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REVIEW

Epidemiology of diabetes and diabetic complications in China

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Abstract

The People's Republic of China (herein referred to as China) has witnessed one of the most dramatic rises in diabetes prevalence anywhere in the world. The latest epidemiological study suggests that approximately 11% of the population has diabetes, with a significant proportion remaining undiagnosed. Risk factors for diabetes in the Chinese population are similar to those in other populations, though gestational diabetes and young-onset diabetes is becoming increasingly common. Data on the prevalence of diabetic complications remain limited, though cardio–renal complications account for significant morbidity and mortality. Other diabetes-related comorbidities are becoming increasingly common, with cancer emerging as a major cause of mortality among individuals with diabetes. There are many challenges and obstacles that impede effective diabetes prevention and the delivery of care, though much progress has occurred over recent years. Lessons learnt from how China has responded to the challenges posed by the diabetes epidemic will be invaluable for other countries facing the many threats of diabetes and its complications.

Keywords China · Coronary heart disease · Diabetes · Diabetic kidney disease · Epidemiology · Genetics · Gestational diabetes · Obesity · Review · Risk factors

Abbreviations

ADVANCE	Action in Diabetes and Vascular Disease
CKB	China Kadoorie Biobank
CKD	Chronic kidney disease
GDM	Gestational diabetes mellitus
HKDR	Hong Kong Diabetes Registry
IADPSG	International Association of the Diabetes and Pregnancy Study Groups
JADE	Joint Asia Diabetes Evaluation
NCD	Non-communicable disease
RMB	Renminbi

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Introduction

The global epidemic of diabetes currently affects more than 440 million individuals. The Asia Pacific region has the largest number of people with diabetes and the prevalence of diabetes has risen dramatically in this region over recent decades [1, 2]. The People's Republic of China (herein referred to as China), with a population of 1.38 billion people and with an estimated 110 million affected by diabetes, currently has the largest number of individuals affected by diabetes of any country. Given the phase of the epidemic, it is likely to see further increases in diabetes prevalence, giving rise to a tremendous burden on the healthcare system. The challenge that diabetes poses to China is considered one of the most significant examples anywhere in the world.

Epidemiology of diabetes in China

Secular trends in prevalence China has witnessed one of the most dramatic rises in diabetes prevalence anywhere in the world. While prevalence was reported to be around less than 1% in the 1980s, a series of large, well-conducted population surveys over the last few years has documented a dramatic increase in prevalence to 9–12%, depending on the exact criteria used [3–5] (Fig. 1 and Table 1). In the latest study, conducted in 2013 and including 170,287 participants, the prevalence of diabetes was reported to be 10.9%, of which over 60% were unaware of their diagnosis [5]. In addition, another 35.7% of the population was found to have abnormal glucose homeostasis, highlighting the large population of people at risk of developing diabetes [5].

The marked increase in diabetes prevalence is mostly attributed to type 2 diabetes. It is estimated that type 1 diabetes accounts for less than 5% of diabetes cases in China [10]. Nevertheless, it is worth noting that there has been a gradual increase in the prevalence of type 1 diabetes in China and other developing countries [11, 12]. Between 1995 and 2010, the incidence of type 1 diabetes among children aged <15 years has increased by approximately 4.4% per year, with the mean age-standardised incidence rate being 1.7 per 100,000 person-years during this period [11]. This increase in type 1 diabetes is particularly problematic in China, where a diagnosis of type 1 diabetes may be associated with significant social stigma [13]. A recent large multicentre study has highlighted the marked variation in access to and delivery of care for patients with type 1 diabetes in China [14].

Risk factors for diabetes Multiple factors have contributed to the dramatic rise in prevalence of type 2 diabetes in China. Major established risk factors include obesity, family history and diet (Table 2), as reported in western populations [15]. Several large cohorts have helped to provide insights into the epidemiology and risk factors of diabetes in China (Table 2). For example, in the large China Kadoorie Biobank (CKB) study, higher fruit consumption was found to be associated with a lower incidence of diabetes, as well as lower risk of major vascular complications among those diagnosed with diabetes [16].

