Unclean Cooking Fuel Use and Slow Gait Speed Among Older Adults From 6 Countries

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ABSTRACT

Background: Outdoor air pollution has been reported to be associated with frailty (including slow gait speed) in older adults. However, to date, no literature exists on the association between indoor air pollution (e.g., unclean cooking fuel use) and gait speed. Therefore, we aimed to examine the cross-sectional association between unclean cooking fuel use and gait speed in a sample of older adults from six low- and middle-income countries (China, Ghana, India, Mexico, Russia, South Africa).

Methods: Cross-sectional, nationally representative data from the WHO Study on global AGEing and adult health (SAGE) were analyzed. Unclean cooking fuel use referred to use of kerosene/paraffin, coal/charcoal, wood, agriculture/crop, animal dung, and shrubs/grass based on self-report. Slow gait speed referred to the slowest quintile based on height, age, and sex-stratified values. Multivariable logistic regression and meta-analysis were done to assess associations.

Results: Data on 14,585 individuals aged ≥65 years were analyzed [mean (SD) age 72.6 (11.4) years; 45.0% males]. Unclean cooking fuel use (vs. clean cooking fuel use) was significantly associated with higher odds for slow gait speed [OR=1.45 (95%CI=1.14-1.85)] based on a meta-analysis using country-wise estimates. The level of between-country heterogeneity was very low (I^2=0%).

Conclusions: Unclean cooking fuel use was associated with slower gait speed among older adults. Future studies of longitudinal design are warranted to provide insight into the underlying mechanisms and possible causality.

Key Words: Unclean cooking fuel; Pollutants; Indoor air pollution; Gait speed; Older adults

INTRODUCTION

The speed at which one walks (gait speed) is an important predictor of functional status (1), and this speed tends to become slower as people age. Among older people, slow gait speed has been associated with a range of adverse health outcomes. For example, in a meta-analysis including 44 articles, it was found that each reduction of 0.1 m/s in gait speed is associated with a 12% increased risk for premature mortality and an 8% increased risk for cardiovascular diseases (2). Slow gait speed has also been associated with increased risks for disability (3), depressive symptoms (4), falls, dementia (5), and hospitalization (6). Slow gait speed or problems with functional mobility may be a particular concern in low- and middle-income countries (LMICs) where population aging is occurring rapidly. Indeed, by 2050, 80% of older people will be living in LMICs (7). Considering the rapid aging occurring in LMICs and the plethora of detrimental health outcomes associated with slow gait speed, it is of upmost importance to identify correlates or risk factors of slow gait speed to aid in the development of targeted interventions. While many risk factors of slow gait speed have been identified to date (e.g., low physical activity) (8–10), one potentially important but understudied potential risk factor, especially in the context of LMICs, is that of unclean cooking fuel use.

Unclean cooking fuel includes kerosene/paraffin and solid fuels (coal/charcoal, wood, agriculture/crop, animal dung, shrubs/grass). Globally, approximately 3 billion people use traditional biomass such as fuelwood, which has detrimental health and environmental effects on households and the world at large, as their main source of cooking fuels. Out of these 3 billion people, it is estimated that almost 2.6 million are residents of LMICs (11). Unclean cooking fuel may increase risk for slow gait speed as fine particulate matter released by the combustion of solid fuel is a chronic source of neuro-inflammation and reactive oxygen species that contribute to neuropathology and central nervous system diseases (12). Moreover, fine particulate matter may cause damage to the nervous system as smaller components of particulate matter can reach the brain (13), and this may lead to a decrease of neurotransmitters, leading to poor muscle function(14).

Despite this, to the best of the authors' knowledge, there are no existing studies on the association between unclean cooking fuel use and gait speed, although there are some studies on unclean cooking fuel use and other measures of functional decline or frailty, such as handgrip strength (15). For example, in one study including 9,382 older participants from China, during a 4-year follow-up, participants who used solid fuel for cooking had more pronounced decreases in handgrip strength than those who used clean fuel (15). However, given that handgrip strength is a measure of muscle strength, and not physical performance, studies on cooking fuel use and gait speed are warranted.

Given this background, the aim of the present study was to examine the cross-sectional association between unclean cooking fuel use and gait speed in a sample of 14585 individuals aged ≥65 years from six LMICs.

METHODS

Data analysis of the Study on Global Ageing and Adult Health (SAGE) 2007-2010 was conducted. China, Ghana, India, Mexico, Russia, and South Africa participated in this survey. These countries broadly represent different geographical locations and levels of socio-economic and demographic transition. Based on the World Bank classification at the time of the survey, Ghana was the only low-income country, and China and India were lower middle-income countries although China became an upper middle-income country in 2010. The remaining countries were upper middle-income countries. Details of the survey methodology have been published elsewhere (16). Briefly, a multistage clustered sampling design method was used with the aim of obtaining nationally representative samples. The target sample was adults aged ≥18 years, while those aged ≥50 years were oversampled. Trained interviewers conducted face-to-face interviews using a standrd questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the World Health Organization (WHO) Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Gait speed

Gait speed was based on a 4m timed walk and was measured by asking the participant to walk at a normal pace at the interview site. The interviewer recorded the time to completion of the 4m walk. The participant was allowed to use any mobility aids they typically use when walking. Gait speed was categorized into quintiles based on height, age, and sex-stratified values (17,18). This variable was dichotomized as lowest quintile of gait speed (slow gait speed) or else (19).

