TRENDS IN NUTRITIONAL EPIDEMIOLOGY RESEARCH IN CHINA, 2000-2018: A SCOPING REVIEW

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ABSTRACT

Nutritional epidemiology provides important information on disease prevention and health management. Facing the rising public concerns of chronic disease, nutritional epidemiology becomes an important component of China's overall health research agenda. This study reviews and classifies nutritional epidemiology research in China during the past two decades, identifying the major trends and possible gaps in terms of the study topic and study content. Study population, study design, exposure, outcome and geographic information of each study are extracted using a coding sheet to explore the trend of the characteristics and interests over time. The results show that China has experienced a rapid increase in the number of nutritional epidemiology studies and a continuously expanded diversity in the outcomes and exposures. It is crucial that research effort and funding be allocated across outcomes and exposures that are most relevant for the nutrition-related health concerns to be anticipated in the future.

BIOGRAPHICAL SKETCH

Jin Shang is currently a second-year master student in the Nutritional Sciences at Cornell University. In May 2019, she will graduate with a Master of Science degree, with a focus on individual track and minor in Epidemiology. In 2017, Jin graduated from China Agricultural University, China, where she earned a Bachelor's in Engineering degree in Food Science and Engineering. During last summer, Jin joined WHO/Cochrane/Cornell University Summer Institute for systematic reviews in nutrition for global policy-making, and she began to work on a Cochrane review of effectiveness of sleep intervention on childhood obesity up until now. Outside of academics, Jin is very involved in film, modern art, fashion design and its history.

This thesis is dedicated to my loving parents, who continuously instill me with affection, love, encouragement and support, and make me able to earn such success and honor. I also dedicate this thesis to Shuo Han, a brilliant man who is always on the way of pursuing excellence with humble and hardworking. These people will always be my lifelong role models.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Nutritional epidemiology focuses on testing hypotheses about nutrition-disease relationships. It examines the role of nutrition in the etiology of disease, monitors nutritional determinants of human health status, and evaluates interventions to achieve and maintain healthy lifestyles among populations ("Nutritional Epidemiology - Epidemiology & Community Health Research,"). It started as a small sub-discipline of epidemiology several decades ago and has grown into a branch with major public health importance ("Nutritional Epidemiology in EPIC,"). If interpreted with caution and applied in appropriate ways, nutritional epidemiology findings can have great practical value to public health. People in academia, public health, health care authorities and the food industry can apply that information to the field of disease prevention and health management (Langseth, 1996).

Although nutritional epidemiology is a relatively young academic area in China, epidemiology has already become important in health policy making more broadly in China. With the growing availability of epidemiology data, this area has drawn attention from scholars as well as public health practitioners. Improvements in the quantity and quality of data has helped China become a pioneer in this area of research, and the use of evidence has gradually become a major part of the Chinese Government's approach to policy making and implementation (Wang & Jin, 2011). In 2009, the Chinese Government approved guidelines for reform of the health-care

system and published a health-care reform plan for 2009-11. In the following three years CNY850 billion (about US$124 billion) was injected into the health-care system (Chen, 2009), including US$150 million for clinical research, which was twice the amount of funding invested in 2008 (Guo, 2010).

The rising rates of chronic disease worldwide and in China, and the widespread public dissatisfaction with the health-care system, has led to an emphasis on health sector innovation in China's public policy agenda (Hu, Liu, & Willett, 2011). As such, scientific evidence to support decision-making is taking on greater importance. In 2016, the Healthy China 2030 Plan, a national long-term strategic plan for the health sector, was launched to promote healthy lifestyles and build a sustainable health-care system. The development of this plan is crucial to the Chinese Government's agenda for health and development and highlights that human health research is of increasing importance in developing public health policy in China (Fu, Zhao, Zhang, Chai, & Goss, 2018). Nutritional epidemiology is an important component of China's overall health research agenda because of its diverse capacity in disease prevention and management.

This study is a descriptive narrative review and classification of nutritional epidemiology research in China during the period between 2000-2018, aiming at the identification of the major trends and possible gaps in terms of the study topic and study content. This study may provide further guidance to public health scholars, policy makers and research funders concerning future research priorities to address the most important health problems and provide evidence for decision making.

REFERENCES

Chen, Z. (2009). Launch of the health-care reform plan in China. *The Lancet, 373*(9672), 1322-1324. doi:10.1016/S0140-6736(09)60753-4

Fu, W., Zhao, S., Zhang, Y., Chai, P., & Goss, J. (2018). Research in health policy making in China: Out-of-pocket payments in healthy China 2030. *BMJ (Online), 360*. doi:10.1136/bmj.k234

Guo, L. (2010). China boosts medical research. *The Lancet, 375*(9716), 711. doi:10.1016/S0140-6736(10)60288-7

Hu, F. B., Liu, Y., & Willett, W. C. (2011). Preventing chronic diseases by promoting healthy diet and lifestyle: Public policy implications for China. *Obesity Reviews, 12*(7), 552-559. doi:10.1111/j.1467-789X.2011.00863.x

Langseth, L. (1996). *Nutritional Epidemiology Possibilities and Limitations*: International Life Science Institute.

Nutritional Epidemiology - Epidemiology & Community Health Research. Retrieved from https://www.sphresearch.umn.edu/epi/nutritional-epidemiology/

Nutritional Epidemiology in EPIC. Retrieved from http://epic.iarc.fr/research/activitiesbyresearchfields/nutritionalepidemiology.php

Wang, J., & Jin, X. (2011). Translating evidence into policy in China: Opportunities and challenges. *Frontiers of Medicine in China, 5*(3), 315-320. doi:10.1007/s11684-011-0146-6

CHAPTER 2

METHOD

Eligibility Criteria for This Review

We included English-language articles that addressed nutrition-related epidemiological issues, with nutrition-related exposure, comparison or outcome. Cross-sectional studies, cohort studies, case-control studies, randomized controlled trials, systematic reviews with meta-analysis and other types of epidemiological designs were included in the present review. Our target study population was Chinese people living in China. In addition, we only included studies that had a sample size more than 50 and were conducted within the Chinese territory.

Search Method and Search Strategy

We searched PubMed and Scopus for the time periods of 2000-2001, 2005-2006, 2010-2011 and 2015-2018, using the search strategy in the form [terms for nutrition] AND [terms for China] AND [terms for epidemiological study design] AND [terms for language]. The exact search strategy is shown as follows:

PubMed	
#	Search terms
1	vitamin[tiab] OR mineral[tiab] OR nutrient[tiab] OR diet[tiab] OR dietary[tiab] OR food intake[tiab] OR nutrition[tiab] OR nutritional[tiab]
2	china[tiab] OR Chinese[tiab]
3	population[tiab] OR epidemiological[tiab] OR case-control[tiab] OR cohort[tiab] OR cross-sectional[tiab] OR longitudinal[tiab] OR survey[tiab] OR trial[tiab] OR meta-analysis[tiab] OR formative or effectiveness[tiab] OR intervention[tiab] OR implementation[tiab] OR national[tiab] OR planning[tiab] OR program[tiab] OR policy[tiab]
4	1 AND 2 AND 3 AND English[lang]
Scopus	

#	Search terms
1	TITLE-ABS-KEY ((vitamin OR mineral OR nutrient OR diet OR dietary OR food intake OR nutrition OR nutritional) AND (china OR Chinese) AND (population OR epidemiological OR case-control OR cohort OR cross-sectional OR longitudinal OR survey OR trial OR meta-analysis OR formative or effectiveness OR intervention OR implementation OR national OR planning OR program OR policy)) AND (LIMIT-TO (LANGUAGE, "English"))

Study Selection and Data Analysis

The search results were imported into EndNote reference manager to remove duplicates. Titles, abstracts and full texts were screened for inclusion. To identify the topic and interest of each study, the remaining articles were imported into a coding sheet for further extraction of five variables: study population, study design, exposure, outcome and geographic information. The description and classification of these five variables are described in Table 2.1.

