Diabetes Research and Clinical Practice (2006) 73 (2): 126-134. doi:10.1016/j.diabres.2006.01.007

Prevalence of Type 2 Diabetes Mellitus of Chinese Populations in Mainland China, Hong Kong, and Taiwan

Kam Cheong Wong and Zhiqiang Wang
Centre for Chronic Disease, School of Medicine, The University of Queensland, Australia

Abstract

This article reviews and describes trends and differences in prevalence of type 2 diabetes mellitus of Chinese populations in Mainland China, Hong Kong and Taiwan based on literatures published in the MEDLINE Advanced database (January 1966–October 2005) in both Chinese and English languages. Chinese populations in Hong Kong and Taiwan have significant higher prevalence rates of diabetes than their Mainland counterparts, with odds ratios 1.5 (95% confidence intervals: 1.4, 1.7) and 2.0 (95% confidence intervals: 1.8, 2.2), respectively in 1995–2003 adjusted for age and diagnostic criteria. Using stratified diagnostic criteria; the odds ratios in Hong Kong and Taiwan were consistently higher than Mainland China for the periods of 1985–1994 and 1995–2003. A large proportion, i.e. 68.6% (95% confidence intervals: 67.4%, 69.7%) of diabetic patients remains undiagnosed in Mainland China as compared to 52.6% (95% confidence intervals: 49.8%, 55.5%) undiagnosed in Hong Kong and Taiwan. The prevalence rates of diabetes and impaired glucose tolerance of the Chinese populations rise in older age groups. In tandem with economic development and change toward lifestyle that is lack of physical activity and rich in high-fat diet, prevalence of diabetes of the Chinese populations are on the rise. If the undiagnosed individuals left uncontrolled, they are subject to higher risks of developing diabetes and its complications. These will increase the burdens of diabetes medically and financially.

Keywords: prevalence; diabetes mellitus; glucose tolerance; China; Chinese

Abbreviations: OGTT, oral glucose tolerance test; IGT, impaired glucose tolerance; FPG, fasting plasma glucose; 2h PG, 2 h plasma glucose after oral glucose challenge; WHO, World Health Organization; ADA, American Diabetes Association

1. Introduction

Along with India, China is one of the countries with the largest number of people suffering from diabetes mellitus [1]. The number of diabetic patients in China is estimated to increase from 20.8 million in 2000 to 42.3 million in 2030 [2]. In the light of economic advancement, urbanisation and change of lifestyle take place in Mainland China. On the other hand, Chinese people who live in urbanised location outside Mainland China such as Hong Kong experience change in environment and lifestyle which can affect the development of diabetes [3]. Chinese people in Hong Kong and Taiwan are genetically comparable to their Mainland counterparts. The prevalence of diabetes of Chinese populations in Hong Kong and Taiwan may reflect the future upward trend in Mainland China. This article is specifically dedicated to describe the trends and differences in prevalence of diabetes of the Chinese populations in Mainland China, Hong Kong, and Taiwan. The prevalence rates reported in this review are for ‘type 2 diabetes mellitus’, which is referred to as ‘diabetes’ in this paper for simplicity. The data are useful for assessing the potential impact of the Chinese populations in their transition into future global burden of diabetes.

2. Method

Searches were performed in MEDLINE Advanced database (January 1966–October 2005) with no limitation on language. The words 'diabet*', 'Chinese', 'China', 'Hong Kong', 'Taiwan', and 'prevalence*' were explored in the searches. Referenced papers published in Chinese journals, which were not indexed in the MEDLINE database, were searched manually. Inclusion criteria were population-based study that reported methodology, diagnostic criteria, and Chinese's prevalence rate of diabetes. The summary of diagnostic criteria based on WHO [4], WHO [5] and ADA [6] is shown in Table 1. Other diagnostic criteria were indicated in the 'criteria' column and footnotes in Table 2. The following papers were excluded: studies that specifically deal with gestational diabetes or type 1 diabetes mellitus; commentary articles that did not provide primary data of studies; duplicated reports in which data were published in another cited paper. Prevalence of diabetes includes previously known and new (undiagnosed) diabetes. The undiagnosed individuals were those who did not know that they were suffering from diabetes until they were screened and diagnosed by using the relevant diagnostic criteria. The time variable was based on the year of the study completed. In papers that did not provide the year of study, the publication year was used instead. Odds ratios and their 95% confidence intervals were computed by using logistic regression adjusting for age of the participants (i.e. median of their age-range) and stratified by three diagnostic criteria. All analyses were performed by using Stata 8.0 [7].

Table 1. Diagnostic criteria of diabetes

	WHO [4]	**WHO [5]**	**ADA [6]**
DM	FPG ≥ 7.8 or 2 h PG ≥ 11.1	FPG ≥ 7.0 or 2 h PG ≥ 11.1	FPG ≥ 7.0
IGT	FPG < 7.8 and 7.8 ≤ 2 h PG < 11.1	FPG < 7.0 and 7.8 ≤ 2 h PG < 11.1	7.8 ≤ 2 h PG < 11.1

All units are in mmol/l. *Note*: detailed elaboration of the diagnostic criteria are given in WHO [4], WHO [5] and ADA [6].

3. Results

A total of 35 studies published in either Chinese or English languages were included in this review. Twenty-one studies were conducted in Mainland China [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29] and [30] (1978–2003), four studies were conducted in Hong Kong [31], [32], [33] and [34] (1987–1996), and 10 studies in Taiwan [35], [36], [37], [38], [39], [40], [41], [42], [43] and [44] (1985–2001). The details of the studies are shown in Table 2.

