Risk factors and non-communicable disease diagnosis in China

Tianxin Pan and Michael Palmer

The University of Melbourne, The University of Western Australia

12 January 2017

Risk factors and non-communicable disease diagnosis in China

Tianxin Pan[1], Michael Palmer[12]

[1] Nossal Institute for Global Health, The University of Melbourne, Melbourne Australia

[2] The University of Western Australia, Perth, Australia

Abstract

The rise of non-communicable diseases has placed enormous stress on health systems leading to calls for improved prevention. This article examines the association of risk factors and non-communicable disease diagnosis in China using longitudinal data which enables us to control for important simultaneity bias. Using three waves of the China Family Panel Studies (CFPS) survey (2010-2014) and a dynamic model conditional on not having an NCD in the first period, we find positive association of being obese, using solid cooking fuels, history of frequent drinking, and household consumption expenditure during the preceding period on non-communicable disease onset. We find significant heterogeneity in risks across the population suggesting that a targeted policy response is required to reduce the burden of non-communicable disease in China.

Key words: Non-communicable diseases, risk factors, longitudinal study, China

JEL classification: C23, I12, I15, I18

1. Introduction

Non-communicable diseases (NCDs) currently account for close to three-quarters of total deaths worldwide, or approximately 40 million deaths annually (GBD 2016 Causes of Death Collaborators, 2017). Of these deaths, the vast majority stem from low- and middle-income countries (LMICs) where the death rate associated with NCDs is increasing at the fastest rate (Checkley et al., 2014; GBD 2016 Causes of Death Collaborators, 2017). This particularly concerns the emerging economies where accelerated economic and epidemiological transitions have sped the shift in the disease burden from communicable to non-communicable disease. Worldwide, the magnitude of the NCD disease burden is rising faster than improvements in prevention and treatment, which suggests that public health policies and interventions have not done enough to curb the global burden of disease attributable to NCDs (Behrman, Behrman, & Perez, 2009; Institute for Health Metrics and Evaluation, 2016b). One explanation, for which this article contributes, relates to the evidence on the risk factors associated with NCD onset (Behrman, Behrman, & Perez, 2009). Improved understanding on the factors associated with NCD onset can help to ensure that risks are delayed to the oldest possible age and are not preceded by long and costly periods of morbidity. This is of particular import to LMICs where public resources allocated to health and social health protections are most limited.

In this paper we estimate associations of a comprehensive set of risk factors and NCD onset in China - the world's largest transitional economy and population. The paper contributes to the building literature on the risk factors associated with NCDs in LMICs (e.g. Aryal et al., 2015; Miranda, Kinra, Casas, Davey Smith, & Ebrahim, 2008; Wu et al., 2015). The vast majority of these studies rely upon cross-sectional data which does not address the dynamic nature of health behaviours (Kerkhofs & Lindeboom, 1997). It is probable that people

diagnosed with NCDs in one period change their risky behaviours in the current or future period. In the case of two-way feedback between risk factors and the probability of having an NCD estimations will be biased. Cross-sectional studies cannot address reverse causality which represents an important source of endogeneity in the literature on risk factors and health. The literature that does address this form of unobserved heterogeneity is contained mostly to industrialised country settings and adopts a range of health measures (not exclusively NCDs) (Bell & Britton, 2014; Bell, Orford, & Britton, 2015).

Using three waves of the China Family Panel Studies (CFPS) survey (2010-2014) and a dynamic model conditional on not having an NCD in the first period, we examine the association of risk factors on the diagnosis of NCDs for the Chinese population. We find positive associations of being obese, using solid fuels to cook, having a history of frequent alcohol consumption, and household consumption expenditures during the preceding period on the current onset of NCD. We find significant heterogeneity across the population. Being obese, using solid cooking fuels and higher household consumption expenditures are associated with the onset of NCDs for people under age 60 while history of frequent drinking is associated with NCD onset for the elderly. The effect of obesity is contained to the non-poor and past drinking is contained to males.

The dramatic demographic and economic change experienced in China over the past four decades is well documented (Banister, Bloom, & Rosenberg, 2012; Golley & Wei, 2015). Life expectancy at birth in China has risen from 44 in the 1960's to 76 in 2015 (World Bank, 2017). The elderly population is expected to increase from under 10% of the total population in 2000 to 30% in 2050 (Kinsella & He, 2009). The county has experienced high yet unequal levels of economic growth which have led to changes in living and nutrition standards including a change in diet towards fatty foods and rise in adult body mass index (Du, Lu,

Zhai, & Popkin, 2002). These changes have coincided with a pronounced shift in the burden of disease with NCDs currently comprising close to 90% of total deaths in China (Institute for Health Metrics and Evaluation, 2017). The three main killers are cardiovascular diseases (CVDs), cancer and chronic respiratory diseases; accounting for 79% of total deaths (Institute for Health Metrics and Evaluation, 2017; National Health and Family Planning Commission, 2015).[1] The epidemiological transition has placed enormous stress on a health system which traditionally has focused on infectious, as opposed to chronic, disease (World Bank, 2016).

The risk factors associated with NCDs in China are the subject of increasing attention. The recent Global Burden of Disease study estimates dietary risks, associated particularly with low consumption of fruit and vegetables and high sodium, to account for approximately one-fifth of DALY's and one-third of deaths in China (Institute for Health Metrics and Evaluation, 2016a). Other important risk factors include high blood pressure, tobacco use, air pollution and alcohol use. The analysis focuses on behavioural, environmental and metabolic risks; socioeconomic factors are not quantified. Several studies have identified indicators of low socio-economic status as triggers of chronic diseases in China, including low education, low income or poverty status, living in a rural location or lesser developed central region (Li, Wang, Jiang, Zhang, & Wang, 2013; Tang, Jian, & Guo, 2014; Yang & Gao, 2014). However, inconsistencies appear in these findings with one study reporting higher subjective social status and higher education as positively associated with chronic diseases (Tang & Jian, 2013). These studies all draw upon cross-sectional data. The exception is the study by Lei, Yin, and Zhao (2012) who use longitudinal data to estimate the risk factors associated with hypertension. In contrast to cross-sectional findings, they find no wealth or education

[1] One-in-four Chinese adults are estimated to have hypertension and one-in-ten are diabetics; the rate of cancer is approximately one-in-400 (National Health and Family Planning Commission, 2015). Another survey estimates one in five adults is living with cardiovascular disease (National Center for Cardiovascular Diseases, 2014).

gradient in disease prevalence. However, as pointed out by the authors, their models cannot rule out reverse causality and other endogeneity bias.

Our paper makes several noteworthy contributions to the literature. First, we apply a dynamic model which investigates the lagged effect of risk factors on the diagnosis of NCDs conditional on not having an NCD in the initial period. By restricting the sample to people without an NCD in the initial period and looking at how the variation in lagged determinants is associated with the variation in NCD diagnosis, we mitigate possible bias associated with reverse causation from disease onset to changes on risk behaviours. Second, unlike most other papers that examine a collection of disease and health states we focus specifically upon NCDs.[2] We provide estimates of a rich set of risk factors, including demographic, socio-economic, lifestyle and environmental factors, whereas most previous studies in China are limited either to demographic and behavioural risk factors or to demographic and socioeconomic factors. Third, to the extent that health status changes with age it is possible that the effect of risk behaviours on health also vary over the life cycle (Jaacks, Gordon-Larsen, Mayer-Davis, Adair, & Popkin, 2013; Kerkhofs & Lindeboom, 1997). We investigate differential effects of risk factors on NCDs across age groups as well as across selected sub-populations to provide a comprehensive analysis of NCDs risk factors across the Chinese population. Due to the sheer size of the population at risk, improved estimations on the risk factors associated with NCDs in China provides health authorities with the opportunity to predict the future growth of NCDs in China and potentially slow the growing burden of NCDs, not only in China but worldwide.

[2] Studies typically use a measure of chronic disease which encompasses a collection of infectious diseases, parasitic diseases, injuries, pregnancy and postpartum complications (Center for Health Statistics and Information, 2015). The misclassification of NCDs may lead to estimation bias and thus mislead policy and intervention response.

