

Cardiovascular diseases and risk factors among Chinese immigrants

Zhizhong Gong¹ · Dong Zhao¹

Received: 1 June 2015 / Accepted: 18 August 2015 / Published online: 8 September 2015
© SIMI 2015

Abstract The aim of this study is to identify the prevalence of cardiovascular disease (CVD) and major CVD risk factors, including diabetes, hypertension, dyslipidemia, obesity and smoking among Chinese immigrants by a systematic review of studies from various countries. PubMed and the China National Knowledge Infrastructure databases were searched for studies of the prevalence of major CVDs and risk factors, and of CVD mortality among Chinese immigrants. The search identified 386 papers, 16 of which met the inclusion criteria for this review. In mainland China, there is a pattern of high stroke prevalence but low coronary heart disease (CHD) prevalence. Among Chinese immigrants, there is a much lower prevalence and mortality of stroke, but a higher prevalence and mortality of CHD, even though these are lower than the rates in immigrants of other ethnicities in the host country. The prevalence of CVD risk factors is also markedly different in immigrants. Compared with mainland Chinese, Chinese immigrants have a higher prevalence of diabetes and hypertension, higher serum cholesterol, poorer dietary patterns, and higher prevalence of obesity and smoking. Thus, the epidemiological pattern of CVD among Chinese immigrants changes compared with resident mainland Chinese. The less healthy environmental factor after immigration may be a major trigger in the adverse CVD status of Chinese immigrants. It is important for policy-makers to pay more attention to

specific minority immigrant groups, and to implement more effective preventive measures to improve the health of immigrant populations.

Keywords Chinese · Immigrants · Epidemiology · Cardiovascular disease · Environmental factors

Introduction

According to a recent World Health Organization (WHO) report, of 56 million deaths globally in 2012, 38 million (approximately 68 %) resulted from non-communicable diseases (NCDs), which have become a serious global public health burden [1–4]. Generally, cardiovascular disease (CVD) is the most prominent worldwide. Almost all NCDs are associated with both environmental and genetic risk factors [5].

Epidemiology studies, especially in migrant groups, can help identify the influence of environmental and genetic factors on CVD risk. Studies of migrant populations can compare the CVD characteristics of a population in their original location, and trace a migrant group through several generations in the new host country [6, 7]. Migration may lead to substantial changes in the natural environment, lifestyle, eating habits, physical activity, education, income, and medical care of migrants and their offspring, possibly resulting in major changes in epidemiological patterns of CVD and risk factors [8]. Comparison of the changes in CVD prevalence, mortality, and risk factors among immigrants and native people can also provide a unique view of the role of environmental and genetic factors on CVD development.

China has the largest population in the world, comprising about one-fifth of the global population, and has

✉ Dong Zhao
deezhao@vip.sina.com

¹ Department of Epidemiology, Beijing Institute of Heart, Lung and Blood Vessel Diseases, Beijing An Zhen Hospital, Capital Medical University, NO. 2 An Zhen Road, Chaoyang District, Beijing 100029, China

also become the one of the largest migrant-exporting countries. During the past century, more than 50 million ethnic Chinese moved overseas [9, 10]. The epidemiological pattern of CVD in mainland China has been clearly documented, and is characterized by a relatively low prevalence of coronary heart disease (CHD), but a high prevalence of stroke [11–14]. It is still unclear whether the epidemiology pattern and risk factors of CVD among Chinese immigrants have changed or not. Several reviews on CVD in migrants have focused on immigrant groups that came from different countries [8, 15–17]. There is still a lack of review focus on the information summary about the epidemiological features of CVD status among Chinese immigrant groups. This systematic review aims to focus on the epidemiology of CVD specifically in Chinese immigrant groups, and to compare the difference in the major CVD risk factors including diabetes, hypertension, dyslipidemia, obesity and smoking between Chinese immigrants and mainland Chinese or other ethnic groups in the new host country.

Methods

Search methodology

The PubMed database was used for searching for previously published studies from 1966 to the present time. The following search terms were used: ‘non-communicable disease’, ‘cardiovascular disease’, ‘stroke’, ‘cerebrovascular disease’, ‘coronary heart disease’, ‘ischemic heart disease’, ‘myocardial infarction’, ‘diabetes’, ‘hypertension’ AND ‘epidemiology’, ‘prevalence’, ‘mortality’, ‘risk factor’ AND ‘migration’, ‘immigration’, ‘emigration’, ‘immigrant’, ‘emigrant’ AND ‘China’, ‘Chinese’. The above search was limited to papers published in English. The China National Knowledge Infrastructure (CNKI) database was also used to search for papers published in Chinese using the same key words. A manual search of the reference lists of the articles and reviews was conducted to identify further key publications.

Study inclusion criteria

Studies were included if they met the following criteria: (1) the study presents original data on the prevalence or mortality of CVDs, such as CHD, stroke, or their related risk factors (diabetes, hypertension, dyslipidemia, obesity and smoking); (2) the study population includes first generation immigrants of Chinese origin with or without their offspring; (3) the study contains a comparison group of their own ethnicity in their country of origin, or of other ethnicity in the host country.

Study exclusion criteria

A study was excluded if the sample size is <100, or if it is a duplicate publication. In the latter case, only one article with the most comprehensive data on a particular study is included.

Results and discussion

Study characteristics

The database search identified 341 English papers in PubMed and 45 Chinese publications in the CNKI. After assessing the titles and abstracts, 313 studies met the exclusion criteria, and the full texts of the remaining 73 articles were examined. Sixteen articles met the inclusion criteria, and are included in the systematic review [18–33].

Data on 258,474 Chinese migrants are reported in the 16 studies. These surveys were mainly conducted in the United States [21, 22, 24, 29, 30, 32], Canada [18, 20, 23, 27], the United Kingdom [19, 26], and Mauritius [25, 28], and there are also two studies of migrants within mainland China [31, 33].