During the screening and coding process, we excluded any paper that was not an epidemiological study, not nutrition-related, not a human study, not conducted in China, not written in English, had a small sample size (smaller than 50), did not have a full text version available, or had missing information for coding.

To enhance coding accuracy, a codebook was developed, and the coding strategy was iteratively revised according to the characteristics of the research articles. In addition, after the coding process, the coding sheet was checked again and updated before further analysis.

Table 2.1 The detailed description of the five variables (study population, study design, exposure, outcome, geographic information) that used in the coding

Study population	include adults, children and adolescents, infants and toddlers, other	**Adults**: aged 18 and older, subgroups include: general adult population (aged more than 18, or mentioned as "general adults", "general adult population" in the paper), young adults (aged 18-35, or mentioned as "young adults in the paper"), mid-aged and elderly (mid-aged defined as 36-55 or mentioned as "mid-aged" in the paper; elderly defined as older than 55 or mentioned as "elderly", "older adults", "older population" in the paper) **Children and adolescents**: aged 3-18, subgroups include: preschool-aged children (aged 3-6, or mention as "preschool-aged" in the paper), school-aged children (aged 7-18, or mentioned as "school-aged" in the paper), college students (students enrolled in a college or university, or mentioned as "college students", "university students" in the paper) **Infants and toddlers**: from birth to 3 years of age, or mentioned as "infants", "newborns", "babies", "toddlers" in the paper **Other**: other kinds of population that cannot be classified into groups above
Study design	include cross-sectional, cohort, case-control, randomized control trial, meta-analysis, other	
Exposure	include dietary factors, nutrient supplements, biomarkers, physical activity, nutrition-related behaviors, social factors, other, multiple exposure, no exposure	**Dietary factors**: factors that related to diet, including dietary patterns, nutrient intakes, specific kinds of food consumption, et al. **Nutrient supplements**: mentioned as "supplements" or "supplementation" in the paper

		Biomarkers: any measurable indicators of health status or severity or presence of some disease state that mentioned in the paper **Physical activity**: mentioned as “physical activity”, “exercise”, “sedentary behavior” in the paper **Nutrition-related behaviors**: behaviors affect or affected by nutritional factors, such as infant feeding patterns, eating habits, et al. **Social factors**: factors from social setting that have influence on lifestyle and nutritional status, such as socio-economic status, urbanization, advertising, one-child policy, et al.
Outcome	include disease and morbidity, mortality, biomarkers, nutrition-related behaviors, other, multiple outcomes, no outcome	**Disease and morbidity**: nutrition-related diseases and morbidities **Mortality**: can be total/all-cause mortality or cause-specific mortality **Biomarkers**: any measurable indicators of health status or severity or presence of some disease state that mentioned in the paper **Nutrition-related behaviors**: behaviors affect or affected by nutritional factors, such as infant feeding patterns, eating habits, et al.
Geographic information	include national, provincial, municipal, rural, special administrative region, other	

Data analysis and interpretation were conducted based on the distribution of each of the five variables to identify the overall trend and to describe the characteristics and interests of nutritional epidemiological studies in China.

CHAPTER 3

RESULTS

Overall, 4,513 articles were identified in PubMed database and 4,091 were identified in Scopus database. 7,108 articles were screened for eligibility after removing the duplicates. 3,903 articles went forward for full text assessment after the title and abstract screening. Finally, 2,385 articles were included for the coding. The flow of the study selection procedure is shown in Figure 3.1.

The left panel of Figure 3.2 shows the number of all the epidemiological studies and the number of nutritional epidemiological studies that were published in PubMed during 2000-2018. Nutritional epidemiological studies only account for a small percentage of the total epidemiological studies (6.8%), while the overall trends in the number of papers published in this period are very similar. The number of nutritional epidemiological papers finally included for coding during each year (2000, 2001, 2005, 2006, 2010, 2011, 2015, 2016, 2017, 2018) is shown in the right panel of Figure 3.2. The figure shows a gradually increasing trend and there is more than 17-fold increase from 2000 to 2018. Year 2010 is observed to be a turning point of the increasing trend. The drop that happens in 2018 may be due to the publication delays in the databases because the article search for year 2018 was conducted in the beginning of 2018.

