</td>
<td><strong>Deficiencies</strong></td>
</tr>
<tr>
<td>* Most doctors gain special skills and knowledge via self-pursued continuing education</td>
<td>1. Diabetes care and services are not well coordinated across different levels (i.e. first-, second-, and third-tier) hospitals and between health care providers and community groups</td>
</tr>
<tr>
<td>* Bayer Diabetes Houses provides comprehensive diabetes care and the training of community physicians</td>
<td>2. Insufficient hospital/clinic initiated follow-ups on diabetics</td>
</tr>
<tr>
<td><strong>Support self-management and prevention</strong></td>
<td><strong>Deficiencies</strong></td>
</tr>
<tr>
<td>* Diabetes self-management education and classes in hospitals</td>
<td>1. Diabetes care and services are not well coordinated across different levels (i.e. first-, second-, and third-tier) hospitals and between health care providers and community groups</td>
</tr>
<tr>
<td>* Center for diabetes prevention in hospitals provide materials and lectures of health education on diabetes</td>
<td>2. Insufficient hospital/clinic initiated follow-ups on diabetics</td>
</tr>
<tr>
<td>* Diabetes clubs held by hospitals and CHSC</td>
<td>3. Lack of clear support and sponsorship for improving the care of diabetes in health care organizations</td>
</tr>
<tr>
<td><strong>Use information systems</strong></td>
<td><strong>Deficiencies</strong></td>
</tr>
<tr>
<td>* Diabetes and Complication Management system</td>
<td>1. Diabetes care and services are not well coordinated across different levels (i.e. first-, second-, and third-tier) hospitals and between health care providers and community groups</td>
</tr>
<tr>
<td>* Medical and Health File system</td>
<td>2. Insufficient hospital/clinic initiated follow-ups on diabetics</td>
</tr>
<tr>
<td>* Electronic database for the diabetes clinic to record patients’ information</td>
<td>3. Lack of clear support and sponsorship for improving the care of diabetes in health care organizations</td>
</tr>
<tr>
<td>* Outpatient hotline for patients to make the appointment with specialized doctors</td>
<td>4. Diabetes care practice is not usually formed by established guidelines</td>
</tr>
<tr>
<td><strong>Deficiencies</strong></td>
<td>5. Information system is not well developed</td>
</tr>
</tbody>
</table>
3.2.2. Community. Community resources are vital to the health care system and management of patients’ chronic conditions. Informed and prepared community resources can fill the gap of services that are not provided by health care organizations. The important functions of community include: (1) raising awareness and reducing stigma, (2) encouraging better outcomes through leadership and support, (3) mobilizing and coordinating resources, and (4) providing complementary services [18].

In China, some efforts in diabetes prevention and control are made by community supporters. Table 3 summarizes these efforts.

Table 3: Community Environment in China

<table>
<thead>
<tr>
<th>Meso-Level Existing Programs and Activities</th>
<th>Micro-Level Current Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raise awareness and reduce stigma</td>
<td>* Boulevard Block Office (BBO) enhance people’s awareness of diabetes</td>
</tr>
<tr>
<td>* Activities of diabetes education and prevention held by BBO</td>
<td></td>
</tr>
<tr>
<td>Encourage better outcomes through leadership and support</td>
<td>* Students and teachers from Medical College doing the planning of diabetes club and delivering seminars in community to provide health care knowledge, news, and information about diabetes-related activities to patients and families</td>
</tr>
<tr>
<td>* Diabetes Friends and Chinese Diabetes Club</td>
<td></td>
</tr>
<tr>
<td>Mobilize and coordinate resources</td>
<td>Nonexistent</td>
</tr>
<tr>
<td>Provide complementary services</td>
<td>* Development of diabetes education programs</td>
</tr>
</tbody>
</table>

**Deficiencies**

1. Not enough efforts in diabetes prevention and control are made by leaders of local community organizations.
2. Few diabetes campaigns, assessment of risk factors, training of community health workers occur through community-based groups.