The paper is structured as follows. Section 2 describes the data and the measures. Section 3 presents the empirical strategy. Results are presented in Section 4, and Section 5 provides a discussion of results. Section 6 concludes.

2. Data, study sample, and description of key variables

The CFPS survey is a nationally representative biennial longitudinal survey designed and conducted by the Institute of Social Science Survey (ISSS) of Peking University. The survey is drawn from 25 provinces, which cover 95% of the national population, and follows a three-stage cluster probability sampling design (Xie et al., 2017). So far, the CFPS has been collected over four waves, including a baseline survey in 2010 and three follow-up surveys in 2012, 2014 and 2016. We use the first three waves of the data which are currently available. We use the nationally representative sample for our study which forms a panel of 14,861 individuals over the three waves.[3] We restrict our sample to persons who are without an NCD in the baseline and remain as respondents in all three waves, which comprises a sample of 13,022 individuals. We use information from wave 2 and wave 3 to construct the outcome variables and information from wave 1 and wave 2 to construct the lagged independent variables.

The CFPS contains a rich collection of information collected at individual, household and community levels.[4] Of particular import to this study is information on disease types, which we use to identify NCDs. Specifically, we identify NCD-affected individuals based on the question set: "During the past six months, have you had any doctor-diagnosed chronic

[3] The survey collected two samples including a sample of oversampled five "large" provinces and twenty other "small" provinces, and a second resampled national sample which includes a second-stage sampling of the five "large provinces" and the twenty "small" provinces (Xie et al., 2017). Our sample is the latter, which is representative of the national population. We tested our results against the oversampled sample and the results were qualitatively very similar (results are available upon request).

[4] The survey contains three modules: an individual- and household-level survey collect demographic, socioeconomic and health-related information, while the community-level survey collects information on infrastructure, demographic profiles, social services and economic conditions.

disease"; and, the doctor's diagnosis of the disease. Each respondent who answered "Yes" to the first question was asked to select the type of disease from the Disease Codebook, and the two most serious diseases were recorded if there was more than one. We adopt the definition of NCDs determined by the National Health and Family Planning Commission, which follows the classification of "Group II Diseases" as per the ICD-10 code (World Health Organization, 2016).[5] Individuals living with NCDs (coded as 1) are defined as persons having either of their two diagnosed diseases as classified within the "Group II Diseases." Respondents who answered "No" to chronic diseases, or for whom neither of the two diagnosed chronic diseases was classified as an NCD, are defined as not living with NCDs (coded as 0). In our restricted sample of individuals who did not report an NCD in the first period, 9.3% report an NCD in 2012, and 14.1% report NCD onset in 2014.

The CFPS collects information on several behavioural risk factors commonly identified in the literature as associated with NCDs, such as smoking status, obesity, and environmental factors. Environmental factors include type of household cooking fuels and level of pollution in the local community. Households that use firewood, straw or coal for cooking are classified as using *solid* fuels (Zhang & Smith, 2007). An indicator for ambient pollution is derived from the question: "Is there any highly polluting enterprise, such as a chemical plant, a metallurgical refinery or a papermill within a 5-kilometer radius centred at your village/residential committee office." Obesity is derived from self-reported height and weight and is classified according to the calculated body mass index (BMI). Following the recommendation of the Working Group on Obesity in China (Chen, Lu, & Department of Disease Control Ministry of Health, 2004), an individual with a BMI >= 28 is classified as obese; and an individual with a BMI < 18.5 is classified as underweight. Information collected on smoking status includes two binary-indicator questions about whether

[5] We consulted with Bureau of Disease Control and Prevention, National Health and Family Planning Commission on the complete list.

respondents currently smoke or have smoked in the past. Drinking status includes whether the volume of pure alcohol consumed by the respondent exceeds the national criteria of heavy drinking behaviour, [6] and whether the respondent used to drink frequently (at least three times per week) in the past.

In addition to NCD and behavioural risk factors, the CFPS provides information on other health measures and access to health services. Past health may have an impact on current health and other covariates, which can be controlled by the inclusion of a lagged health variable in the regression (Bockerman & Ilmakunnas, 2009). We include a lagged measure of self-rated health (SRH) in our model as an indicator for the individual's health status in the preceding period.[7] We rescale the SRH variable into three categories of healthy, fair and unhealthy.[8] An indicator for having access to health service is derived from the question: "How long does it take from your house to the nearest health facility by the fastest means of transportation? (in minutes)." We consider within 15 minutes as having (physical) access to health service which is a target of the Chinese government to achieve by 2030 (Xinhuanet, 2016).

The CFPS includes a rich collection of demographic and socio-economic factors. Notably, the survey collects information on household consumption expenditure and income. We elect to use total household consumption expenditure rather than income as it is commonly deemed

[6] The binary variable of heavy drinking behaviour derives from the questions: "Have you often drunk alcohol (at least 3 times a week) in the past one month"; if yes, "What types of alcohol have you drunk, strong spirits, wine or beer" and the level of consumption for each type of alcohol. The amount of pure alcohol consumed was calculated according to proportions of 4% for beer, 52% for strong spirits and 10% for wine (Li et al., 2011). Heavy drinking was defined as whether the daily quantity of pure alcohol consumed exceeded 61 g for a male and 41 g for a female as per national guidelines (National Health and Family Planning Commission, 2015).

[7] SRH is commonly used as a general health measure in household surveys and has been consistently found to be a strong predictor of morbidity and physical functioning (Xu & Xie, 2016). We are aware of the potential reporting heterogeneity bias of SRH and methods to adjust for the bias such as anchoring vignettes. However, the lack of anchoring vignette data in the 2010 baseline and inconsistent measures of SRH between the baseline and the 2012 follow-up survey prevents us from using such techniques to adjust in both years.

[8] The original scale included five categories but there was inconsistency across the waves. The scale in 2010 was "1. Healthy; 2. Fair; 3. Relatively unhealthy; 4. Unhealthy; and 5. Very unhealthy" and in 2012 was "1. Excellent; 2. Very good; 3. Good; 4. Fair; 5. Poor."

a better measure of permanent income in the context of China and particularly in the rural context (Deaton, 1997). Consistent with other studies, we also include explanatory variables for the years of schooling as well as age, gender, ethnicity, and geographic residency as standard demographic variables.

Classification of urban residency in this study is based on the Hukou registration system. The Hukou registration system in China divides the population into agricultural (rural) and non-agricultural (urban) sectors, which influences access to a range of resources, services and opportunities, such as jobs, education, housing, and health care. We include a set of province dummies to control for variation in disease profiles and other differences across the 25 provinces. Definitions of the dependent and independent variables are provided in Appendix Table 1.

Table 1 displays weighted means and robust standard errors for the lagged variables used in the regressions. The mean age of our sample is 48 years in 2010 which increases to 50 years in 2012. There is a slightly higher proportion of females (54%) relative to males and the vast majority of respondents are of Han ethnicity, married, and with rural Hukou registration. The mean year of schooling of the sample is approximately 6 years. Obesity prevalence increases slightly from 6% to 7% and the prevalence of being underweight remains at 10%. The proportion of the sample using solid cooking fuels falls from 47% to 36%. Smoking prevalence remains high at 29-28% and an additional 6-9% of the sample has smoked at some time in the past. The prevalence of heavy drinking behaviour decreases from 6% in 2010 to 4% in 2012 and higher proportion of people no longer drink frequently (10% versus 4%). The proportion of the sample exposed to ambient pollution falls from 27% to 22% over the two waves.

[Table 1]

3. Empirical strategy

In order to investigate associations between risk factors and NCD diagnosis, for those alive and NCD free in China, we apply a dynamic pooled linear probability model for the sample reporting no NCD in the baseline period according to the following specification:

$$N_{it} = \alpha + \beta X_{it-1} + \gamma_t + \gamma_p + \varepsilon_{it} \quad (1)$$

where N is a binary indicator of NCD status for individual *i* in year *t*; X denotes a set of individual characteristics including demographic, socioeconomic and risk factors associated with NCDs. These variables are lagged by one period, *t-1*. In addition, we include a set of year and provincial fixed effects, γ_t and γ_p, respectively; and ε_{it} is an individual error term. The model estimated coefficients, β, represent the partial effects of risk factors on NCD diagnosis for the at-risk population. Robust standard errors are computed and adjusted for clustering at the household level.