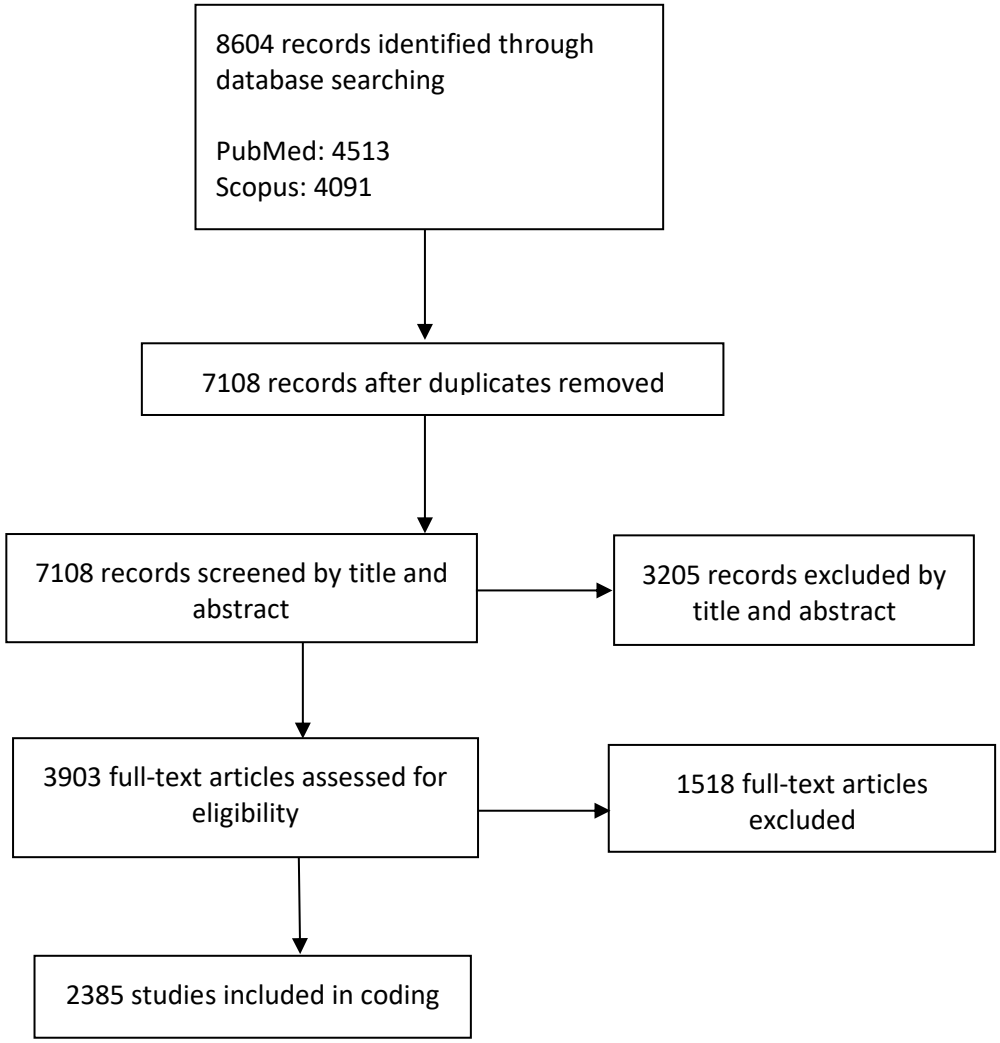

Figure 3.1 Study flow diagram of year 2000-2001, 2005-2006, 2010-2011, 2015-2018

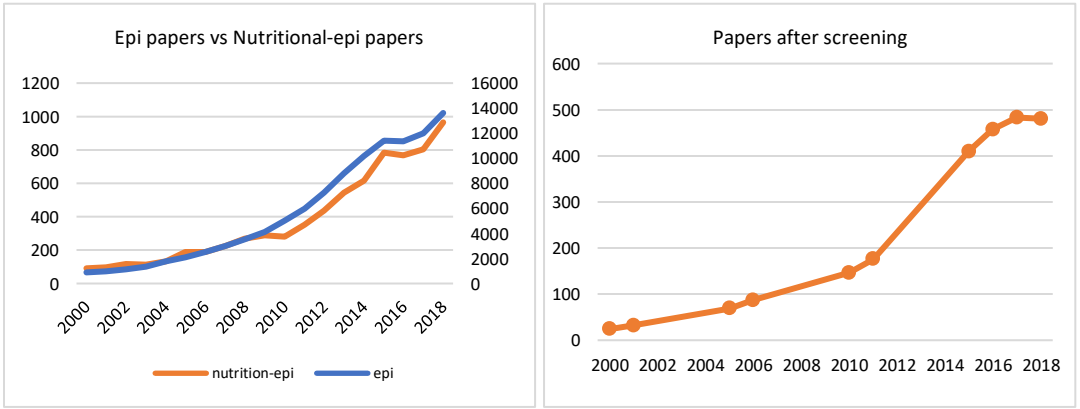

Figure 3.2 The number of epi/nutritional-epi papers published in PubMed during 2000-2018 (left panel) and the number of papers included in coding (right panel)

The distribution of the following variables is displayed in Figure 3.3: population, study design, exposure, outcome, geographic distribution. The time period was divided into 2000-2006, 2010-2016 and 2017-2018 (hereafter called Period 1, 2 and 3). For Period 1 and Period 2, we included the first two years and the last two years in each period to represent the whole six-year interval (i.e., 2000-2001 and 2005-2006 for Period 1; and 2010-2011 and 2015-2016, for Period 2). This was done to create a manageable the workload due to limitations of time. There was a similar distribution for each of coded variables in Period 1, 2 and 3, but with some slight differences. For study population, researchers focused more on general adult population and less on middle-aged and elderly population in Period 3 compared to the earlier two periods. Regarding study design, the cross-sectional studies had an increased tendency in proportion of the total across three time periods, and case-control studies showed a decreased tendency in proportion at the same time. As for exposure, there was a higher proportion of papers studying biomarkers during Period 2 compared to the other two time periods. Similarly, disease and morbidities as outcomes also had a higher proportion during Period 2 than the other two time periods. With regard to the geographic distribution, there was a greater proportion of national studies, lower proportion of provincial studies, rural studies and studies in special administrative regions in the latter two periods compared with Period 1.

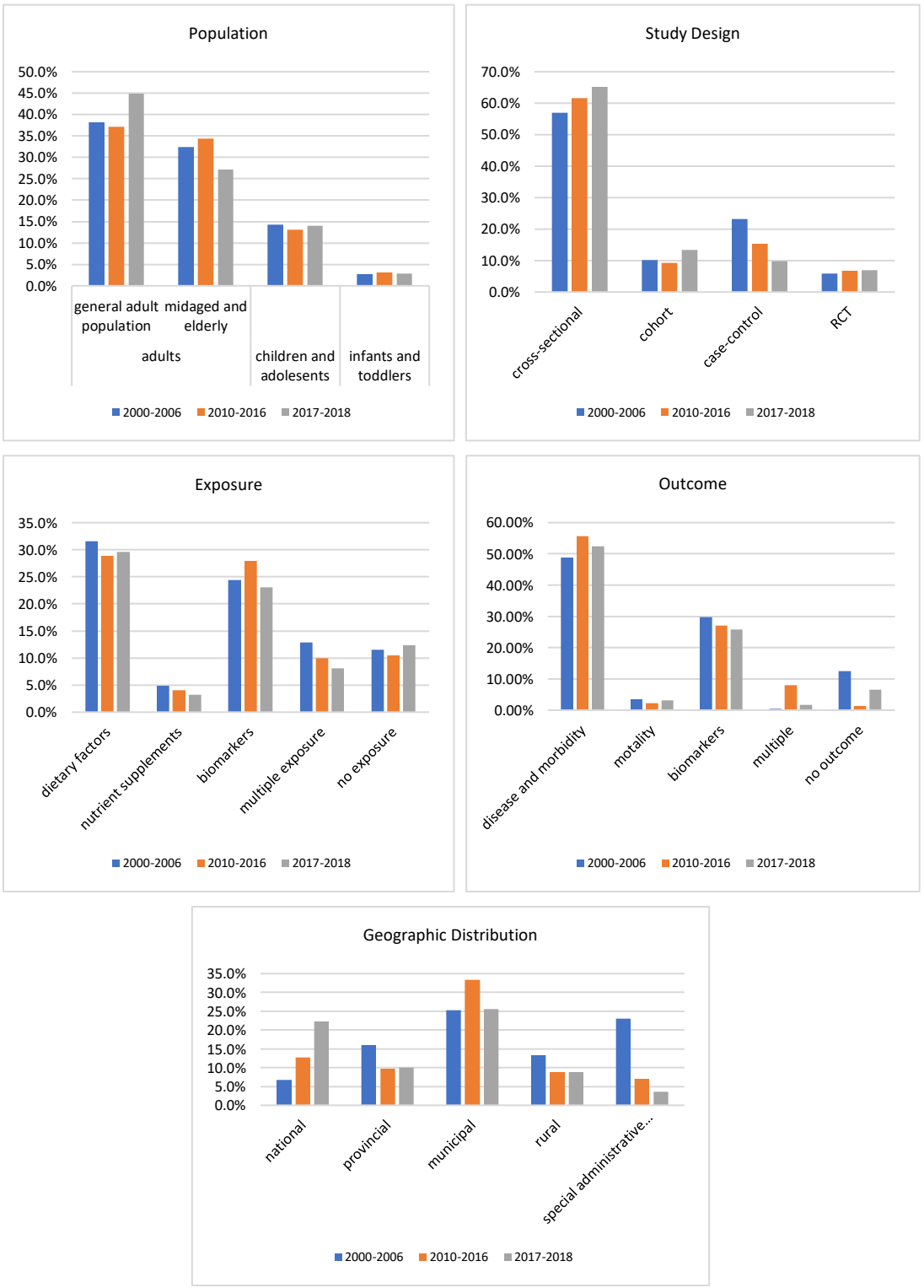

Figure 3.3 Comparison of the variables (population, study design, exposure, outcome, geographic distribution) between 2000-2006, 2010-2016 and 2017-2018