Table 2. Studies of prevalence of diabetes in Mainland China, Hong Kong, and Taiwan

Location	**Criteria**	**Applied OGTT?**	**Sampling methodology**
Mainland China			
Shanghai, 1978 [8] *N* = 78298	Note 1	Yes	Subjects were randomly selected according to the age, sex, and occupation distributions in Shanghai

Location	**Criteria**	**Applied OGTT?**	**Sampling methodology**
14 Provinces, 1980 [9] and [11] *N* = 156119	Note 2	Yes	Subjects were randomly selected according to the age, sex, occupation, and ethnicity distributions in Mainland China
Beijing, 1980 [10] *N* = 21671	A	Yes	Subjects were randomly selected according to the age and sex distributions in Beijing
DaQing, 1986 [12] *N* = 110687	B	Yes	50% of the clinics in DaQing were randomly selected to screen subjects over a 6-month period
Beijing, 1993 [13] and [14] *N* = 29938	B	Yes	All employees over the age of 30 years working in 32 units of Shougang Corporation in Beijing
19 Provinces, 1994 [15] *N* = 213515	B	Yes	The selection of subjects depended on the willingness of local doctors to volunteer time and effort and the support by the local administrative office in 19 provinces in Mainland China
Shanghai, 1994 [16] *N* = 12509	B	Yes	Subjects were randomly selected from 11 districts in Shanghai
Hubei, 1995 [17] *N* = 9446	B	Yes	Stratified random cluster sample of residents from urban and rural areas in Hubei province
Changsha, 1996 [18] *N* = 1369	B	Yes	Employees from 22 companies and enterprises in Changsha
Shenzhen, 1997 [19] *N* = 7842	B	Yes	Subjects were randomly selected proportional to the population density in each district and age distribution
Baotou, 1997 [20] *N* = 10867	B	Yes	Six work-units in Electric Power System in Baotou city were randomly selected. All the employees in the selected units were surveyed
11 Provinces, 1997 [21] *N* = 42751	B	Yes	Stratified cluster sample from 11 provinces in Mainland China
Beijing, 1997 [22] *N* = 1429	C	Yes	Population-based sample reported in DECODA[a] study
Shunyi, 1998 [22] *N* = 646	C	Yes	Population-based sample reported in DECODA[a] study
12 Provinces, 1998 [24] *N* = 27010	B	Yes	Stratified random sampling of residents over 40 years old in 12 provinces in Mainland China
Shanghai, 2000 [25]	C	Yes	Multiple-stage random sampling on residents aged 20 years and above and who had been

Location	**Criteria**	**Applied OGTT?**	**Sampling methodology**
N = 2771			living in Shanghai for more than 10 years
Baotou, 2000 [26] *N* = 20221	D	Yes	90% of the employees aged 20 years and above in Baotou Iron & Steel Company in Baotou city were screened
31 Provinces, 2001 [27] *N* = 15540	D	No	Four-stage stratified sampling to select nationally representative sample in 31 provinces in Mainland China
Qingdao, 2002 [29] *N* = 12436	C	Yes	Stratified random cluster sampling to select representative samples in rural and urban areas in Qingdao city
Chongqing, 2002 [28] *N* = 2810	C	Yes	Stratified random sampling of residents aged 20 years and above in Chongqing
Hangzhou, 2003 [30] *N* = 4682	Note 3	Yes	Multiple-stage stratified random sampling on residents aged 15 years and above in Hangzhou
Outside Mainland China			
Hong Kong, 1987 [31] *N* = 427	B	Yes	Cluster sampling of elderly (aged 60 and above)
Hong Kong, 1993 [32] *N* = 1609	B	Yes	All employees from two work sites of a major public utility company and a regional hospital were invited to participate
Hong Kong, 1996 [34] *N* = 2664	B	Yes	Participants were selected randomly from the registry of telephone number
Hong Kong, 1996 [33] *N* = 1467	B	Yes	Members from seven community day-centers at various locations were invited to participate in a health-screening program
Taiwan, [Taipei] 1985 [35] *N* = 2206	A	Yes	Residents from 16 districts of Taipei were randomly sampled for the screening
Taiwan, [Pu Li] 1988 [36] *N* = 1152	B	Yes	Stratified cluster sampling based on the population density of the 31 neighborhoods in Pu Li
Taiwan, [Yang Ming]1989 [37] *N* = 4713	Note 4	No	Residents from eight towns were surveyed by the Yang-Ming Crusade (National Yang-Ming Medical College)
Taiwan, [Ann-Lo] 1990 [38] *N* = 9087	Note 5	No	One third of all the families in the Ann-Lo district were sampled randomly
Taiwan, [Kinmen] 1991 [39] *N* = 3236	B	Yes	According to household registration, subject ≥30 years were invited to attend the screening test

Location	Criteria	Applied OGTT?	Sampling methodology
Taiwan, [Hualian] 1995 [40] *N* = 580	B	Yes	Six villages were selected randomly from the Hualian county. Data from three Chinese (Han) villages were included in this review
Taiwan, [Penghu] 1996 [41] *N* = 1601	D	No	Stratified random sample proportional to the population density in six residential areas in Penghu
Taiwan, [Taipei] 1996 [42] *N* = 46 603	Note 6	No	Individuals who attended a health-screening center for health examination of their own volition
Taiwan, [Tainan] 1996 [43] *N* = 1638	B	Yes	Stratified systematic cluster sample, i.e. the city was stratified into seven strata according to administrative districts in which every fifth household was selected
Taiwan, [Taipei] 2001 [44] *N* = 1293	D	No	Two-stage proportional stratified random cluster sample from each township from lists of all residents' names