Another emerging issue is the importance of developmental origins of diabetes and early life exposures [20]. Different studies have highlighted the increased risk of diabetes among offspring who were exposed to undernutrition in utero but exposed to overnutrition later in life. This was highlighted in a study of fetal exposure to the severe Chinese famine [21], whereby adults who had been exposed to famine in utero had an approximately fourfold increased risk of hyperglycaemia in adulthood; this risk was further increased in individuals who adopted an affluent/western dietary pattern. In line with this, there is significant geographical variation in the prevalence of diabetes in China. For example, compared with minority ethnic groups, Han Chinese are at significantly higher risk [5].

There is also growing recognition of the increased risk of obesity and glucose intolerance among offspring of mothers with pre-existing diabetes, gestational diabetes mellitus (GDM) or maternal obesity, highlighting the intergenerational effects of maternal hyperglycaemia [20, 22]. For example, maternal GDM (diagnosed according to International Association

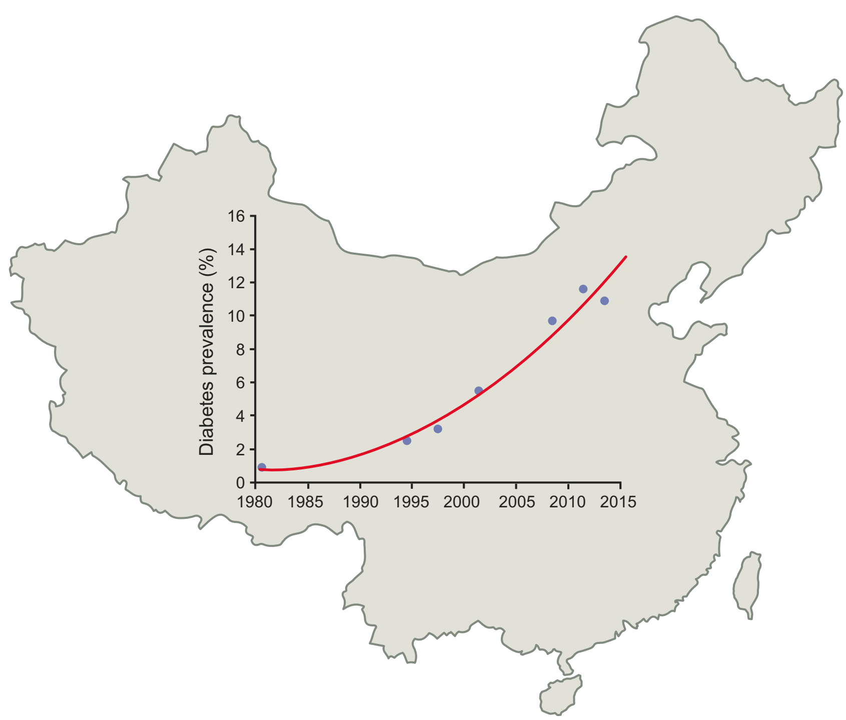

Fig. 1 Prevalence of diabetes in China over recent decades. For data sources please refer to Table 1. This figure is available as part of a downloadable slideset

Table 1 Prevalence data reported by major epidemiological studies of diabetes in China

Study year and reference	Participants (N)	Sampling characteristics	Diagnostic criteria for diabetes	Prevalence reported	Proportion undiagnosed	Prevalence of prediabetes[a]
1980 [6]	~300,000	14 provinces; all age groups		0.9%	–	0.8% (IGT only)
1994 [7]	213,515	Age 25–64 years	Self-reported diabetes, fasting PG ≥7.8 mmol/l or 2 h PG ≥11.1 mmol/l	2.5%	–	3.2(IGT only)
1995–1997 [8]	42,751	11 provinces/regions; age 20–74 years		3.2%	–	4.8% (IGT only)
2001 [9]	15,838	Nationally representative stratified sampling; ten provinces; age 35–74 years	FPG ≥7.0 mmol/l or 2 h PG ≥11.1 mmol/l	5.5%	76%	7.3% (IFG only)
2007–2008 [3]	46,239	14 provinces/municipalities, (urban and/ rural); age ≥20 years	FPG ≥7.0 mmol/l or 2 h PG ≥11.1 mmol/l	9.7%	58.7%	15.5%
2010 [4]	98,658	Complex, multistage probability sampling design; 31 provinces; age ≥18 years	FPG ≥7.0 mmol/l, 2 h PG ≥11.1 mmol/l or HbA_{1c} ≥47.5 mmol/mol (6.5%)	11.6%	69.9%	50.1%
2013 [5]	170,287	Complex, multistage probability sampling design; 1176 rural townships/urban subdistricts; age ≥18 years; mean BMI, 24.0 kg/m^2	FPG ≥7.0 mmol/l, 2 h PG ≥11.1 mmol or HbA_{1c} ≥47.5 mmol/mol (6.5%)	10.9%	63.5%	35.7%

