Indoor solid fuel use for cooking and the risk of incidental non-fatal cardiovascular disease among middle-aged and elderly Chinese adults: a prospective cohort study

Haoqiang Ji,1 Qian Chen,2 Ruiheng Wu,1 Jia Xu,1 Xu Chen,1 Liang Du,1 Yunting Chen,1 Yuanping Pan,1 Yuxin Duan,1 Meng Sun,1 Ling Zhou1

ABSTRACT

Objectives The harm of indoor air pollution to health has gradually attracted attention, but the effect of indoor air pollution from burning solid fuels on incidental non-fatal cardiovascular disease (CVD) is not well understood. Under these circumstances, this study examined the association between solid fuel use and incidental non-fatal CVD.

Design The prospective cohort study was conducted in 2011, 2013, 2015 and 2018.

Setting The nationally representative survey was conducted in 28 provinces of China.

Participants This study included 13,544 middle-aged and elderly adults without CVD in the baseline survey, and they were followed for 7 years.

Outcome measures First incidence of non-fatal CVD (heart disease or stroke).

Methods Based on longitudinal data, Cox proportional hazards models were used to assess the effects of solid fuel use and persistent use on incidental CVD events.

Results During the 7-year follow-up period, there were 1533 non-fatal CVD cases. A total of 7310 (54%) participants used solid fuel for cooking at the baseline survey, and 2998 (41%) users continued to use solid fuel. Solid fuel use was associated with incidental non-fatal CVD (HR: 1.18; 95% CI: 1.05 to 1.32) compared with clean fuel, and persistent solid fuel use might lead to a higher risk of incidental non-fatal CVD (HR: 1.38; 95% CI: 1.18 to 1.61) and heart disease (HR: 1.49; 95% CI: 1.24 to 1.81). In the subgroup analysis, the relationship remained significant in the female, elderly, rural and hypertensive groups. However, we found no significant interaction between these risk factors and fuel use (all p<0.05).

Conclusions This cohort study provides evidence for the effects of solid fuel use on incidental non-fatal CVD in middle-aged and elderly Chinese adults. Advocating for the use of clean energy and ventilation stoves is important to cardiovascular health.

INTRODUCTION

Worldwide, indoor air pollution (IAP) is an important public health problem, and is 1 of the top 10 risk factors for global disease burden and mortality.1 A total of 1.8 million deaths and 60.9 million disability-adjusted life years can be attributed to IAP for cooking in developing countries.2 In addition, the damage may be underestimated because indoor cooking with solid fuel also contributes a part of ambient air pollution.3 Even so, as the International Energy Agency reports, nearly 3 billion people lack access to clean or modern energy in low-income and middle-income countries, so they use readily available solid fuels (firewood, straw, coal, animal dung) to meet their daily demands.4 These fuels are often burned in inefficient and highly polluting stoves, which can exhaust many air pollutants, such as carbon monoxide (CO), nitrogen dioxide, particulate matter (PM) and organic compounds.5-8 When users inhale these pollutants, they can pass through the alveolar capillaries,9 eventually reaching the circulatory system or brain,10 11 which may cause cardiovascular inflammation or other severe problems.12 13

Cardiovascular disease (CVD) was the underlying cause of 18.5 million deaths (approximately one-third of all deaths globally) and the leading cause of disability in 2019.14 In previous studies, exposure to solid...
fuel use was found to be associated with an increased risk of respiratory infections, tuberculosis, chronic obstructive pulmonary disease, lung cancer, increased carotid intima media thickness and low birth weight. However, few studies have examined the association between solid fuel use and CVD, and most of these studies were cross-sectional studies, small sample studies or studies in other countries. Only a few cohort studies have examined the relationship between solid fuel use and cardiopulmonary mortality globally, and almost no nationwide cohort studies have investigated incidental non-fatal CVD among the Chinese population. This may be because most studies have focused only on the effects of outdoor air pollution or smoking on CVD but have ignored the impacts of IAP from burning solid fuels on CVD. Therefore, it is necessary to provide relevant evidence, especially in China.