N = total sample size. A: WHO, 1980, B: WHO [4], C: WHO [5], D: ADA [6]. *Note 1*: FPG > 130 mg/dl or 2 h post-prandial glucose > 160 mg/dl. *Note 2*: FPG > 130 mg/dl or 2 h post-prandial glucose >200 mg/dl. *Note 3*: the version of WHO criteria was not stated. *Note 4*: fasting plasma glucose >140 mg/dl. *Note 5*: 2-hour post prandial blood glucose ≥200 mg/dl or subject has diabetic history and is receiving treatment. *Note 6*: 12 h fasting plasma glucose. FPG >126 mg/dl or use of anti-diabetic medication.

[a] Diabetes Epidemiology: Collaborative analysis of Diagnostic Criteria in Asia.

Each line in Fig. 1 represents the age-specific prevalence rates for one study of Chinese population. In the period of 1985–1994, Mainland Chinese's prevalence rates of diabetes were consistently lower than their counterparts in Hong Kong and Taiwan in the same age groups. In the period 1995–2003, the prevalence of diabetes in some studies in Mainland China remained low, but some studies were on par with or even higher than some of their counterparts in Hong Kong and Taiwan. The variations of the prevalence rates of diabetes in Mainland China were large (Fig. 1).

After adjusting for age and diagnostic criteria, Chinese people in Hong Kong and Taiwan have a substantially higher prevalence of diabetes than their Mainland counterparts, with odds ratios 1.4 (95% confidence intervals: 1.1, 1.7) and 2.2 (95% confidence intervals: 1.9, 2.5), respectively in 1985–1994. The corresponding odds ratios in 1995–2003 were 1.5 (95% confidence intervals: 1.4, 1.7) [Hong Kong versus Mainland China] and 2.0 (95% confidence intervals: 1.8, 2.2) [Taiwan versus Mainland China]. To examine the trend over time in the prevalence of diabetes, we compared the prevalence rates of studies that applied WHO, 1985 criteria between two periods of 1985–1994 and 1995–2003 for Mainland China, and Hong Kong and Taiwan combined. The odds ratio in Mainland China was 1.33 (95% confidence interval: 1.28, 1.39) with the data from 1985 to 1994 as reference. The corresponding odds ratio in Hong Kong and Taiwan combined was 1.15 (95% confidence interval: 1.02, 1.32).

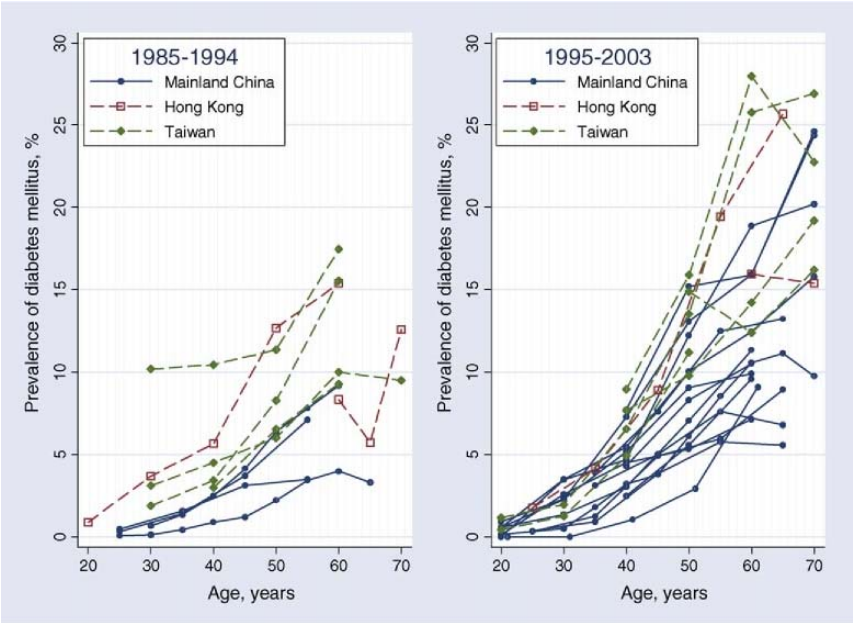

Fig. 1. Prevalence of diabetes of Chinese populations in Mainland China, Hong Kong and Taiwan. *Note*: Each line represents the age-specific prevalence rates for one study of Chinese population.

We further stratified the analysis by diagnostic criteria to reduce the effect of change in diagnostic criteria on the variation of prevalence rates. As shown in Table 3, the odds ratios for Hong Kong and Taiwan versus Mainland China were significantly higher than the null effect in all strata with the data available.

Table 3. Odds ratios stratified by diagnostic criteria and time, adjusted for age

	Year	**WHO [4]**		**ADA [6]**	
		Odds ratio	**95% CI**	**Odds ratio**	**95% CI**
Hong Kong vs. Mainland China					
	1985–1994	1.40	1.15, 1.72	[a]	[a]
	1995–2003	1.56	1.40, 1.74	[a]	[a]
Taiwan vs. Mainland China					
	1985–1994	2.18	1.94, 2.45	[a]	[a]
	1995–2003	1.92	1.65, 2.23	2.1	1.81, 2.43

[a] No comparable studies published using the same diagnostic criteria during that period of time.

