Published in final edited form as:

J Epidemiol Community Health. 2018 January ; 72(1): 21–26. doi:10.1136/jech-2017-209704.

Indoor air pollution and cognitive function among older Mexican adults

Joseph L Saenz¹, Rebeca Wong², and Jennifer A Ailshire¹

¹Leonard Davis School of Gerontology, University of Southern California, Los Angeles, California, USA

²Department of Preventive Medicine and Community Health, University of Texas Medical Branch, Galveston, Texas, USA

Abstract

Background—A growing body of research suggests exposure to high levels of outdoor air pollution may negatively affect cognitive functioning in older adults, but less is known about the link between indoor sources of air pollution and cognitive functioning. We examine the association between exposure to indoor air pollution and cognitive function among older adults in Mexico, a developing country where combustion of biomass for domestic energy remains common.

Method—Data come from the 2012 Wave of the Mexican Health and Aging Study. The analytic sample consists of 13 023 Mexican adults over age 50. Indoor air pollution is assessed by the reported use of wood or coal as the household's primary cooking fuel. Cognitive function is measured with assessments of verbal learning, verbal recall, attention, orientation and verbal fluency. Ordinary least squares regression is used to examine cross-sectional differences in cognitive function according to indoor air pollution exposure while accounting for demographic, household, health and economic characteristics.

Results—Approximately 16% of the sample reported using wood or coal as their primary cooking fuel, but this was far more common among those residing in the most rural areas (53%). Exposure to indoor air pollution was associated with poorer cognitive performance across all assessments, with the exception of verbal recall, even in fully adjusted models.

Conclusions—Indoor air pollution may be an important factor for the cognitive health of older Mexican adults. Public health efforts should continue to develop interventions to reduce exposure to indoor air pollution in rural Mexico.

No commercial use is permitted unless otherwise expressly granted. Produced by [BMJ Publishing Group Ltd](#) under licence

Correspondence to: Dr Joseph L Saenz, Davis School of Gerontology, University of Southern California, Los Angeles, CA 90089, USA; saenzj@usc.edu.

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/jech-2017-209704>)

Contributors All authors have contributed to the background, methodological and theoretical aspects of the manuscript.

Competing interests None declared.

Ethics approval The study was approved by the Institutional Review Boards or Ethics Committees of the University of Texas Medical Branch in the USA, the Instituto Nacional de Estadística y Geografía (INEGI) and the Instituto Nacional de Salud Pública (INSP) in Mexico.

Provenance and peer review Not commissioned; externally peer reviewed.

INTRODUCTION

A growing body of evidence suggests that exposure to high levels of air pollution may negatively affect cognitive functioning among older adults.^{1–6} While studies of air pollution and cognition in older adults have focused on air pollution from outdoor sources including traffic and industry, less is known regarding how pollution from indoor combustion of biomass for domestic energy relates to cognitive function. However, indoor air pollution remains a serious public health concern in developing countries. The WHO estimates that approximately 3 billion people at a global level rely on the combustion of biomass for domestic energy and over 4 million premature deaths a year from pneumonia, stroke, ischaemic heart disease, chronic obstructive pulmonary disease and lung cancer can be attributed to indoor air pollution.⁷ Further, research from Guatemala has suggested that prenatal exposure to woodsmoke is associated with impaired neurodevelopment among children.⁸ Indoor air pollution is most prevalent in rural areas of developing countries, where as many as 90% of the population may rely on biomass for domestic energy.⁹ This practice is common in Mexico, especially in rural areas and in southern regions. For example, in Oaxaca and Chiapas, an estimated 50%–60% of the population relied on solid fuels for domestic energy as of 2000¹⁰ and an estimated 48% of total residential energy demand in Mexico still came from fuelwood and charcoal in 2010.¹¹

Understanding the social and environmental factors that influence cognitive function in old age is becoming increasingly important as the Mexican population continues to age rapidly. The Mexican population age 60+ is projected to expand from 6.9 to 36.3 million from 2000 to 2050,¹² but ageing in Mexico is occurring with limited institutional support for older adults.¹³ The expansion of the older population may lead to a growth in the absolute number of older adults suffering from cognitive impairments, which may place substantial burdens on both family caregivers¹⁴ as well as healthcare systems.¹⁵ Given these trends, identifying modifiable factors that may harm cognitive function in old age is a major public health priority. In this analysis, we seek to determine how exposure to indoor air pollution is associated with cognitive functioning among older adults in the context of Mexico using a nationally representative data set of older adults from a developing country where combustion of biomass for domestic energy remains common. Based on previous research on air pollution from outdoor sources and cognitive function, we hypothesise a negative association between indoor air pollution and cognition.