China is a large developing country with a sizeable population, and many of these people who use solid fuels are threatened by IAP. In addition, due to the long-term use of solid fuels, IAP has a more lasting impact on health and increases the disease burden because of relying on solid fuel. Although people with CVD have higher rates of disability and death than others, there is insufficient evidence to support government intervention on IAP as a risk factor. Therefore, we conducted a nationwide cohort study to examine the association between solid fuel use for cooking and incidental non-fatal CVD (heart disease and stroke) among middle-aged and elderly Chinese adults, and further nationwide cohort studies are needed on this important issue.

METHODS
Study sample
This prospective study was from the China Health and Retirement Longitudinal Study (CHARLS), which is a nationally representative longitudinal study. It is intended to provide a high-quality public microdatabase serving the needs of scientific and policy research on ageing-related issues. The data for CHARLS are available at: http://charls.pku.edu.cn/. In this study, 17,708 participants were recruited from 28 Chinese provinces using multistage stratified sampling in 2011 and three follow-up surveys in 2013, 2015 and 2018. Details of the study design have been described elsewhere. In this study, 13,544 participants met the study criteria (age >45 years old, no history of CVD at baseline survey, no missing values for primary variables), including 1533 incidental non-fatal CVD, 2884 lost to follow-up or death, and 9127 with no incidental non-fatal CVD. Figure 1 shows more details about the process of sample exclusion.

Assessment of incidental non-fatal CVD events
The outcome of this study was incidental non-fatal CVD (heart disease or stroke). First, according to other studies, non-fatal CVD events were assessed by two standardised questions: ‘Have you been diagnosed with a
coronary heart disease, heart attack, angina, congestive heart failure or other heart problems by a doctor?’ and ‘Have you been diagnosed with a stroke by a doctor?’ Second, with reference to other similar study,35 patients who did not die before the next follow-up survey were defined as having non-fatal CVD. Finally, the date of CVD diagnosis was defined as the date of first reporting any CVD event.

**Exposure of solid fuel use**

Participants’ exposure to solid fuel use was assessed by the following standardised question: ‘What is the main source of cooking fuel?’ Question options included coal, crop residue, wood, natural gas, marsh gas, liquefied petroleum gas, electric, never cook and other fuels.36 We excluded participants who never cooked and used other fuels. According to the health effects of fuel burning,37 we defined cooking fuel as clean fuel (natural gas, marsh gas, liquefied petroleum gas, electric) and solid fuel (coal, crop residue and wood). In addition, we defined persistent solid (or clean) fuel users as someone who had been using solid (or clean) fuel through the end of the event, and defined alternate use as any other style of fuel use.

**Covariates**

At baseline, we incorporated three parts of potential covariates, including sociodemographic status, health behaviour and health status. First, sociodemographic status included residential area (rural village/urban community), gender (male/female), age (45–64/≥65) and highest level of education (did not finish primary school/primary school/middle school/high school above). Second, health behaviours included smoking status (never/former/current), drinking status (never/occasionally/frequently) and sleep time (<6 hours/6–8 hours/>8 hours). Third, health status included hypertension (yes/no), self-reported doctor-diagnosis hypertension), diabetes (yes/no, self-reported doctor-diagnosis diabetes), dyslipidaemia (yes/no, self-reported doctor-diagnosis dyslipidaemia), self-rated health (good/fair/poor) and body mass index (continuous). Body mass index was calculated as weight in kilograms divided by height in metres squared.

**Statistical analysis**

We conducted multiple imputation to estimate these remaining missing values of sleep time and body mass index using Stata V.14.0. We created 10 replications and pooled the imputed results to account for the missing data using linear regression models.36 Baseline data are described as frequencies (percentages) for categorical variables and means (SDs) for continuous variables. Baseline characteristics are summarised according to cooking fuel use, and the X² test (for categorical variables) or t-test (for continuous variables) was used to compare the differences in baseline characteristics among different fuel users.

We computed the person-time of follow-up for every respondent from baseline to the dates of incidental non-fatal CVD, death, loss to follow-up or the end of follow-up (2018), whichever came first. Incidence rates of non-fatal CVD events per 1000 person-years were calculated according to cooking fuel use. To examine if there is a relationship between solid fuel use and incident non-fatal CVD events. Cox proportional hazards models were used to calculate HRs with 95% CIs. In addition, we used the Schoenfeld residuals test to verify the proportional hazards assumption and found that the Cox proportional hazards models met the condition (p>0.05 for all models). To examine the health impact of persistent solid fuel use, we assessed the effect of persistent solid fuel use on incidental non-fatal CVD events. Subgroup analysis was used to verify the relationship between solid fuel use and incidental CVD. Two-sided p<0.05 was defined as statistically significant. All data processing and analyses were performed in Stata software V.14.0 (StataCorp).