Stroke

Stroke has become the leading cause of death in China after the rapid changes in health status from 1990 to 2010 [3]. The recent China National Stroke Prevention Project (CSPP) reports that the standardized prevalence rate of stroke is 1.9 %, whereas the mean prevalence of stroke globally is only 0.5–0.6 % [34, 35].

Table 1 presents the general characteristics of four studies of stroke prevalence in Chinese immigrants [18–21]. Two studies conducted by Anand et al. [18] and Chiu et al. [20] investigated the epidemiologic characteristics of stroke among Chinese immigrants and other ethnic groups living in Canada. Their results show that Chinese immigrants have the lowest prevalence of stroke (0.3–0.6 %), compared with immigrants from South Asia (0.6–1.7 %) and Europe (1.8 %). Another study conducted in England by Zaninotto et al. reports that the age-standardized prevalence of stroke is significantly lower among Chinese men and women (0.9 and 0.3 %, respectively) compared with other ethnic groups, such as Indians (men 1.2 %; women 0.9 %) and Irish (men 1.8 %; women 1.4 %) [19]. Corlin et al. also report similar findings in Chinese immigrants and resident Whites in the United States (1.4 and 6.0 %, respectively) [21].

Another three studies report stroke-related mortality in Chinese immigrants (Table 1) [22–24]. In 2014, Jose et al. published a study of stroke mortality among Chinese,

Table 1 Characteristics of seven studies of stroke prevalence and mortality among Chinese immigrants

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)			Rates		
							Male	Female	Total	Male	Female	Total
Anand et al. [18]	Canada	The Study of Health Assessment and Risk in Ethnic groups (SHARE)	NA	Prevalence of stroke	Chinese	317	47.4 ± 9.8	NA	NA	0.3 %	NA	0.3 %
					Europeans	326	51.2 ± 9.8	NA	NA	1.8 %	NA	1.8 %
Zaminotto et al. [19]	United Kingdom	The Health Survey for England (HSE)	1999–2004	Age-standardized prevalence of stroke	South Asians	342	49.4 ± 9.8	NA	NA	0.6 %	NA	0.6 %
					Chinese	1385	M: 39.1 F: 39.9	0.9 %	0.3 %	NA	NA	
					Black Caribbean	2362	M: 44.3 F: 42.1	1.6 %	1.3 %	NA	NA	
					Indian	2467	M: 41.8 F: 40.5	1.2 %	0.9 %	NA	NA	
					Pakistani	2204	M: 37.1 F: 34.8	1.5 %	2.1 %	NA	NA	
					Irish	2398	M: 47.2 F: 47.2	1.8 %	1.4 %	NA	NA	
Chiu et al. [20]	Canada	Statistics Canada's Cross-sectional National Population Health Survey	1996–2007	Age- and sex-standardized prevalence of stroke	Chinese	3038	Average 42.3	0.5 %	0.8 %	0.6 %	0.6 %	
					White	154,653		1.1 %	1.2 %	1.1 %	1.1 %	
Corlin et al. [21]	United States	Cross-section study	2009–2012	Prevalence of stroke	South Asian	3364		1.1 %	2.2 %	1.7 %	1.7 %	
					Black	2742		1.4 %	1.1 %	1.3 %	1.3 %	
Fang et al. [22]	New York City, United States	Mortality data from NYC Department of Health	1988–1992	Age-adjusted stroke death rate (1/100,000)	Chinese	147	65.3 ± 13.3	NA	NA	1.4 %	1.4 %	
					White	167	59.8 ± 11.9	NA	NA	6.0 %	6.0 %	
Sheth et al. [23]	Canada	Canadian Mortality Database	1979–1993	Cerebrovascular disease death rate (1/100,000)	Chinese, NYC	245,565	34.8 ± 19.9	13.4	17.7	NA	NA	
					Chinese, China	NA	NA	115.9	116.7	NA	NA	
Jose et al. [24]	United States	Death database from the National Center for Health Statistics	2003–2010	Age-adjusted mortality of cerebrovascular disease (1/100,000)	Whites, NYC	3,165,172	41.8 ± 22.9	12.9	14.9	NA	NA	
					Chinese	NA	NA	45.8	42.2	NA	NA	
					European origin	NA		49.5	34.8	NA	NA	
					South Asian	NA		47.0	39.0	NA	NA	
					Chinese	NA	NA	47.39	41.99	NA	NA	
					White	NA		50.30	55.26	NA	NA	
					Asian Indian	NA		37.88	39.27	NA	NA	
					Japanese	NA		56.57	44.82	NA	NA	
					Korean	NA		44.79	47.33	NA	NA	

NA not available, M male, F female, NYC New York City

Asian Indian, Japanese, and Whites in the United States [24]. The age-standardized mortality among men and women of Chinese origin is 47.39 and 41.99 per 100,000, respectively, and is markedly lower than in those of Japanese origin (men 56.57 and women 44.82 per 100,000) or in resident Whites (men 50.30 and women 55.26 per 100,000). It is also significantly lower than the stroke-related mortality among Chinese in mainland China (men 139.12 and women 111.62 per 100,000) based on the data of the China Health and Family Planning Statistics Yearbook in 2014 [36].

These studies suggest that after migrating to Western developed countries, the prevalence and mortality of stroke among Chinese immigrants are much lower than the rates in the population remaining in mainland China. The CSPP study reports that 54 % of stroke patients in China are eligible for antihypertensive, statin and antiplatelet medications, but that triple agents are used in only 6.9 % of stroke patients [34]. The REACH Registry enrolled Chinese stroke patients aged 45 years or older in mainland China, Western Europe, and North America, and finds that the use of triple agents is highest among Chinese in Western Europe (53.8 %), and in North America (51.8 %) [37]. Because of the better medical service and availability of stroke drug therapy in Western countries, there is a significant benefit for the primary and secondary prevention of stroke, which is reflected in the marked reduction in the prevalence and mortality of stroke after migration.