[a] Prediabetes was defined as impaired glucose tolerance and/or impaired fasting glucose

FPG, fasting plasma glucose; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; PG plasma glucose

of the Diabetes and Pregnancy Study Groups [IADPSG]/WHO 2013 criteria) was associated with an approximately twofold higher risk of childhood obesity among Chinese children aged 7 years [23]. The prevalence of GDM in Tianjin in 2012 was 8.1% according to the WHO 1999 criteria (and 9.3% according to the IADPSG/WHO 2013 criteria), which represented a 3.5-fold increase compared with figures from 1999 [24]. Given the markedly increased prevalence of GDM, the contribution of maternal hyperglycaemia to the epidemic of diabetes and non-communicable disease (NCD) is increasing and the need to address these early-life exposures becomes ever more pressing [22].

Another important issue is the increasing prevalence of young-onset diabetes in China. In the Joint Asia Diabetes Evaluation (JADE) programme, approximately 20% of individuals with diabetes in China, as well as in the rest of Asia, are now diagnosed before the age of 40 years [25]. Furthermore, in general, individuals with diabetes onset before 40 years of age had worse glycaemic control, were less likely to achieve HbA_{1c} and LDL treatment goals, had higher prevalence of retinopathy, and were less likely to receive organ-protective drugs, such as statins and renin–angiotensin system inhibitors [25]. Given the adverse long-term prognosis of individuals with young-onset diabetes [26–28], this trend of suboptimal control among those with early-onset disease is particularly alarming. Furthermore, the increasing prevalence of young-onset diabetes results in an increasing proportion of men and women at reproductive age being affected by hyperglycaemia, with potential intergenerational effects [20, 22].

Pathophysiology Chinese individuals develop diabetes at a lower BMI than those from western populations, suggesting that the relationship between BMI and adiposity may differ between populations and that Asians have a higher percentage of body fat at the same BMI compared with Europeans [15, 29, 30]. Further, almost 50% of individuals with undiagnosed diabetes have isolated postprandial hyperglycaemia [3]. In the Shanghai Diabetes Study, postprandial hyperglycaemia was a strong predictor of incident diabetes [31]. Beta cell dysfunction has also been shown to be a major determinant of type 2 diabetes risk in Chinese and other East Asian populations [30]. One of the most important risk factors for diabetes, however, is a positive family history of the disease; although fewer genetic factors have been identified so far in Chinese and other East Asian populations than in European populations. This is mainly owing to the limited sample sizes of studies conducted in East Asian populations to date [15, 32].

Epidemiology of diabetic complications in China

Ethnic variation Multi-ethnic studies have highlighted a difference in the pattern of complications according to geographical regions or ethnicity. In the landmark WHO Multinational Study

Table 2 Examples of major longitudinal cohorts investigating risk factors for diabetes in China

Study	Year	Region of recruitment	Participants (*N*)	Mean age (years)	Diabetes prevalence	T2D risk factors identified	Follow-up duration	Genetics studies
CHNS [17][a]	1989, 1991, 1993, 1997, 2000, 2004, 2006	15 provinces	30,000	–	–	Weight gain, dietary pattern	–	DNA stored from 2009
China National Diabetes and Metabolic Disorders Study [3]	2007–2008	152 urban districts/112 rural villages	46,239 (40.0% male)	~50	9.7%	Male sex, age, family history of diabetes, less than college education, overweight, obesity, central obesity, increased heart rate, raised SBP, raised TG, urban residence	–	Yes
REACTION study [18]	2010–2012	12 rural/13 urban centres, stratified sampling	259,657 (34.4% male)	57.4 ± 9.6	21.4%	Depression, early adulthood weight gain	5 years to date, ongoing	Yes (ongoing)
GBCS [19][b]	2003–2008 baseline; 2008–2012 follow-up	Guangzhou, China	30,519 (27.6% male)	64	12.5%	Central adiposity, reduced physical activity, low muscle mass, napping, elevated liver enzymes	4 years	Yes
CKB Study [16][c]	2004–2008	Ten geographically defined regions in China	512,891 (41% male)	52	5.2%	BMI, waist circumference, waist:hip ratio, body fat %, major depression, generalised anxiety disorder, short and long sleep duration, low fresh fruit intake	9 years to date (ongoing)	Yes (ongoing)

