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REVIEW

Burden of diabetes in the adult Chinese population: A systematic literature review and future projections

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Background: The diabetes epidemic in China imposes an increasing burden on the health care system and the economy. We derived prospective diabetes prevalence rates in China until 2016 from a systematic review of the published literature in the period 1987–2007. The results could help to guide resources of the Chinese health care system in order to address the diabetes epidemic.

Methods: We selected articles published in the English/Chinese languages from MEDLINE and the China Wanfang Digital Database using the keywords "China", "diabetes mellitus", "prevalence", and "epidemiology" in order to estimate the current diabetes prevalence in China. For projecting future prevalence rates, we considered the population growth, and assumed that China's diabetes prevalence in first tier cities in 2016 would equal Hong Kong's diabetes prevalence in 2007.

Results: The number of Chinese adults with diabetes is projected to rise from 53.1 million in 2009 to 76.1 million in 2016. The estimated diabetes prevalence rate in China in 2009 was 3.9% (urban 5.2%, rural 2.9%) and is projected to increase to 5.4% (urban 6.9%, rural 3.8%) in 2016, corresponding to an annual consolidated aggregate growth rate of 4.6%.

Conclusion: We estimate a considerably higher diabetes prevalence in the adult Chinese population than that reported in previous studies. The diabetes prevalence will continue to rise in the future, which points to the importance of increasing awareness and better diagnosis of diabetes in China.

Keywords: diabetes, prevalence, epidemic, China, Chinese, systematic review

Introduction

Diabetes increases the risk of developing long-term microvascular and macrovascular complications and represents a major public health concern.[1] The World Health Organization (WHO) estimates that more than 180 million people worldwide suffered from diabetes in 2008, a number which will be more than twice as high by 2030.[2] Prevalence estimates of diabetes and impaired glucose tolerance in all Asian countries, adjusted to those for the world population, are high and are expected to increase further.[3] China has one of the largest single diabetes populations worldwide, due to rapid westernization, with its associated changes in dietary habits and a sedentary lifestyle.[4] Diabetes and its complications also have significant economic consequences for individuals, families, and health care systems. The WHO estimates that from 2006 to 2015 China will lose $558 billion of its national income due to heart disease, stroke, and diabetes.[2] Therefore, adequate financial resources and structures of health care delivery are required to deal with the future diabetes burden, particularly in the context of continued rapid

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urbanization.[5] Previous nationwide epidemiologic studies, conducted between 1997 and 2006, showed diabetes prevalence rates varying between 0.6%–6.8%.[6–11] However, these studies were cross-sectional in nature and were carried out in different cities at various time points. Furthermore, estimation of future diabetes prevalence will allow us to understand and address better the diabetes burden in China. We carried out a systematic literature review of the published data for diabetes prevalence in China and tried to estimate prevalence rates of diabetes for the years 2009–2016 for the urban and rural populations.

Methodology

Search strategy

We conducted a systematic literature search of MEDLINE and the China Wanfang Digital Database[12] for articles containing the keywords "China", "diabetes mellitus", "prevalence", and "epidemiology", published in the English or Chinese language for 1987–2007. Titles and abstracts of the resulting publications were screened for further articles that were possibly of interest for our review. The references in the relevant articles and review articles were checked for additional studies of interest. We included original articles of observational studies on diabetes prevalence for China published in peer-reviewed journals. We excluded randomized controlled trials, editorials, letters to the editor, and review articles.

Data extraction

The key parameter of interest was the prevalence of diabetes. On initial screening, articles were selected if they reported prevalence data on diabetes. The full texts of relevant articles were scrutinized, and the extracted data on coverage, study population, age group, year of study, and results (original/age-standardized prevalence rates) were organized in tables. The definitions and diagnostic measures used to define diabetes prevalence varied across studies. The population-based studies from China used the 1997 criteria from the American Diabetes Association (ADA) or the 1999 criteria from WHO to diagnose diabetes.[6–9] In the present study, we selected publications using the WHO/ADA criteria for diabetes diagnosis (ie, fasting plasma glucose >7.0 mmol/L).