The prevalence rates of diabetes and impaired glucose tolerance (IGT) rise in older age groups. The prevalence of IGT is higher than diabetes in younger age groups as reflected in the IGT/diabetes ratio, which generally declines as age increases (Fig. 2).

The prevalence rates of diabetes and impaired glucose tolerance (IGT) rise in older age groups. The prevalence of IGT is higher than diabetes in younger age groups as reflected in the IGT/diabetes ratio, which generally declines as age increases (Fig. 2).

The percentage of undiagnosed diabetes is 68.6% (95% confidence interval: 67.4%, 69.7%) in Mainland China as compared to 52.6% (95% confidence interval: 49.8%, 55.5%) in their counterparts in Hong Kong and Taiwan (Table 4).

Table 4. Percentages of undiagnosed diabetes of the Chinese populations in Mainland China, Hong Kong and Taiwan

Study	**Total diabetes**	**Undiagnosed diabetes**		
	N	***n***	**Percentage**	**95% CI**
Mainland China	6157	4221	68.6	67.4, 69.7
19 Provinces, 1994 [15]	4868	3426	70.4	69.1, 71.7
Chongqing, 2002 [28]	368	195	53.0	47.7, 58.2
Qingdao, 2002 [29]	921	600	65.1	62.0, 68.2
Hong Kong and Taiwan combined	1195	629	52.6	49.8, 55.5
Hong Kong, 1995 [34]	253	163	64.4	58.2, 70.3
Hong Kong, 1996 [33]	232	74	31.9	25.9, 38.3
Taiwan, [Taipei] 1985 [35]	133	75	56.4	47.5, 65.0
Taiwan, [Pu Li] 1988 [36]	143	66	46.2	37.7, 54.7
Taiwan, [Kinmen] 1991 [39]	211	146	69.2	62.5, 75.4
Taiwan, [Hualian] 1995 [40]	75	37	49.3	37.6, 61.1
Taiwan, [Tainan] 1996 [43]	148	68	45.9	37.7, 54.3

4. Discussion

In our review, we found that the prevalence rates of diabetes were consistently higher in Hong Kong and Taiwan than Mainland China regardless of diagnostic criteria for the periods of 1985–1994 and 1995–2003.

Chinese people in Hong Kong and Taiwan are generally living in an urbanised environment. Physical inactivity, diets high in fat and sodium and low in fruit and vegetables, and increase work-related stress are a few of the lifestyle factors associated with urbanisation [45]. In Hong Kong, with reference to two large-scale population-based studies, the prevalence of overweight (using BMI $\geq$ 25 kg/m^2) increased from 28% to 38% in men, and from 28% to 34% in women in 1990 and 1995, respectively [46]. A prospective study on obese Hong Kong Chinese found that the obese people, after a mean follow-up of 2 years, had significantly higher rates of progression to diabetes (14.6% per year for people with BMI $\geq$ 28 kg/m^2) than their non-obese counterparts (8.4% per year) [47].

In Taiwan, a population-based nutritional survey revealed that 24.5% of the male and 25.2% of the female adults in Taiwan were obese, and this prevalence was particularly high (men: 36.6%; women: 44.6%) among those aged 45–64 years [48]. A cross-sectional study in Taiwan (2002–2003) reported a significant upward trend of body mass index (BMI) of Taiwanese people. The obese Taiwanese are at increased risk of developing diabetes [48]. This finding was consistent with the reports from two large-scale studies (Nutrition and Health Survey in Taiwan 1993–1996, and Cardiovascular Disease Risk Factor Two-township Study 1994–1997) which stated that age-adjusted relative risk of diabetes were higher for people with increased BMI (BMI above 75th percentile) [49].

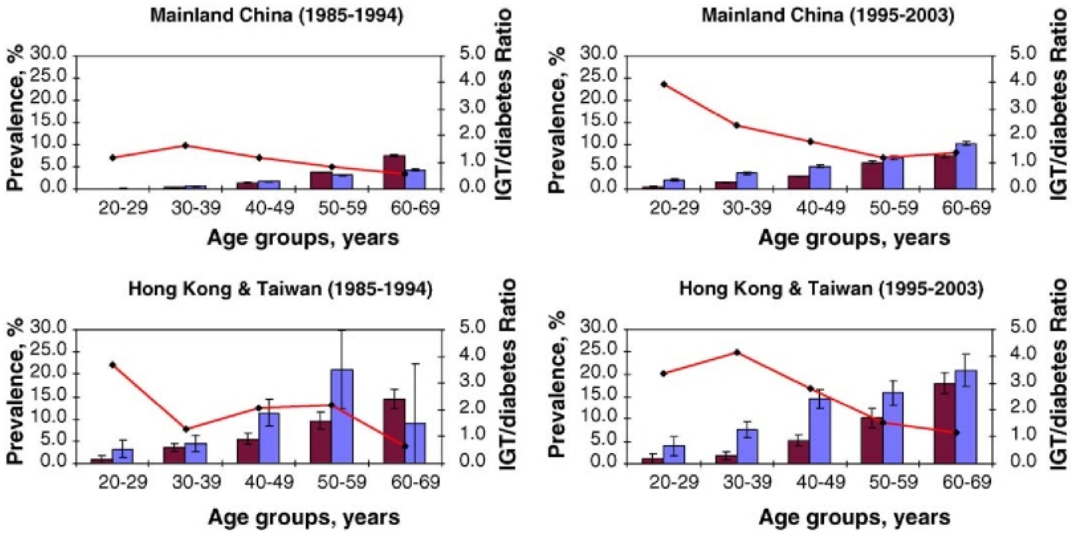

Fig. 2. Consolidated prevalence rates of diabetes and IGT, and IGT/diabetes ratio of the Chinese populations in Mainland China, Hong Kong and Taiwan based on studies that applied OGTT and WHO, 1985 criteria. Red bar: diabetes; blue bar: impaired glucose tolerance; 95% confidence intervals overlay on the bars. Red line: IGT/diabetes ratio. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