[a] For further details, see www.cpc.unc.edu/projects/china (accessed 2 August 2017)

[b] For further details, see www.birmingham.ac.uk/research/activity/mds/projects/HaPS/PHEB/Guangzhou/index.aspx (accessed 2 August 2017)

[c] For further details, see www.ckbiobank.org/site/ (accessed 2 August 2017)

CHNS, China Health and Nutrition Survey; GBCS, Guangzhou Biobank Cohort Study; REACTION study, Risk Evaluation of cAncers in Chinese diabeTic Individuals: a lONgitudinal study; SBP, systolic BP; T2D, type 2 diabetes; TG, triacylglycerols of Vascular Disease in Diabetes (WHO MSVDD), conducted in the 1980s, it was noted that individuals with diabetes in China and Hong Kong had significantly higher risk of diabetic nephropathy than individuals from Europe, apparently independent of the effect of hypertension [33, 34]. Furthermore, a comparatively low frequency of macrovascular disease in Chinese individuals with diabetes was confirmed in the follow-up study of incident complications [34, 35]. Subsequent studies in other multi-ethnic populations have highlighted the increased risk of diabetic nephropathy and stroke among Chinese individuals with diabetes. For example, in the Action in Diabetes and Vascular Disease (ADVANCE) study, incident nephropathy was found to be significantly higher in East Asian participants recruited from China compared with participants recruited from Australia or Europe [36]. Furthermore, over 40% of individuals listed in the Hong Kong Diabetes Registry (HKDR) had microalbuminuria or macroalbuminuria at baseline, while around 15% had chronic kidney disease (CKD; eGFR <60 ml min^{-1} $[1.73\ \text{m}]^{-2}$) (Table 3).

Frequency of diabetic complications More recent data, for example, from the Hong Kong Diabetes Biobank, have reported a similar prevalence of diabetic complications (Table 3). Notably, an analysis of secular trends in risk factor control and complication rates over the last two decades in individuals treated in public hospitals and clinics in Hong Kong demonstrated significant improvements in metabolic control over the study period and a reduction in rates of cardiovascular and renal complications in recent years [39]. This finding highlights that systematic screening for diabetes complications and structured care delivery, both of which have been systematically adopted and implemented in diabetes centres in Hong Kong, are associated with improved outcomes for people with diabetes [29, 37, 39].

There are few large-scale studies on the prevalence of diabetic complications that have been conducted in mainland China. In a cross-sectional study of 1542 individuals with type 2 diabetes, more than 50% had at least one chronic diabetes complication, with the prevalence of cardiovascular and cerebrovascular complications being 30.1% and 6.8%, respectively, and neuropathy, nephropathy, eye problems and foot disease being 17.8%, 10.7%, 14.8% and 0.8%, respectively [43]. In the Shanghai Diabetes Complication Study (SHDCS), among 930 participants with type 2 diabetes (mean duration of disease, 7.4 years), the frequency of albuminuria was 26.2% (microalbuminuria 22.8%, macroalbuminuria 3.4%) [44]. Similar findings were reported in another study from Shanghai; in a group of 1018 individuals with type 2 diabetes (mean age, 66.1 years; mean duration of diabetes, 7.9 ± 7.2 years), the frequency of microalbuminuria was 41.4% and of macroalbuminuria was 8.2% [45]. In a recent population-based study in Shanghai, prevalence of CKD was reported to be 30.9% among individuals with diabetes, with dysglycaemia and hypertension being the main determinants of CKD [46]. In terms of macrovascular complications, it is worth noting that in the ADVANCE study, participants recruited from China had lower incident cardiovascular complications than those from Europe and Australia but had higher incident cerebrovascular events [36]. The frequency of complications and target attainment reported in other large studies from China are shown in Table 3. However, it is important to highlight that using hospital-based cohorts, such as those included in Table 3 (compared with population-based cohorts), to assess the frequency of complications has several limitations, including potential selection bias of participants.