Estimation of diabetes prevalence

Estimates of the nationwide diabetes prevalence rate were derived from major diabetes epidemiologic surveys in China,[6,7,9,11,13] and are summarized in Table 1. Table 2 presents prevalence rates as measured in studies of various Chinese populations.[5,6,14–30] Differences in prevalence rates are most likely to be due to different survey methodologies, diagnostic criteria, time points of analyses, and the cities where the studies were conducted. Based on a database of 661 Chinese cities, the urban population was classified into four city tiers according to wealth distribution (Gross Domestic Product per capita) and population.[31] The categorization into urban and rural segments was based on the definition provided in the China Statistics Yearbook.[32] Since the patients' ages differed significantly, the crude overall prevalence rates were corrected for age (see Table 3). We used the 2000 China National Census data for standardizing prevalence. For first tier cities, we selected a standardized prevalence of 7.6% from the most recently published report.[15] For other city tiers, we calculated the prevalence rate for 2009 by taking an average of the age-standardized

Table 1 Major nationwide surveys on diabetes prevalence in China

Reference	Sample	Sample size	Age (years)	Year of study	Prevalence (%)
Southern Research Institute of Medicine Economics DM prevalence survey, 2004[11]	Nationwide	NA	All	1978	0.6
				1990	1.2
				1995	1.5
				2000	2.4
Pan et al[6]	19 provinces, urban and rural	224,251	25–64	1994	2.5
Yang et al[7]	12 areas	29,559	40–99	1998	5.9
	12 urban areas				6.8
	12 rural areas				3.8
Gu et al[9]	Nationwide	15,540	35–74	2000	5.5
Li et al[13]	Nationwide	NA	≥18	2002	2.6
	Urban				4.5
	Rural				1.8

Abbreviation: NA, not available.

Table 2 Studies on diabetes prevalence in China by city/province

Reference	Tier	Region	Sample size	Age (years)	Year of survey	Prevalence (%)	Age-standardized prevalence[a] (%)
City level							
Pan et al[6]	1	Beijing	–	>25	1994	4.5	3.2
Pan et al[14]	1	Beijing	29,859	30–64	1995	–	3.6
Jia et al[15]	1	Beijing	2706	>18	2005	–	7.6
Zhu et al[16]	1	Beijing	–	>15	2006	7.7	–
Pan et al[5]	1	Guangzhou	775	>20	2002	6.6	4.4
Sheng et al[17]	1	Shanghai	–	>30	1998	3.7	4.8
Li et al[18]	1	Shanghai	11,589	>15	2005	8.6	6.2
Hu et al[19]	2	Chengdu	1445	20–74	2004	4.6	3.3
Hu et al[20]	2	Hangzhou	–	>15	2001	6.9	4.9
Dong et al[21]	2	Qingdao	2634	20–74	2004	–	10.0
Luo et al[22]	2	Changsha	5124	25–80	1994	6.1	5.4
Huang et al[23]	3	Nantong	36,849	>20	2006	4.8	3.4
Zhong et al[24]	4	Ganzhou	2908	>18	2006	4.4	3.1
Feng et al[25]	4	Jinzhong	3000	>20	2006	4.2	3.2
Tan et al[26]	4	Shaoyang	786	>20	2005	4.5	3.2
Province level							
Sun et al[27]	Urban and rural	Hebei	5892	>25	2002	5.8	–
Zhang et al[28]	Urban and rural	Sichuan	4641	>3	2002	2.2	2.6
Hu et al[20]	Urban and rural	Zhejiang	7417	>35	2002	5.9	–
Li et al[29]	Urban and rural	Jilin	1649	All	2005	3.5	2.5
Ma et al[30]	Urban and rural	Qinghai	2276	20–74	2003	3.1	2.2
	Urban	Qinghai urban	–	–	2003	4.5	4.7
	Rural	Qinghai rural	–	–	2003	1.5	1.0

Notes: [a]Age-standardized prevalence of diabetes was calculated if not reported in published study.

prevalence rates (fifth column in Table 3). This approach was confirmed to be reasonable by diabetes experts in China. We adjusted the average age-standardized prevalence rate by the difference between percentage of the adult population (>19 years) in 2000 (67.9%) and 2009 (72.3%) to calculate the prevalence rate in 2009 (eighth column in Table 3).[33] We projected a prevalence rate increase for each forecast year thereafter (2010–2016) based on the trends suggested by the available data and assumptions for prevalence growth rate (Table 4). For first tier cities, we assumed that the 2016 diabetes prevalence in China would equal the 2007 diabetes prevalence in Hong Kong, where the population had the earliest exposure to risk factors for diabetes, in particular, a more sedentary lifestyle and a high-fat diet, but is of the same ethnic origin as the population in mainland China. The annual growth rate of diabetes