There exist several challenges in the consistent estimation of β. First, there may be two-way effects between onset of NCDs and risk factors. For example, people diagnosed with NCD in the one period may change behaviour (smoking, drinking) in that or future periods. Our strategy is to apply a dynamic model of health where NCD onset is a function of lagged risk factors. The lagged model presents coefficients as average effects of change in NCD status but we are primarily interested in the development of new NCD cases (i.e. from no NCD to being diagnosed with an NCD). This requires us to restrict our sample to those who are free of NCDs in the initial period. As such we do not consider those who already have an NCD.

The traditional approach to address sample selection issues is to introduce a sample selection correction which, in effect, derives theoretical population estimates for the group who already have an NCD and those that do not. The factors which trigger disease among persons who

already have an NCD (pretending that they did not) is arguably of less practical importance or relevance than those associated with being diagnosed with an NCD conditional on not having an NCD to start with. There remains the problem that some covariates may have already caused an individual to develop an NCD by the time we first observe them which cannot be addressed by the traditional selection correction.[9] We address this issue relating to the lifetime influence of the covariate on NCD status through the disaggregation of impacts by age subgroups, particularly the younger sample which has much less initial-year prevalence. This further allows us to better understand the lifetime impacts of the factors on NCD onset as their roles at different ages in the life-cycle may be different.

Second, there is potential measurement error in the self-reported NCDs variable. Though our measure of NCD is more objective, as determined by doctor diagnosis, it remains open to potential bias relating to factors such as those associated with education level and access to health service (Strauss & Thomas, 2008). To reduce this potential bias, we include a rich set of controls including years of schooling, and a binary variable indicating whether the individual resides within a household within 15 minutes of the nearest health facility. However, there may remain unobserved factors which influence both the measurement of NCDs and risk factors of interest. One potential such factor is the scale-up of the National Public Health Service Program after 2012 which offered free blood pressure and glucose check-ups for the high-risk population (State Council, 2012). This program likely explains the jump in reported cardiovascular disease (and overall NCD prevalence) in the 2014 wave of the data. If this is the case and that unobserved characteristics which determined program participation are related to our set of risk factors then the estimates may be biased. Whilst we cannot rule out measurement bias, estimates for the 2012 period before the scale-up of the program are qualitatively very similar to the main results for the pooled 2012-2014 sample

[9] By extension there are also those people already deceased who we do not observe at all where their risk factors and NCDs onset may have contributed to an early death.

presented in the following section which suggests that unobserved factors related to the jump in reported NCD prevalence are not driving our results. These estimates are presented in Appendix Table 2 (column 2). We also present estimates using contemporaneous controls (column 1) for the 2012 outcome and observe several changes in the lagged specification (column 2) which suggests the presence of feedback effects. Notably, the negative impact of heavy drinking on NCD onset becomes insignificant and the magnitude and significance level of the positive impact of past frequent drinking effects become greater in the lagged specification.

Third, the presence of unobserved determinants of both NCDs and risk factors of interest can bias our estimation. The availability of panel data can normally help attenuate the effects of unobserved heterogeneity at the individual level by applying a fixed-effects specification. However, given the persistence of most NCDs (individual's simply manage their NCDs after onset rather than becoming NCD free again) a fixed effects specification adds little in this context. In addition, a fixed-effects model cannot identify the impact of important factors that lack of variation over time, such as gender and education. Given our short four-year panel we elect the dynamic pooled OLS model as our preferred specification and acknowledge that our results remain subject to bias in terms of being casual estimates.[10] So while we cannot infer causality from these estimates our panel data and use of lagged risk factors does help reduce the endogeneity associated with reverse causation which represents a first in the literature on the determinants of NCDs in LMICs.

4. Results

Table 2 presents results from the pooled OLS specifications for the full sample and by age groups. For the full sample (column 1), conditional on not having an NCD to start with, there

[10] We also ran random effects specifications and the results were qualitatively very similar. Our results are also robust to the inclusion of community fixed effects. These results are available from the authors upon request.

is a significant positive association between obesity and NCD onset. People who are obese in the preceding period experience a 4% higher probability of reporting an NCD in the following period. We also find a strong positive effect of frequent drinking history on NCD onset of 3.4%. The use of solid cooking fuels increases the probability of reporting an NCD by 1.1% (significant at the ten percent level). Other factors positively associated with NCDs include age, poor or unhealthy self-rated health, education level, household consumption expenditures, being female, and living in an urban location. The coefficient on the age-squared term is positive and highly significant indicating that the likelihood of NCD onset increases at a higher rate with age. We find a mildly significant negative effect of being underweight and no significant associations for smoking and current drinking status, living within 5 km of a polluting enterprise within 15 minutes from a health facility.

Table 2 also presents the effects of risk factors by age group. The obesity effect is highest among the middle age group of 45-60 years at 6.6% followed by the age group less than 45 years at 3.7% with no significant association among the elderly age group above 60 years of age. Conversely, the effects of past heavy drinking are highest among the elderly at 7.7% followed by 2.2% among the young (the latter is significant at the ten percent level only) with no association among the middle-aged. The negative population effect associated with being underweight increases in size (and significance level) to 4.6% among the elderly population and becomes insignificant for the non-elderly population. The positive effect of using solid cooking fuels is contained to the non-elderly population with similar sized effects among the young and middle-aged populations though the effect is significant for the former only. The effects of poor self-rated health and female gender increase across the life-cycle whereas effects associated with schooling and urban location remain relatively consistent with age.

[Table 2]

Table 3 presents the effects of risk factors across subpopulations as determined by gender, urban/rural and poverty[11] status. The effect of obesity is higher among the female, urban and non-poor populations and is insignificant among the poor. The effect of solid cooking fuels use is significantly higher among the female, urban and poor populations and is insignificant among the male and rural populations. The positive association of past frequent drinking is contained to the male, urban and non-poor populations. The negative effect associated with being underweight is contained among the urban population whereas positive consumption expenditure effects are highest among the poor. Effects associated with poor self-rated health are higher among the female, urban and non-poor populations. The positive effect associated with living in an urban area is higher among the non-poor population and is insignificant among the poor. We observe small, yet statistically significant, negative effects of current smoking behaviour among males and heavy drinking among the rural and non-poor populations.

[Table 3]

In Table 4, we dig further to examine the associations of selected risk factors by age and subpopulation. The obesity effect among females is contained to the population below the age of 60 years of age and in fact reverses direction for the middle age group where the effect for males is higher and more significant than females. The higher effects associated with obesity among urban and non-poor populations derive mostly from the middle-aged population. The effect of solid cooking fuel among females and among the poor doubles for the middle-aged population to 2.9% and 7.0%, respectively. We observe a large significant effect of 20.5% for heavy drinking among the elderly poor population. The effects of past frequent drinking are contained to the elderly male, urban, non-poor population.

[11] Poor and non-poor households are classified based on the self-report of whether the household received any poverty subsidy or a low living allowance from the government.

[Table 4]

5. Discussion

Our results add new weight to the literature on the risk factors of NCDs in China. Our contribution lies in attempting to address simultaneity bias and in the analysis of heterogeneous effects across the population. Several of the key findings warrant further discussion and analysis.

The positive association between obesity and the probability of reporting NCDs is a common finding in the literature (Wang et al., 2015; Wang, Mi, Shan, Wang, & Ge, 2007; Zhou et al., 2002). The effect is confined to the non-poor and this pattern is consistent across all age groups. Studies show that Chinese residents with a higher socioeconomic status (SES) are more likely to be overweight or obese (Jaacks, Gordon-Larsen, Mayer-Davis, Adair, & Popkin, 2013; Zhang, Dagevos, He, van der Lans, & Zhai, 2008), although there is a shift in the burden of obesity towards the poor (Du, Mroz, Zhai, & Popkin, 2004). In our sample, the prevalence of obesity at baseline is higher among the non-poor than the poor (6% vs. 4%), which suggests that it is still more of a problem among the non-poor. There exists the caveat that the poor may have less access to quality health care from which to report diagnosed disease.