Other diabetes outcomes Other comorbidities are emerging as important healthcare problems associated with diabetes. For example, numerous studies have reported the increased risk of malignancy in individuals with type 1 diabetes or type 2 diabetes, especially hepatocellular carcinoma, colorectal carcinoma, pancreatic cancer, lung cancer and breast cancer. Earlier studies reported that Chinese individuals with type 2 diabetes have an approximately 30% increased risk of all-site cancers [47] and subsequent studies have confirmed this relationship [48, 49]. The large Risk Evaluation of cAncers in Chinese DiabeTic Individuals: a lONgitudinal (REACTION) study was initiated to specifically characterise risk factors associated with increased cancer risk in people with diabetes [50]. This tremendous endeavour, including more than 280,000 individuals recruited across 25 local communities, aims to follow-up this group of high-risk adults (20.9% with diabetes and 25.0% with impaired glucose tolerance or impaired fasting glucose) for incident cancer development. Of note, with better control of metabolic risk factors, malignancy is emerging as an increasingly important cause of death among people with diabetes, accounting for 20% of deaths in the HKDR [37, 51] and the CKB [49].

Another comorbidity that is increasingly being linked to diabetes includes depression, with which diabetes has a bi-directional relationship. In a cross-sectional study involving 2538 participants from four cities across China, 6.1% had depression (diagnosed using the Patient Health Questionnaire-9 [PHQ-9]). Importantly, those with depression had worse glycaemic control and were less likely to achieve glycaemic targets (seemingly partly mediated by suboptimal treatment compliance) [52].

Diabetes is also associated with dementia and accelerates the progression from mild cognitive impairment to dementia by around 3 years [53]. Duration of diabetes and glycaemic control are associated with increased risk of progression to dementia [54].

Using data from 0.5 million participants and 3.64 million person-years of follow-up, it was recently estimated that individuals with diabetes in China had an approximately twofold increased risk of all-cause mortality, with the excess risk being

Table 3 Examples of major cohorts reporting frequency of different diabetes complications and levels of attainment of glycaemic and other metabolic variables