Within Mainland China, there is an upward trend in the prevalence of diabetes when the prevalence rates are compared between the time intervals (1985–1994 and 1995–2003) for the same age groups (Fig. 1 and Fig. 2). This upward trend can be addressed from aspects such as change of diagnostic criteria, urbanisation, and change of lifestyle (such as diet and physical activity) within Mainland China. With reference to the WHO, 1985 criteria, WHO, 1999 criteria may over-estimate prevalence rates by 0.7–1.4%, and ADA, 1997 criteria may under-estimate the rates by 2.1–2.4% [50] and [51] (Table 1). With omission of 2 h plasma glucose after a glucose challenge, fewer people will be diagnosed with diabetes. For an instance, a study in Hong Kong reported that the prevalence of diabetes (WHO, 1985 criteria) was reduced by half when ADA, 1997 criteria was applied by using fasting plasma glucose alone [52]. Hence, we calculated the odds ratio stratified by diagnostic criteria. Using the same diagnostic criteria and the same time period, the prevalence rates of diabetes were higher in Hong Kong and Taiwan (Table 3). There seems to be a catch up trend in the prevalence of diabetes in Mainland China. Using identical diagnostic criteria (WHO, 1985), we found that a 33% increase in diabetes risk from 1985–1994 to 1995–2003 periods in Mainland China while only 15% in Hong Kong and Taiwan combined.

The recent study of 31 provinces in Mainland China in 2000–2001 reported that the age-standardised prevalence of diabetes was 1.5-fold higher among urban residents (7.8%) as compared to rural residents (5.1%) ($p < 0.001$) [53]. Similarly, in 2002, a study on the prevalence of diabetes in urban and rural Chinese populations in Qingdao (Mainland China)

reported higher prevalence of diabetes in the urban versus rural areas, i.e. 6.9% versus 5.6% ($p < 0.001$) [29]. In a cosmopolitan city such as Shanghai in Mainland China, the lifestyle of the Chinese has changed markedly as a result of less physical activity and abundant food [54]. A study of dietary transition in China during the past 50 years based on data collected from the representative national surveys, i.e. China Health and Nutrition Survey (1989–1997) and China National Nutrition Survey (1982 and 1992) reported a trend that is shifting towards a high-fat, high-energy-density and low-fibre diet [55]. A national study in Mainland China reported that participation in moderate or vigorous leisure-time physical activity was low, being 7.9% and 28.9%, among urban and rural Chinese in Mainland China, respectively [56]. The age-standardised prevalence of overweight (BMI ≥ 25 kg/m^2) was 26.9% (95% confidence intervals: 25.7–28.1%) in men and 31.1% (95% confidence intervals: 29.7–32.5%) in women [45]. This could have attributed to the upward trend of the prevalence of diabetes because overweight has been associated with increased risk of diabetes [57]. Another example is DaQing, which is an industrial city in Mainland China. A study comparing the prevalence rates in 1986 and 1994 showed that the standardised prevalence rates of diabetes were 1.04% and 3.51%, respectively, which showed a 3.4 times increase in an interval of 8 years [58].

The higher prevalence of diabetes in the older age groups of Chinese populations may raise concern in aging populations, as this will add greater burden to the healthcare cost. On the other hand, the prevalence rates of diabetes of the younger age groups (i.e. 20–29 and 30–39 years) are relatively low, but the IGT/diabetes ratios are high in these groups (Fig. 2). There is higher risk for individuals with impaired glucose tolerance to progress to diabetes. The progression rates from IGT to diabetes are approximately 8.8% per year (95% confidence interval 6.3–11.3%) [59]. Hence, many of the current cohorts of younger populations will become diabetic patients if their IGT is undiagnosed and/or uncontrolled.

Two out of three diabetic patients in Mainland China and half of the Chinese diabetic patients in Hong Kong and Taiwan remain undiagnosed. Diabetic patients are prone to various complications such as stroke, heart failure, acute myocardial infarction, nephropathy, and retinopathy [60] and [61]. Like diagnosed diabetic patients, the undiagnosed diabetic individuals are experiencing risk of coronary heart disease about twice that for non-diabetic individuals and significantly higher mortality rate, i.e. 23% as compared to 9% in non-diabetic individuals [61].

Chinese populations are huge in and outside Mainland China. Within Mainland China, the population is estimated to reach 1.38 billion in the year 2023 [62]. Hence, increase in prevalence of diabetes will result in tremendous rise in healthcare costs in treatment, hospitalisations and management of complications associated with diabetes [63] and [64]. In Taiwan, healthcare cost for diabetic patients accounted for 13% of the National Health Insurance cost in 1999 [65]. As compared to non-diabetic patients, the diabetic patients incurred 3.5 times more inpatient costs due to their more frequent hospitalisation and longer hospital stay [66]. Impact of diabetes on healthcare cost was reflected in reports published in other countries as well. In Mexico, the average annual cost per diabetic patient was 708 American dollars resulted in a 15.5% of the total health spending in a population with a prevalence rate of diabetes of 7.2% in 1993 [67]. In the United States of America, the healthcare cost of diabetes accounted for 14.6% of the total health spending (105 billion American dollars) with a prevalence rate of diabetes of 4.5% in 1992 [68]. Approximately half of the expenditures were for treatment of diabetes and half for treatment of the complications of diabetes [69]. Hence, the burden in healthcare costs will be greater if diabetes is undiagnosed and/or uncontrolled as complications will develop.