METHODS

Data

Data come from the Mexican Health and Aging Study (MHAS).¹⁶ The MHAS is a large, nationally representative study of older Mexican adults (age 50+) and their spouses. While data have been collected in 2001, 2003, 2012 and 2015, we focus on the 2012 Wave as this is a nationally representative sample of the Mexican population age 50+ and is an excellent resource to examine the health effects of exposure to indoor air pollution. The MHAS is representative of both rural and urban areas and collects data across a variety of domains including demographics, physical health, cognitive functioning, dwelling characteristics and financial well-being. The MHAS is partly sponsored by the National Institutes of Health/

National Institute on Aging (grant number NIH R01AG018016). Data files and documentation are public use and available at <http://www.MHASweb.org>. There were 15 723 respondents in 2012. Our eligibility criteria include being over the age of 50 and having complete information on independent variables and at least one cognitive domain. We excluded 851 respondents under the age of 50; 1235 proxy interviews; 65 who could not be classified based on cooking fuel; 280 with incomplete information on covariates; and 269 without information on any cognitive assessment, resulting in an analytic sample size of 13 023.

Indoor air pollution

Indoor air pollution is assessed by what fuel the respondent uses most frequently for cooking. Possible responses include ‘gas’, ‘wood or coal’ or ‘other’ (oil, electricity, other). Because less than 1% of the sample reported ‘other’ and we could not determine whether this group was exposed to indoor air pollution, we exclude those reporting ‘other’ and code indoor air pollution as use of ‘wood or coal’ versus ‘gas’.

Cognitive functioning

Cognitive functioning in the MHAS is assessed using the Cross-Cultural Cognitive Examination (CCCE) which is especially useful in populations with limited literacy and mathematical abilities.¹⁷ The CCCE evaluates cognitive functioning using several assessments including verbal learning (the average number of eight words recalled correctly across three trials) (0–8), verbal recall of the eight-word list (0–8), an attention task in which the respondent identifies a stimulus in a visual array of different stimuli (0–60), an orientation task in which the respondent is asked to identify the day, month and year (0–3), and a verbal fluency task in which the respondent lists as many animals as he/she can within 1 min (0–60).

Confounding variables

Demographic covariates include age, sex, educational attainment, locality size, household wealth and dwelling characteristics. Educational attainment is measured as the completed number of years of formal education. We also account for differences in poor housing quality and living conditions by including several characteristics of the dwelling: wall material (partition/brick/stone/concrete, wood, adobe, or other), roof material (concrete/partition/brick, palm/shingles/wood, asbestos/metal laminate, or other), floor material (wood/mosaic/other, concrete, or mud), plumbing type (piped inside, piped outside, or unpiped) and whether insecticide is used regularly in the household. Locality size is a categorical variable indicating whether the respondent’s community of residence has 100 000+, 15 000–99 999, 2500–14 999, or fewer than 2500 inhabitants. Household wealth captures financial well-being and is calculated as the sum of the value of all assets including businesses, money in stocks and accounts, vehicles, and real estate and missing values are imputed by the MHAS.¹⁸ Health covariates include a count of chronic conditions (hypertension, diabetes, cancer, respiratory conditions, heart attack and stroke), whether or not the respondent had health insurance coverage at the time of the survey and smoking behaviours (never smoker, former smoker, current smoker).

Statistical analysis

Each cognitive score, by assessment, is modelled individually using ordinary least squares (OLS) regression. Analysing cognitive assessments separately allows us to determine whether indoor air pollution is associated with cognitive function broadly, or only in specific tasks, and serves as a robustness check for our results. In model 1, each score is modelled as a function of only age, sex, educational attainment and locality size. In model 2, we add quartiles of household wealth. In model 3, we add other characteristics of the household (wall, floor, ceiling materials, plumbing type and use of insecticide). In model 4, we add the count of chronic conditions, health insurance coverage and smoking behaviour. All statistical models are estimated using Stata V.14. We also examined different models of cognitive function including Poisson and logistic which produced similar results; for this reason we present the OLS results to facilitate interpretation. Models were also tested with and without applying sampling weights which yielded similar results. We present the results of the unweighted regression models, but apply the sampling weights to the descriptive results.