Variable	Hong Kong Diabetes Registry (HKDR) [37, 38]	Hong Kong Diabetes Database (HKDD) [39]	Hong Kong Diabetes Biobank (HKDB) [40]	China 3B Study [41]	China A1c Study [42]
Study period	1994–2007	2000–2012	2014–ongoing	2010–2011	2011
Participants (N)	10,129 (9668 with T2D included in analysis)	338,908	11,467, ongoing recruitment	25,454	26,151 (late-onset diabetes)
Male/female (n %)	46.8/53.2	48.7/51.3	58.3/41.7	47/53	52/48
Setting	Teaching hospital/primary care	All 16 diabetes centres in public hospitals + public clinics	Hospital diabetes centres	104 hospitals	77 tertiary centres
Age (years)	57.4 ± 13.2	62.8 ± 12.2	60.7 ± 11	62.6 ± 11.9	62.1 ± 9.8
Disease duration at baseline (years)	5 (1–11)	4.0 (8.0)	10 (4–17)	8.1 ± 6.8	4.6 (2.1–9.3)
Current smoking status (n %)	12.7	30.2[a]	12.7	16.4	–
BMI (kg/m^2)	25.2 ± 4.0	25.7 ± 4.1	26.4 ± 4.6	≥24[b]	24.5 ± 3.2
Baseline mean HbA_{1c} (mmol/mol)	59.6 ± 19.7	60 ± 17.5	61 ± 16.4	66 ± 25.1	60.3 ± 17.5
Baseline HbA_{1c} (%)	7.6 ± 1.8	7.6 ± 1.6	7.7 ± 1.5	8.2 ± 2.3	7.7 ± 1.6
SBP (mmHg)	135 ± 21	138 ± 19	134 ± 18	–	132 ± 14
DBP (mmHg)	75 ± 11	76 ± 11	76 ± 11	–	81 ± 11
LDL-cholesterol (mmol/l)	3.1 ± 1.0	3.0 ± 0.9	2.4 ± 0.8	–	3.0 ± 1.1
ACR	2.1 (0.8–11.1)	–	2.7 (1–12.2)	–	–
eGFR (ml min^{-1} [1.73 m^{-2}])	103.2 (82.1–124.5)	76.5 ± 22.8	105.8 (83.4–125.8)	–	–
Targets achieved (n %)					
HbA_{1c} <53 mmol/mol (7%)	41.9	42.9	36.6	47.7	40.2
BP ≤130/80 mmHg	40.2	29.3	37.3	28.4	56.3[c]
LDL-cholesterol <2.6 mmol/l	31.3	33.1	66.7	42.9	37.8
All three targets achieved	6.8	3.8	7.7	5.6	–
Medications (n %)					
Lipid-lowering agents	18.8	16.3[d]	64.4	23.1	–
Antihypertensive agents	47.2	59.1	70.1	42.9	–
ACEI/ARB	22.3	28.3	–	24.3	–
Antiplatelet agents	14.1	13.3	–	18.5	–
OHA	66.2	62.7	–	55	73.4
Insulin	17.0	5.0	31.8	35.6	26.7
Complications (n %)					
Retinopathy	26.8	29.7	27.4	16.5	7.3
Neuropathy	21.9	–	–	15.2	–
Microalbuminuria	26.1	26.0	31.8	–	–
Macroalbuminuria	16.9	8.2	17.0	–	–
Albuminuria	43.0	34.2	48.8	14.4	4.4
CHD	7.9	5.8	14.7	NR	–

Table 3 (continued)

Variable	Hong Kong Diabetes Registry (HKDR) [37, 38]	Hong Kong Diabetes Database (HKDD) [39]	Hong Kong Diabetes Biobank (HKDB) [40]	China 3B Study [41]	China A1c Study [42]
Stroke	2.8	4.9	7.4	10.1	–
PVD	5.9	NR	0.1	1.5	–
CVD	15.0	NR		14.6	–
Hospitalisation with CHF	2.3	NR	2.6	–	–
CKD	14.7	18.1	11.3	–	–
ESRD	1.2	0.5	0.6	–	–
Major findings	Epidemiology and novel risk factors for T2D complications in Chinese individuals, including data on: erectile dysfunction; genetic markers; risk scores for different incident T2D complications, HBV for nephropathy. High risk of complications in YDM	Improved risk factor control and declining incidence of cardio-renal complications during the study period	Novel genetic risk factors for diabetic complications	Challenges in achieving control of risk factors and low rates of targets achievement	Higher burden of microvascular complications among those with YDM

Data are displayed as means ± SD, medians (interquartile range) or percentages

[a] Current smokers and ex smokers

[b] 58.3% had BMI ≥24 kg/m^2

[c] Systolic BP <140 mmHg

[d] Statins only

ACEI, angiotensin-converting-enzyme inhibitor; ACR, spot urine albumin/creatinine ratio; ARB, angiotensin receptor blocker; CHF, congestive heart failure; CVD, cardiovascular disease; DBP, diastolic BP; ESRD, end-stage renal disease; HBV, hepatitis B viral infection; OHA, oral hypoglycaemic agent; PVD, peripheral vascular disease; T2D, type 2 diabetes;YDM, young-onset type 2 diabetes higher in rural areas than in urban areas [49]. The presence of diabetes has been associated with increased mortality from many diseases, including ischaemic heart disease, stroke, chronic liver disease, respiratory diseases, infections, liver cancer, pancreatic cancer, breast cancer and cancer of the female reproductive tract, with the excess risk highest for CKD and diabetic ketoacidosis or coma [49] (Fig. 2).

Perspectives on prevention and treatment

Diabetes prevention The large number of people affected by diabetes, the large proportion of undiagnosed cases and the suboptimal control of risk factors among many individuals undergoing treatment highlight the great burden diabetes poses to the healthcare system in China, at present and in the future. Recent studies also demonstrate the marked geographical variation in the detection of diabetes across different regions in China, ranging from around 40% in urban high-socioeconomic counties to around 20% in rural low-socioeconomic areas [55].