Coronary heart disease

In the 2008 National Health Services Survey in China, the prevalence of CHD is 0.77 % (urban 1.59 %; rural 0.48 %) [38]. The World Health Organization MONICA study reports that there is a lower incidence of CHD in China compared with that in Western countries [11, 12].

Of the 16 eligible articles, six report data on the prevalence of CHD in Chinese immigrants (Table 2) [18–20, 25–27]. The studies of Chiu et al. and Wang et al. analyzed the prevalence of CHD in 3038 and 2008 Chinese immigrants, respectively, and in other ethnic groups living in Canada [20, 27]. The age- and sex-standardized prevalence of CHD ranges from a low level of 3.1–3.2 % in Chinese immigrants to 4.8–5.1 % in Canadians and 4.3–5.2 % in South Asian immigrants. Another study conducted in the United Kingdom by Harland et al. also reveals that the prevalence of CHD is significantly lower in Chinese immigrants than in European men (4.9 vs 16.6 %, $P < 0.001$) [26]. However, Li et al. find that the prevalence of CHD is several times higher in Chinese immigrants living in Mauritius than in those living in Beijing (24.3 vs 4.0 %), but is similar to the prevalence in Asian Indians and Creoles in Mauritius (24.5 %) [25]. Although the

reported prevalence of CHD among Chinese immigrants varies in different studies, all show that CHD prevalence is higher among Chinese migrants than among mainland Chinese.

Another three studies report CHD mortality in Chinese immigrants (Table 2) [22–24]. Fang et al. report that CHD mortality of Chinese immigrants in New York City is substantially lower than that of Whites (men: 61.0 vs 161.7 per 100,000; women: 56.1 vs 143.9 per 100,000), but is significantly higher than that of Chinese in mainland China (men 45.4 and women 46.1 per 100,000) [22]. Another two studies also report similar results [22, 23].

In six studies reporting the prevalence or mortality of both CHD and stroke, the epidemiological pattern of CVD changes among Chinese immigrants [18–20, 22–24]. Chinese people traditionally have a very high level of stroke, but a low prevalence of CHD compared with other races, but after migrating to Western developed countries, the prevalence and mortality of stroke among Chinese immigrants are much lower than the rates in the population of mainland China [11–14]. For CHD, however, Chinese immigrants have a higher prevalence and mortality of CHD than mainland Chinese, but these rates are still lower than the rates in immigrants of other ethnicities. These studies support the hypothesis that the shift in the epidemiological pattern of CVD among Chinese immigrants might be ascribed to the changes in the living environment and related lifestyle factors after immigration.

Risk factors

Diabetes mellitus

In this review, 9 of the 16 selected articles present data on diabetes prevalence or mortality in Chinese immigrants as shown in Table 3 [19–21, 23, 27–31]. Two studies of Kandula et al. and Veeranna et al. both using the data of the MESA study in the United States, reveal that the prevalence of diabetes among Chinese Americans was 12.7–13.3 % during 2000–2002 [29, 30]. Whereas, the Inter ASIA study by Hu et al. in 2001 using the same diagnostic criteria, reports that the age-standardized prevalence of diabetes is only 5.49 % in mainland Chinese, which indicates that the prevalence of diabetes in Chinese immigrants is higher than that in mainland China [39, 40].

However, other two studies in Canada show that the prevalence in Chinese Canadians is 4.26–4.30 %, and a study of Zaninotto et al. in the United Kingdom also reveals that the age-standardized prevalence of diabetes is only 4.0 % for men and 3.9 % for women in Chinese immigrants [19, 20, 27]. Given the discrepant results among studies, they might be ascribed to the different methods for diabetes diagnosis used to estimate the

Table 2 Characteristics of nine studies of the prevalence and mortality of coronary heart disease among Chinese immigrants

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Li et al. [25]	Mauritius	Cross-sectional survey	1984–1985	Prevalence of CHD	Chinese in Mauritius	267	35–64	19.7 %	29.2 %	24.3 %
					Non-Chinese in Mauritius	2697		15.9 %	32.2 %	24.5 %
Harland et al. [26]	United Kingdom	Cross-sectional survey	1991–1993	Prevalence of CHD	Chinese in Beijing	1263		2.9 %	5.0 %	4.0 %
Anand et al. [18]	Canada	The Study of Health Assessment and Risk in ethnic groups (SHARE)	1996–1998	Prevalence of CHD	Chinese	380	25–64	4.9 %	7.3 %	NA
					Europeans	625		16.6 %	11.1 %	NA
					Chinese	317	47.4 ± 9.8	NA	NA	1.7 %
					Europeans	326	51.2 ± 9.8	NA	NA	4.6 %
					South Asian	342	49.4 ± 9.8	NA	NA	10.7 %
Zaninotto et al. [19]	United Kingdom	The Health Survey for England (HSE)	1999–2004	Age-standardized prevalence of CHD	Chinese	1385	M: 39.1 F: 39.9	1.7 %	1.1 %	NA
					Black Caribbean	2362	M: 44.3 F: 42.1	2.3 %	2.1 %	NA
					Indian	2467	M: 41.8 F: 40.5	5.7 %	2.8 %	NA
					Pakistani	2204	M: 37.1 F: 34.8	8.9 %	4.0 %	NA
					Irish	2398	M: 47.2 F: 47.2	3.7 %	2.0 %	NA
Chiu et al. [20]	Canada	Statistics Canada's Cross-sectional National Population Health Survey	1996–2007	Age- and Sex-standardized prevalence of Heart disease	Chinese	3038	Average 42.3	3.8 %	2.7 %	3.2 %
					White	154,653		5.4 %	4.7 %	5.1 %
					South Asian	3364		5.2 %	5.2 %	5.2 %
					Black	2742		2.5 %	4.2 %	3.4 %
					Chinese	2008	18–75	NA	NA	3.08 %
					Canadian	73,806		NA	NA	4.80 %
					South Asian	1973		NA	NA	4.32 %
					Italian	891		NA	NA	4.25 %
					Portuguese	439		NA	NA	4.36 %
					Chinese, NYC	245,565	34.8 ± 19.9	61.0	56.1	NA
					Chinese, China	NA	NA	45.4	46.1	NA
					Whites, NYC	3165,172	41.8 ± 22.9	161.7	143.9	NA
					Chinese	NA	NA	107.0	40.0	NA
					European origin	NA	NA	319.6	109.9	NA
					South Asian	NA	NA	320.2	144.5	NA
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of Heart disease	Chinese	2742		2.5 %	4.2 %	3.4 %
					Black	2742		2.5 %	4.2 %	3.4 %
					Chinese	2008	18–75	NA	NA	3.08 %
					Canadian	73,806		NA	NA	4.80 %
					South Asian	1973		NA	NA	4.32 %
					Italian	891		NA	NA	4.25 %
					Portuguese	439		NA	NA	4.36 %
Fang et al. [22]	New York City, United States	Mortality data from NYC Department of Health	1988–1992	Age-adjusted CHD death rate (1/100,000)	Chinese, NYC	245,565	34.8 ± 19.9	61.0	56.1	NA
					Chinese, China	NA	NA	45.4	46.1	NA
					Whites, NYC	3165,172	41.8 ± 22.9	161.7	143.9	NA
					Chinese	NA	NA	107.0	40.0	NA
Sheth et al. [23]	Canada	Canadian Mortality Database	1979–1993	CHD death rate (1/100,000)	Chinese	NA	NA	319.6	109.9	NA
					European origin	NA	NA	319.6	109.9	NA
					South Asian	NA	NA	320.2	144.5	NA