Table 3 Estimation of baseline prevalence rate for 2009 based on analysis of available data

	City	Year of survey	Age-standardized prevalence (%)	Average of age-standardized prevalence (%)	Total population in 2009 (million)	Number of people with diabetes in 2009 (million)	Prevalence rate in 2009 (%)
Urban	–	–	–	–	596.945	31.410	5.2
Tier 1	Beijing	2005	7.6	7.6	32.756	2.735	8.3
Tier 2	Chengdu	2004	3.3	6.1	154.282	10.410	6.7
	Hangzho	2006	4.9				
	Qingdao	2004	10.0				
Tier 3	Nantong	2005	5.4	5.4	113.857	6.903	6.0
Tier 4	Ganzhao	2006	3.4	3.2	296.050	11.362	3.8
	Jinzhong	2004	3.1				
	Shaoyang	2006	3.2				
Rural	–	–	–	2.7[a]	748.264	21.679	2.9
Total	–	–	–	–	1345.209	53.089	3.9

Notes: [a]Prevalence rate for rural area was assumed to be 80% of fourth tier prevalence rate in 2009.

Table 4 Projections for the increase in prevalence rate in 2016 based on assumptions

	Age-standardized prevalence rate in 2009 (%)	Total population size in 2016 (million)	Assumptions	Number of people with diabetes in 2016 (million)	Growth (%/year) 2009–2016	Prevalence rate in 2016 (%)
Urban	5.2	704.917	–	49.318	4.1	6.9
Tier 1	8.3	38,751	By 2016, the prevalence rate of tier 1 cities will reach the 2007 prevalence rate in Hong Kong	3.790	2.3	9.8
Tier 2	6.7	182,518	By 2016, the prevalence rate of tier 2 cities will reach 90% of the 2007 prevalence rate in tier 1 cities	15.008	2.9	8.2
Tier 3	6.0	134,695	By 2016, the prevalence rate of tier 3 cities will reach the 2007 prevalence rate in tier 2 cities	9.902	2.8	7.3
Tier 4	3.8	350,231	By 2016, the prevalence rate of tier 4 cities will reach 90% of the 2007 prevalence rate in tier 3 cities	20.618	6.3	5.8
Rural	2.9	701,624	By 2016, the prevalence rate of rural area will reach the 2007 prevalence rate in tier 4 cities	26.766	4.0	3.8
Total	3.9	1406.541	–	76.084	4.6	5.4

prevalence was described as the consolidated aggregate growth rate (CAGR) from 2009–2016, and was calculated as the ending value/beginning value/number of years.

Results

The literature search yielded 70 potentially relevant papers. Of these, 27 epidemiologic studies on diabetes prevalence rate in China were included, ie, five national studies with a large patient population and representative of entire China (Table 1) and 22 provincial/city level (Table 2) studies. Of the total Chinese population (1345 million), approximately 597 million resided in urban areas, while 748 million people resided in rural areas in 2009 (Figure 1). The estimated diabetes prevalence rates in China were 3.9% (urban 5.2%, rural 2.9%) in 2009 and were estimated to increase to 5.4% (urban 6.9%, rural 3.8%) in 2016. Accordingly, the total number of people suffering from diabetes is projected to rise from 53.1 million in 2009 to 76.1 million in 2016. From 2009 to 2016, the urban population is projected to increase more than the rural population (1.6-fold versus 1.2-fold). From 2009 to 2016, the number of diabetes cases in urban areas will increase from 31.4 million (59%) to 49.3 million (65%), while in rural areas it will increase from 21.7 million (41%) to 26.8 million (35%). The prevalent population, prevalence rates, and CAGR for all the four tiers are presented in Table 3. The CAGR calculated from 2009 to 2016 was 4.6%, describing the rate at which prevalence might grow, if it grew at a steady rate. The prevalence increase in the urban, rural, and total Chinese population by year is presented in Figure 2.