RESULTS

Descriptive results

We present our descriptive results, stratified by reported type of cooking fuel, in table 1. About 84.2% of the sample reported using gas while 15.8% relied on wood/coal for cooking fuel. Respondents who used biomass as cooking fuel had significantly lower mean scores across all cognitive assessments than those who used gas as cooking fuel. Further, compared with those who used gas, those who used wood/coal had fewer years of education (6.5 vs 2.6 years) and were more likely to live in rural areas. Respondents who used wood/coal as cooking fuel also appeared more socioeconomically disadvantaged as they were more concentrated in the lowest quartile of wealth, and had lower rates of health insurance. However, those who used gas reported more chronic conditions, and were more likely to be former or current smokers. Respondents also differed in dwelling materials and characteristics according to fuel type. There was also large variation of fuel source by locality size: the per cent of respondents relying on biomass for cooking fuel ranged from only 1.3% in localities with 100 000+ residents to 53.3% in localities with fewer than 2500 residents (results not shown).

Regression analyses

We present the parameter estimates for using wood/coal as main cooking fuel compared with using gas, by cognitive assessment in table 2. Focusing first on models of verbal learning, in model 1, using biomass as cooking fuel was associated with decreased performance (β : -0.18 , $P<0.001$) even after accounting for age, sex, educational attainment and locality size. When household wealth is added in model 2, use of biomass as cooking fuel remains statistically significant. We then adjust for dwelling characteristics in model 3. Although the parameter estimate for use of biomass as cooking fuel is reduced, the estimate remains significant and is unaltered in model 4 (β : -0.13 , $P<0.001$) when health covariates are added. Using wood/coal as cooking fuel was also negatively associated with verbal recall performance, although the estimate was only marginally significant (β : -0.11 , $P=0.06$) in model 1, but not with further adjustment. For the attention assessment, those who reported

using wood/coal as cooking fuel performed significantly worse across all models. The parameter estimate was reduced when dwelling characteristics were added in model 3, but remained significant even in fully adjusted models (β : -3.27 , $P<0.001$). Further, those who used biomass as cooking fuel identified fewer animals in the verbal fluency task. This association remained significant even in fully adjusted models (β : -0.68 , $P<0.001$). Respondents who relied on wood/coal for cooking fuel performed significantly worse on the orientation task as well. While the parameter estimate was reduced by the inclusion of dwelling characteristics, the estimate remained significant (β : -0.12 , $P<0.001$) in fully adjusted models.

The full results from model 1 and model 4 by cognitive assessment are shown in online supplementary table 1. Older age, fewer years of education and living in a more rural area were associated with lower scores across the cognitive function assessments. We provide some context for the size of the associations between wood/coal use as cooking fuel and cognitive function by plotting parameter sizes in terms of additional years of age or fewer years of education in figure 1. We calculated effect sizes by dividing parameter estimates for wood/coal use by the parameter estimates for age and educational attainment in fully adjusted models (model 4) in online supplementary table 1. The association between wood/coal use and cognition was equivalent to 3.5–6.5 additional years of age, or 1.7–3.3 fewer years of schooling.

Sensitivity analyses

We conducted sensitivity analyses to test the robustness of our results. First, while respondents may not report using wood/coal as cooking fuel at the time of the survey, they may have used it in the past. While 95% of those who used gas as cooking fuel in 2003 still reported using gas in 2012, only 60% of those who used wood/coal as cooking fuel in 2003 still used biomass as cooking fuel in 2012. This may lead to exposure in our ‘unexposed’ group which should, theoretically, bias our estimates towards the null. We take advantage of the longitudinal nature of the MHAS by modelling cognitive scores in 2012 as a function of the reported cooking fuel approximately a decade prior. Cooking with biomass in 2001 was associated with worse cognitive function in 2012. We obtained similar results using reported cooking fuel in 2003. Results of these sensitivity analyses are shown in online supplementary table 2. Second, women may be particularly impacted by indoor air pollution as they are typically tasked with cooking.¹⁹ We stratified analyses by sex and found that indoor air pollution was associated with the same assessments (verbal learning, attention, verbal fluency and orientation) for men and women, and the interaction between cooking fuel type and sex never reached statistical significance. However, our indicator of indoor air pollution is based only on cooking fuel. Households that rely on wood/coal for cooking may rely on biomass for other domestic energy including heating and lighting. Smoke and particulate matter from these latter sources may circulate throughout the household, exposing men and women to indoor air pollution. Third, to assess the effect of missing data on our findings, we estimated the cross-sectional associations between cooking fuel and cognition in prior waves (2001 and 2003) among respondents who were omitted in our 2012 data analyses. We found similar negative associations between cooking with biomass and cognitive performance, which suggests a similar pattern of relationship between indoor air