To explore the change in the most popular topics and the diversity of the research topic over time, the 10 most popular diseases and morbidities, biomarkers (as outcome), dietary factors and cities during Period 1, 2 and 3 are summarized in Table 3.1-3.4. We calculated the percentage of total studies represented by each topic as well as cumulative percent across all ten topics (the absolute number for each topic can be found in Table 3.5-3.8). Obesity, hypertension, colorectal cancer, and anemia were popular, in the aggregate, in all three time periods and accounted for a total of 6.6%, 10.7%, 10.2% of all studies, respectively. Diabetes, osteoporosis, metabolic syndrome and depression did not appear in the top 10 in Period 1 but did appear in the later periods, with diabetes representing 3.4% and 4.8% in Periods 2 and 3 respectively; in these two periods osteoporosis represents 2.3% and 1.7%, respectively; metabolic syndrome represents 1.8% and 2.0%, respectively; and depression represents 1.0% and 1.5%, respectively. As to biomarkers, BMD, BMI, blood pressure, weight, serum lipid profiles and vitamin D status were popular topics in all time periods (in total accounting for a total of 24.4%, 13.2%, 9.7%, respectively) and BMD occupied the first place in each time period. Cognitive function and fasting plasma glucose did not appear in the top 10 in Period 1 but did appear in the later 2 periods, with cognitive function representing 1.1% and 1.1% respectively, and plasma glucose representing 0.4% and 0.3% respectively. For dietary factors, dietary patterns, fruit and vegetables intake, tea consumption, nutrients intake, and soy food intake were popular in all time periods (accounting for a total of 18.7%, 10.9%, 12.1%, respectively, for the three time periods) and dietary patterns remained the most popular dietary factor over time. Sodium/salt intake did not appear in the top 10 in Period 1 but did appear in the later 2

periods, representing 1.3% and 0.9% respectively. Substantial changes in popular cities were observed. Shanghai, Hong Kong and Beijing ranked high in all three time periods (accounting for a total of 37.8%, 22.1%, 13.1%, respectively), however, Shanghai exceeded Hong Kong during Period 2 (10.0% vs 6.7%, respectively) and Beijing exceeded Hong Kong during Period 3 (3.6% vs 3.2%, respectively), which indicates the change of geographic distribution and the rise of nutritional epidemiologic studies in mainland China. The count of total diseases and morbidities, biomarkers, dietary factors and cities are also presented in Table 3.1-3.8.

Graphs for the cumulative percentage of the 10 most popular topics in each time period are made as a measure for diversity, which can be found in Figure 3.4-3.7. Both slopes of the lines and the cumulative percentage of the 10^{th} topic indicates an increased diversity in later periods compared to Period 1.

Table 3.1 Top 10 popular diseases and morbidities during 2000-2006, 2010-2016 and 2017-2018 (shown as percentage of total and cumulative percentage)

Top 10 diseases and morbidities studied									
Rank	2000-2006			2010-2016			2017-2018		
	Disease	%	cumulative %	Disease	%	cumulative %	Disease	%	cumulative %
1	breast cancer	5.3	5.3	obesity	5.9	5.9	obesity	4.9	4.9
2	esophageal cancer	4.0	9.3	diabetes	3.4	9.3	diabetes	4.8	9.7
3	gastric cancer	3.6	12.9	hypertension	2.9	12.2	hypertension	2.8	12.5
4	fracture	2.2	15.1	osteoporosis	2.3	14.5	metabolic syndrome	2.0	14.5
5	obesity	2.2	17.3	breast cancer	2.0	16.5	osteoporosis	1.7	16.2
6	hypertension	1.8	19.1	metabolic syndrome	1.8	18.3	depression	1.5	17.7
7	nasopharyngeal carcinoma	1.8	20.9	cardiovascular disease	1.1	19.4	fracture	1.4	19.1
8	anemia	1.3	22.2	depression	1.0	20.4	anemia	1.3	20.4
9	colorectal cancer	1.3	23.5	colorectal cancer	1.0	21.4	colorectal cancer	1.2	21.6
10	hepatocellular carcinoma	1.3	24.8	anemia	0.9	22.3	malnutrition	1.0	22.6
# of diseases	52			233			196		
# of total papers	225			1197			963		

Table 3.2 Top 10 popular biomarkers as outcome during 2000-2006, 2010-2016 and 2017-2018 (shown as percentage of total and cumulative percentage)

Top 10 biomarkers (as outcome) studied									
Rank	2000-2006			2010-2016			2017-2018		
	Biomarker	%	cumulative %	Biomarker	%	cumulative %	Biomarker	%	cumulative %
1	BMD	14.2	14.2	BMD	6.1	6.1	BMD	3.3	3.3
2	BMI	2.7	16.9	blood pressure	3.3	9.4	BMI	1.7	5.0
3	weight	2.7	19.6	weight	1.8	11.2	weight	1.7	6.7
4	blood pressure	2.2	21.8	cognitive function	1.1	12.3	vitamin D status	1.2	7.9
5	serum lipid profiles	1.8	23.6	BMI	1.0	13.3	cognitive function	1.1	9.0
6	height	1.3	24.9	waist circumference	0.6	13.9	blood pressure	1.0	10.0
7	ankle-brachial index	0.9	25.8	serum lipid profiles	0.5	14.4	serum lipid profiles	0.8	10.8
8	iron status	0.9	26.7	vitamin D status	0.5	14.9	insulin resistance	0.5	11.3
9	peak bone mass	0.9	27.6	fasting plasma glucose	0.4	15.3	fasting plasma glucose	0.3	11.6
10	vitamin D status	0.8	28.4	iron status	0.3	15.7	glycemic control	0.3	11.9
# biomarkers	31			133			120		
# of total papers	225			1197			963		

Table 3.3 Top 10 popular dietary factors during 2000-2006, 2010-2016 and 2017-2018 (shown as percentage of total and cumulative percentage)

Top 10 dietary factors studied									
Rank	2000-2006			2010-2016			2017-2018		
	Dietary factor	%	cumulative %	Dietary factor	%	cumulative %	Dietary factor	%	cumulative %
1	dietary patterns	9.8	9.8	dietary patterns	7.5	7.5	dietary patterns	8.1	8.1
2	soy food intake	4.4	14.2	tea consumption	1.4	8.9	fruit and vegetables intake	2.0	10.1
3	fat intake	1.8	16.00	sodium/salt intake	1.3	10.2	sodium/salt intake	0.9	11.0
4	fruit and vegetables intake	1.8	17.8	fruit and vegetables intake	0.8	11.0	spicy food consumption	0.9	11.9
5	nutrients intake	1.8	19.6	soy food intake	0.7	11.7	tea consumption	0.9	12.8
6	fiber intake	0.9	20.5	dietary fiber intake	0.5	12.2	nutrients intake	0.6	13.4
7	iodine intake	0.9	21.4	nutrients intake	0.5	12.7	diet quality	0.5	13.9
8	protein intake	0.9	22.3	seafood consumption	0.4	13.1	soy food intake	0.5	14.4
9	seafood consumption	0.9	23.2	diet quality	0.3	13.4	dietary protein intake	0.4	14.8
10	tea consumption	0.9	24.1	fast food consumption	0.3	13.7	dietary sugar intake	0.4	15.2
# dietary factors	36			146			117		
# of total papers	225			1197			963		

Table 3.4 Top 10 popular cities during 2000-2006, 2010-2016 and 2017-2018 (shown as percentage of total and cumulative percentage)

Top 10 cities studied									
Rank	2000-2006			2010-2016			2017-2018		
	City	%	cumulative %	City	%	cumulative %	City	%	cumulative %
1	Hong Kong	22.7	22.7	Shanghai	10.0	10.0	Shanghai	6.3	6.3
2	Shanghai	12.4	35.1	Hong Kong	6.7	16.7	Beijing	3.6	9.9
3	Beijing	2.7	37.8	Beijing	5.4	22.1	Hong Kong	3.2	13.1
4	Shenyang	1.8	39.6	Guangzhou	4.5	26.6	Guangzhou	3.2	16.3
5	Chaoshan	0.9	40.5	Tianjin	2.3	28.9	Tianjin	1.8	18.1
6	Changsha	0.9	41.4	Harbin	1.5	30.4	Nanjing	0.9	19.0
7	Guangzhou	0.9	42.3	Chengdu	1.1	31.5	Chengdu	0.8	19.8
8	Harbin	0.9	43.2	Chongqing	1.1	32.6	Chongqing	0.6	20.4
9	Taixing	0.9	44.1	Shenyang	0.8	33.5	Shenyang	0.5	20.9
10	Tianjin	0.9	45.0	Xi’an	0.8	34.3	Suzhou	0.5	21.4
# of cities	20			64			50		
# of total papers	225			1197			963		