**Sensitivity analysis**

Three sensitivity analyses were conducted. First, we used the data without multiple imputation (10866 samples) for further analysis. Second, we used the Fine and Gray competing risk model to account for competing risks due to mortality.38 Third, after considering the clustering effect of the family, we examined the association between (persistent) solid fuel use and incidental CVD events.

**Patient and public involvement**

Patients were not involved in developing the research questions, measuring the outcomes or designing the overall of the study. Because we could not access specific patient information, we could not communicate the results to them.

**RESULTS**

**Baseline characteristics**

A total of 13544 participants were included in the study. Table 1 shows more details about the characteristics of the baseline participants. A total of 7310 (54%) participants used solid fuel for cooking, 2998 (41%) users continued to use solid fuel during the seven follow-up periods and 3810 (28.13%) participants continued to use clean fuel. In addition, solid fuel users were more likely to be rural residents (94.3%), older adults (29.6%), individuals who had not finished primary school (55.7%), never smokers (59.9%), never drinkers (67%), individuals who had a sleep time of 6–8 hours (59.2%), individuals who had no history of diabetes disease (96%), individuals who had dyslipidaemia disease (94.4%), individuals who had a fair self-rated health status (67.1%) and individuals who had a lower body mass index (mean, SD: 23.93, 3.59) (p<0.01 for all).
| Characteristics                          | Total sample (N=13 544) | Clean fuel users (n=6234) | Solid fuel users (n=7310) | P value |
|-----------------------------------------|-------------------------|---------------------------|---------------------------|---------|
| Residential area, N (%)                 |                         |                           |                           | <0.001  |
| Rural village                           | 10 546                  | 3653 (58.6)               | 6893 (94.3)               |         |
| Urban community                         | 2998                    | 2581 (41.4)               | 417 (5.7)                 |         |
| Gender, N (%)                           |                         |                           |                           | 0.561   |
| Male                                    | 6524                    | 2986 (47.9)               | 3538 (48.4)               |         |
| Female                                  | 7020                    | 3248 (52.1)               | 3772 (51.6)               |         |
| Age, N (%)                              |                         |                           |                           | <0.001  |
| 45–64                                   | 10 032                  | 4887 (78.4)               | 5145 (70.4)               |         |
| >65                                     | 3512                    | 1347 (21.6)               | 2165 (29.6)               |         |
| Highest level of education, N (%)       |                         |                           |                           | <0.001  |
| Did not finish primary school           | 6155                    | 2085 (33.4)               | 4070 (55.7)               |         |
| Primary school                          | 2885                    | 1292 (20.7)               | 1593 (21.8)               |         |
| Middle school                           | 2810                    | 1577 (25.3)               | 1233 (16.9)               |         |
| High school or above                    | 1694                    | 1280 (20.5)               | 414 (5.7)                 |         |
| Smoke status, N (%)                     |                         |                           |                           | <0.001  |
| Never                                   | 8337                    | 3956 (63.5)               | 4381 (59.9)               |         |
| Former                                  | 1079                    | 501 (8)                   | 578 (7.9)                 |         |
| Current                                 | 4128                    | 1777 (28.5)               | 2351 (32.2)               |         |
| Drinking status, N (%)                  |                         |                           |                           | 0.007   |
| Never                                   | 8982                    | 4083 (65.5)               | 4899 (67)                 |         |
| Occasionally                            | 1079                    | 545 (8.7)                 | 534 (7.3)                 |         |
| Frequently                              | 3483                    | 1606 (25.8)               | 1877 (25.7)               |         |
| Sleep time, N (%)                       |                         |                           |                           | <0.001  |
| 6 hours                                 | 3813                    | 1507 (24.2)               | 2306 (31.5)               |         |
| 6–8 hours                               | 8605                    | 4281 (68.7)               | 4324 (59.2)               |         |
| 8 hours                                 | 1126                    | 446 (7.2)                 | 680 (9.3)                 |         |
| Hypertension, N (%)                     |                         |                           |                           | 0.101   |
| No                                      | 10 779                  | 4923 (79)                 | 5856 (80.1)               |         |
| Yes                                     | 2765                    | 1311 (21)                 | 1454 (19.9)               |         |
| Diabetes, N (%)                         |                         |                           |                           | <0.001  |
| No                                      | 12 915                  | 5898 (94.6)               | 7017 (96)                 |         |
| Yes                                     | 629                     | 336 (5.4)                 | 293 (4)                   |         |
| Dyslipidaemia, N (%)                    |                         |                           |                           | <0.001  |
| No                                      | 12 562                  | 5665 (90.9)               | 6897 (94.4)               |         |
| Yes                                     | 982                     | 569 (9.1)                 | 413 (5.6)                 |         |
| Self-comment of health, N (%)           |                         |                           |                           | <0.001  |
| Good                                    | 3583                    | 2028 (32.5)               | 1555 (21.3)               |         |
| Fair                                    | 6535                    | 3078 (49.4)               | 3457 (47.3)               |         |
| Poor                                    | 3426                    | 1128 (18.1)               | 2298 (31.4)               |         |
| Styles of using fuel, N (%)             |                         |                           |                           | <0.001  |
| Persistent clean fuel use               | 3810                    | 3810 (61.1)               | 0 (0)                     |         |
| Alternate use                           | 6736                    | 2424 (38.9)               | 4312 (59)                 |         |
| Persistent solid fuel use               | 2998                    | 0 (0)                     | 2998 (41)                 |         |
| Body mass index, mean (SD)              | 23.41 (3.59)            | 23.93 (3.59)              | 22.97 (3.53)              | <0.001  |
Incidence of CVDs
During the 7-year follow-up period, 1533 participants experienced non-fatal CVD cases (heart disease, 1006 cases; stroke, 636 cases). The incidence rate of non-fatal CVD of solid fuel users (21.48 per 1000 person-years) was higher than that of clean fuel users (19.36 per 1000 person-years), and persistent solid fuel users had the highest incidence rate of non-fatal CVD (24.42 per 1000 person-years).