3.3 Micro Level

The micro level in the ICCC framework is a triad consisting of the patient and his/her family, community supporters, and health care team. Better outcomes for chronic conditions are achieved only when all three parties are informed, motivated, prepared, and working together [18].

The micro level is probably one of the most challenging areas. Several studies have shown that common problems exist among diabetic patients and their families in China [19, 20]: (1) no attention to diabetes, (2) incorrect understanding of diabetes and its complications, (3) no awareness of self-management, (4) much emphasis on treatment rather than health monitoring, and (5) much emphasis on medicine rather than diet and exercise. Table 4 depicts the micro level situation.

Table 4: Micro Level: Patient Interaction in China

<table>
<thead>
<tr>
<th>Prepared, Informed, and Motivated Patients and Families</th>
<th>Micro-Level Current Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Doctors will address the concerns of patients and families</td>
<td></td>
</tr>
<tr>
<td>* Patients are free to visit the hospital or a class to ask questions or to get further education</td>
<td></td>
</tr>
<tr>
<td>* Understanding, adherence, and prevention problems exist among diabetic patients and their families</td>
<td></td>
</tr>
</tbody>
</table>

**Deficiencies**

1. Weak patient-physician interaction: patients usually are not informed about guidelines for diabetes by physicians.

3.4 ICCC Specified: Multi-level Summary

In summary, Figure 3 shows the specified diabetes ICCC model for China.

China Diabetes Chronic Care Model

4. Discussion

Based on our review of diabetes care in China, several challenges and opportunities are illustrated through the lens of the ICCC framework. As part of this discussion, we showcase technological situations and possibilities.

4.1 Macro-Level

At the macro-level, the first challenge facing diabetes care is the lack of investment and active advocacy from the state government. There are few national and integrated diabetes programs. Most advocacy and media/press coverage related to diabetes are sponsored by commercial pharmaceutical companies. None or a few partnerships for diabetes care exist among governmental sectors, the private health sector, and community groups and organizations.

For example, some of China’s national policies are
promoting broadband and wireless infrastructure development and deployment. In January 2009, the Ministry of Industry and Information Technology of China awarded TD-SCDMA (locally developed standard) to China Mobile, WCDMA (international standard) to China Unicom, and CDMA200 (international standard) to China Telecom. These three carriers will collectively spend almost $60 billion (measured in U.S. dollars) to establish infrastructure for tens of millions of subscribers [28]. While policies promoting wireless 3G infrastructures are strong, currently there is no integration with the Ministry of Health towards policy effort promoting using these technologies toward the goal of chronic care management.

To optimize and advance care for diabetes, the state government should provide leadership in establishing a system of integrated diabetes management, which can be established through the alignment of governmental organizations (e.g., Bureau of Health), health care organizations, and local community organizations [21, 22]. Such a system does not yet exist. Diabetes care data collected from primary care sites and other sources may not be detailed, resulting data is not often aggregated, and there is no centralized, comprehensive electronic repository. This limits data analysis, research, and reporting capabilities. However, change may be on the horizon. On May 20, 2009, China Business News announced that the Ministry of Health (MoH) will start establishing a nationwide electronic health record system this year as part of the health care reform, in a bid to standardize health records for all Chinese residents.

A second macro challenge is the lack of an integrated financing structure. As for all chronic conditions, diabetic patients need care throughout their life span. This elevates the importance of prevention and maintenance programs. Macro-level health diabetes promotion programs generally use conventional media (television, ads in public transportation) rather than the Internet or other modern technologies to promote awareness. Time and space constraints of the media limit educational substance. The Internet creates a media to extend reach, form and content for those with Internet access via private or public facility computers. We could find no government sponsored Internet site that addressed acute public health concerns such as the prevention, care, and management of chronic illnesses for the aging population.

Given the cost of diabetes management, the health care system should have a sustainable and consistent financing mechanism to provide and coordinate care services. Although health insurance has been implemented in urban and rural China, none of the insurance programs have prevention initiatives for chronic conditions. In addition, no appropriate provider incentives have been established in the current health delivery system. Pay-for-performance (P4P), which aligns providers' incentives with quality improvement agenda, might be a good option to be implemented in China [23]. One study showed that usage of the P4P program for low-income patient populations in a large network of community health centers correlated with dramatic improvements in the rate of patients receiving the recommended number of HbA1c tests [24].