One of the earliest studies on diabetes prevention was undertaken in Da Qing, China, which started in 1986, with the intervention lasting 6 years [56]. This provided some of the first evidence that lifestyle modification can reduce the progression of at-risk individuals to diabetes. Now, more than three decades later, the study continues to provide important insights into the long-term benefits of lifestyle modification. During the 23 years of follow-up, the intervention group continued to derive significant benefit, displaying a 40% reduction in cardiovascular disease mortality and a 30% reduction in all-cause mortality [57]. Given the large at-risk population, systematic implementation of behavioural modification to increase physical activity and improve diet is key to diabetes prevention efforts. Unfortunately, a recent large population-based survey reported that, despite an increase in leisure-time physical activity, the proportion of individuals who are overweight and obese in China continues to increase, suggesting more targeted screening and interventions are needed to stem the tide of increasing obesity [58]. Of note, a Chinese Diabetes Risk Score has been developed to help identify high-risk individuals, with the main predictors being age, sex, waist circumference, BMI, systolic blood pressure and family history of diabetes [59].

Addressing intergenerational transmission of risk The increasing number of women affected by GDM and maternal obesity highlights the importance of efforts to reduce the impact of these and other adverse early life factors. Lifestyle intervention during pregnancy aimed at reducing GDM in overweight women is, by and large, not effective, unless initiated in early pregnancy [60]. Furthermore, women with GDM have an approximately eightfold higher risk of developing diabetes [61], showing adolescence, pre-pregnancy, pregnancy and post-pregnancy periods to be important windows of opportunity for the prevention of diabetes and other NCDs [62]. There are many challenges, including establishing uniform screening and diagnostic strategies for the large numbers of women at risk of GDM, providing education and treatment where needed and optimising management approaches, while considering the specific needs of low-resource settings [22, 63].

Diabetes treatment Current treatment guidelines for type 2 diabetes advocate the early use of metformin, acarbose or insulin secretagogues [10]. Acarbose has comparable efficacy to metformin and potentially beneficial effects on the incretin pathway [64]. Incretin therapies appear to have greater glucose-lowering effects in Asians than in other populations [65]. Given the prominent role of beta cell dysfunction in the pathogenesis of diabetes, there has also been much interest in the early use of intensive insulin therapy [66], though the long-term sustainability of this

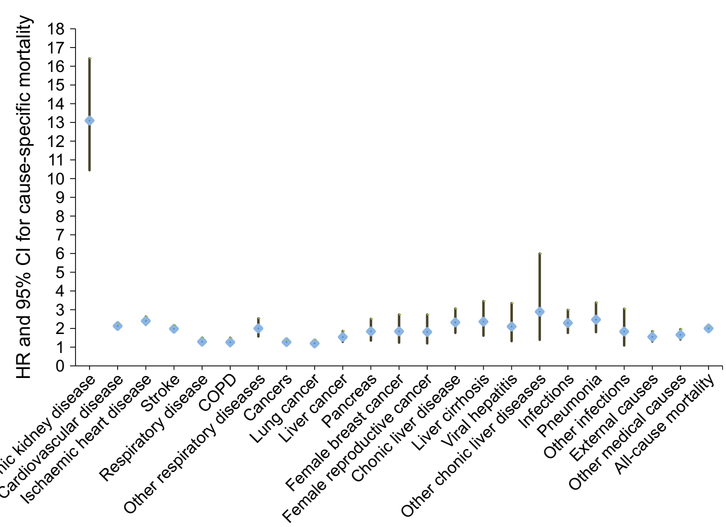

Fig. 2 Cause-specific mortality associated with diabetes in China. HR and 95% CIs for each cause of death in individuals with vs without diabetes. The figure is drawn based on data from reference [35]. COPD, chronic obstructive pulmonary disease. This figure is available as part of a downloadable slideset

approach, outside of specialist centres, poses significant challenges. With increasing early onset of disease, progression of diabetes and deterioration of glycaemic control will be inevitable. In the HKDR, over a median follow-up duration of 8.8 years, 43.9% of individuals developed oral drug failure or required insulin treatment [67].