Some limitations of this review are illustrated as follows. The percentages of undiagnosed diabetes were computed based on the limited numbers of studies that provided primary data on undiagnosed diabetes. In categorising age-ranges, a problem was faced with age-range such as 25–34 years because it somehow overlapped with 20–29 and 30–39 years age groups. Hence, pooling of age groups was applied, i.e. data for 25–34 years group was pooled into 30–39 years; 35–44 years group was pooled into 40–49 years, etc. This pooling method led to discrepancy in categorisation in five studies [15], [16], [17], [27] and [34],

which was assumed to be negligible in comparing the trends and differences of the prevalence rates.

5. Conclusion

Despite the limitations, this review provides consolidated information about the overall trends of prevalence of diabetes and IGT, and significance of undiagnosed diabetes of the Chinese populations in Mainland China, Hong Kong, and Taiwan. The findings may reflect some potential effects of urbanisation and lifestyle (such as lack of physical activity and high-fat diet) on prevalence of diabetes. This information is useful for public health planning and health promotion such as diabetes screening, management and education.

Chinese people in Mainland China are currently experiencing an upward trend in the prevalence of diabetes. They have not reached the level of Chinese people living in developed regions. With economic advancement, change toward urbanised lifestyle (i.e. lack of physical activity and increase caloric intake), and the consequent increase in obesity; there will be potential increase in the prevalence of diabetes in the Chinese population. The high proportions of diabetic patients are undiagnosed should raise the awareness for intervention to curb the undesirable upward trend. If there are no early diagnosis and intervention strategies for diabetes and IGT, tremendous increase in burdens caused by diabetes will ensue.

Acknowledgement

This work was partly supported by the Colonial Foundation Trust (Australia) and the University of Queensland.

References

1. H. King, R.E. Aubert and W.H. Herman, Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections, *Diabetes Care* (1998), pp. 1414–1431.
2. A. Boutayeb and S. Boutayeb, The burden of non-communicable diseases in developing countries, *Int. J. Equity Health* (2005), p. 2.
3. M. Schooling *et al.*, Childhood migration and cardiovascular risk, *Int. J. Epidemiol.* (2004), pp. 1219–1226.
4. World Health Organisation, Diabetes Mellitus: Report of a WHO Study Group, Geneva, World Health Org., 1985 (Tech. Rep. Ser., no. 727).
5. World Health Organization, Definition, Diagnosis and Classification of Diabete Mellitus and its Complications, Report of a WHO Consultation. Part 1. Diagnosis and Classification of Diabetes Mellitus, Geneva, Department of Noncommunicable Disease Surveillance, 1999.
6. Report of the expert committee on the diagnosis and classification of diabetes mellitus, *Diabetes Care* 20 (1997) (7), pp. 1183–1197.
7. StataCorp, Stata Statistical Software: Release 8.0, *College Station*, Stata Corporation, TX (2003).
8. Shanghai Diabetes Research Cooperative Group, Diabetes mellitus survey in Shanghai, *Chin. Med. J. (Engl.)* 93 (1980) (10), pp. 663–672.
9. National Diabetes Research Cooperative Group, A mass survey of diabetes mellitus in a population of 300,000 in 14 provinces and municipalities in China (author's transl), *Zhonghua Nei Ke Za Zhi* 20 (1981) (11), pp. 678–683.
10. Beijing Diabetes Survey Cooperative Group, Zhonghua Nei Ka Za Zhi. [the incidence of diabetes mellitus in 40000 population in Beijing with discussion on difference criteria of its diagnosis], *Chin. J. Int. Med.* 21 (1982) (2), pp. 85–87.
11. X.L. Zhong, Diabetes mellitus survey in China, *Chin. Med. J. (Engl.)* 95 (1982) (6), pp. 423–430.
12. G. Li, Y. Hu and X. Pan, Prevalence and incidence of NIDDM in Daqing City, *Chin. Med. J. (Engl.)* 109 (1996) (8), pp. 599–602.
13. C. Pan, J. Lu and H. Tian, Epidemiology of adult diabetes mellitus in a population of Capital Iron and Steel Company in Beijing, *Zhonghua Yi Xue Za Zhi* 75 (1995) (7) pp. 409–413, 446.
14. C.Y. Pan *et al.*, Study of the prevalence of diabetes mellitus in adults in the Shougang Corporation in Beijing, *Diabet. Med.* 13 (1996) (7), pp. 663–668.
15. X.R. Pan *et al.*, Prevalence of diabetes and its risk factors in China. National Diabetes Prevention and Control Cooperative Group, *Diabetes Care* 20 (1997) (11), pp. 1664–1669.