We find significantly higher effects of obesity among the non-elderly population, particularly the middle-aged population, which is in line with the international literature (Cameron et al., 2003; Flegal, Carroll, Ogden, & Curtin, 2010; Mokdad et al., 1999). The effect of obesity on the onset of disease disappears among the elderly population. The intuition is that NCDs are age-related and that there are a host of other factors that determine disease among the elderly (Suzuki et al., 2009; Wang & Yang, 2014). There are also issues relating to sample selection

and the death of older obese people prior to survey. In our sample, we may have removed elderly obese people already diagnosed with NCDs. The finding of a protective effect of being underweight among the elderly suggests that those who remain in our sample are more likely to be the healthier.

We find interesting gender differences in the effects of obesity by age. For people under 45 years of age, the effect is higher and more significant for females which is in line with our main results and the literature (Strauss & Thomas, 2008). However, we find that for an older population (aged between 45-60 years) obese males have a higher probability of reporting NCD than females. One explanation is a period shift towards a high-fat, high-energy-density and low-fibre diet experienced since the economic reform in 1980s (Du, Lu, Zhai, & Popkin, 2002; Wang, Mi, Shan, Wang, & Ge, 2007), and that a large body is considered as a sign of prowess, prosperity and wealth among Chinese males (Xiao et al., 2013). We add interactions between household consumption expenditures and obesity and indeed find a positive effect on the intervening variables for the male (*p-value* <0.001) but not the female sample (*p-value*= 0.200). Our results of a positive association among middle-aged males and younger females are consistent with Jaccks et al. (2013) who conclude that period effects in China have a stronger influence on obesity among males while younger female cohorts are at an increased risk compared with their older counterparts.

Our results add to the evidence on the harmful effects of household solid fuel use on health. Several studies identify the harmful impact of household air pollution on health in China and other low- and middle-income country contexts (Lin, Murray, Cohen, Colijn, & Ezzati, 2008; Mestl, Aunan, & Seip, 2007; Nie, Sousa-Poza, & Xue, 2016; Rehfuess, Mehta, & Pruss-Ustun, 2006; Zhang & Smith, 2007). To identify the effect of solid fuel use accurately it is necessary to take a multitude of confounding factors into account, such as exposure time,

indoor activity, room layout, smoking and ambient pollution. Our study controlled for an array of factors including smoking status, area pollution and fixed effects.[12] When controlling for individual and community level exposure to pollution, we identify solid cooking fuel use as a key risk factor associated with NCD onset, particularly in urban areas. Most studies on the impact of solid fuel use on health have focused on the rural population and have found significant association between solid fuels and increased risk of diseases including cardiovascular diseases, respiratory diseases (Liao, Tang, & Wei, 2016; Lin, Murray, Cohen, Colijn, & Ezzati, 2008; Qu, Yan, Qu, & Ikram, 2015). In our sample, usage of solid fuels is significantly higher in rural than urban areas (19 % vs 58% at baseline). However, there is evidence that with incomplete switch to clean fuels in urban area, urban residents still face an increased associated health risks (Kim et al., 2015; Mestl, Aunan, & Seip, 2007). Our estimation suggests that, conditional on not having an NCD to start with, solid fuel use in urban areas is associated with higher risk of NCD onset than in rural areas. We find further that females are at greatest risk and particularly those between 45 and 60 years of age. When we disaggregate further we find that the effect is largely among rural women. We add interactions between solid fuel use and female gender into the models and find positive significant effects on the intervening variable for the rural sample (0.015, *p-value* = 0.088) and in particular for rural sampled aged 45-60 years (0.041, *p-value* = 0.040).[13] This is in line with several previous studies which likely reflects gender differences in cooking and domestic duties in China (Liao, Tang, & Wei, 2016; Lin, Murray, Cohen, Colijn, & Ezzati, 2008; Nie, Sousa-Poza, & Xue, 2016). It is at odds with one study which finds no significant gender difference in the health of members of households which use coal for cooking (Mestl, Aunan, & Seip, 2006).

[12] Our results are robust to both provincial and community level fixed effects.
[13] The analogous results for the urban sample were insignificant at 0.027 (*p*-value=0.329) and 0.038 (*p*-value=0.496), respectively. The complete model results are available from the authors upon request.

We find no significant effect of smoking behaviour and past smoking behaviour on the risk of NCD onset at the population level. This is at odds with existing knowledge that tobacco use is a key risk factor of NCDs (Wolf, Dagostino, Kannel, Bonita, & Belanger, 1988). Surprisingly, we find a negative effect of smoking on NCD onset among the male sample. One possibility is that smoking or drinking may play a part in professional career development of males in China (Hao, Chen, & Su, 2005). To examine such potential pathways, we add interactions between expenditure and smoking in the models and find no conclusive evidence of intervening variables at standard levels of significance (*p-value*=0.358). In addition, we find a negative effect of heavy drinking behaviour among the rural and non-poor subpopulations. These effects are counter-intuitive and may be related to omitted variable bias. When we run the fixed effects specification the negative effects disappear which suggests that this may be the case.[14]

Whilst we do not find significant effects associated with current heavy drinking behaviour we find strong positive effects of past drinking behaviour on NCD onset. The effects associated with a history of frequent drinking are concentrated largely among the elderly male population. In addition, we find a very large positive effect of current heavy drinking behaviour (21%) on NCD onset among the elderly poor which upon further analysis is found also to be contained to the male population. In China, heavy drinking behaviour is more common among males so our results are not surprising (Hao, Chen, & Su, 2005). However, the age-related effects are novel and may imply a life-time or chronic effect of drinking on health which has been reported in the literature (Fillmore & Midanik, 1984).

We find that household consumption expenditure is positively associated with the onset – or at least the reporting – of NCDs. Though counter-intuitive, this is not an uncommon finding in LMIC settings (Cai, He, Song, Zhao, & Cui, 2013; Subramanian, Corsi, Subramanyam, &

[14] Results are available from the authors upon request.

Smith, 2013; Zimmer & Kwong, 2004). Such countries are characterized by inadequacies in public investment and social protection mechanisms that are manifested in unequal access to health services; disadvantaged segments of the community are less likely to seek health care and therefore be diagnosed with disease (Gao, Qian, Tang, Eriksson, & Blas, 2002; Strauss et al., 2012; Wang et al., 2012). We in fact find positive effects for both the poor and non-poor populations, and the effect is larger among the poor individuals (0.027 versus 0.009) which suggests that the consumption gradient associated with health care use is steeper among the poor (Table 3).

Our results take us a step forward in the literature on risk factors and NCDs in China however there remain several noteworthy caveats. Our dynamic model conditional on being free of NCDs in the initial period helps to reduce potential two-way bias between disease onset and risk factors yet introduces a selection bias. Our estimates on the probability of acquiring an NCD relate only to the population free of NCDs and not for the population as a whole. Another source of selection bias is the *survivor* effect. By restricting our sample to those who remain in all three waves it could be that only respondents in good health remain. Our results furthermore do not address endogeneity bias associated with omitted variables and measurement error. Our four-year panel data provides limited analysis on the long-term influence of the risk factors, and with pooled OLS specifications we cannot distinguish age from birth cohort effect, thus further research is needed to distangle these effects.

Nonetheless by focusing on the healthier NCD-free population and identifying risk factors associated with diagnosis of an NCD for the at-risk population our results provide important information from a prevention point of view. Our results shed light on the lifetime impacts of risk factors on NCD diagnosis as their roles are found to differ at different stages in the life-cycle. Meanwhile, some risk behaviours such as frequent drinking may have long-term and

accumulative effects on health. Looking at general population effects or focusing on certain population groups such as the working aged population may mask these important differences. Our results also reveal important differential effects determined by other personal and geographic characteristics.