Table 3.5 Top 10 popular diseases and morbidities during 2000-2006, 2010-2016 and 2017-2018 (shown as absolute number)

Top 10 diseases and morbidities studied						
Rank	2000-2006		2010-2016		2017-2018	
	Disease	count	Disease	count	Disease	count
1	breast cancer	12	obesity	71	obesity	47
2	esophageal cancer	8	diabetes	41	diabetes	46
3	gastric cancer	9	hypertension	35	hypertension	27
4	fracture	5	osteoporosis	27	metabolic syndrome	19
5	obesity	5	breast cancer	24	osteoporosis	16
6	hypertension	4	metabolic syndrome	22	depression	14
7	nasopharyngeal carcinoma	4	cardiovascular disease	13	fracture	13
8	anemia	3	depression	12	anemia	12
9	colorectal cancer	3	colorectal cancer	12	colorectal cancer	12
10	hepatocellular carcinoma	3	anemia	11	malnutrition	10
# of diseases	52		233		196	
# of total papers	225		1197		963	

Table 3.6 Top 10 popular biomarkers as outcome during 2000-2006, 2010-2016 and 2017-2018 (shown as absolute number)

Top 10 biomarkers (as outcome) studied						
Rank	2000-2006		2010-2016		2017-2018	
	Biomarker	count	Biomarker	count	Biomarker	count
1	BMD	32	BMD	72	BMD	32
2	BMI	6	blood pressure	39	BMI	16
3	weight	6	weight	21	weight	16
4	blood pressure	5	cognitive function	13	vitamin D status	12
5	serum lipid profiles	4	BMI	12	cognitive function	11
6	height	3	waist circumference	7	blood pressure	10
7	ankle-brachial index	2	serum lipid profiles	6	serum lipid profiles	7
8	iron status	2	vitamin D status	6	insulin resistance	5
9	peak bone mass	2	fasting plasma glucose	5	fasting plasma glucose	3
10	vitamin D status	2	iron status	4	glycemic control	3
# of biomarkers	31		133		120	
# of total papers	225		1197		963	

Table 3.7 Top 10 popular dietary factors during 2000-2006, 2010-2016 and 2017-2018 (shown as absolute number)

Top 10 dietary factors studied						
	2000-2006		2010-2016		2017-2018	
Rank	Dietary factor	count	Dietary factor	count	Dietary factor	count
1	dietary patterns	22	dietary patterns	86	dietary patterns	78
2	soy food intake	10	tea consumption	17	fruit and vegetables intake	19
3	fat intake	4	sodium/salt intake	16	sodium/salt intake	9
4	fruit and vegetables intake	4	fruit and vegetables intake	10	spicy food consumption	9
5	nutrients intake	4	soy food intake	8	tea consumption	9
6	fiber intake	2	dietary fiber intake	6	nutrients intake	6
7	iodine intake	2	nutrients intake	6	diet quality	5
8	protein intake	2	seafood consumption	5	soy food intake	5
9	seafood consumption	2	diet quality	4	dietary protein intake	4
10	tea consumption	2	fast food consumption	3	dietary sugar intake	4
# of dietary factors	36		146		117	
# of total papers	225		1197		963	

Table 3.8 Top 10 popular cities during 2000-2006, 2010-2016 and 2017-2018 (shown as absolute number)

Top 10 cities studied						
Rank	2000-2006		2010-2016		2017-2018	
	City	count	City	count	City	count
1	Hong Kong	51	Shanghai	121	Shanghai	61
2	Shanghai	28	Hong Kong	80	Beijing	35
3	Beijing	6	Beijing	65	Hong Kong	31
4	Shenyang	4	Guangzhou	54	Guangzhou	31
5	Chaoshan	2	Tianjin	27	Tianjin	17
6	Changsha	2	Harbin	18	Nanjing	9
7	Guangzhou	2	Chengdu	13	Chengdu	8
8	Harbin	2	Chongqing	13	Chongqing	6
9	Taixing	2	Shenyang	10	Shenyang	5
10	Tianjin	2	Xi'an	10	Suzhou	5
# of cities	20		64		50	
# of total papers	225		1197		963	

Figure 3.4 Cumulative figures of top 10 popular diseases and morbidities during 2000-2006, 2010-2016 and 2017-2018

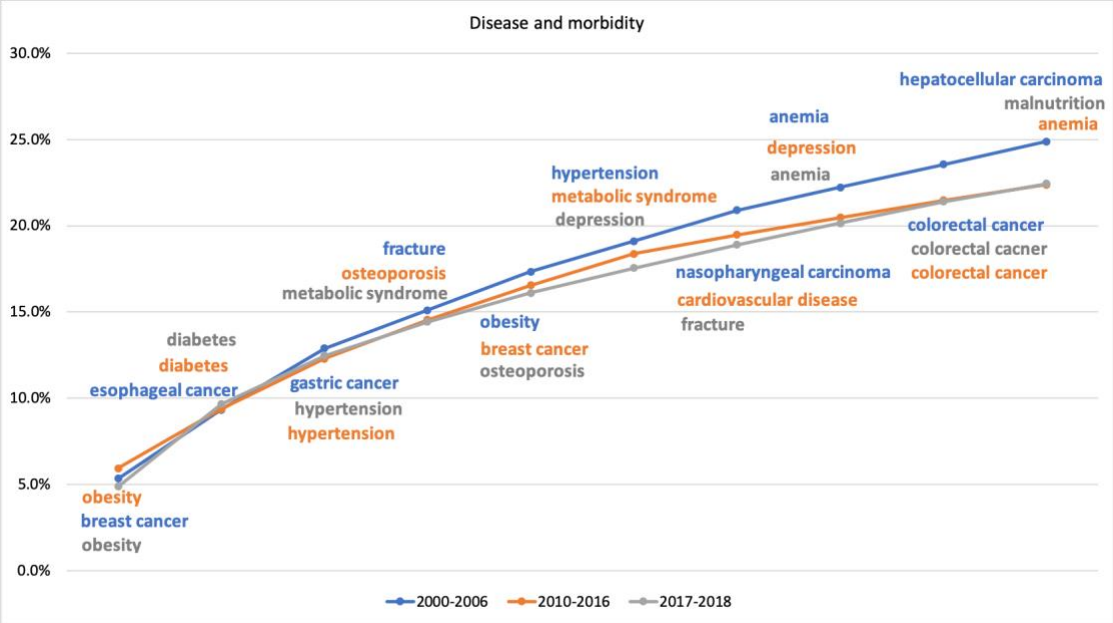

Figure 3.5 Cumulative figures of top 10 popular biomarkers as outcome during 2000-2006, 2010-2016 and 2017-2018