16. H.L. Shi, J.C. Fang and X.X. Zhu, Prevalence of diabetes mellitus and associated risk factors in an adult urban population in Shanghai, *Diabetes Metab.* 24 (1998) (6), pp. 539–542.
17. Z.Z. Wang *et al.*, The prevalence of NIDDM and IGT and related factors among residents in some areas of Hubei province, *China Biomed. Environ. Sci.* 13 (2000) (2), pp. 148–153.
18. Y. Duan, H. Luo and Z. Zhou, The prevalence of hypertension, diabetes mellitus and hyperlipemia among 1369 subjects for physical examination in Changsha, *Hunan Yi Ke Da Xue Xue Bao* 22 (1997) (5), pp. 407–410.
19. J. Peng *et al.*, Epidemiological feature on diabetes mellitus among permanent inhabitant in the Special Economic Zone of Shenzhen, *Zhonghua Liu Xing Bing Xue Za Zhi* 21 (2000) (2), pp. 114–116.
20. G. Jia, J. Zhang and L. Sun, A survey on diabetes mellitus in the staff of electric power system in Baotou city, *Zhonghua Liu Xing Bing Xue Za Zhi* 19 (1998) (4), pp. 205–207.
21. K. Wang, T. Li and H. Xiang, Study on the epidemiological characteristics of diabetes mellitus and IGT in China, *Zhonghua Liu Xing Bing Xue Za Zhi* 19 (1998) (5), pp. 282–285.
22. Q. Qiao *et al.*, Age- and sex-specific prevalence of diabetes and impaired glucose regulation in 11 Asian cohorts, *Diabetes Care* 26 (2003) (6), pp. 1770–1780.
23. Q. Qiao *et al.*, Comparison of the fasting and the 2-h glucose criteria for diabetes in different Asian cohorts, *Diabetologia* 43 (2000) (12), pp. 1470–1475.
24. Z. Yang, A survey of diabetes prevalence in the middle-aged and elderly Chinese from 12 areas of China, *Chin. J. Endocrinol. Metab.* 18 (2002) (4), pp. 280–284.
25. W.P. Jia *et al.*, Epidemiological study on obesity and its comorbidities in urban Chinese older than 20 years of age in Shanghai, *China. Obes. Rev.* 3 (2002) (3), pp. 157–165.
26. F.Y. Shi *et al.*, An epidemiologic study of diabetes mellitus in employees of Baotou Iron & Steel Company, *Zhonghua Yu Fang Yi Xue Za Zhi* 37 (2003) (5), pp. 361–364.
27. D. Gu *et al.*, Prevalence of diabetes and impaired fasting glucose in the Chinese adult population: International Collaborative Study of Cardiovascular Disease in Asia (InterASIA), *Diabetologia* 46 (2003) (9), pp. 1190–1198.
28. S.H. Zhang *et al.*, The clinical characteristics and its relationship with metabolic syndrome in elderly subjects with impaired glucose regulation, *Zhonghua Yi Xue Za Zhi* 83 (2003) (22), pp. 1957–1961.
29. Y. Dong *et al.*, Prevalence of type 2 diabetes in urban and rural Chinese populations in Qingdao, *China Diabet. Med.* 22 (2005) (10), pp. 1427–1433.
30. W.M. Xu *et al.*, Epidemiologic characters of diabetic mellitus in urban and rural community in 2003 in Hangzhou City, *Zhonghua Liu Xing Bing Xue Za Zhi* 25 (2004) (8), p. 729.
31. J. Woo *et al.*, The prevalence of diabetes mellitus and an assessment of methods of detection among a community of elderly Chinese in Hong Kong, *Diabetologia* 30 (1987) (11), pp. 863–868.
32. C.S. Cockram *et al.*, The prevalence of diabetes mellitus and impaired glucose tolerance among Hong Kong Chinese adults of working age, *Diabetes Res. Clin. Pract.* 21 (1993) (1), pp. 67–73.
33. A.W.C. Kung, E.D. Janus and C. Lau, The prevalence of diabetes mellitus and its effect in elderly subjects in Hong Kong, *Hong Kong Med. J.* 2 (1996) (1), pp. 26–33.
34. T.H. Lam *et al.*, Fibrinogen, other cardiovascular risk factors and diabetes mellitus in Hong Kong: a community with high prevalence of type 2 diabetes mellitus and impaired glucose tolerance, *Diabet. Med.* 17 (2000) (11), pp. 798–806.
35. K.W. Wu and T.H. Wei, The prevalence rate of diabetes mellitus in a group aged 40-69 in Taipei City 1985, *Taiwan Yi Xue Hui Za Zhi* 85 (1986) (11), pp. 1069–1077.
36. P. Chou, H.H. Chen and K.J. Hsiao, Community-based epidemiological study on diabetes in Pu–Li, *Taiwan Diabetes Care* 15 (1992) (1), pp. 81–89.
37. N.P. Yang, S.Y. Lee and P. Chou, Community-based epidemiological study on hypertension and diabetes—community-based preventive medicine by Yang-Ming Crusade in 1989, *Zhonghua Yi Xue Za Zhi (Taipei)* 46 (1990) (3), pp. 134–146.
38. J.D. Lin *et al.*, Diabetes mellitus and hypertension based on the family history and 2-h postprandial blood sugar in the Ann-Lo district (northern Taiwan), *Diabetes Res. Clin. Pract.* 20 (1993) (1), pp. 75–85.
39. P. Chou *et al.*, A population survey on the prevalence of diabetes in Kin-Hu, *Kinmen Diabetes Care* 17 (1994) (9), pp. 1055–1058.
40. H.D. Chen *et al.*, Prevalence of diabetes mellitus and impaired glucose tolerance in Aborigines and Chinese in eastern Taiwan, *Diabetes Res. Clin. Pract.* 38 (1997) (3), pp. 199–205.
41. K.T. Chen *et al.*, High prevalence of impaired fasting glucose and type 2 diabetes mellitus in Penghu Islets. Taiwan: evidence of a rapidly emerging epidemic?, *Diabetes Res. Clin. Pract.* 44 (1999) (1), pp. 59–69.
42. D.M. Wu *et al.*, Prevalence and clustering of cardiovascular risk factors among healthy adults in a Chinese population: the MJ Health Screening Center Study in Taiwan, *Int. J. Obes. Relat. Metab. Disord.* 25 (2001) (8), pp. 1189–1195.
43. F.H. Lu *et al.*, A population-based study of the prevalence and associated factors of diabetes mellitus in southern Taiwan, *Diabet. Med.* 15 (1998) (7), pp. 564–572.