pollution and cognition among the analytic sample and omitted respondents. Results of sensitivity analyses are not shown but are available upon request.

DISCUSSION

Although the use of biomass for domestic energy is declining in Mexico,²⁰ we found that approximately 16% of older adults in Mexico still relied on biomass for cooking fuel as of 2012. This differed greatly by locality size with over half of the respondents in the most rural areas reporting using biomass as cooking fuel. In our analyses, exposure to indoor air pollution was associated with decreased performance across several cognitive assessments including verbal learning, attention, orientation and verbal fluency. Further, the associations were equivalent to between 3.5 and 6.5 additional years of age, or 1.7–3.3 fewer years of schooling. These results suggest that the negative associations between air pollution and cognition are not only present from outdoor sources; rather, indoor air pollution may be an important factor in the cognitive ageing of older adults in Mexico and other developing countries.

Our work comes with limitations. While our primary analyses are cross-sectional, future work should examine the length of exposure to indoor air pollution in greater detail, as well as trajectories of cognitive decline. Further, while our analysis relied on indirect measures of indoor air pollution, future studies should directly measure air quality within the home to evaluate associations between levels of air quality and cognition. We were also unable to examine cognition among proxy interviews. While respondents who used biomass for cooking were more likely to require proxy interviews (13% of biomass users required a proxy while only 7% of gas users required a proxy), proxies tend to be in worse health and have poorer cognitive function. Our findings may, therefore, underestimate the negative association between indoor air pollution and cognition. Last, lacking access to clean sources of household energy is correlated with both poverty and rurality. We include several important measures of rurality and poverty including community size, education, household wealth and several housing quality indicators. However, there may be other important confounders that we did not measure, such as diet, that may be related both to rurality and cognitive function.

We were also unable to explore the mechanisms through which indoor air pollution may affect cognition. However, outdoor pollution and pollution from combustion of biomass both contain high concentrations of nitrogen oxide, sulfur dioxide, carbon monoxide, as well as fine particulate matter.^{19,21} Although previous research has demonstrated important differences in the chemical content of smoke produced from various sources,²² it is possible that indoor and outdoor pollution may impact the brain and cognitive function in similar manners. Studies of air pollution from outdoor sources suggest that high concentrations of fine particulate matter (PM_{2.5}) may affect cognition by decreasing white matter²³ and cerebral volume.²⁴ It is possible then that indoor air pollution may affect cognition via similar mechanisms.

While exposure to indoor air pollution may be reduced by promoting cleaner fuel sources and improving ventilation within homes, this is challenging given the rural location of

households cooking with biomass. Remote rural areas may have limited access to alternative 'clean' fuel sources and people may use biomass because alternative sources of fuel are not affordable. Policymakers and public health workers must consider the unique needs of these populations and collaborate with community leaders in the implementation of programmes to reduce exposure to indoor air pollution. Programmes to reduce exposure to indoor air pollution have been implemented in Michoacán, Mexico, involving the dissemination of Patsari style cookstoves which allow smoke from the combustion of biomass to leave the house via a pipe to the outside. Patsari stoves were developed with a participatory approach as a low-cost solution that is appropriate for rural dwellers. These stoves may reduce concentrations of carbon monoxide and PM_{2.5} by approximately two-thirds²⁵ with others finding significant reductions as well.²⁶ However, the effectiveness of this intervention depends on adherence, which has been low.²⁷ Expanding and improving programmes to reduce exposure to indoor air pollution resulting from the indoor combustion of biomass may be an important step towards improving the health of rural and indigenous populations in Mexico.

