

How Do Household Energy Transitions Work?*

Jill Baumgartner (Co-PI)¹ Sam Harper (Co-PI)¹
Chris Barrington-Leigh¹ Collin Brehmer² Ellison M. Carter²
Xiaoying Li² Brian E. Robinson¹ Guofeng Shen³
Talía J. Sternbach¹ Shu Tao³ Kaibing Xue⁴ Wenlu Yuan¹
Xiang Zhang¹ Yuanxun Zhang⁴

2024-10-13

Table of contents

1	Introduction	2
1.1	Subheading	2
1.1.1	Sub-subheading	2
1.1.2	Personal exposure	3
	Abbreviations and other terms	6

*Affiliations [1] McGill University; [2] Colorado State University; [3] Peking University; [4] University of the Chinese Academy of Sciences

1 Introduction

China is deploying an ambitious policy to transition up to 70% of households in northern China from residential coal heating to electric or gas “clean” space heating, including a large-scale roll out across rural and peri-urban Beijing, referred to in this document as China’s Coal Ban and Heat Pump (CBHP) subsidy policy. To meet this target the Beijing municipal government announced a two-pronged program that designates coal-restricted areas and simultaneously offers subsidies to night-time electricity rates and for the purchase and installation of electric-powered heat pumps to replace traditional coal-heating stoves. The policy was piloted in 2015 and, starting in 2016, was rolled out on a village-by-village basis. The variability in when the policy was applied to each village allowed us to treat the roll-out of the program as a quasi-randomized intervention and evaluate its impacts on air quality and health. Household air pollution is a well-established risk factor for adverse health outcomes over the entire lifecourse, yet there is no consensus that clean energy interventions can improve these health outcomes based on evidence from randomized trials (Lai et al. 2024). Households may be differentially affected by the CBHP due to factors such as financial constraints and user preferences, and there is uncertainty about whether and how the policy may affect indoor and outdoor air pollution, as well as heating behaviors and health outcomes.

1.1 Subheading

1.1.1 Sub-subheading

1.1.2 Personal exposure

Table ?@tbl-a-het-personal shows limited evidence that the ATT s across cohorts and time demonstrate meaningful heterogeneity.

Table 1: Missing and valid values of variables used in multiple imputation.

Variable	Valid (%)	Non-response (%)	Not sampled (%)
Study wave	3082 (100)	0 (0)	0 (0)
District	3082 (100)	0 (0)	0 (0)
Village	3082 (100)	0 (0)	0 (0)
Household ID	3082 (100)	0 (0)	0 (0)
Participant ID	3082 (100)	0 (0)	0 (0)
Village-level policy treatment status	3082 (100)	0 (0)	0 (0)
Systolic central BP	3081 (100)	1 (0)	0 (0)
Diastolic central BP	3081 (100)	1 (0)	0 (0)
Systolic brachial BP	3082 (100)	0 (0)	0 (0)
Diastolic brachial BP	3082 (100)	0 (0)	0 (0)
Participant sex	3081 (100)	1 (0)	0 (0)
Participant age	3078 (99.9)	4 (0.1)	0 (0)
Exposure to tobacco smoke	3081 (100)	1 (0)	0 (0)
Frequency of alcohol consumption in the past 12 months	3081 (100)	1 (0)	0 (0)
Physician diagnosis of high BP	3081 (100)	1 (0)	0 (0)
Whether participant took medication for high BP	1527 (49.5)	39 (1.3)	1516 (49.2)
Waist circumference	2568 (83.3)	514 (16.7)	0 (0)
Weight	2614 (84.8)	468 (15.2)	0 (0)
Height	2610 (84.7)	472 (15.3)	0 (0)
Self-reported diagnosis of diabetes	3082 (100)	0 (0)	0 (0)
Self-reported diagnosis of chronic kidney disease	3082 (100)	0 (0)	0 (0)
Household wealth index	2945 (95.6)	137 (4.4)	0 (0)
Whether BP was measured in AM or PM	3082 (100)	0 (0)	0 (0)
Right arm circumference	3073 (99.7)	9 (0.3)	0 (0)
Frequency of farming activities in past 6 months	3081 (100)	1 (0)	0 (0)
Frequency of exercise in the past 6 months	3081 (100)	1 (0)	0 (0)
If participant snores while sleeping	3081 (100)	1 (0)	0 (0)
If participant quits breathing while sleeping	3081 (100)	1 (0)	0 (0)
Marital status	3054 (99.1)	28 (0.9)	0 (0)
Self-reported diagnosis for coronary heart disease or myocardial infarction	3081 (100)	1 (0)	0 (0)
Self-reported diagnosis for stroke or transient ischemic attack (TIA)	3081 (100)	1 (0)	0 (0)
Heating season (Jan 15 to Mar 15) mean indoor PM2.5	494 (16)	122 (4)	2466 (80)
Indoor temperature	3074 (99.7)	8 (0.3)	0 (0)
Self-reported health status	3081 (100)	1 (0)	0 (0)
Blood pressure cuff size	3078 (99.9)	4 (0.1)	0 (0)
Participant's highest level of education	3059 (99.3)	23 (0.7)	0 (0)
Participant's current occupation	3053 (99.1)	29 (0.9)	0 (0)
Time-varying binary indicator for enrollment in policy	3082 (100)	0 (0)	0 (0)
Year of first treatment with policy	3082 (100)	0 (0)	0 (0)

ANMB	absolute normalized mean bias
ATT	Average Treatment Effect on the Treated
BAM	Beta Attenuation Monitor
BC	Black carbon
BP	Blood pressure
CI	Confidence Interval
CIE	International Commission on Illumination
CHP	Clean Heating Policy
cDBP	Central diastolic blood pressure
CRP	C-reactive protein
cSBP	Central systolic blood pressure
DAG	Directed acyclic graph
DiD	Difference-in-Differences
EC	Elemental carbon
EDXRF	Evo energy-dispersive X-ray fluorescence
ETWFE	Extended Two-Way Fixed Effects
FEM	Federal equivalent method
FID	Flame ionization detector
FeNO	Fractional exhaled nitric oxide
HAPIN	Household Air Pollution Intervention Network
HPLC	High-performance liquid chromatography
IL-6	Interleukin-6
MDA	Malondialdehyde
NISP	National Improved Stove Program
NIST	National Institute of Standards and Technology
ns-S	Non-Sulfate Sulfur
OC	Organic Carbon
OD	Optic densities
PKU	Peking University
PM _{2.5}	Particulate matter less than 2.5 microns in aerodynamic diameter
RMSE	Root mean square error
SRM	Standard reference material
TNF- α	Tumour necrosis factor alpha
UCAS	University of Chinese Academy of Sciences
UPAS	Ultrasonic Personal Aerosol Samplers
W1, W2, W3, W4	Wave 1, Wave 2, Wave 3, Wave 4
wi	Water Insoluble Species
ws	Water Soluble Species

Abbreviations and other terms

ATT

Lai PS, Lam NL, Gallery B, Lee AG, Adair-Rohani H, Alexander D, et al. 2024. Household Air Pollution Interventions to Improve Health in Low- and Middle-Income Countries: An Official American Thoracic Society Research Statement. *American Journal of Respiratory and Critical Care Medicine* 209:909–927; doi:[10.1164/rccm.202402-0398ST](https://doi.org/10.1164/rccm.202402-0398ST).