6. Conclusion

In this paper, we estimate the dynamic effects of risk factors on the diagnosis of NCDs in China, the world's most populated country. Our specification enables us to control for important simultaneity bias. We find positive impacts of being obese, using solid fuels to cook, having a history of frequent drinking, and household consumption expenditures during the preceding period on the current diagnosis of NCDs. Our results are broadly in line with earlier findings in China and other country settings. However, our results across age groups add new weight to the literature on China. Obesity, solid fuel use and consumption effects are confined to people under age 60 whereas effects associated with drinking history are confined to the elderly population. Obesity effects are contained to the non-poor population and frequent drinking history effects are contained to the male population.

Whilst our results must be interpreted with a certain degree of caution they offer several considerations for policy makers. First, public health promotion and interventions relating to eating, drinking and activity behaviours should be gender and age sensitive e.g. to address elevated risks associated with obesity among young females. Second, interventions and public health messages should be delivered at an early stage since some risk factors may take a long time to take effect, such as frequent drinking. Third, interventions should be geographically targeted to address elevated risks associated with obesity, past drinking habits and solid cooking fuel use in urban areas and the use of solid cooking fuels among middle-aged women in rural areas. Better-informed public health policy can help to ensure that NCD

risks in China are delayed to the oldest possible age and are not preceded by long and costly periods of morbidity.

Table 1. Descriptive statistics of the lagged covariates

	2010		2012	
	Mean	S.E.	Mean	S.E.
Behaviors				
Obese	0.057	(0.004)	0.066	(0.004)
Underweight	0.096	(0.007)	0.099	(0.007)
Heavy drinker	0.061	(0.005)	0.043	(0.004)
Past frequent drinker	0.041	(0.003)	0.098	(0.006)
Smoker	0.289	(0.007)	0.282	(0.007)
Past smoker	0.062	(0.004)	0.092	(0.005)
Solid cooking fuels	0.468	(0.030)	0.362	(0.029)
Polluting enterprises within 5 km radius	0.267	(0.027)	0.216	(0.027)
Self-rated health: healthy	0.497	(0.013)	0.624	(0.012)
Self-rated health: fair	0.370	(0.011)	0.205	(0.010)
Self-rated health: unhealthy	0.133	(0.007)	0.171	(0.008)
Health care facility within 15 minutes	0.843	(0.017)	0.855	(0.014)
SES				
Year of schooling	6.686	(0.189)	6.415	(0.195)
Logarithm of household consumption expenditures	9.786	(0.034)	10.207	(0.035)
Demographic				
Age	47.856	(0.494)	49.837	(0.493)
Female	0.535	(0.004)	0.535	(0.004)
Married	0.855	(0.005)	0.851	(0.006)
Household size	4.093	(0.088)	4.088	(0.089)
Urban Hukou	0.277	(0.030)	0.294	(0.032)
Han ethnicity	0.894	(0.027)	0.894	(0.027)
Observations	13,022		13,022	

Source: China Family Panel Studies 2010-2012.
Notes: Provincial dummy variables are not displayed. Robust standard errors clustered at the household level are in parenthesis. Estimates are appropriately weighted to reflect the complex survey design.

Table 2. Pooled OLS estimated effects of risk factors on NCD diagnosis for the full sample, and by age group

	Full sample	< 45 years	45-60 years	> 60 years
Obese	0.040***	0.037***	0.066***	-0.024
	(0.011)	(0.013)	(0.020)	(0.035)
Underweight	-0.015*	0.004	-0.013	-0.046**
	(0.009)	(0.009)	(0.019)	(0.021)
Heavy drinker	-0.015	-0.014	-0.019	0.014
	(0.01)	(0.012)	(0.017)	(0.025)
Past frequent drinker	0.034***	0.022*	0.031	0.077***
	(0.011)	(0.013)	(0.020)	(0.029)
Smoker	-0.011	-0.003	-0.009	-0.022
	(0.007)	(0.007)	(0.015)	(0.020)
Past smoker	-0.001	0.000	0.022	-0.031
	(0.011)	(0.012)	(0.022)	(0.025)
Solid cooking fuels	0.011*	0.011*	0.012	0.002
	(0.006)	(0.006)	(0.011)	(0.018)
Polluting enterprises within 5 km radius	0.000	-0.003	0.004	-0.002
	(0.006)	(0.006)	(0.012)	(0.018)
Self-rated health (reference category: healthy)				
Fair	0.041***	0.031***	0.052***	0.045***
	(0.005)	(0.006)	(0.010)	(0.016)
Unhealthy	0.154***	0.144***	0.151***	0.178***
	(0.009)	(0.015)	(0.015)	(0.021)
Health care facility within 15 minutes	0.004	0.007	0.003	0.011
	(0.007)	(0.007)	(0.014)	(0.019)
Years of schooling	0.002**	0.001	0.002*	0.007***
	(0.001)	(0.001)	(0.001)	(0.002)
Natural logarithm of household consumption expenditure	0.012***	0.008**	0.018***	0.004
	(0.003)	(0.004)	(0.006)	(0.009)
Age	0.000	-0.008***	-0.015	0.072***
	(0.001)	(0.003)	(0.027)	(0.025)
Age squared	0.000***	0.000***	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.026***	0.013*	0.034**	0.087***
	(0.006)	(0.007)	(0.014)	(0.020)
Married	0.010	0.016*	0.028	0.022
	(0.008)	(0.008)	(0.019)	(0.020)
Household size	0.001	-0.001	0.002	0.002
	(0.002)	(0.002)	(0.003)	(0.005)
Urban hukou registration	0.017**	0.013*	0.020	0.020
	(0.007)	(0.007)	(0.014)	(0.020)
Han ethnicity	-0.005	-0.005	0.001	0.010
	(0.009)	(0.009)	(0.020)	(0.035)
Year	0.038***	0.018***	0.043***	0.085***
	(0.005)	(0.005)	(0.010)	(0.016)
Province dummies	Yes	Yes	Yes	Yes
Observations	26044	14028	7962	4054
R-squared	0.081	0.047	0.064	0.088

Source: China Family Panel Studies 2010-2014.

Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Pooled OLS estimated effects of risk factors on NCD diagnosis by subpopulation

	Full	Female	Male	Urban	Rural	Poor	Non-poor
Obese	0.040***	0.039**	0.036***	0.040**	0.039***	0.040	0.040***
	(0.011)	(0.017)	(0.013)	(0.019)	(0.013)	(0.040)	(0.011)
Underweight	-0.015*	-0.008	-0.023*	-0.036**	-0.007	0.006	-0.016*
	(0.009)	(0.011)	(0.012)	(0.017)	(0.010)	(0.023)	(0.009)
Heavy drinker	-0.015	-0.001	-0.012	0.016	-0.022**	0.037	-0.021**
	(0.010)	(0.058)	(0.010)	(0.023)	(0.010)	(0.033)	(0.010)
Past frequent drinker	0.034***	-0.022	0.050***	0.058***	0.025*	0.046	0.034***
	(0.011)	(0.025)	(0.012)	(0.022)	(0.013)	(0.035)	(0.012)
Smoker	-0.011	0.023	-0.014**	-0.014	-0.010	-0.008	-0.012
	(0.007)	(0.024)	(0.007)	(0.014)	(0.008)	(0.021)	(0.007)
Past smoker	-0.001	-0.027	0.002	-0.016	0.004	-0.031	0.000
	(0.011)	(0.030)	(0.012)	(0.023)	(0.012)	(0.033)	(0.012)
Solid cooking fuels	0.011*	0.014*	0.008	0.035**	0.007	0.033*	0.010
	(0.006)	(0.008)	(0.007)	(0.015)	(0.006)	(0.019)	(0.006)
Polluting enterprises within 5 km radius	0.000	0.002	-0.003	-0.028**	0.009	0.018	-0.002
	(0.006)	(0.008)	(0.007)	(0.011)	(0.007)	(0.021)	(0.006)
Self-rated health (reference category: healthy)							
Fair	0.041***	0.052***	0.029***	0.038***	0.040***	0.036**	0.041***
	(0.005)	(0.007)	(0.007)	(0.011)	(0.006)	(0.018)	(0.005)
Unhealthy	0.154***	0.166***	0.135***	0.189***	0.146***	0.133***	0.159***
	(0.009)	(0.012)	(0.014)	(0.023)	(0.010)	(0.024)	(0.010)
Health care facility within 15 minutes	0.004	0.008	-0.001	-0.018	0.006	-0.031	0.008
	(0.007)	(0.010)	(0.009)	(0.020)	(0.007)	(0.020)	(0.007)
Years of schooling	0.002**	0.002*	0.002**	0.004**	0.001	0.004*	0.001*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Natural logarithm of household consumption expenditure	0.012***	0.009**	0.014***	0.014*	0.009***	0.027***	0.009***
	(0.003)	(0.005)	(0.004)	(0.007)	(0.004)	(0.010)	(0.003)
Age	0.000	-0.001	0.000	0.000	0.000	0.004	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)
Age squared	0.000***	0.000***	0.000***	0.000***	0.000***	0.000	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.026***			0.028**	0.025***	0.059***	0.022***
	(0.006)			(0.013)	(0.007)	(0.019)	(0.007)
Married	0.010	0.016	0.015	0.010	0.004	0.018	0.009
	(0.008)	(0.012)	(0.010)	(0.016)	(0.009)	(0.020)	(0.008)
Household size	0.001	0.005**	-0.004*	0.000	0.001	-0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)
Urban hukou registration	0.017**	0.018*	0.015*			0.013	0.018***
	(0.007)	(0.010)	(0.009)			(0.022)	(0.007)
Han ethnicity	-0.005	-0.006	-0.004	0.020	-0.009	-0.007	-0.005
	(0.009)	(0.014)	(0.011)	(0.027)	(0.010)	(0.022)	(0.010)
Year	0.038***	0.049***	0.026***	0.037***	0.038***	0.049***	0.038***
	(0.005)	(0.007)	(0.006)	(0.010)	(0.006)	(0.016)	(0.005)
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26044	13485	12559	6612	19325	2602	23395
R-squared	0.081	0.092	0.071	0.108	0.075	0.103	0.082