Table 2 continued

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Jose et al. [24]	United States	Death database from the National Center for Health Statistics	2003–2010	Age-adjusted mortality of CHD (1/100,000)	Chinese White Asian Indian Japanese Korean	NA	NA	121.12	77.61	NA
								240.75	134.99	NA
								167.45	108.28	NA
								146.60	66.23	NA
								121.16	94.74	NA

CHD coronary heart disease, NA not available, M male, F female, NYC New York City

prevalence of diabetes. Diabetes in these studies was all defined by participants who self-reported without blood glucose testing, which may significantly underestimate the prevalence of diabetes among Chinese immigrants [19, 20, 27].

Diabetes is often asymptomatic in its early stages, and can remain undiagnosed for several years until significant complications appear [41–43]. A national study by Yang et al. in 2010 reveals that the prevalence of undiagnosed diabetes reaches up to 60.7 % in China (men 61.3 %, women 59.8 %) [44]. Another study in the United Kingdom by Unwin et al. in 1997 also shows that the Chinese immigrants have a higher prevalence of undiagnosed diabetes compared with Europeans living in United Kingdom (62.5 vs 57.7 %) [45]. The high prevalence of undiagnosed diabetes is probably to be linked to the low prevalence of diabetes in Chinese immigrants. It also indicates the lack of diabetes awareness and shortage of medical treatment in both Chinese immigrants and mainland Chinese. Therefore, early diagnosis and treatment for diabetes are highly needed for the prevention of diabetes.

Hypertension

Hypertension is one of the most common CVDs, and is the most important and modifiable risk factor for CHD and stroke [46]. From data of the Chinese National Nutrition and Health Survey, the overall prevalence of hypertension is estimated as 18.8 % among Chinese aged ≥ 18 years [47]. Table 4 lists eight studies of hypertension prevalence or mortality among Chinese immigrants [19–21, 24, 27, 30, 32, 33]. The Health Survey for England reports that the age- and sex-standardized prevalence of hypertension is lowest in Chinese immigrants (men 20.2 %; women 25.0 %), higher in Irish immigrants (men 27.7 %; women 25.3 %), and highest in Black Caribbean immigrants (men 31.5 %; women 33.6 %) [19]. Moran et al. also find that the age-adjusted prevalence of hypertension is 35.2 % in Chinese immigrants living in the United States, and is similar to that in native Whites (36.1 %) [32]. They further show that for people born outside the United States, each 10-year increment in residence in the United States is associated with a higher prevalence of hypertension. Compared to participants living in the United States for 10 years or less, the adjusted odds ratio of hypertension is 1.26 (95 % confidence interval 1.05–1.51) for participants who lived in United States over 30 years after adjusting for age, gender, socioeconomic status and other risk factors of hypertension.

These studies suggest that the prevalence of hypertension among Chinese immigrants is significantly higher than in mainland Chinese. Moreover, Hsu et al. report that 52 % of Chinese immigrants comply with antihypertensive

Table 3 Characteristics of nine studies of diabetes mellitus prevalence and mortality among Chinese immigrants