Other than providing incentives for providers, the fundamental element for effective health care is the training of health care professionals. In China, diabetes education is not generally included in the formal medical curricula; therefore, it is imperative for decision-makers in Ministry of Education to update the model curricula and adopt active teaching techniques in medical and nursing schools. For example, adoption of the case study method for nursing students may better enable students to understand the difficulty in taking care of patients with chronic illnesses [25]. The development of additional continuing education programs for health care professionals is also critical, because up-to-date information and diabetes management skills are needed to treat and educate patients with diabetes. Various diabetes education programs and workshops can be established inside or outside the organization to provide current diabetes management skills to health care workers [26, 27]. Most, if not all, medical facilities provide some form of computer access (though often shared) to health care professionals. Some health care professionals possess their own computers. Government-sponsored computer-based training using the Internet or other technology provides a cost-efficient vehicle for wide-reaching diabetes education to health professional across China. Although computer-based training may not be effective for all learners, educated and mature health professionals with unaccommodating schedules for in-person training may be a promising using group. We did not find any government sponsored educational programs for health care providers.

4.2 Meso-Level

Within the meso-level of health care, the most common problem is the failure to organize care for chronic conditions. Physicians play the role of leaders in health care organizations in China. However, they do not have a formal structured role in the management of chronic conditions. The lack of organized and coordinated diabetes care may be attributed to lack of provider incentives, ambiguous organizational goals, and improvement strategies.

The current organization and information structures do not generally provide a structure supporting follow-up for patients with chronic conditions. Information systems, such as an appointment system and a reminder system for patient interaction are not firmly established in China, which may hamper continued care. Patient records need to be enhanced to support follow-up (e.g., completed contact information), such as a telephone follow-up, outpatient follow-up, and community follow-up [29, 30]. Technology has the capability to support each of these needed functions, but is not generally available. For example, in Beijing, only a few
primary hospitals at the municipal level have started experimenting with electronic patient records. The initial adoption was limited to a couple of selected departments within a hospital.

Inside the health care organizations, the lack of tools and information systems creates another problem. In China, physicians provide diabetes care by using non-mandated, collaboratively developed general guidelines rather than with the structure and benefit of evidenced-based guidelines. Available guidelines based on scientific evidence for the diabetes management are very important in practice. Without available guidelines, it will be difficult for health care team members to make effective treatments and interventions in diabetes care. The American Diabetes Association and the American Association of Clinical Endocrinologists outlined an evidence-based guide for managing patients with diabetes while maintaining the clinical practice guidelines [31]. This could serve as a good foundational reference for health care professionals to adopt and develop appropriate diabetes guidelines according to China’s health care context. Another important issue inside the health care organizations is that medical and training tools for diabetes care (e.g., diabetes diet food model) need to be more accessible and affordable.

Outside the hospital, community resources are critical to the care of chronically ill patients. They can fill the gap of services or resources not provided by health care organizations. Unfortunately, no formal link exists between community resources and health care organizations in China. Hospital physicians rarely integrate efforts with community resources for the purposes of improving chronic illnesses care. Hospitals and community health service centers are not yet connected by shared technical infrastructure. There are virtually no community centers with technology. Successful connection with community resources may result in better outcomes for patients with chronic conditions.

4.3 Micro-level

At the micro-level, patient-physician interaction is the most common problem. In China, physicians do not actively inform patients about guidelines for diabetes care, or provide information about outside resources for diabetes management. Most patients are not being included in the decision-making and treatment-planning process. For a modern hospital, it is important to establish a comprehensive system of patient-physician communication. Presently, hospitals in China are beginning to emphasize this important issue in order to improve health care outcomes [32]. With the rapid development and widespread of the Internet in China [13], more people communicate over the Internet via mailing lists, news and discussion groups. Self-help groups such as Diabetes Friends and Chinese Diabetes Club, that represent grass roots efforts formed by diabetics, use online blogs and discussion boards to communicate with each other and with physicians [33, 34]. This enables diabetics and their family members to talk with others who have diabetes and receive timely answers to their questions. Internet technology makes it possible to expand the social networking of diabetes care broadly and quickly.