Source: China Family Panel Studies 2010-2014.

Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Pooled OLS estimated effects of selected risk factors by age group and subpopulation

	Full sample	Female	Male	Urban	Rural	Poor	Non-poor
Obese							
<45	0.037***	0.046**	0.027*	0.030	0.038**	0.063	0.034***
	(0.013)	(0.023)	(0.015)	(0.023)	(0.015)	(0.051)	(0.013)
45-60	0.066***	0.051*	0.081***	0.082**	0.057**	0.101	0.065***
	(0.020)	(0.028)	(0.029)	(0.035)	(0.025)	(0.077)	(0.021)
>60	-0.024	-0.033	-0.031	-0.035	-0.027	-0.141	-0.014
	(0.035)	(0.051)	(0.050)	(0.061)	(0.045)	(0.097)	(0.038)
Heavy drinker							
<45	-0.014	0.062	-0.014	-0.003	-0.016	-0.011	-0.014
	(0.012)	(0.116)	(0.012)	(0.030)	(0.012)	(0.033)	(0.013)
45-60	-0.019	0.089	-0.021	0.023	-0.030*	0.005	-0.019
	(0.017)	(0.110)	(0.017)	(0.042)	(0.018)	(0.052)	(0.018)
>60	0.014	-0.121	0.025	0.032	0.005	0.205**	-0.011
	(0.025)	(0.077)	(0.026)	(0.053)	(0.028)	(0.083)	(0.025)
Past frequent drinker							
<45	0.022*	-0.006	0.031**	0.006	0.028*	0.107*	0.016
	(0.013)	(0.031)	(0.015)	(0.023)	(0.016)	(0.060)	(0.014)
45-60	0.031	0.009	0.042*	0.071*	0.016	-0.012	0.037*
	(0.020)	(0.043)	(0.022)	(0.042)	(0.023)	(0.057)	(0.022)
>60	0.077***	-0.066	0.106***	0.149**	0.051	0.054	0.084***
	(0.029)	(0.072)	(0.031)	(0.061)	(0.032)	(0.067)	(0.032)
Solid cooking fuels							
<45	0.011*	0.007	0.017**	0.036*	0.009	0.030	0.010
	(0.006)	(0.009)	(0.008)	(0.020)	(0.006)	(0.020)	(0.007)
45-60	0.012	0.029*	-0.005	0.041	0.005	0.070*	0.009
	(0.011)	(0.016)	(0.015)	(0.031)	(0.012)	(0.039)	(0.012)
>60	0.002	-0.005	0.003	0.055	-0.006	-0.032	0.006
	(0.018)	(0.028)	(0.022)	(0.039)	(0.020)	(0.056)	(0.019)

Source: China Family Panel Studies 2010-2014.

Notes: Each coefficient is from a separate regression model. Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 1. Definition of variables

Variable	Definition
NCD	= 1 if respondent reports at least one NCD; = 0 if otherwise.
Behaviors	
Obese	= 1 if BMI of respondent is equal to or greater than 28 kg/m^2; =0 if otherwise.
Underweight	= 1 if BMI of respondent is less than 18.5 kg/m^2; =0 if otherwise.
Heavy drinker	= 1 if the daily quantity of pure alcohol consumed by a male respondent is in excess of 61g or that by a female respondent is in excess of 41g; = 0 if otherwise.
Past frequent drinker	= 1 if respondent used to drink alcohol at least 3 times a week in the past; =0 if otherwise.
Smoker	= 1 if respondent currently smokes; = 0 if otherwise.
Past smoker	= 1 if respondent used to smoke in the past; = 0 if otherwise.
Solid cooking fuels	= 1 if household uses open firewood, straw and coal to cook; =0 if otherwise.
Polluting enterprises within 5 km radius	= 1 if household is located in a community which is within 5 km from a polluting enterprise; =0 if otherwise.
Self-rated health (SRH)	=1 if self-rated as healthy; =2 if self-rated as fair; =3 if self-rated as unhealthy.
Health care facility within 15 minutes	=1 if household could access to the nearest health facility within 15 minutes; =0 if otherwise.
SES	
Years of schooling	Years of schooling.
Logarithm of household consumption expenditure	Natural log of total household consumption expenditure.
Demographic	
Age	Age in years.
Female	= 1 if respondent is female; =0 if otherwise.
Married	= 1 if respondent is married or cohabitation; =0 if otherwise.
Household size	Number of household members.
Urban hukou registration	= 1 if Hukou is non-agricultural; =0 if otherwise.
Han ethnicity	= 1 if respondent is Han ethnicity; =0 if otherwise.
Province of residence	25 provincial dummies.
Year of interview	= 1 if 2010; = 2 if 2012.

Appendix Table 2. OLS estimated effects of risk factors on NCD diagnosis in 2012

	Contemporaneous controls	Lagged controls
Obese	0.019	0.019
	(0.012)	(0.014)
Underweight	-0.013	-0.020**
	(0.011)	(0.010)
Heavy drinker	-0.032**	-0.017
	(0.014)	(0.011)
Past frequent drinker	0.020*	0.037**
	(0.011)	(0.019)
Smoker	-0.012	-0.012
	(0.010)	(0.008)
Past smoker	0.003	-0.004
	(0.013)	(0.015)
Solid cooking fuels	0.015**	0.014**
	(0.007)	(0.007)
Polluting enterprises within 5 km radius	-0.001	-0.009
	(0.008)	(0.007)
Self-rated health (reference category: healthy)		
Fair	0.052***	0.036***
	(0.008)	(0.006)
Unhealthy	0.173***	0.110***
	(0.012)	(0.012)
Health care facility within 15 minutes	0.009	0.000
	(0.009)	(0.008)
Years of schooling	0.002***	0.001
	(0.001)	(0.001)
Natural logarithm of household consumption expenditure	0.020***	0.015***
	(0.004)	(0.004)
Age	-0.001	0.000
	(0.001)	(0.001)
Age squared	0.000***	0.000***
	0.000	0.000
Female	0.009	0.017**
	(0.009)	(0.008)
Married	0.010	0.006
	(0.010)	(0.009)
Household size	0.000	0.002
	(0.002)	(0.002)
Urban hukou registration	0.017**	0.017**
	(0.008)	(0.008)
Han ethnicity	0.007	0.001
	(0.011)	(0.010)
Province dummies	Yes	Yes
Observations	13022	13022
R-squared	0.085	0.060

Source: China Family Panel Studies 2010-2012.