Discussion

We estimate the number of adult patients with diabetes in China to have been approximately 53.1 million in 2009 and that it will increase to about 76.1 million in 2016, with an annual growth rate of 4.6%. These numbers are much higher than the previous estimates of 39.8 million adult patients with diabetes in 2007 and 59.3 million in 2025.[34] Because we used the same total population size as reported in previous papers

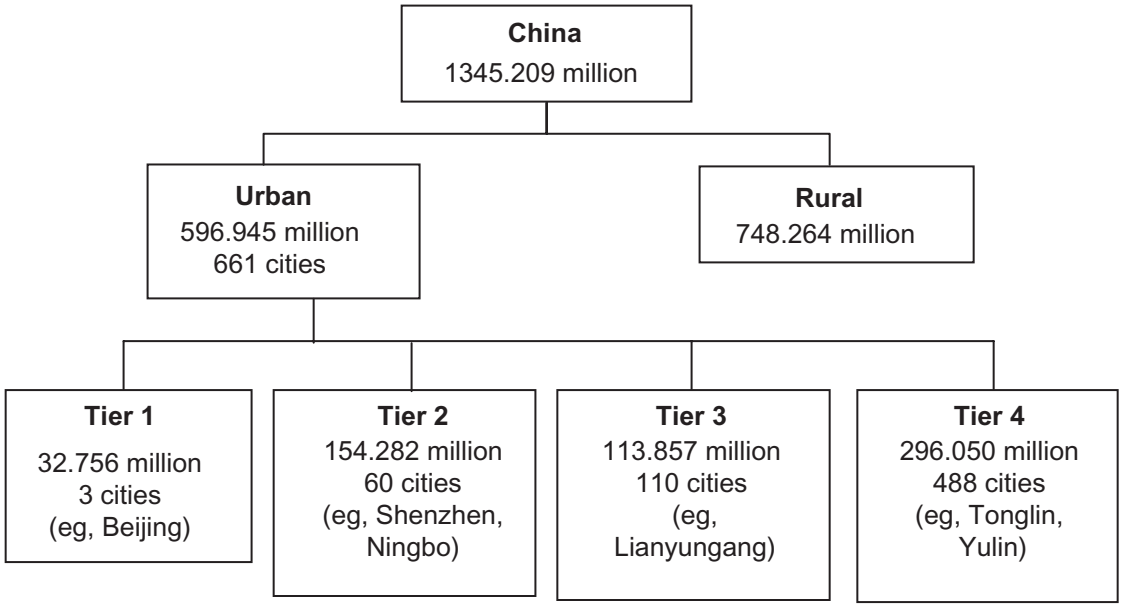

Figure 1 Flow chart of the distribution of Chinese population in 2009.

for calculating 2009 and 2016 prevalence, demographic changes cannot account completely for the difference in estimated prevalence. However, the higher prevalence can potentially be explained by the inclusion of recent studies that reported a higher prevalence of diabetes, or has less stringent inclusion criteria (eg, studies considering only fasting plasma glucose >7.0 mmol/L) for diagnosis of diabetes. However, our data are confirmed by more recent data provided by the International Diabetes Federation.[47]

The present study shows that the prevalence of diabetes in China in 2009 is higher in urban areas (5.2%, 31.4 million people) than in rural areas (2.9%, 21.6 million people). In the urban population, the projected diabetes prevalence in first tier cities increased from 2.7 million (8.3%) to 3.7 million (9.8%), while that in fourth tier cities increased from 11.3 million (3.8%) to 20.6 million people (5.8%). These findings are in agreement with those of previous epidemiologic studies conducted in China.[7–9,16,35] Further-