The results of this research suggest a negative association between indoor air pollution exposure and cognition in Mexico. This may have substantial public health implications given the rapid expansion of the aged population in Mexico and the economic and social costs associated with their cognitive impairment. In addition to exploring possible mechanisms and how indoor air pollution exposure is associated with cognition longitudinally, future work should evaluate these associations in other Latin American countries and at a global level in contexts where the indoor combustion of biomass for domestic energy remains common.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding This study was conducted with the support of the National Institutes of Health/National Institute on Aging grants (T32AG000037, P30AG043073, R01AG018016 and R00AG039528). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Oudin A, Forsberg B, Adolfsson AN, et al. Traffic-related air pollution and dementia incidence in Northern Sweden: a longitudinal study. *Environ Health Perspect.* 2016; 124:306–12. [PubMed: 26305859]
2. Weuve J, Puett RC, Schwartz J, et al. Exposure to particulate air pollution and cognitive decline in older women. *Arch Intern Med.* 2012; 172:219–27. [PubMed: 22332151]
3. Ailshire JA, Crimmins EM. Fine particulate matter air pollution and cognitive function among older US adults. *Am J Epidemiol.* 2014; 180:359–66. [PubMed: 24966214]
4. Gatto NM, Henderson VW, Hodis HN, et al. Components of air pollution and cognitive function in middle-aged and older adults in Los Angeles. *Neurotoxicology.* 2014; 40:1–7. [PubMed: 24148924]
5. Ranft U, Schikowski T, Sugiri D, et al. Long-term exposure to traffic-related particulate matter impairs cognitive function in the elderly. *Environ Res.* 2009; 109:1004–11. [PubMed: 19733348]

6. Tonne C, Elbaz A, Beevers S, et al. Traffic-related air pollution in relation to cognitive function in older adults. *Epidemiology*. 2014; 25:674–81. [PubMed: 25036434]
7. World Health Organization. Household air pollution and health. 2016. <http://www.who.int/mediacentre/factsheets/fs292/en/> (accessed 2 May 2017)
8. Dix-Cooper L, Eskenazi B, Romero C, et al. Neurodevelopmental performance among school age children in rural Guatemala is associated with prenatal and postnatal exposure to carbon monoxide, a marker for exposure to woodsmoke. *Neurotoxicology*. 2012; 33:246–54. [PubMed: 21963523]
9. World Resources Institute, UNEP, UNDP, World Bank. 1998–1999 world resources: a guide to the global environment. 1998
10. Maldonado, INP., Álvarez, LGP., Díaz-Barriga, F., et al. Impact of air pollution on health, economy, environment and agricultural sources. Croatia: InTech; 2011. Indoor air pollution in Mexico; p. 361-78.
11. Serrano-Medrano M, Arias-Chalico T, Ghilardi A, et al. Spatial and temporal projection of fuelwood and charcoal consumption in Mexico. *Energy Sustain Dev*. 2014; 19:39–46.
12. Consejo Nacional de Población. Envejecimiento de la población de México: reto del siglo XXI. 2004. http://www.conapo.gob.mx/es/CONAPO/Envejecimiento_de_la_poblacion_de_Mexico_reto_del_Siglo_XXI
13. Wong, R., Palloni, A. International handbook of population aging. Springer; 2009. Aging in Mexico and Latin America; p. 231-52. <http://link.springer.com/chapter/> (accessed 1 Nov 2013)
14. Langa KM, Chernew ME, Kabeto MU, et al. National estimates of the quantity and cost of informal caregiving for the elderly with dementia. *J Gen Intern Med*. 2001; 16:770–8. [PubMed: 11722692]
15. Kelley AS, McGarry K, Gorges R, et al. The burden of health care costs in the last 5 years of Life. *Ann Intern Med*. 2015; 163:729–36. [PubMed: 26502320]
16. MHAS. Mexican Health and Aging Study (2001,2003,2012). Data files and documentation (Public Use). 2012. <http://www.MHASweb.org> (accessed 1 Jun 2013)
17. Glosser G, Wolfe N, Albert ML, et al. Cross-cultural cognitive examination: validation of a dementia screening instrument for neuroepidemiological research. *J Am Geriatr Soc*. 1993; 41:931–9. [PubMed: 8409180]
18. Wong, R., Orozco-Rocha, K., Zhang, D., et al. Imputation of non-response on economic variables in the Mexican Health and Aging Study (MHAS/ENASEM) 2012. 2016. http://mhasweb.org/Resources/DOCUMENTS/2012/Imputations/Imputation_of_Non_Reponse_on_Economic_Variables_in_the_MHAS_ENASEM_2012.pdf
19. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bull World Health Organ*. 2000; 78:1078–92. [PubMed: 11019457]
20. Hernández-Garduño E, Gómez-García E, Campos-Gómez S. Prevalence trends of wood use as the main cooking fuel in Mexico, 1990–2013. *Salud Publica Mex*. 2017; 59:68–75. [PubMed: 28423112]
21. Leung DY. Outdoor-indoor air pollution in urban environment: challenges and opportunity. *Front Environ Sci*. 2015; 2
22. Jin W, Su S, Wang B, et al. Properties and cellular effects of particulate matter from direct emissions and ambient sources. *J Environ Sci Health A Tox Hazard Subst Environ Eng*. 2016; 51:1075–83. [PubMed: 27409416]
23. Chen JC, Wang X, Wellenius GA, et al. Ambient air pollution and neurotoxicity on brain structure: evidence from women's health initiative memory study. *Ann Neurol*. 2015; 78:466–76. [PubMed: 26075655]
24. Wilker EH, Preis SR, Beiser AS, et al. Long-term exposure to fine particulate matter, residential proximity to major roads and measures of brain structure. *Stroke*. 2015; 46:1161–6. [PubMed: 25908455]
25. Masera O, Edwards R, Arnez CA, et al. Impact of Patsari improved cookstoves on indoor air quality in Michoacán, Mexico. *Energy for Sustainable Development*. 2007; 11:45–56.