The association between solid fuel use and non-fatal CVD
Table 2 shows more details about the association between solid fuel use and non-fatal CVD. After adjusting all the covariates (in model 3), baseline solid fuel users had a higher risk of incident non-fatal CVD (HR: 1.18; 95% CI: 1.05 to 1.32), and persistent use of solid fuel amplified the negative impact. In model 3, compared with references, persistent solid fuel use was independently associated with a 38% increased risk of incidental non-fatal CVD and a 49% risk of incidental heart disease (CVD: HR 1.38; 95% CI 1.18 to 1.61; heart disease: HR 1.49; 95% CI 1.24 to 1.81).

Urban community (HR: 1.35; 95% CI: 1.17 to 1.55), ≥65 years old (HR: 1.41; 95% CI: 1.26 to 1.58), current smoker (HR: 1.32; 95% CI: 1.08 to 1.61), sleep time <6 hours (HR: 1.14; 95% CI: 1.02 to 1.28), hypertension (HR: 1.76; 95% CI: 1.57 to 1.98), dyslipidaemia (HR: 1.32; 95% CI: 1.12 to 1.55), poor health status (HR: 1.78; 95% CI: 1.53 to 2.07) and higher body mass index (HR: 1.03; 95% CI: 1.01 to 1.04) were risk factors for incidental non-fatal CVD. More details about the risk factors for incidental CVD events are provided in online supplemental table A1.

In the Fine and Gray competing risk models, we considered the competing risk of mortality for the outcome. After adjusting for confounding factors, we found results that were basically consistent with model 3, except that solid fuel use increased the risk of incidental non-fatal heart disease (Sub-distribution Hazard Ratio (SHR):
1.17; 95% CI: 1.02 to 1.34) in the competing risk model (online supplemental table A.2). In another sensitivity analysis, similar results were found when 10,866 records were obtained without multiple imputation (online supplemental table A.3). In addition, after considering the clustering effect of every family, the associations between solid fuel use, persistent solid fuel and incidental non-fatal CVD were still significant (online supplemental table A.4).

**Association between solid fuel use and non-fatal CVD event risk stratified by different factors**

In the subgroup analysis, the relationship remained significant in the female (HR: 1.22; 95% CI: 1.05 to 1.43), elderly (HR: 1.20; 95% CI: 1.05 to 1.38), rural (HR: 1.18; 95% CI: 1.04 to 1.34), hypertensive groups (HR: 1.24; 95% CI: 1.01 to 1.51). However, no significant interaction effects between solid fuel use and these factors were found (all p<0.05), and these results are presented by the forest plots in figure 2.