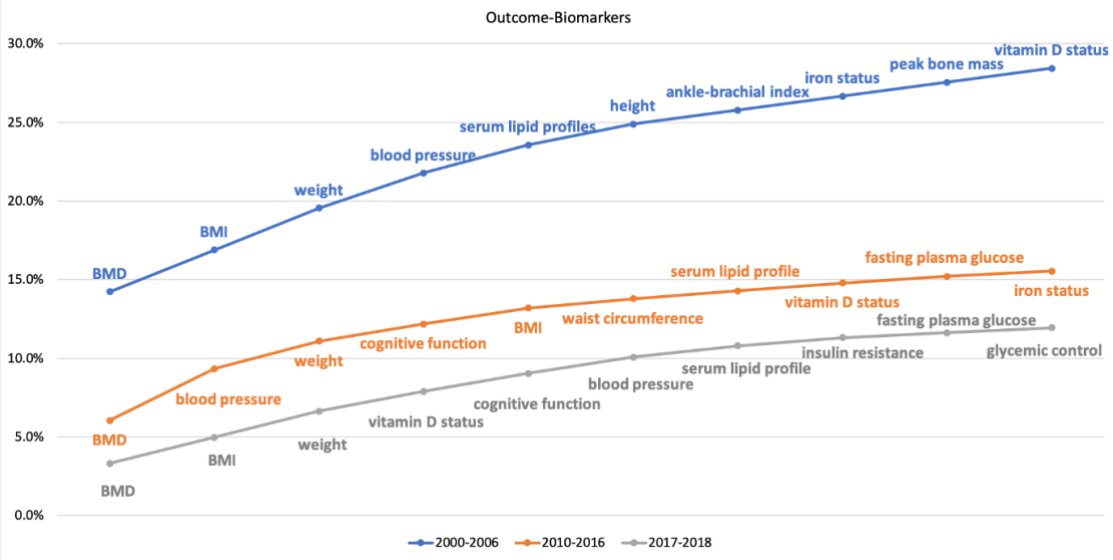

Figure 3.6 Cumulative figures of top 10 popular dietary factors during 2000-2006, 2010-2016 and 2017-2018

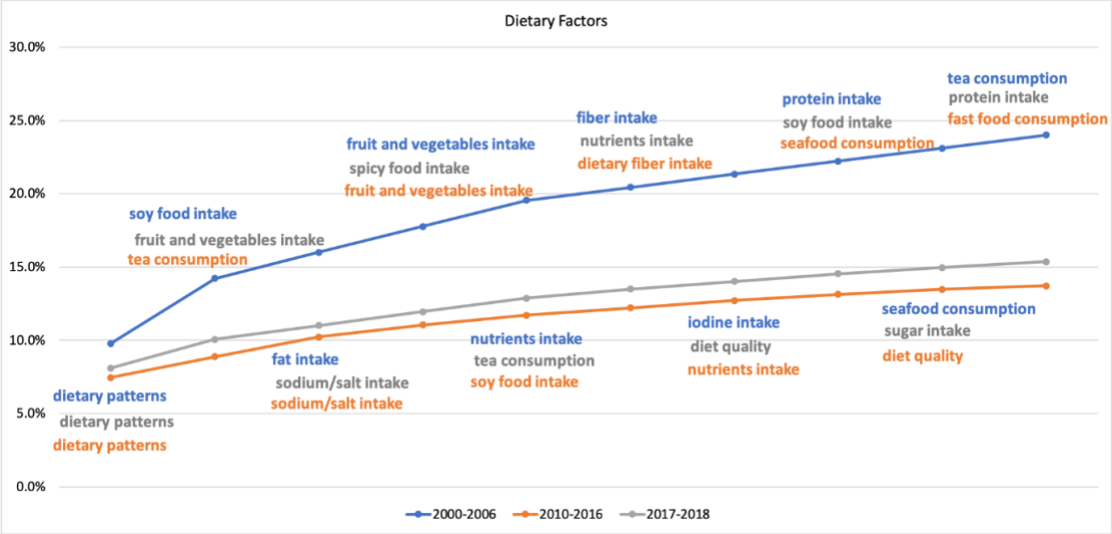

Figure 3.7 Cumulative figures of top 10 popular cities during 2000-2006, 2010-2016 and 2017-2018

With respect to outcome, more than 50% of the publications studied an outcome that was classified as disease or morbidity. Therefore, a special comparison was made between cardiometabolic disease verses cancer. The trends in the number of these two categories are shown in Figure 3.8. The percentage of the total for studies focused on cardiometabolic disease increased by 10% in Period 2 compared to Period 1, while the percentage for studies focused on cancer decreased by 10%.

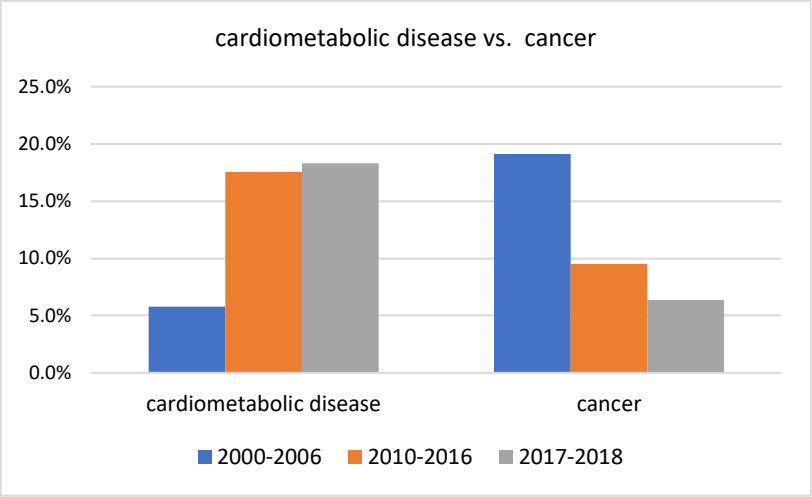

Figure 3.8 Comparison of the number of papers focused on cardiometabolic disease versus cancer during 2000-2006, 2010-2016 and 2017-2018 (shown as percentage of the total studies)

The comparison between studies conducted in urban area and rural area was made and the results are shown in Figures 3.9 and 3.10. There was an increase in the number of studies in both rural and urban area. As for study population, urban studies focused more on middle-aged and elderly population than rural studies (39% vs 30% of the total, respectively, for urban and rural). Regarding study design, RCTs represented a larger percentage in rural studies (6.2% vs 13.0% of the total, respectively, for urban and rural) and the percentage of cross-sectional and cohort studies were smaller in

rural studies (67.0% vs 58.6% of the total for cross-sectional studies; 13.2% vs 8.4% of the total for cohort studies).

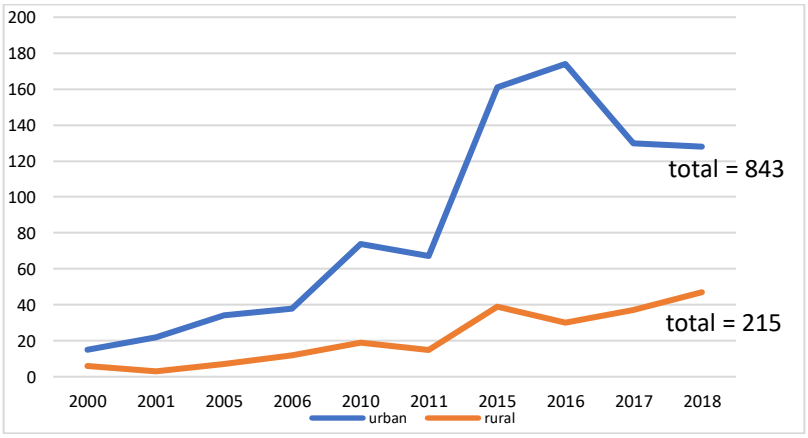

Figure 3.9 Amount of studies conducted in urban area and rural area during 2000-2018