26. Cynthia AA, Edwards RD, Johnson M, et al. Reduction in personal exposures to particulate matter and carbon monoxide as a result of the installation of a Patsari improved cook stove in Michoacan Mexico. *Indoor Air*. 2008; 18:93–105. [PubMed: 18333989]
27. Romieu I, Riojas-Rodríguez H, Marrón-Mares AT, et al. Improved biomass stove intervention in Rural Mexico. *Am J Respir Crit Care Med*. 2009; 180:649–56. [PubMed: 19556519]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

What is already known on this subject

Several studies suggest exposure to high levels of outdoor air pollution negatively affects cognitive function and one study suggests exposure to woodsmoke may impair children's neurodevelopment. However, exposure to air pollution from indoor combustion of biomass for domestic energy remains common in rural areas of developing countries. The association between exposure to indoor air pollution and cognition among older adults has not been assessed in the scientific literature.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

What this study adds

This study adds to the literature on air pollution and cognitive function by demonstrating the negative association between exposure to indoor air pollution and cognition among older adults. Public health efforts should focus on reducing exposure to indoor air pollution, especially in rural areas of developing countries.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.

Estimates calculated using the parameter estimates for wood/coal use, age and educational attainment located in online supplementary table 1. Estimates are from models adjusting for age, sex, locality size, household wealth, dwelling characteristics, chronic condition count, smoking behaviour and health insurance coverage.

Table 1

Descriptive characteristics of Mexican adults (age 50+) from the 2012 Mexican Health and Aging Study by reported type of cooking fuel (n=13 023)

Type of cooking fuel	Gas	Wood or coal	P value
	(n=11 515, 84.2%)	(n=1508, 15.8%)	
Type of cooking fuel	Frequency (%)	Frequency (%)	P value
Cognitive assessments			
Verbal learning (mean, SD)	4.95 (1.2)	4.28 (1.2)	***
Verbal recall (mean, SD)	4.69 (2.0)	4.04 (2.1)	***
Attention (mean, SD)	32.0 (15.4)	20.2 (12.4)	***
Verbal fluency (mean, SD)	15.8 (5.3)	12.9 (4.4)	***
Orientation (mean, SD)	2.55 (0.8)	2.18 (1.0)	***
Demographic characteristics			
Age (mean, SD)	62.3 (9.3)	63.8 (9.7)	
Female	6675 (54.7)	803 (51.0)	***
Years of education (mean, SD)	6.5 (4.8)	2.6 (2.7)	***
Locality size			
100 000+	7653 (59.0)	109 (4.2)	***
15 000–99 999	1323 (16.2)	128 (5.2)	
2500–14 999	1159 (12.8)	254 (17.6)	
<2500	1380 (12.0)	1017 (73.0)	
Household wealth quartile			
First quartile (lowest)	2427 (23.0)	619 (42.8)	***
Second quartile	2940 (25.0)	384 (26.3)	
Third quartile	3005 (26.9)	280 (18.9)	
Fourth quartile (highest)	3143 (25.2)	225 (11.9)	
Wall material			
Partition/brick/stone/concrete	10 769 (93.5)	991 (66.1)	***
Wood	178 (1.7)	195 (13.9)	
Adobe	501 (4.4)	266 (16.4)	
Other	67 (0.4)	56 (3.7)	
Roof material			
Concrete/partition/brick	9895 (84.3)	601 (37.9)	***