**DISCUSSION**

This study found 7310 (54%) participants used solid fuel for cooking at baseline, and 2998 (41%) users continued to use solid fuel during the follow-up period. Solid fuel use was associated with incidental non-fatal CVD compared with clean fuel, and persistent solid fuel use can lead to a higher risk of incidental non-fatal CVD compared with the reference. In addition, we found that the association between solid fuel use and incidental non-fatal CVD was significant among rural residents, females, the elderly and people with hypertension compared with clean fuel users.

In Chinese villages, even though electricity has been popularised, solid fuel is still widely used. Some solid fuels (such as firewood, straw and animal dung) are available everywhere in some poorer areas, which influences villagers to save money by using these fuels for a long time. In addition, some poor families do not have a stove or good ventilation, which increases the health risk of attaching to IAP from using solid fuel. Therefore, pollutants from burning solid fuels produce long-term and lasting harm to people under the circumstances.

The studies found that female users of solid fuel had an increased risk of incidental CVD, which is consistent with other studies. As a Chinese tradition, men usually work away from home, and women must spend more time taking care of their family and cooking. Therefore, women are more exposed to IAPs from burning solid fuel and experience IAP-related health problems. In addition, elderly users of solid fuels are more at risk from solid fuels, and other previous studies also found the same problems. In the elderly population, the function of cardiovascular declines and exposure time increases persistently with age, which makes these people more vulnerable to coping with adverse risk factors. Therefore,
their daily use of solid fuel increases their cardiovascular burden. Moreover, hypertension is a major risk factor for incidental CVD and a major health problem in middle-aged and elderly populations, and this disease can lead to arteriosclerosis and abnormal constriction of the arteries over time. Studies have reported that some IAPs (CO and PM) from burning solid fuels can exacerbate vascular inflammation and increase vascular burden. If patients with hypertension do not stop using solid fuels, there may be a combined negative effect on cardiovascular function and eventually lead to CVD.

These results support the opinion that solid fuel use for cooking increases the risk of incidental non-fatal CVD and health harm among Chinese people. More cohort studies should be conducted to verify these results. Meanwhile, necessary measures must be taken to reduce the health threat from IAP. Using clean energy is the most efficient way, but some people may struggle to pay for their daily clean energy consumption. This may be because some solid fuels are available everywhere throughout their life. Therefore, governments must consider the actual situation to gradually implement clean energy popularisation and promote the use of stoves with high-ventilation efficiency in poor areas. In addition, governments should vigorously develop local industries by using the local labour force and environment. After all, human health benefits more from the fruit of economic development.

The study has some advantages. Most previous studies were cross-sectional studies, but we used 7 years of follow-up data to enhance statistical power. In addition, this is the first nationwide cohort study that examined the association between persistent solid fuel use and incidental non-fatal CVD in a Chinese population. However, this study still has some unsolvable limitations. First, it only included Chinese participants, so the results may not generalise to other countries. Second, some risk factors for the association between solid fuel use and CVD events, such as indoor ventilation condition, income, dietary habit and physical exercise, were not adjusted for. Third, there may have been recall bias in collecting important information (such as disease status) by questionnaire. Finally, we could not acquire accurate information exposure time and doses; therefore, we used the type of cooking fuel use as study variables.

CONCLUSIONS

As a cohort study that followed individuals in China for 7 years, the study suggests that solid fuel use for cooking was associated with incidental non-fatal CVD events compared with clean fuel use and that persistent solid fuel use can lead to a higher risk of incidental non-fatal CVD in middle-aged and elderly Chinese populations. In addition, we found that the association between solid fuel use and incidental non-fatal CVD was significant among rural residents, females, the elderly and people with hypertension compared with clean fuel users. To our knowledge, our study is the first to find evidence from a nationwide cohort study about the effects of persistent solid fuel use on incidental non-fatal CVD in a middle-aged and elderly Chinese population. Advocating for the use of clean energy and ventilation stoves is important to the protection of cardiovascular health.