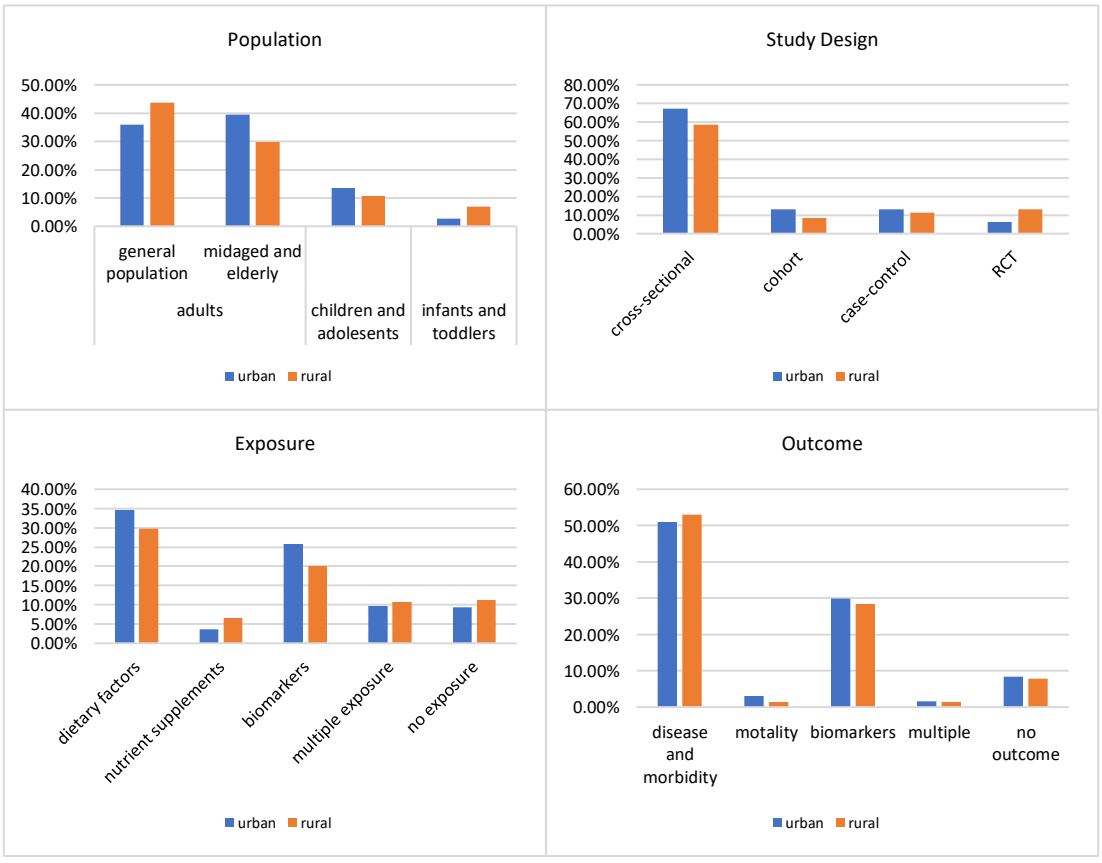

Figure 3.10 Comparison of the variables between urban and rural

Table 3.9 Summary of the PICO from the RCTs from 2000-2018

Population	healthy participants: 13.8% patients with disease: 54.0% not specified: 32.2%	Top 5 diseases and morbidities studied:	
		diabetes	7.2%
		hypertension	7.2%
		obesity	5.3%
		cognitive impairment	3.3%
		impaired glucose tolerance	3.3%
Intervention	Supplement: 46.7% Lifestyle intervention: 18.4% Diet intervention: 13.8% Nutrition education: 3.3% Other: 17.8%	Top 5 supplementations studied:	
		folic acid supplementation	6.6%
		vitamin D supplementation	6.6%
		calcium supplementation	4.0%
		iron supplementation	3.3%
		potassium supplementation	3.3%
Comparison	Control/placebo/conventional treatment: 67.11% Other: 32.89%		
Outcome	Biomarker: 86.2% Disease and morbidity: 8.5% Other: 5.3%	Top 5 biomarkers studied:	
		blood pressure	9.9%
		bone mineral density	7.2%
		weight	6.6%
		iron status	3.3%
		serum lipid profiles	3.3%
		vitamin D status	3.3%

We also extracted the RCTs and analyzed the characteristics separately and the summary is outlined in Table 3.9. Briefly, more than half of the studies focused on patients with disease and the top 5 disease and morbidities of interest were diabetes, hypertension, obesity, cognitive impairment, and impaired glucose intolerance (7.2%, 7.2%, 5.3%, 3.3%, 3.3%, respectively). We found a strong focus on supplementation as the intervention (46.7% of the total), and the top 5 popular supplements are: folic acid, vitamin D, calcium, iron and potassium. (6.6%, 6.6%, 4.00%, 3.3%, 3.3%, respectively). For outcome, the most popular biomarkers were: blood pressure, bone mineral density, weight, iron status, serum lipid profiles, and vitamin D status (9.9%,

7.2%, 6.6%, 3.3%, 3.3%, 3.3%, respectively). These results show that the RCTs and overall nutritional epidemiology studies shared similar topics and interests.

CHAPTER 4

DISSCUSSION

To our knowledge, this is the first review and classification of nutritional epidemiology research in China published between 2000-2018. A comprehensive search strategy was developed to maximize the coverage and relevance. We identified the major time trends in the studies and observed how study topics and research designs changed over time.

We observed an overall rising trend in the number of studies that were published, with a much more rapid increase after year 2010, which presumably resulted from the input of greater funding by the Chinese government during 2009-2010 (Guo, 2010). The consistent increase also led to a shift in the geographic distribution of the studies. More municipal areas were being studied and the study sites became more diverse. During the screening and coding, we noticed that a number of comprehensive national surveys were conducted in mainland China, which contributed to the increase in cross-sectional studies observed over time.

We observed that the distribution of study populations by age did not change much over time. However, the percentage of papers studying middle-aged and elderly population did decrease by 6% in the two recent periods. This is important because of changes in the disease profile and age distribution of the Chinese population. In 2009, approximately 85% of Chinese adults aged over 40 years had high levels of two or more cardiometabolic risk factors (Chen et al., 2011) and by the year 2040 nearly 20% of the population will be over 65 years. The increasing number of elderly adults is

estimated to lead to a 40% increase in the non-communicable disease (NCD) burden by 2030 (Langenbrunner, Marquez, & Wang, 2011) and the burden of the five leading NCDs (myocardial infarction, stroke, diabetes, COPD, and lung cancer) among Chinese adults over 40 is predicted to double or even triple between 2010-2030 (Junshi & Wenhua, 2012). In light of these forthcoming demographic changes and corresponding changes in NCD rates, the findings in Figure 4 are of special importance. The increased focus on cardiometabolic disease is consistent with public concerns about the aging problem and the burden of NDCs, while the focus on cancer should also be given serious concern. From the findings of the Global Burden of Disease study(GBD Disease Injury Incidence Prevalence Collaborators, 2018), eight out of the top 10 causes of years lived with disability (YLDs) in China in 2017 were NCDs, including four cardiometabolic diseases and two types of cancer, which highlighted the importance of mitigating the threat of both cardiometabolic disease and cancer, as well as other NCDs. Thus, for the purposes of treatment and secondary prevention, the health status of the middle-aged and elderly population should be given more attention in research with a focus on NCDs being expanded in the future. For the purpose of primary prevention, younger populations should also be given consideration with a focus on behaviors – diet and physical activity relationships.