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Dowse et al. [28]	Mauritius	Cross-sectional study	1982–1986	Age-standardized prevalence of diabetes	Chinese	409	25–74	13.5 %	9.5 %	11.5 %
					Indian	2543		14.0 %	10.9 %	12.4 %
					Muslim	671		12.7 %	13.8 %	13.3 %
Zaminotto et al. [19]	United Kingdom	The Health Survey for England (HSE)	1999–2004	Age-standardized prevalence of diabetes	Chinese	1385	M: 39.1 F: 39.9	4.0 %	3.9 %	NA
					Black Caribbean	2362	M: 44.3 F: 42.1	6.4 %	7.3 %	NA
					Indian	2467	M: 41.8 F: 40.5	8.6 %	5.7 %	NA
Kandula et al. [29]	United States	The multi-ethnic study of atherosclerosis (MESA)	2000–2002	Prevalence of diabetes	Pakistani	2204	M: 37.1 F: 34.8	11.0 %	12.3 %	NA
					Irish	2398	M: 47.2 F: 47.2	2.8 %	1.8 %	NA
					Chinese	737	62.8 ± 10.2	NA	NA	13.30 %
Chiu et al. [20]	Canada	Statistics Canada's Cross-sectional National Population Health Survey	1996–2007	Age- and sex-standardized prevalence of diabetes	Mexican	708	61.6 ± 10.4	NA	NA	21.05 %
					Non-Mexican Hispanic	547	61.5 ± 10.5	NA	NA	13.71 %
					Chinese	3038	Average 42.3	4.0 %	4.6 %	4.3 %
Veeranna et al. [30]	United States	The multi-ethnic study of atherosclerosis (MESA)	2000–2002	Prevalence of diabetes	White	154,653		4.8 %	4.1 %	4.2 %
					South Asian	3364		9.4 %	6.8 %	8.1 %
					Black	2742		7.4 %	9.5 %	8.5 %
Bin et al. [31]	China	Cross-sectional study	2007–2008	Age-standardized prevalence of diabetes	Chinese	751	62.6 ± 10.3	NA	NA	12.7 %
					Caucasians	2362	62.4 ± 10.2	NA	NA	5.7 %
					African Americans	1601	61.6 ± 10.0	NA	NA	17.1 %
Corlin et al. [21]	United States	Cross-sectional study	2009–2012	Prevalence of diabetes	Hispanics	1353	61.3 ± 10.3	NA	NA	17.2 %
					Yi Migrant	1329	39.03 ± 11.75	10.35 %	6.37 %	8.87 %
					Yi Farmer	1549	39.72 ± 11.89	6.05 %	2.41 %	4.01 %
Corlin et al. [21]	United States	Cross-sectional study	2009–2012	Prevalence of diabetes	Han People	2150	44.26 ± 13.15	6.21 %	6.02 %	6.22 %
					Chinese	147	65.3 ± 13.3	NA	NA	15.0 %
					White	167	59.8 ± 11.9	NA	NA	13.3 %

Table 3 continued

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of diabetes	Chinese Canadian South Asian Italian Portuguese	2008 73,806 1973 891 439	18–75	NA NA NA NA NA	NA NA NA NA NA	4.26 % 5.64 % 13.23 % 6.23 % 6.98 %
Sheth et al. [23]	Canada	Canadian Mortality Database	1979–1993	Diabetes death rate (1/100,000)	Chinese European origin South Asian	NA	NA	11.6 19.1 31.4	11.4 13.9 28.7	NA NA NA

NA not available, M male, F female

medication, and the MESA study shows that only 39 % of immigrant Chinese with hypertension have adequate treatment and control of the condition [48, 49].

Dyslipidemia

Elevated serum cholesterol is also one of the most important modifiable risk factors for CVD [46]. The China National Diabetes and Metabolic Disorders Study conducted during 2007–2008, reports that the age- and sex-standardized mean levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) are 4.72, 2.68, 1.30, and 1.57 mmol/L, respectively, in a general Chinese population aged ≥ 20 years. The age-standardized prevalence of high TC (≥ 6.22 mmol/L) is 9.0 % [50].

Studies of Chinese immigrants in Melbourne, Australia and in California, United States finds that the cholesterol level is 5.50–5.59 and 5.30–5.33 mmol/L among Chinese men and women, respectively, and is significantly higher than the level in mainland Chinese (men 4.70 mmol/L; women 4.73 mmol/L) [50–52]. The SHARE study further reveals that the mean LDL-C and triglyceride levels among Chinese immigrants in Canada are 3.14 and 1.78 mmol/L, respectively, and also higher than that in mainland Chinese, while the level of HDL-C is lower (1.19 vs 1.30 mmol/L) [18]. These studies suggest that serum TC and LDL-C levels increase in Chinese immigrants, likely related to adverse changes in lifestyle after migrating to developed countries.

Obesity

In general, Chinese have a low prevalence of overweight or obesity. Chiu et al. find that the mean body mass index (BMI) is lowest among Chinese immigrants (22.3 kg/m²), followed by South Asian (24.2 kg/m²), White (25.3 kg/m²), and Black populations (25.5 kg/m²) in Canada [20]. Two other studies also find that Chinese immigrants have a lower adjusted mean BMI and waist circumference than other ethnic groups living in United States [53, 54]. However, there is evidence to suggest that changes in socioeconomic conditions and urbanization in China have resulted in a rapid rise in obesity levels, as in Chinese immigrants [55, 56]. The prevalence of obesity among Chinese immigrants increases with longer duration of residence overseas [57]. In addition, Zhou et al. and Au et al. find that nearly one-third of Chinese American children aged 6–11 years are overweight or obese [58, 59]. Chinese immigrants in the United States carry higher risks of being overweight or having obesity compared with European immigrants. Moreover, Chinese individuals with the same

Table 4 Characteristics of eight studies of hypertension prevalence and mortality among Chinese immigrants