REFERENCES

1. AbbafatiC, AbbastKM, AbbasiM, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019; a systematic analysis for the global burden of disease study 2019. Lancet 2020;396:1204–22.

2. Lee KK, Bing R, Kiang J, et al. Adverse health effects associated with household air pollution: a systematic review, meta-analysis, and burden estimation study. Lancet Glob Health 2020;8:e1427–34.

3. ChafeZA, BrauerM, KlimontZ, et al. Household cooking with solid fuels contributes to ambient PM2.5 air pollution and the burden of disease. Environ Health Perspect 2014;122:1314–20.

4. Mestl HES, EdwardsR. Global burden of disease as a result of indoor air pollution in Shanxi, Hebei and Zhejiang, China. Sci Total Environ 2011;409:1391–8.
Ji H, et al. BMJ Open 2022;12:e054170. doi:10.1136/bmjopen-2021-054170

1. Paris International Energy Agency. *World energy outlook*, 2018.
2. Naehler LP, Brauer M, Lipsett M, et al. Woodsomke health effects: a review. *Inhal Toxicol* 2007;19:57–106.
3. Hu W, Downward G, Wong JYY, et al. Characterization of outdoor air pollution from solid-fuel combustion in Xuanwei and Fuyuan, a rural region of China. *Sci Rep* 2020;10:11335.
4. Ofori SN, Fobil JN, Odia OJ. Household biomass fuel use, blood pressure and carotid intima media thickness: a cross sectional study of rural dwelling women in southern Nigeria. *Environ Pollut* 2016;214:34–40.
5. Samet JM, Bahrami H, Berhane K. Indoor air pollution and cardiovascular disease: new evidence from Iran. *Circulation* 2016;133:2342–4.
6. Luo Y, Zhong Y, Pang L, et al. The effects of indoor air pollution from solid fuel use on cognitive function among middle-aged and older people in China. *Sci Total Environ* 2021;754:142460.
7. Qiu G, Yang D, et al. Association of exhaled carbon monoxide with risk of cardiovascular-vascular disease in the China Kadoorie Biobank cohort study. *Sci Rep* 2020;10:19507.
8. Chin MT. Basic mechanisms for adverse cardiovascular events associated with air pollution. *Heart* 2015;101:253–6.
9. Saenz JL, Wong R, Ailshire JA. Indoor air pollution and cognitive function among older Mexican adults. *J Epidemiol Community Health* 2018;72:21–6.
10. Roth GA, Mensah GA, Fuster V. The global burden of cardiovascular diseases and risks: a compass for global action. *J Am Coll Cardiol* 2020;76:2980–1.
11. Pandey MR, Bolej JS, Smith KR, et al. Indoor air pollution in developing countries and acute respiratory infection in children. *Lancet* 1989;1:427–9.
12. Lin H-H, Murray M, Cohen T, et al. Effects of smoking and solid-fuel use on COPD, lung cancer, and tuberculosis in China: a time-based, multiple risk factor, modelling study. *Lancet* 2008;372:1473–83.
13. Chapman RS, He X, Blair AE, et al. Improvement in household stoves and risk of chronic obstructive pulmonary disease in Xuanwei, China: retrospective cohort study. *BMJ* 2005;331:1050–2.
14. Zhao Y, Wang S, Aunan K, et al. Particulate matter pollution and cardiovascular disease: an update to the scientific statement. *Circulation* 2017;135:1107–14.
15. Phillips DIW, Osmond C, Williams ML, et al. Air pollution in early life and adult mortality from chronic rheumatic heart disease. *Int J Epidemiol* 2017;46:1107–14.
16. Liu J, Hou B, Ma X-W, et al. Solid fuel use for cooking and its health effects on the elderly in rural China. *Environ Sci Pollut Res Int* 2018;25:3669–80. 10.1007/s11356-017-0720-9.
17. Brook RD, Rajagopalan S, Pope CA, et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American heart association. *Circulation* 2016;133:2360–6.
18. Raza W, Krachler B, Forsberg B, et al. Air pollution, physical activity and ischaemic heart disease: a prospective cohort study of interaction effects. *BMJ Open* 2021;11:e040912.
19. Mortimer K, Gordon SB, Jindal SK, et al. Household air pollution is a major avoidable risk factor for cardiorespiratory disease. *Chest* 2012;140:1308–15.