Steady distributions of the exposure and outcome variables were also observed, while there was a relative neglect of physical activity and nutrition-related behaviors. For example, there was a large proportion of studies that examined the role of dietary factors in the etiology of disease, as well as the relationships between biomarkers and disease. However, as an exposure variable, physical activity accounted for less than

1% of the total studies, and nutrition-related behaviors accounted for less than 4% of the total. As an outcome, nutrition-related behaviors represented only 2% of the total. From the perspective of disease prevention, it is important to look into the associations between disease and lifestyle factors, such as physical activity and nutrition-related behaviors, and their potential influence on biomarker modification and disease prevention. Social factors and environmental changes should also be taken into consideration as they are influential in shaping the behavior of individual and populations. For example, the high rate of NCDs in China is probably a consequence of various factors including rapid economic growth and urbanization, which altered the lifestyles of Chinese people and led to sedentary behaviors, decreased physical activity, unhealthy diets, increased alcohol consumption and increased tobacco use (Wang, Wang, & Qu, 2016). More studies may be needed to support and guide effective actions to promote healthy lifestyles and eating habits, as well as prevent chronic disease.

Regarding the study design, more RCTs should be conducted in the future to provide strong evidence in decision-making. We observed a rising trend in the proportion of cross-sectional studies, a decrease trend in case-control studies, and steady trends in cohort studies, RCTs and meta-analyses. Cross-sectional studies were the most popular over all time periods. Together with cohort studies and case-control studies, they are good at measuring associations, but have inherent weaknesses in testing causality. Representing high level of evidence, RCTs and systematic reviews with meta-analysis were less common over time (6.8% of the total for RCTs and 4.0% for meta-analyses). As a representative of high-quality evidence, RCTs seem to be less

available in the domain of public health than in the field of medical research (Jiang, Zhang, & Shen, 2013). Systematic reviews and meta-analyses, synthesizing and evaluating the findings from multiple RCTs that shared a common topic, have been regarded to be the most authoritative form of evidence and provide guidance for decision makers (Satija, Yu, Willett, & Hu, 2015). To improve the research environment of evidence-based policy making, more efforts should be made by public health researchers, policy makers, as well as research funders to increase the engagement in RCTs, meta-analyses, and non-randomized clinical trials such as quasi-experimental trials, which, in some cases, are more practical than RCTs. Results from studies conducted in other countries ca be applicable for Chinese populations, although in some cases there possibly exists population-specific relationships. For example, some studies have provided strong evidence that race and ethnicity have a significant impact on the relationships between multiple exposures and health outcomes (Butler, 2017; Walker, Strom Williams, & Egede, 2016).

China has made great progress in controlling communicable diseases via high-level policy interventions and an effective political system for implementation and coordination of multiple forms of health sectors (Hu, Liu, & Willett, 2011). Similar tactics can be applied to tackle the emerging epidemic of NCDs. Addressing this issue successfully will not only make a great difference all over the country but will also benefit other nations throughout the world.

Limitations

The present study has some potential limitations. Our including criteria only looked at literature published in English, and 1032 Chinese language studies were excluded

during the searching and screening process. This might introduce some issues related to the publication bias, such as the selection of the language and also the preference in research topics and study designs. Therefore, we did a search in China National Knowledge Infrastructure (CKNI) database to investigate the flow of the numbers during the same time period. Compared to the English language studies, similar time trends in the number of epidemiological studies and nutritional epidemiological studies were observed in the Chinese language literature. This provides some indication that the findings of this study may be broadly representative, although this would need to be confirmed by conducting a similar analysis in the Chinese language literature. To limit the work load, the present study coded and analyzed papers for four of the six years in each of the first two periods (representing the first two and the last two years in each case) which should provide reliable estimates in each case, but this too could be confirmed by including data for all six years in each period. Finally, in future research it may be helpful to include independent coders to conduct some sample tests for examining the accuracy of the coding.

While these issues may have introduced some degree of inaccuracy in some of the results, it is likely that the overall findings are largely representative of the main trends and tendencies in nutritional epidemiology research during this period.

REFERENCES

Butler, A. M. (2017). Social Determinants of Health and Racial/Ethnic Disparities in Type 2 Diabetes in Youth. *Current Diabetes Reports, 17*(8). doi:10.1007/s11892-017-0885-0

Chen, L., Zhao, Z. G., Liu, J., Yang, W. Y., Yang, Z. J., & Ge, J. P. (2011). Prevalence of cardiovascular disease risk factor in the Chinese population: the 2007-2008 China National Diabetes and Metabolic Disorders Study. *European Heart Journal, 33*(2), 213-220. doi:10.1093/eurheartj/ehr205

GBD Disease Injury Incidence Prevalence Collaborators. (2018). Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet (London, England), 392*(10159), 1789-1858. doi:10.1016/S0140-6736(18)32279-7

Guo, L. (2010). China boosts medical research. *The Lancet, 375*(9716), 711. doi:10.1016/S0140-6736(10)60288-7

Hu, F. B., Liu, Y., & Willett, W. C. (2011). Preventing chronic diseases by promoting healthy diet and lifestyle: Public policy implications for China. *Obesity Reviews, 12*(7), 552-559. doi:10.1111/j.1467-789X.2011.00863.x

Jiang, F., Zhang, J., & Shen, X. (2013). Towards evidence-based public health policy in China. *The Lancet, 381*(9882), 1962-1964. doi:10.1016/s0140-6736(13)61083-1

Junshi, C., & Wenhua, Z. (2012). Diet, nutrition and chronic disease in Mainland China. *Journal of Food and Drug Analysis, 20*, 222-225.

Langenbrunner, J. C., Marquez, P. V., & Wang, S. (2011). *Toward a Healthy and Harmonious Life in China: Stemming the Rising Tide of Non-Communicable Diseases*. Retrieved from Washington, D.C., U.S.A.: http://documents.worldbank.org/curated/en/618431468012000892/Toward-a-healthy-and-harmonious-life-in-China-stemming-the-rising-tide-of-non-communicable-diseases

Satija, A., Yu, E., Willett, W. C., & Hu, F. B. (2015). Understanding Nutritional Epidemiology and Its Role in Policy. *Advances in Nutrition, 6*(1), 5-18. doi:10.3945/an.114.007492

Walker, R. J., Strom Williams, J., & Egede, L. E. (2016). Influence of Race, Ethnicity and Social Determinants of Health on Diabetes Outcomes. *American Journal of the Medical Sciences, 351*(4), 366-373. doi:10.1016/j.amjms.2016.01.008

Wang, Y., Wang, L., & Qu, W. (2016). New national data show alarming increase in obesity and noncommunicable chronic diseases in China. *European Journal Of Clinical Nutrition, 71*, 149. doi:10.1038/ejcn.2016.171

CHAPTER 5

CONCLUSION

This study shows that China has experienced a rapid increase in the number of nutritional epidemiology studies, a continuously expanding diversity in the outcomes and exposures under study and a heavy reliance on cross-sectional designs. Going forward, it is crucial that research efforts and funding be allocated across outcomes and exposures that are most relevant for the nutrition-related health concerns to be anticipated in the future, notably cardiometabolic, cancer and other non-communicable diseases, and that research into the associated dietary patterns and their determinants be expanded. In addition, it is important that the current emphasis on observational studies be complemented by an increase in RCTs, quasi-experimental studies, systematic reviews and the emerging field of implementation science (Brownson et al., 2015).

REFERENCES

Brownson, R. C., Samet, J. M., Chavez, G. F., Davies, M. M., Galea, S., Hiatt, R. A., . . . Yarber, L. (2015). Charting a future for epidemiologic training. *Annals of Epidemiology, 25*(6), 458-465. doi:10.1016/J.ANNEPIDEM.2015.03.002