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Moran et al. [32]	United States	The multi-ethnic study of atherosclerosis (MESA)	2000–2002	Age-adjusted prevalence of Hypertension	Chinese	803	62.9 ± 10.3	NA	NA	35.2 %
					Whites	2619	63.1 ± 10.3	NA	NA	36.1 %
Zaninotto et al. [19]	United Kingdom	The Health Survey for England (HSE)	1999–2004	Age-standardized prevalence of Hypertension	African American	1898	62.7 ± 10.1	NA	NA	59.4 %
					Hispanics	1494	61.8 ± 10.4	NA	NA	41.6 %
					Chinese	1385	M: 39.1 F: 39.9	20.2 %	25.0 %	NA
					Black Caribbean	2362	M: 44.3 F: 42.1	31.5 %	33.6 %	NA
Chiu et al. [20]	Canada	Statistics Canada's Cross-sectional National Population Health Survey	1996–2007	Age- and Sex-standardized prevalence of Hypertension	Indian	2467	M: 41.8 F: 40.5	29.5 %	28.2 %	NA
					Pakistani	2204	M: 37.1 F: 34.8	24.4 %	44.8 %	NA
					Irish	2398	M: 47.2 F: 47.2	27.7 %	25.3 %	NA
					Chinese	3038	Average 42.3	15.1 %	14.4 %	15.8 %
Bin et al. [33]	China	Cross-sectional study	2007–2008	Prevalence of Hypertension	White	154,653		13.1 %	14.8 %	13.7 %
					South Asian	3364		17.0 %	16.0 %	17.9 %
Veeranna et al. [30]	United States	The multi-ethnic study of atherosclerosis (MESA)	2000–2002	Prevalence of Hypertension	Black	2742		17.7 %	21.7 %	19.8 %
					Yi Migrant	1338	39.01 ± 11.76	19.08 %	9.52 %	15.10 %
Corlin et al. [21]	United States	Cross-sectional study	2009–2012	Prevalence of Hypertension	Yi Farmer	1628	39.74 ± 11.93	4.73 %	1.92 %	3.19 %
					Chinese	751	62.6 ± 10.3	NA	NA	40.9 %
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of Hypertension	Caucasians	2362	62.4 ± 10.2	NA	NA	42.9 %
					African Americans	1601	61.6 ± 10.0	NA	NA	59.7 %
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of Hypertension	Hispanics	1353	61.3 ± 10.3	NA	NA	44.4 %
					Chinese	147	65.3 ± 13.3	NA	NA	54.7 %
					White	167	59.8 ± 11.9	NA	NA	46.4 %
					Chinese	2008	18–75	NA	NA	14.66 %
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of Hypertension	Canadian	73,806		NA	NA	16.99 %
					South Asian	1973		NA	NA	19.09 %
Wang [27]	Canada	Canadian Community Health Survey (CCHS)	2005–2010	Age-standardized prevalence of Hypertension	Italian	891		NA	NA	17.13 %
					Portuguese	439		NA	NA	19.02 %

Table 4 continued

References	Host country	Study design and data collection	Study period	Outcome	Birth country of immigrant	Sample size	Age (years)	Rates		
								Male	Female	Total
Jose et al. [24]	United States	Death database from the National Center for Health Statistics	2003–2010	Age-adjusted mortality of Hypertension (1/100,000)	Chinese White Asian Indian Japanese Korean	NA	NA	10.09	9.63	NA
								13.59	11.19	NA
								8.31	9.73	NA
								9.48	7.23	NA
								9.24	9.59	NA

NA not available, M male, F female

BMI as Whites are at a higher risk of developing CVD and diabetes [60, 61].

The transition in dietary patterns may significantly influence the development of obesity. Lv et al. suggest that Chinese Americans increase the frequency of consumption of Western foods (more fats, sugars and soft drinks), resulting in a reduction in intake of traditional Chinese foods after migration [62]. A recent review published in 2014, reports that Chinese immigrants appear to adopt poor dietary habits and inactive lifestyles since moving to the United States [63]. Their traditional diet of vegetables, meats, and whole grains appears to have been replaced by readily available processed, high fat, and sugary food.

Smoking

The Community Assessment of Freeway Exposure and Health study in the United States finds that Chinese immigrants are less likely to be current smokers or to be exposed to cigarette smoke than American whites [odds ratio (95 % confidence interval) 0.31 (0.16–0.60) and 0.34 (0.18–0.66), respectively] [21]. However, the smoking trends increase with acculturation to the host country. For males, the smoking prevalence increases from 52.9 % in China to 70.0 % in the United States [21, 64]. The California Tobacco Survey and the California Youth Tobacco Survey show that acculturation is significantly associated with smoking onset among Chinese Americans [65, 66]. Although Chinese American adolescents have a lower level of smoking than White adolescents, the prevalence in Chinese Americans continues to rise after 15 years of age, in contrast to a decline in Whites. Thus, tobacco prevention policies, strategies and programs should be targeted to specific immigrant populations and to take acculturation factors into account.

Conclusions

This systematic review and summary of the available published studies regarding the changes of epidemiology of CVD among Chinese immigrants establishes that the prevalence and mortality of stroke among Chinese migrants are much lower than the rates in the native population of mainland China, but there is a higher prevalence and mortality of CHD in Chinese migrants. The prevalence of CVD risk factors is also markedly different in Chinese immigrants with a higher prevalence of diabetes and hypertension, higher serum cholesterol, poorer dietary patterns, and higher prevalence of obesity and smoking when compared with mainland Chinese, indicating that a less healthy lifestyle related environmental factor after immigration may be a major trigger in the adverse CVD

status of Chinese immigrants. Therefore, it is very important for policy-makers to pay more attention to specific minority immigrant groups, and to formulate more effective preventive measures to improve the health of these populations.

Acknowledgments This study was sponsored by the National Science and Technology Pillar Program during the Twelfth Five-Year Plan Period of China (NO. 2011BAI08B01).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with human and animals performed by any of the authors.

Informed consent None.