Technology at the micro-layer is available and relatively affordable to upward mobile Chinese (particular in cities). However, there is a tremendous variation in technology accessibility and savvy at individual user level across the different regions of China due to the big gap in social-economical status. In general, consumer health technologies are not widely used.

5. Proposed Technology Infrastructure

China is the world’s largest cell phone market with over 600 million users [35]. More people own smart phones than standard PC’s. Therefore, it seems that that smart phones will be the main access to the Internet for many Internet users. For instance, a recent article in Business Week reported that though the iPhone has not been officially introduced into China market, over 600,000 iPhones are in use in China.

Regarding facilitating standards, China has an aggressive policy concerning 3G wireless standards. TD-SCDMA is a Chinese standard that has been internationally ratified by the International Telecommunications Union (ITU). The ITU rejected TD-SCDMA at first because it did not believe another international 3G standard was needed if it did not offer clear improvements over WCDMA or CDMA2000. However, when pressured by the Chinese government, the ITU relented and approved the standard. The Chinese government has also pushed the vendors to supply TD-SCDMA compatible devices and infrastructure. It is likely that TD-SCDMA would have failed without the strong support by the Chinese Government.

Figure 4 in Appendix A illustrates the macro, meso, and micro levels of the technology infrastructure to facilitate effective and scalable chronic care management in China. Patient care is demonstrated in dense urban cities, in the less populated country surrounding cities, and remote rural locations. We discuss the infrastructure as they generally relate to each level below.

5.1.1 Micro. The smart device can be used as an input device for the patient to log diet, activity, and compliance to medication. This mobile device acts as a communication hub and application platform. It also uploads current education content to be presented to end user patients.

The patient’s smart phone device is able to send Internet Protocol (IP) packets, and has at least a web browser application. It is preferred that this device support java applications and have a web services stack that can decode XML data sent in an HTTP message. The smart phone will have the ability to connect to wireless interface such as
Bluetooth or Wifi to utilize the growing choice of “smart” wireless medical devices and sensors, such as weight scales, pulse oximeters, and glucose monitors for the automatic collection of vital signs.

This infrastructure will help facilitate patient-physician interaction by providing a better and more effective communication medium. Patient information can migrate back to the care provider, and the care provider can provide feedback to the patient using Internet-based medical services. This communication could be email-based, private chats, or one-to-one voice communications.

Regarding geographic access, upwardly mobile Chinese in cities can afford mobile devices and home monitoring medical devices for use in private residences, and have access to wireless and broadband infrastructure. In county and relatively rural areas, it is more likely that several patients will share the physical equipment and services. For use in the most remote areas, our proposed application supports a roaming care provider who uses the application on visits to patient residences.

China does not have a HIPPA comparable. Though there was no evidence of concern over health data security (in fact focus group transcripts revealed patients are often in line in the exam room while a patient is being examined), securing the system is possible. Security and privacy at the micro-layer is based on 3G security and end-to-end encryption. Highjacking or spoofing 3G network connections is highly complex and expensive. Strong end-to-end encryption such as SSH tunnels used in HTTP connections has become a standard for all security web transactions including banking and credit card processing, and has proven secure so far. The cost of sealing data at the micro-layer far exceeds its value.

5.1.2 Meso. The proposed infrastructure would provide patient data not currently available to meso-level health care providers via the easy integration of web and web services-based applications that can help coordinate care. The deficiency of insufficient hospital/clinic initiated follow-ups on diabetics can be addressed by integrating an automated follow-up and reminding/scheduling system. An Individualized portfolio of chronic illness management can be addressed by integrating an automated follow-up and reminding/scheduling system. An Individualized portfolio of chronic illness management can be addressed by integrating an automated follow-up and reminding/scheduling system. An Individualized portfolio of chronic illness management can be addressed by integrating an automated follow-up and reminding/scheduling system. An Individualized portfolio of chronic illness management can be addressed by integrating an automated follow-up and reminding/scheduling system.