Notes: Provincial dummy coefficients are not displayed. Robust standard errors clustered at the household level are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1.

References

Aryal, K. K., Mehata, S., Neupane, S., Vaidya, A., Dhimal, M., Dhakal, P., . . . Karki, K. B. (2015). The Burden and Determinants of Non Communicable Diseases Risk Factors in Nepal: Findings from a Nationwide STEPS Survey. *PLoS One, 10*(8), e0134834. doi:10.1371/journal.pone.0134834

Banister, J., Bloom, D. E., & Rosenberg, L. (2012). Population Aging and Economic Growth in China. In M. Aoki & J. Wu (Eds.), *The Chinese Economy* (pp. 114-149). London: Palgrave Macmillan.

Behrman, J. R., Behrman, J. A., & Perez, N. M. (2009). On what diseases and health conditions should new economic research on health and development focus? . *Health Economics, 18*(S1), S109-S128.

Bell, S., & Britton, A. (2014). An exploration of the dynamic longitudinal relationship between mental health and alcohol consumption: a prospective cohort study. *Bmc Medicine, 12*, 91. doi:10.1186/1741-7015-12-91

Bell, S., Orford, J., & Britton, A. (2015). Heavy Drinking Days and Mental Health: An Exploration of the Dynamic 10-Year Longitudinal Relationship in a Prospective Cohort of Untreated Heavy Drinkers. *Alcoholism: Clinical and Experimental Research, 39*(4), 688-696. doi:10.1111/acer.12681

Bockerman, P., & Ilmakunnas, P. (2009). Unemployment and self-assessed health: evidence from panel data. *Health Economics, 18*(2), 161-179. doi:10.1002/hec.1361

Cai, L., He, J., Song, Y., Zhao, K., & Cui, W. (2013). Association of obesity with socio-economic factors and obesity-related chronic diseases in rural southwest China. *Public Health, 127*(3), 247-251. doi:10.1016/j.puhe.2012.12.027

Cameron, A. J., Welborn, T. A., Zimmet, P. Z., Dunstan, D. W., Owen, N., Salmon, J., . . . Shaw, J. E. (2003). Overweight and obesity in Australia: The 1999-2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Medical Journal of Australia, 178*(9), 427-432.

Center for Health Statistics and Information. (2015). *An Analysis Report of National Health Services Survey in China 2013*. Beijing,China: National Health and Family Planning Commission.

Checkley, W., Ghannem, H., Irazola, V., Kimaiyo, S., Levitt, N. S., Miranda, J. J., . . . Yan, L. L. (2014). Management of NCD in low- and middle-income countries. *Global Heart, 9*(4), 431-443. doi:10.1016/j.gheart.2014.11.003

Chen, C., Lu, F. C., & Department of Disease Control Ministry of Health, P. R. C. (2004). The guidelines for prevention and control of overweight and obesity in Chinese adults. *Biomedical and Environmental Sciences, 17 Suppl*, 1-36.

Deaton, A. (1997). *The Analysis of Household Surveys: a microeconomic approach to development policy*. Washington, D.C.: The World Bank.

Du, S., Lu, B., Zhai, F., & Popkin, B. M. (2002). A new stage of the nutrition transition in China. *Public Health Nutrition, 5*(1A), 169-174. doi:10.1079/PHN2001290

Du, S., Mroz, T. A., Zhai, F. Y., & Popkin, B. M. (2004). Rapid income growth adversely affects diet quality in China particularly for the poor! *Social Science & Medicine, 59*(7), 1505-1515. doi:10.1016/j.socscimed.2004.01.021

Fillmore, K. M., & Midanik, L. (1984). Chronicity of drinking problems among men: a longitudinal study. *Journal of Studies on Alcohol, 45*(3), 228-236.
Flegal, K. M., Carroll, M. D., Ogden, C. L., & Curtin, L. R. (2010). Prevalence and Trends in Obesity Among US Adults, 1999-2008. *Journal of the American Medical Association, 303*(3), 235-241. doi:10.1001/jama.2009.2014
Gao, J., Qian, J., Tang, S., Eriksson, B. O., & Blas, E. (2002). Health equity in transition from planned to market economy in China. *Health Policy and Planning, 17 Suppl*, 20-29.
GBD 2016 Causes of Death Collaborators. (2017). Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet, 390*(10100), 1151–1210.
Golley, J., & Wei, Z. (2015). Population dynamics and economic growth in China. *China Economic Review, 35*, 15-32. doi:10.1016/j.chieco.2015.05.005
Hao, W., Chen, H., & Su, Z. (2005). China: alcohol today. *Addiction, 100*(6), 737-741. doi:10.1111/j.1360-0443.2005.01036.x
Institute for Health Metrics and Evaluation. (2016a). Global Burden of Disease 2015 Country Profile: China. Retrieved 26 Dec 2017 http://www.healthdata.org/china
Institute for Health Metrics and Evaluation. (2016b). *Rethinking Development and Health: Findings from the Global Burden of Disease Study*. Seattle, Washington: Institute for Health Metrics and Evaluation.
Institute for Health Metrics and Evaluation. (2017). GBD Compare. Retrieved from https://vizhub.healthdata.org/gbd-compare/. [26 Dec 2017]
Jaacks, L. M., Gordon-Larsen, P., Mayer-Davis, E. J., Adair, L. S., & Popkin, B. (2013). Age, Period and Cohort Effects on Adult Body Mass Index and Overweight from 1991 to 2009 in China: the China Health and Nutrition Survey. *International Journal of Epidemiology, 42*(3), 828-837. doi:10.1093/ije/dyt052
Kerkhofs, M., & Lindeboom, M. (1997). Age related health dynamics and changes in labour market status. *Health Economics, 6*(4), 407-423.
Kim, C., Gao, Y. T., Xiang, Y. B., Barone-Adesi, F., Zhang, Y. W., Hosgood, H. D., . . . Lan, Q. (2015). Home kitchen ventilation, cooking fuels, and lung cancer risk in a prospective cohort of never smoking women in Shanghai, China. *International Journal of Cancer, 136*(3), 632-638. doi:10.1002/ijc.29020
Kinsella, K., & He, W. (2009). *An Aging World: 2008*. Washington, D.C.: U.S. Government Printing Office.
Lei, X. Y., Yin, N. N., & Zhao, Y. H. (2012). Socioeconomic status and chronic diseases: The case of hypertension in China. *China Economic Review, 23*(1), 105-121. doi:10.1016/j.chieco.2011.08.004
Li, Y., Jiang, Y., Zhang, M., Yin, P., Wu, F., & Zhao, W. H. (2011). Drinking behaviour among men and women in China: the 2007 China Chronic Disease and Risk Factor Surveillance. *Addiction, 106*(11), 1946-1956. doi:10.1111/j.1360-0443.2011.03514.x
Li, Y., Wang, L., Jiang, Y., Zhang, M., & Wang, L. (2013). Risk factors for noncommunicable chronic diseases in women in China: surveillance efforts. *Bulletin of the World Health Organization,, 91*(9), 650-660. doi:10.2471/BLT.13.117549

Liao, H., Tang, X., & Wei, Y. (2016). Solid fuel use in rural China and its health effects. *Renewable & Sustainable Energy Reviews, 60*, 900-908. doi:10.1016/j.rser.2016.01.121

Lin, H., Murray, M., Cohen, T., Colijn, C., & Ezzati, M. (2008). Effects of smoking and solid-fuel use on COPD, lung cancer, and tuberculosis in China: a time-based, multiple risk factor, modelling study. *Lancet, 372*(9648), 1473-1483. doi:10.1016/S0140-6736(08)61345-8

Mestl, H. E. S., Aunan, K., & Seip, H. M. (2006). Potential health benefit of reducing household solid fuel use in Shanxi province, China. *Science of the Total Environment, 372*(1), 120-132. doi:10.1016/j.scitotenv.2006.09.007

Mestl, H. E. S., Aunan, K., & Seip, H. M. (2007). Health benefits from reducing indoor air pollution from household solid fuel use in China - Three abatement scenarios. *Environment International, 33*(6), 831-840. doi:10.1016/j.envint.2007.03.012

Miranda, J. J., Kinra, S., Casas, J. P., Davey Smith, G., & Ebrahim, S. (2008). Non-communicable diseases in low- and middle-income countries: context, determinants and health policy. *Tropical Medicine and International Health, 13*(10), 1225-1234. doi:10.1111/j.1365-3156.2008.02116.x

Mokdad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. A., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the United States, 1991-1998. *Journal of the American Medical Association, 282*(16), 1519-1522.