References

- World Health Organization (2014) Global status report on non-communicable diseases
- GDB (2013) Mortality and causes of death collaborators. global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden Of Disease Study. *Lancet* 385(9963):117–171
- Yang G, Wang Y, Zeng Y et al (2013) Rapid health transition in china, 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet* 381(9882):1987–2015
- Habib SH, Saha S (2010) Burden of non-communicable disease: global overview. *Diabetes Metab Syndr* 4(1):41–47
- Vineis P, Stringhini S, Porta M (2014) The environmental roots of non-communicable diseases (NcDs) and the epigenetic impacts of globalization. *Environ Res* 133:424–430
- Mahalingam R, Rabelo VC (2013) Theoretical, methodological, and ethical challenges to the study of immigrants: perils and possibilities. *New Dir Child Adolesc Dev* 2013(141):25–41
- Ko Y, Butcher R, Leong RW (2014) Epidemiological studies of migration and environmental risk factors in the inflammatory bowel diseases. *World J Gastroenterol* 20(5):1238–1247
- Dassanayake J, Gurrin L, Payne WR et al (2011) Cardiovascular disease risk in immigrants: what is the evidence and where are the gaps. *Asia Pac J Public Health* 23(6):882–895
- Hoeffel EM, Rastogi S, Kim MO et al (2010) The Asian Population (2010) US Department Of Commerce, Economics And Statistics Administration, US Census Bureau
- Gryn T, Gambino C (2012) The foreign born from Asia: 2011. American Community Survey Briefs
- Tunstall-Pedoe H, Kuulasmaa K, Mahonen M et al (1999) Contribution of trends in survival and coronary-event rates to changes in coronary heart disease mortality: 10-year results from 37 who MONICA project populations. Monitoring trends and determinants in cardiovascular disease. *Lancet* 353(9164):1547–1557
- Wu Z, Yao C, Zhao D et al (2001) Sino-MONICA Project: a Collaborative Study on trends and determinants in cardiovascular diseases in China, part I: morbidity and mortality monitoring. *Circulation* 103(3):462–468
- Chen D, Roman GC, Wu GX et al (1992) Stroke in China (Sino-MONICA-Beijing Study) 1984–1986. *Neuroepidemiology* 11(1):15–23
- Zhao D, Liu J, Wang W et al (2008) Epidemiological transition of stroke in china: twenty-one-year observational study from the Sino-MONICA-Beijing project. *Stroke* 39(6):1668–1674
- Modesti PA, Bianchi S, Borghi C et al (2014) Cardiovascular health in migrants: current status and issues for prevention. a collaborative multidisciplinary task force report. *J Cardiovasc Med* 15(9):683–692
- Bhopal R (2000) What is the risk of coronary heart disease in South Asians? A review of UK research. *J Public Health Med* 22(3):375–385
- Raza Q, Doak CM, Khan A et al (2013) Obesity and cardiovascular disease risk factors among the indigenous and immigrant Pakistani population: a systematic review. *Obes Facts* 6(6):523–535
- Anand SS, Yusuf S, Vuksan V et al (2000) Differences in risk factors, atherosclerosis, and cardiovascular disease between ethnic groups in Canada: the Study Of Health Assessment And Risk In Ethnic Groups (SHARE). *Lancet* 356(9226):279–284
- Zaninotto P, Mindell J, Hirani V (2007) Prevalence of cardiovascular risk factors among ethnic groups: results from the Health Surveys For England. *Atherosclerosis* 195(1):E48–E57
- Chiu M, Austin PC, Manuel DG, Tu JV (2010) Comparison of cardiovascular risk profiles among ethnic groups using Population Health Surveys between 1996 and 2007. *CMAJ* 182(8):E301–E310
- Corlin L, Woodin M, Thanikachalam M et al (2014) Evidence for the healthy migrant effect in older chinese immigrants: a cross-sectional study. *BMC Public Health* 14:603
- Fang J, Madhavan S, Alderman MH (1999) Cardiovascular mortality of Chinese in New York City. *J Urban Health* 76(1):51–61
- Sheth T, Nair C, Nargundkar M et al (1999) Cardiovascular and cancer mortality among Canadians of European, South Asian and Chinese origin from 1979 to 1993: an analysis of 1.2 million deaths. *CMAJ* 161(2):132–138
- Jose PO, Frank AT, Kappahn KI et al (2014) Cardiovascular disease mortality in Asian Americans. *J Am Coll Cardiol* 64(23):2486–2494
- Li N, Tuomilehto J, Dowse G et al (1992) Electrocardiographic abnormalities and associated factors in Chinese living in Beijing and in Mauritius. The Mauritius Non-Communicable Disease Study Group. *BMJ* 304(6842):1596–1601
- Harland JO, Unwin N, Bhopal RS et al (1997) Low levels of cardiovascular risk factors and coronary heart disease in a UK Chinese population. *J Epidemiol Community Health* 51(6):636–642
- Wang L (2014) Immigrant health, socioeconomic factors and residential neighbourhood characteristics: a comparison of multiple ethnic groups in Canada. *Appl Geogr* 52:90–98
- Dowse GK, Gareeboo H, Zimmet PZ et al (1990) High prevalence Of NIDDM and impaired glucose tolerance in Indian, Creole And Chinese Mauritians. *Diabetes* 39(3):390–396
- Kandula NR, Diez-Roux AV, Chan C et al (2008) Association of acculturation levels and prevalence of diabetes in the multi-ethnic study of atherosclerosis (MESA). *Diabetes Care* 31(8):1621–1628
- Veeranna V, Zalawadiya SK, Niraj A et al (2013) Association of novel biomarkers with future cardiovascular events is influenced by ethnicity: results from a multi-ethnic cohort. *Int J Cardiol* 166(2):487–493
- Wang B, Wei DY, Wang CX et al (2010) A research on prevalence and risk factors of type 2 diabetes mellitus in the farmers