20. Baumgartner J, Brauer M, Ezzati M. The role of cities in reducing the cardiovascular impacts of environmental pollution in low- and middle-income countries. *BMJ* 2020;369.
21. Nie P, Sousa-Poza A, Xue J. Fuel for Life: Domestic Cooking Fuels and Women’s Health in Rural China. *Int J Environ Res Public Health* 2016;13:810.
22. Zhao Y, Hu Y, Smith JP, et al. Cohort profile: the China health and retirement longitudinal study (CHARLS). *Int J Epidemiol* 2014;43:61–8.
23. Yaohu Z. Data from: China health and retirement longitudinal study, 2006. Peking university open research data. Available: http://charsl.pku.edu.cn/.
24. Li W-Q, Fan J-L, Manson JE, et al. Psoriasis and risk of nonfatal cardiovascular disease in U.S. women: a cohort study. *Br J Dermatol* 2010;163:81–7.
25. Ji H, Du L, Sun M, et al. Association between solid fuel use and risk of hypertension among Chinese older people: a cohort study. *Lancet Glob Health* 2020;8:e430–9.
26. Phillips DIW, Osmond C, Williams ML, et al. Air pollution in early life and adult mortality from chronic rheumatic heart disease. *Int J Epidemiol* 2017;46:1107–14.
27. Liu J, Hou B, Ma X-W, et al. Solid fuel use for cooking and its health effects on the elderly in rural China. *Environ Sci Pollut Res Int* 2018;25:3669–80. 10.1007/s11356-017-0720-9.
28. Brook RD, Rajagopalan S, Pope CA, et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American heart association. *Circulation* 2016;133:2360–6.
29. Raza W, Krachler B, Forsberg B, et al. Air pollution, physical activity and ischaemic heart disease: a prospective cohort study of interaction effects. *BMJ Open* 2021;11:e040912.
30. Mortimer K, Gordon SB, Jindal SK, et al. Household air pollution is a major avoidable risk factor for cardiorespiratory disease. *Chest* 2012;140:1308–15.
31. Baumgartner J, Brauer M, Ezzati M. The role of cities in reducing the cardiovascular impacts of environmental pollution in low- and middle-income countries. *BMJ* 2020;369.
32. Nie P, Sousa-Poza A, Xue J. Fuel for Life: Domestic Cooking Fuels and Women’s Health in Rural China. *Int J Environ Res Public Health* 2016;13:810.
33. Zhao Y, Hu Y, Smith JP, et al. Cohort profile: the China health and retirement longitudinal study (CHARLS). *Int J Epidemiol* 2014;43:61–8.
34. Yaohu Z. Data from: China health and retirement longitudinal study, 2006. Peking university open research data. Available: http://charsl.pku.edu.cn/.
35. Li W-Q, Fan J-L, Manson JE, et al. Psoriasis and risk of nonfatal cardiovascular disease in U.S. women: a cohort study. *Br J Dermatol* 2010;163:81–7.
36. Ji H, Du L, Sun M, et al. Association between solid fuel use and cognitive decline among middle-aged and elderly Chinese adults: a longitudinal study. *Sci Rep* 2021;11:3634.
37. Yun X, Shen G, Shen H, et al. Residential solid fuel emissions contribute significantly to air pollution and associated health impacts in China. *Sci Adv* 2020;6. doi:10.1126/sciadv.aba7621. [Epub ahead of print: 28 10 2020].
38. Fine JP, Gray RJ. A proportional hazards model for the Subdistribution of a competing risk. *J Am Stat Assoc* 1999;94:495–500.
39. Mannucci PM, Franchini M. Health effects of ambient air pollution in developing countries. *Int J Environ Res Public Health* 2017;14. doi:10.3390/ijerph14091048. [Epub ahead of print: 12 09 2017].
40. Mitter SS, Vedantham R, Islam F, et al. Household fuel use and cardiovascular disease mortality: Golestan cohort study. *Circulation* 2016;133:2360–6.
41. Deng Y, Gao Q, Yang D, et al. Association between biomass fuel use and risk of hypertension among Chinese older people: a cohort study, *Environ Int* 2020;138:105620.
42. Kim C, Seow WJ, Shu X-O, et al. Cooking coal use and all-cause and cause-specific mortality in a prospective cohort study of women in Shanghai, China. *Environ Health Perspect* 2016;124:1384–9.