Healthcare costs associated with diabetes in China has rocketed from 2.2 billion renminbi (RMB) in 1993 to 200 billion RMB in 2007, and is forecasted to exceed 360 billion RMB by 2030 [68, 69]. This huge healthcare burden associated with diabetes (in particular with chronic diabetes complications) highlights the need for effective early detection and treatment to reduce the impact of diabetes. Hyperglycaemia and cardiometabolic risk factors are the main drivers for the risk of complications. In the latest nationwide survey, less than half of those receiving treatment for diabetes have achieved adequate glycaemic control (defined as HbA_{1c} <53 mmol/mol [7%]) [5]. Similar figures were reported in a large multicentre study involving more than 25,000 individuals, whereby only 47.7% achieved HbA_{1c} <53 mmol/mol (7%), 28.4% achieved the blood pressure goal of <130/80 mmHg, 36.1% achieved the total cholesterol goal of <4.5 mmol/l and a meagre 5.6% achieved all three targets [39]. In the JADE programme, among those with diabetes and CKD, despite high prevalence of albuminuria (74.8%) and dyslipidaemia (93%), only 49% were using renin–angiotensin system inhibitors, while 53.6% received statins [70]. These treatment gaps highlight the need to improve treatment-target attainment to reduce the escalating burden of diabetic complications.

Epidemiology of diabetes in China

- Diabetes prevalence in China has increased from ~1% in 1980 to ~11% in 2013
- An estimated 110 million people in China have diabetes, making it the country with the largest population of people with diabetes in the world
- There is also significant geographical variation in the prevalence of diabetes in China
- Risk factors include obesity, family history, dietary factors, early life exposure and developmental origins
- Chinese individuals develop diabetes at a lower BMI than those from Western populations; the mean BMI of individuals with type 2 diabetes in Chinese cohorts is around 25 kg/m^2
- There remains a significant treatment gap, with only 5.6% of individuals achieving optimal control of blood glucose, blood pressure and lipid targets concurrently

Current challenges and the way forward

There are many challenges and obstacles that impede effective diabetes prevention and care delivery, including, but not limited to, the large ageing population, rapid urbanisation, social isolation, lack of structured care delivery in many healthcare settings, social disparity and unequal access to care [29, 71]. Optimal diabetes management requires not only good medical care but also patient empowerment, health literacy, self-management and self-discipline [10, 29, 72]. Chinese individuals who have received diabetes education have better self-care and improved glycaemic control [73]. However, there is a relative lack of diabetes nurse educators in China, and support provided by patient peer leaders may be helpful [74]. Judicious use of information technology, with support from healthcare professionals, may also be a potential way forward. In a randomised clinical trial involving more than 3800 individuals with type 2 diabetes in China it was noted that integrated care augmented by information technology improved cardiometabolic control, while additional nurse contact with patients helped to reduce the number of missed appointments and improved patient self-care [75]. Given the immense burden of diabetes and its associated complications, multi-pronged strategies will be required to tackle the challenge diabetes poses [29]. In the China National Plan for Non-Communicable Disease Prevention and Treatment (2012–2015), the Chinese Government proposed healthcare reforms, different public measures, multi-sectoral collaborations and social mobilisation to create a health-enabling environment approach to prevent NCDs [76]. While many such interventions will require changes in individual choices, such as diet and physical activity, these must occur hand in hand with other systematic changes in healthcare infrastructure, the built and living environment and the food industry in order to minimise the adverse consequences of the current diabetes epidemic [29].

While recent research has improved our understanding of the epidemiology of diabetes and diabetic complications in China, many gaps in knowledge remain. These include: (1) the reasons for the different pattern of diabetes observed in Chinese individuals compared with Europeans; (2) the relative contribution and population-attributed fraction of adiposity and other risk factors to diabetes; (3) underlying factors that account for the pattern of complications, including the comparatively higher prevalence of diabetic kidney complications in Chinese individuals; (4) whether population-specific genetic factors exist for diabetes and diabetic complications in Chinese people; and (5) whether prevention and treatment approaches in Chinese individuals should differ from that currently advocated in other populations. Insights provided by further research in these areas may help improve ongoing public health and treatment efforts.

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