- and immigrants of Yi people on Liangshan, Sichuan province, China. *Chin J Prev Med* 44(6):510–515
32. Moran A, Diez RAV, Jackson SA et al (2007) Acculturation is associated with hypertension in a multiethnic sample. *Am J Hypertens* 20(4):354–363
 33. Bin W, Chunxiu W, Daying W et al (2010) Prevalence and risk factors of essential hypertension in Yi people in Sichuan province, China. *Chin J Public Health* 26(4):472–473
 34. Longde W, Ling Y, Yang H et al (2015) Fixed-dose combination treatment after stroke for secondary prevention in China: a National Community-Based Study. *Stroke* 46(5):1295–1300
 35. Zhai Y, Wang WZ, Zhao WH et al (2009) The prevalence and onset of age of stroke in Chinese adults. *Chin J Prev Med* 43(12):1069–1072
 36. Ministry of Health in China (2014) China Health And Family Planning Statistics Yearbook
 37. Chiu JF, Bell AD, Herman RJ et al (2010) Cardiovascular risk profiles and outcomes of Chinese living inside and outside China. *Eur J Cardiovasc Prev Rehabil* 17(6):668–675
 38. Center for Health Statistic and Information (2009) An Analysis Report Of National Health Services Survey In China, 2008
 39. Hu D, Fu P, Xie J et al (2008) Increasing prevalence and low awareness, treatment and control of diabetes mellitus among Chinese adults: the InterASIA Study. *Diabetes Res Clin Pract* 81(2):250–257
 40. Hu D, Sun L, Fu P et al (2009) Prevalence and risk factors for type 2 diabetes mellitus in the Chinese adult population: the InterASIA Study. *Diabetes Res Clin Pract* 84(3):288–295
 41. Dong JJ, Lou NJ, Zhao JJ et al (2011) Evaluation of a risk factor scoring model in screening for undiagnosed diabetes in China population. *J Zhejiang Univ Sci B* 12(10):846–852
 42. Park PJ, Griffin SJ, Sargeant L, Wareham NJ (2002) The performance of a risk score in predicting undiagnosed hyperglycemia. *Diabetes Care* 25(6):984–988
 43. Meisinger C, Strassburger K, Heier M et al (2010) Prevalence of undiagnosed diabetes and impaired glucose regulation in 35–59-year-old individuals in Southern Germany: the KORA F4 Study. *Diabet Med* 27(3):360–362
 44. Yang W, Lu J, Weng J et al (2010) Prevalence Of diabetes among men and women in China. *N Engl J Med* 362(12):1090–1101
 45. Unwin N, Harland J, White M et al (1997) Body mass index, waist circumference, waist-hip ratio, and glucose intolerance in Chinese and European adults in Newcastle, UK
 46. Eastern Stroke Coronary Heart Disease Collaborative Research Group (1998) Blood pressure, cholesterol, and stroke in eastern Asia. *The Lancet* 352(9143):1801–1807
 47. Li LM, Rao KQ, Kong LZ et al (2005) A description on the Chinese national nutrition and health survey in 2002. *Zhonghua Liu Xing Bing Xue Za Zhi* 26(7):478–484
 48. Hsu YH, Mao CL, Wey M (2010) Antihypertensive medication adherence among elderly Chinese Americans. *J Transcult Nurs* 21(4):297–305
 49. Kramer H, Han C, Post W et al (2004) Racial/ethnic differences in hypertension and hypertension treatment and control in the multi-ethnic study of atherosclerosis (MESA). *Am J Hypertens* 17(10):963–970
 50. Yang W, Xiao J, Yang Z et al (2012) Serum lipids and lipoproteins in Chinese Men and Women. *Circulation* 125(18):2212–2221
 51. Wahlqvist ML (2002) Asian migration to Australia: food and health consequences. *Asia Pac J Clin Nutr* 11(Suppl 3):S562–S568
 52. Klatsky AL, Armstrong MA (1991) Cardiovascular risk factors among Asian Americans living in northern California. *Am J Public Health* 81(11):1423–1428
 53. Narayan KM, Aviles-Santa L, Oza-Frank R et al (2010) Report of a National Heart, Lung, and Blood Institute Workshop: heterogeneity in cardiometabolic risk in Asian Americans in the US opportunities for research. *J Am Coll Cardiol* 55(10):966–973
 54. Albrecht SS, Roux AVD, Kandula NR et al (2013) Immigrant assimilation and bmi and waist size: a longitudinal examination among hispanic and Chinese participants in the multi-ethnic study of atherosclerosis. *Obesity* 21(8):1695–1703
 55. Zhai F, Wang H, Du S et al (2007) Lifespan nutrition and changing socio-economic conditions in China. *Asia Pac J Clin Nutr* 16(Suppl 1):374–382
 56. Johnson CA, Xie B, Liu C et al (2006) Socio-demographic and cultural comparison of overweight and obesity risk and prevalence in adolescents in southern California and Wuhan, China. *J Adolesc Health* 39(6):925.E1–8
 57. Chiu M, Austin PC, Manuel DG, Tu JV (2012) Cardiovascular risk factor profiles of recent immigrants vs long-term residents of Ontario: a multi-ethnic study. *Can J Cardiol* 28(1):20–26
 58. Zhou N, Cheah CS (2015) Ecological risk model of childhood obesity in Chinese immigrant children. *Appetite* 90:99–107
 59. Au L, Kwong K, Chou JC et al (2009) Prevalence of overweight and obesity in Chinese American children in New York City. *J Immigr Minor Health* 11(5):337–341
 60. Razak F, Anand SS, Shannon H et al (2007) Defining obesity cut points in a multiethnic population. *Circulation* 115(16):2111–2118
 61. Pan WH, Flegal KM, Chang HY et al (2004) Body mass index and obesity-related metabolic disorders in taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. *Am J Clin Nutr* 79(1):31–39
 62. Lv N, Brown JL (2010) Chinese American family food systems: impact of western influences. *J Nutr Educ Behav* 42(2):106–114
 63. Rosenthal T (2014) The effect of migration on hypertension and other cardiovascular risk factors: a review. *J Am Soc Hypertens*
 64. Li Q, Hsia J, Yang G (2011) Prevalence of smoking in China in 2010. *N Engl J Med* 364(25):2469–2470
 65. Chen X, Unger JB, Johnson CA (1999) Is acculturation a risk factor for early smoking initiation among Chinese American minors? A Comparative Perspective. *Tob Control* 8(4):402–410
 66. Chen X, Unger JB, Cruz TB, Johnson CA (1999) Smoking patterns of Asian–American youth in California and their Relationship with acculturation. *J Adolesc Health* 24(5):321–328