	Gas	Wood or coal	
	(n=11 515, 84.2%)	(n=1508, 15.8%)	
Type of cooking fuel	Frequency (%)	Frequency (%)	P value
Palm/shingles/wood	434 (4.4)	219 (12.1)	
Asbestos/metal laminate	1092 (10.4)	590 (40.5)	
Other	94 (1.0)	98 (9.6)	
Floor material			
Wood/mosaic/other	7141 (60.4)	162 (9.5)	***
Concrete	4232 (38.5)	1167 (76.9)	
Mud	142 (1.1)	179 (13.7)	
Plumbing type			
Piped inside	10 342 (87.3)	520 (26.9)	***
Piped outside	1014 (11.0)	721 (50.5)	
Unpiped	159 (1.7)	267 (22.6)	
Insecticide use			
Regular use of insecticide	5685 (42.3)	483 (30.8)	***
Health covariates			
Chronic condition count (mean, SD)	0.82 (0.9)	0.75 (0.9)	***
Never smoker	7092 (59.2)	1022 (65.5)	***
Former smoker	2973 (26.0)	349 (24.3)	
Current smoker	1450 (14.8)	137 (10.2)	
Insured	10 218 (86.2)	1250 (80.8)	***

Source: Authors' own calculation using data from the Mexican Health and Aging Study (MHAS). All percentages, means and SD are calculated using MHAS sampling weights.

* P<0.05;

** P<0.01;

*** P<0.001.

Table 2

Parameter estimates of use of wood/coal as cooking fuel versus gas using OLS regression by cognitive assessment among older Mexican adults (age 50+)

	Model 1[†]	Model 2[‡]	Model 3[§]	Model 4[¶]
Verbal learning				
$\beta(p)$	-0.18 ***	-0.16 ***	-0.13 ***	-0.13 ***
95% CI	-0.24 to -0.11	-0.23 to -0.10	-0.20 to -0.06	-0.21 to -0.06
Verbal recall				
$\beta(p)$	-0.11	-0.10	-0.07	-0.07
95% CI	-0.23 to 0.00	-0.22 to 0.01	(-0.19 to 0.06	-0.19 to 0.06
Attention				
$\beta(p)$	-4.50 ***	-4.33 ***	-3.22 ***	-3.27 ***
95% CI	-5.26 to -3.73	-5.10 to -3.57	(-4.05 to -2.40	-4.09 to -2.44
Verbal fluency				
$\beta(p)$	-0.97 ***	-0.93 ***	-0.69 ***	-0.68 ***
95% CI	-1.25 to -0.69	-1.21 to -0.65	(-0.99 to -0.39	-0.98 to -0.38
Orientation				
$\beta(p)$	-0.21 ***	-0.20 ***	-0.12 ***	-0.12 ***
95% CI	-0.26 to -0.16	-0.25 to -0.15	-0.17 to -0.07	-0.17 to -0.07

Source: Authors' own calculation using data from the Mexican Health and Aging Study (MHAS).

Sample size for verbal learning, verbal recall, attention, verbal fluency and orientation is 12 929, 12 864, 11 993, 12 901 and 12 971, respectively.

* P<0.05;

** P<0.01;

*** P<0.001.

[†]Model 1 includes: age, sex, years of education and locality size.

[‡]Model 2 adds household wealth quartile.

[§]Model 3 adds floor material, wall material, ceiling material, plumbing type and insecticide use.

[¶]Model 4 adds chronic condition count, smoking behaviour and health insurance coverage.

OLS, ordinary least squares.