National Center for Cardiovascular Diseases. (2014). *Report on Cardiovascular Diseases in China*. Beijing, China: Encyclopedia of China Publishing House.

National Health and Family Planning Commission. (2015). Chinese Citizens Nutrition and Chronic Disease Report 2015. Beijing,China: People's Medical Publishing House.

Nie, P., Sousa-Poza, A., & Xue, J. (2016). Fuel for Life: Domestic Cooking Fuels and Women's Health in Rural China. *International Journal of Environmental Research and Public Health, 13*(8), 810.

Qu, W. H., Yan, Z. J., Qu, G. H., & Ikram, M. (2015). Household Solid Fuel Use and Cardiovascular Disease in Rural Areas in Shanxi, China. *Iranian Journal of Public Health, 44*(5), 625-638.

Rehfuess, E., Mehta, S., & Pruss-Ustun, A. (2006). Assessing Household Solid Fuel Use: Multiple Implications for the Millennium Development Goals. *Environmental Health Perspectives, 114*(3), 373-378. doi:10.1289/ehp.8603

State Council. (2012). *Circular of the State Council on Printing and Issuing the Plan/Implementing Program for Deepening Reform to the Pharmaceutical and Healthcare System During the Period of the Twelfth Five-year Plan*. Beijing, China: State Council, Retrieved from http://www.gov.cn/zwgk/2012-03/21/content_2096671.htm.

Strauss, J., Hong, H., Lei, X., Li, L., Park, A., Li;, Y., & Zhao, Y. (2012). Healthcare and Insurance Among the Elderly in China: Evidence from the CHARLS Pilot. In J. Smith & M. Majmundar (Eds.), *Aging in Asia: Findings From New and Emerging Data Initiatives.* Washington, DC: National Academies Press (US).

Strauss, J., & Thomas, D. (2008). Health over the life course. In Schultz TP & J. Stauss (Eds.), *Handbook of Development Economic*. Amsterdam: Elsevier.

Subramanian, S., Corsi, D. J., Subramanyam, M. A., & Smith, G. D. (2013). Jumping the gun: the problematic discourse on socioeconomic status and cardiovascular health in India. *International Journal of Epidemiology, 42*(5), 1410-1426.

Suzuki, E., Yorifuji, T., Ueshima, K., Takao, S., Sugiyama, M., Ohta, T., . . . Doi, H. (2009). Sleep duration, sleep quality and cardiovascular disease mortality among the elderly: A population-based cohort study. *Preventive Medicine, 49*(2-3), 135-141. doi:10.1016/j.ypmed.2009.06.016

Tang, S., & Jian, W. (2013). Social determinants of chronic disease in a working population in China. *Journal of Peking Univeristy (Health Sciences), 45*(3), 443-447.

Tang, S., Jian, W., & Guo, Y. (2014). Analysis on social determinants of chronic disease of the elderly in Beijing. *Chinese Journal of Health Policy, 7*(5), 63-67.

Wang, A., & Yang, L. (2014). Investigation of the Prevalence and Determinants of Chronic Diseases Among "Empty-nest" Elderly in China. *China and Foreign Medical Treatment, 7*, 42-45.

Wang, C., Li, J., Xue, H., Li, Y., Huang, J., Mai, J., . . . Gu, D. (2015). Type 2 diabetes mellitus incidence in Chinese: contributions of overweight and obesity. *Diabetes Research and Clinical Practice, 107*(3), 424-432. doi:10.1016/j.diabres.2014.09.059

Wang, Y., Mi, J., Shan, X., Wang, Q., & Ge, K. (2007). Is China facing an obesity epidemic and the consequences? The trends in obesity and chronic disease in China. *International Journal of Obesity, 31*, 177-188.

Wang, Y., Wang, J., Maitland, E., Zhao, Y. H., Nicholas, S., & Lu, M. S. (2012). Growing old before growing rich: inequality in health service utilization among the mid-aged and elderly in Gansu and Zhejiang Provinces, China. *Bmc Health Services Research, 12*, 302.

Wolf, P. A., Dagostino, R. B., Kannel, W. B., Bonita, R., & Belanger, A. J. (1988). Cigarette Smoking as a Risk Factor for Stroke: The Framingham Study. *Journal of the American Medical Association, 259*(7), 1025-1029. doi:DOI 10.1001/jama.259.7.1025

World Bank. (2016). *Deepening health reform in China : building high-quality and value-based service delivery - policy summary*. Washington, D.C: World Bank Group.

World Bank. (2017). Life expectancy at birth, total (years). Retrieved from https://data.worldbank.org/indicator/SP.DYN.LE00.IN?locations=CN. [13 Dec 2017]

World Health Organization. (2016). ICD-10 Version:2016. Retrieved from http://apps.who.int/classifications/icd10/browse/2016/en. [10 July 2016]

Wu, F., Guo, Y. F., Chatterji, S., Zheng, Y., Naidoo, N., Jiang, Y., . . . Kowal, P. (2015). Common risk factors for chronic non-communicable diseases among older adults in China, Ghana, Mexico, India, Russia and South Africa: the study on global AGEing and adult health (SAGE) wave 1. *Bmc Public Health, 15*, 88. doi:10.1186/s12889-015-1407-0

Xiao, Y., Zhao, N., Wang, H., Zhang, J., He, Q., Su, D., . . . Ye, Z. (2013). Association between socioeconomic status and obesity in a Chinese adult population. *Bmc Public Health, 13*, 355.

Xie, Y., Zhang, X., Tu, P., Ren, Q., Sun, Y., Lv, P., . . . Wu, Q. (2017). China Family Panel Studies User's Manual (Third Edition). Retrieved from http://www.isss.pku.edu.cn/cfps/d/file/p/dc865c7f22a353eade26a534eedf92ba.pdf. [26 Dec 2017]

Xinhuanet. (2016, 22 Nov 2016). The Commissioner of National Health and Family Planning Commssion: "six insists" in the future 15 years. *Xinhua*. Retrieved from http://news.xinhuanet.com/health/2016-11/22/c_1119960880.htm

Xu, H., & Xie, Y. (2016). Assessing the Effectiveness of Anchoring Vignettes in Bias Reduction for Socioeconomic Disparities in Self-Rated Health among Chinese Adults. *Sociological Methodology, 46*(1), 84-120. doi:10.1177/0081175015599808

Yang, F., & Gao, L. (2014). Prevalence and determinants of chronic diseases among middle age and elderly population in China. *Foreign Medicine Health Economics, 31*(3), 137-139.

Zhang, J. J., & Smith, K. R. (2007). Household Air Pollution from Coal and Biomass Fuels in China: Measurements, Health Impacts, and Interventions. *Environmental Health Perspectives, 115*(6), 848-855. doi:10.1289/ehp.9479

Zhang, X. Y., Dagevos, H., He, Y. N., van der Lans, I., & Zhai, F. Y. (2008). Consumption and corpulence in China - A consumer segmentation study based on the food perspective. *Food Policy, 33*(1), 37-47. doi:10.1016/j.foodpol.2007.06.002

Zhou, B., Wu, Y., Yang, J., Li, Y., Zhang, H., & Zhao, L. (2002). Overweight is an independent risk factor for cardiovascular disease in Chinese populations. *Obesity Reviews, 3*(3), 147-156.

Zimmer, Z., & Kwong, J. (2004). Socioeconomic status and health among older adults in rural and urban China. *Journal of Aging and Health, 16*(1), 44-70. doi:10.1177/0898264303260440