The technology at the meso layer consists of servers providing health related services to both patients and health care professionals. These servers host applications from community hospitals, grass root organizations, personal record care providers, community based servers and portals. The proposed architecture is service-oriented, based on web services with XML encoded data. This data is produced and consumed as lightweight web services without a SOAP envelope with data encode as XML data into an HTTP message transferred with the secure HTTP protocol. Security and privacy is enhanced by password-based authentication and role-based authorization.

The key to long-term success is interoperability among mobile devices, medical devices, and network-based health care services. Interoperability between all of China’s 3G providers is important to long-term success because nobody knows which of the three 3G standards will dominate, or which mobile devices Chinese users will favor. With a layered service-oriented architecture (SOA) users of all three of China’s 3G infrastructures can exchange data and use Internet-based health care services. Layered standards for interoperability and SOA are extensible to new mobile devices and infrastructure. The pre-defined standardized schemes are flexible to support many different service delivery models, extensible to adopt emerging devices and services, and interoperable to exchange data with a wide variety of international, national, and local health related service providers.

5.1.3 Macro. Our infrastructure has the potential to address the lack of training and continuing education for health care professionals (deficiency (3) in table 1) via either PC or smart phone access (for times when PC is not readily accessible). Smart mobile devices with 3G connectivity can provide rich web-based educational content to a heterogeneous group of health care professionals over a wide geographic range.

The smart mobile platform downloads information to external data services for data aggregation, public health, research, informing care providers, and backup storage. Using Internet protocols such as HTTP and TCP along with web and web services protocols such as HTML, XML and SOAP provides interoperability with a wide variety of platforms to implement health-based services such as Microsoft’s HealthVault, Google Health, and Dossia.

5.1.4 Service-Oriented Architecture. The proposed architecture is service-oriented, based on web services with XML encoded data. The key to long-term success is interoperability among mobile devices, medical devices, and network-based health care services. Nobody knows which of the three 3G standards will dominate, or which mobile devices Chinese users will favor. With a layered service oriented architecture (SOA), users of all three of China’s 3G infrastructures can exchange data and use Internet-based health care services. Layered standards for interoperability and SOA are extensible to new mobile devices and infrastructure. The pre-defined standardized schemes are flexible to support many different service delivery models, extensible to adopt emerging devices and services, and interoperable to exchange data with a wide variety of
6. Conclusions

Diabetes has become a critical issue related to people’s health and the health care system in China. We specified the ICCC framework to China to better understand the strengths and weaknesses of the current environment of diabetes care in China with an integrated perspective of macro, meso, and micro-layers. Understanding the current gaps in policy and technology infrastructure in China will help advance the chronic disease management infrastructure. Today, responsibilities for diabetes care and management in China are mainly delegated to health care providers. This effort could be enhanced and complemented by increased support from the government, resources for diabetes management in the community, additional resources and structures from health organizations, and stronger partnerships between health care organizations and the community. The roles of patients and their families should also be elevated.

Our proposed technological infrastructure uses the China specified ICCC framework to begin to address gaps and demonstrate how integrated and interoperable technology can facilitate linkage and integration among micro, meso, and macro-levels to provide positive strides toward better outcomes for diabetes management. Building a layered chronic care infrastructure based on standards is achievable, scalable, and will promote better overall care outcomes.

Policy, technology, and service infrastructure at the macro, meso, and micro-layers must be in strategic alignment to address the gaps and opportunities illuminated by the specified ICCC framework. The collective efforts of the government, health care organizations, community, and patients are needed to achieve the goal of providing effective diabetes management.

6. References


7. Appendix I - A Multi-layer Infrastructure Figure

![Figure 4. Flexible China Multi-Level Deployment](image-url)