44. K.T. Chen *et al.*, Prevalence of type 2 diabetes mellitus in Taiwan: ethnic variation and risk factors, *Diabetes Res. Clin. Pract.* 51 (2001) (1), pp. 59–66.
45. D. Gu *et al.*, Prevalence of the metabolic syndrome and overweight among adults in China, *Lancet* 365 (2005) (9468), pp. 1398–1405.
46. Z.S. Lee *et al.*, Obesity and cardiovascular risk factors in Hong Kong Chinese, *Obes. Rev.* 3 (2002) (3), pp. 173–182.
47. T.C. Gary, J.C.C. Ko, C.-C. Chow, V.T.F. Yeung, W.-B. Chan, W.-Y. So and C.S. Cockram, Effects of obesity on the conversion from normal glucose tolerance to diabetes in Hong Kong Chinese, *Obes. Res.* 13 (2004) (6), pp. 889–895.
48. W.L. Tsai *et al.*, Impact of obesity on medical problems and quality of life in Taiwan, *Am. J. Epidemiol.* 160 (2004) (6), pp. 557–565.
49. W.T. Yeh *et al.*, Do centrally obese Chinese with normal BMI have increased risk of metabolic disorders?, *Int. J. Obes. (Lond.)* 29 (2005) (7), pp. 818–825.
50. M.M. Gabir *et al.*, The 1997 American Diabetes Association and 1999 World Health Organization criteria for hyperglycemia in the diagnosis and prediction of diabetes, *Diabetes Care* (2000), pp. 1108–1112.
51. P. Botas *et al.*, Comparison of the diagnostic criteria for diabetes mellitus, WHO-1985, ADA-1997 and WHO-1999 in the adult population of Asturias (Spain), *Diabet. Med.* (2003), pp. 904–908.
52. G.T. Ko *et al.*, Use of the 1997 American Diabetes Association diagnostic criteria for diabetes in a Hong Kong Chinese population, *Diabetes Care* 21 (1998) (12), pp. 2094–2097.
53. D. Gu *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), pp. 1190–1198.
54. W.P. Jia *et al.*, Epidemiological study on obesity and its comorbidities in urban Chinese older than 20 years of age in Shanghai, China, *Obes. Rev.* (2002), pp. 157–165.
55. S. Du *et al.*, A new stage of the nutrition transition in China, *Public Health Nutr.* (2002), pp. 169–174.
56. P. Muntner *et al.*, Prevalence of physical activity among Chinese adults: results from the International Collaborative Study of Cardiovascular Disease in Asia, *Am. J. Public Health* 95 (2005) (9), pp. 1631–1636.
57. B.F. Zhou, Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases—report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults, *Biomed. Environ. Sci.* 15 (2002) (3), pp. 245–252.
58. P. Bennett, G. Li and X. Pan, China. In: J.-M. Ekoe, P. Zimmet and R. Williams, Editors, *The Epidemiology of Diabetes Mellitus, An International Perspective* (1st ed.), John Wiley (2001), pp. 247–251.
59. P. Chou *et al.*, Progression to type 2 diabetes among high-risk groups, Kin-Chen, Kinmen. Exploring the natural history of type 2 diabetes, *Diabetes Care* (1998), pp. 1183–1187.
60. J.C. Chan and C.S. Cockram, Diabetes in the Chinese population and its implications for health care, *Diabetes Care* (1997), pp. 1785–1790.
61. M.I. Harris, Undiagnosed NIDDM: clinical and public health issues, *Diabetes Care* (1993), pp. 642–652.
62. Y. Hu, A prediction of the trend of population development in urban and rural areas in China, *Chin. J. Popul. Sci.* (1998), pp. 75–87.
63. J.C. Chan *et al.*, Diabetes mellitus—a special medical challenge from a Chinese perspective, *Diabetes Res. Clin. Pract.* (2001), pp. S19–S27.
64. T.J. Songer, The economic costs of NIDDM, *Diabetes Metab. Rev.* (1992), pp. 389–404.
65. T. Lin *et al.*, Predicting factors associated with costs of diabetic patients in Taiwan, *Diabetes Res. Clin. Pract.* 63 (2004) (2), pp. 119–125.
66. W.C. Yang *et al.*, The impact of diabetes on economic costs in dialysis patients: experiences in Taiwan, *Diabetes Res. Clin. Pract.* 54 (2001) (Suppl. 1), pp. S47–S54.
67. E. Villarreal-Rios *et al.*, The cost of diabetes mellitus and its impact on health spending in Mexico, *Arch. Med. Res.* (2000), pp. 511–514.
68. R.J. Rubin, W.M. Altman and D.N. Mendelson, Health care expenditures for people with diabetes mellitus, *J. Clin. Endocrinol. Metab.* (1994), pp. 809A–809F.
69. W.H. Herman *et al.*, The cost-effectiveness of intensive therapy for diabetes mellitus, *Endocrinol. Metab. Clin. North Am.* (1997), pp. 679–695.