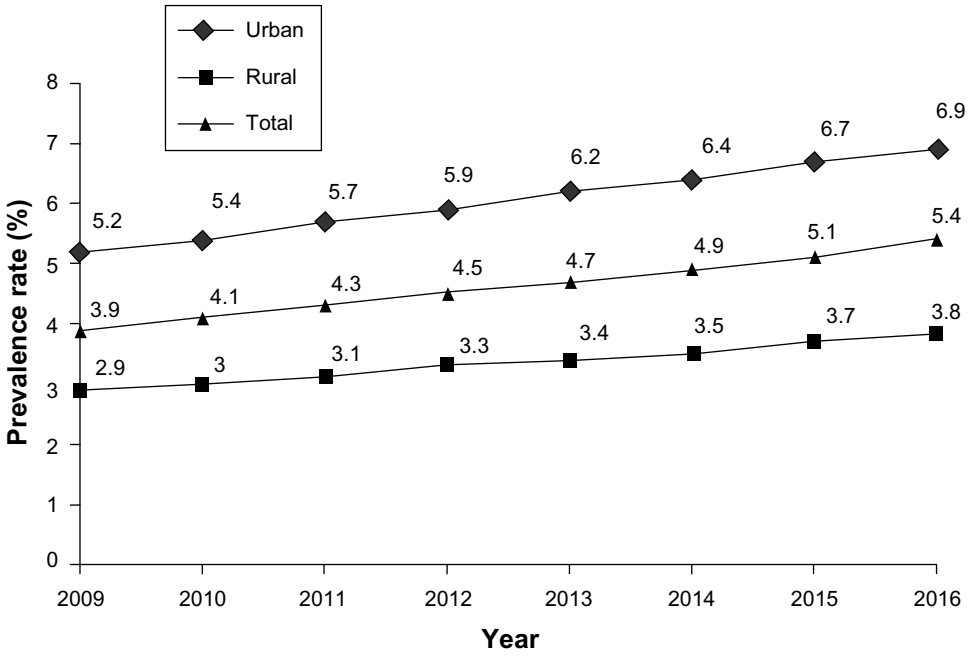

Figure 2 Projected rate of diabetes prevalence in China.

more, our findings also underscore the increasing importance of obesity as the strongest risk factor for the development of diabetes in China, which in turn is caused by excessive consumption of high-calorie food and declining physical activity, a phenomenon which is particularly evident in urban communities.[36–39] The present study reported an estimated prevalence rate of 3.9% in 2009, which is comparable with an earlier reported prevalence rate of 3.9% for China in 2007.[40] An earlier study showed that the diabetes prevalence rate in China is lower than that in Hong Kong and Singapore, where estimated rates are 9%–12%.[38,41] Hong Kong, being one of the most cosmopolitan cities in the world, can be considered as the demographic prototype of China in the future.[42] Rapid changes in lifestyle, such as an increasingly high-fat diet, physical inactivity, and psychosocial stress might unmask a genetic predisposition of some individuals to develop diabetes.[43] Therefore, based on trends suggested by the available data, we predict that the diabetes prevalence rate in first tier Chinese cities will reach the level of Hong Kong's 2007 prevalence by 2016. Although the present study suggests a high diabetes prevalence in China, our data likely still underestimates the real burden of diabetes, since many diabetic patients are undiagnosed or are diagnosed late.[44,45] Our findings are in agreement with data from other large Asian countries. India, which is undergoing the same development as China, is facing an even higher and rapidly increasing burden of diabetes, with an estimated 50 million people suffering from diabetes today, and projected to increase to 87 million people by 2030.[47] Thus, in the light of the expected high prevalence of diabetes in 2016, rigorous efforts are required to improve on prevention strategies and diagnosis of diabetes by putting in place effective public health policies. This would be important in light of the fact that Type 2 diabetes can be delayed or even prevented by lifestyle counseling or drug therapy in the primary care setting.[46]

The strength of our study is that that we analyzed data published during the past two decades, in both English and Chinese languages, representing adult populations from all over China, including rural and urban populations. The limitations of our study are that the prevalence of diabetes was based solely on the growth in Chinese population, no modifications were made for possible increases in age-specific prevalence over time, and we searched the selected papers from 1987 to 2007, hence more recent publications were not included in the analysis.

Taken together, our results predict a constant rise in the prevalence of diabetes in China from 2009 to 2016, at an annual growth rate of 4%–5%. The much higher current diabetes burden in China than that observed in earlier studies represents a serious concern for the Chinese health care system. Even though there are national education programs on diabetes in China (eg, Project HOPE), our findings point to the necessity for developing further strategies for diabetes prevention, awareness, and early diagnosis of the disease, in order to reduce the economic and societal burden of the disease and its long-term complications.

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Disclosures

SS and MT are employees of Sanofi-aventis, China.

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