Cooking fuel

Information on the type of cooking fuel used in the household was obtained by the question "What type of fuel does your household mainly use for cooking?" with the following answer options: gas, electricity, kerosene/paraffin, coal/charcoal, wood, agriculture/crop, animal dung, and shrubs/grass. In line with a previous SAGE publication (20), this variable was dichotomized as clean fuels (gas, electricity), and non-clean fuels [kerosene/paraffin, solid fuels (coal/charcoal, wood, agriculture/crop, animal dung, shrubs/grass)]. Type of stove and chimney/hood used was further asked only among those who use solid fuels (i.e., coal and biomass fuels). Type of stove was asked by the question "In this household, is food cooked on an open fire, an open or closed stove?" This variable was dichotomized as 'open fire/stove' or 'closed stove' (20). Presence of chimney/hood was assessed with the question "Does the fire/stove have a chimney, hood, or neither?" A dichotomous variable of 'chimney or hood' or 'neither' was created (20). Finally, place for cooking was assessed by the question "Where is cooking usually done?" and this variable was dichotomized as 'In a room used for living or sleeping' or 'else' (i.e., in a separate room/building used as kitchen, outdoor) (20).

Control variables

The selection of the control variables was based on past literature (21), and included age, sex, highest level of education achieved, wealth quintiles based on income, marital status (currently married/cohabiting, never married, separated/divorced/widowed), setting (rural, urban), smoking (never, current, past), physical activity, alcohol consumption, body mass index (BMI), and disability. Education was categorized as ≤primary (never been to school, less than primary school, primary school completed), secondary (secondary school completed, high school or equivalent completed), and tertiary (college/pre-university/university completed, post graduate degree completed). Levels of physical activity were assessed with the Global Physical Activity Questionnaire and were classified as low, moderate, and high based on conventional cut-offs (22). Consumers of at least four (females) or five drinks (males) of any alcoholic beverage per day on at least one day in the past week were considered ‘heavy’ drinkers. Those who had ever consumed alcohol but were not heavy drinkers were categorized as ‘non-heavy’ drinkers (23). BMI was calculated as weight in kilograms divided by height in meters squared based on measured weight and height, and was categorized as <18.5 kg/m^2 (underweight), 18.5-24.9 kg/m^2 (normal weight), 25.0-29.9 kg/m^2 (overweight), and ≥30.0 kg/m^2 (obesity) (24). Disability was assessed by standard basic activities of daily living (ADL questions) which included six questions with the introductory phrase “overall in the last 30 days, how much difficulty did you have” followed by: in washing your whole body?; in getting dressed?; with moving around inside your home?; with eating (including cutting up your food)?; with getting up from lying down?; and with getting to and using the toilet? Answer options were none, mild, moderate, severe, extreme/cannot do. ADL disability was a dichotomous variable where those who answered severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL.

Statistical analysis

The statistical analysis was performed with Stata 14.2 (Stata Corp LP, College station, Texas). The analysis was restricted to those ≥65 years. Multivariable logistic regression analysis was conducted to assess the association between unclean cooking fuel use (exposure) and slow gait speed (outcome). Country-wise estimates were obtained, and a pooled estimate was calculated based on these estimates in a meta-analysis with fixed effects. In order to assess the level of between-country heterogeneity in the association between unclean cooking fuel use and slow gait speed, the Higgin’s I^2 was calculated based on country-wise estimates. The Higgins’ I^2 represents the degree of heterogeneity that is not explained by sampling error with a value of <40% often considered as negligible and 40-60% as moderate heterogeneity (25). Furthermore, using the sample including all countries, we also conducted analysis with cooking ventilation type or individual cooking fuel type (e.g., animal dung, wood) as the exposure. The analysis on cooking ventilation type was restricted to people using solid fuels as this data was only collected among these people (n=6205). The regression analyses were adjusted for age, sex, education, wealth, marital status, setting, smoking, physical activity, alcohol consumption, body mass index, disability, and country, with the exception of the country-wise analysis, which was not adjusted for country. Adjustment for country was also done by including dummy variables for each country in the model as in previous SAGE publications (26,27). The sample weighting and the complex study design were taken into account in all analyses. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs) (28). The level of statistical significance was set at two-sided P<0.05.

RESULTS

Data on 14,585 individuals aged ≥65 years were analyzed. The sample characteristics are provided in **Table 1**. The sample size ranged from 1375 in Mexico to 5360 in China. In the overall sample, the mean (SD) age of the sample was 72.6 (11.4) years, and 45.0% were males. The mean age ranged from 71.6 years in India to 74.7 years in Mexico, while the % of males ranged from 31.8% in Russia to 52.0% in Ghana and India. The level of education was particularly high in Russia. Furthermore, the prevalence of slow gait speed and unclean cooking fuel use was 19.2% and 45.9%, respectively, although there was a wide variation by country. Specifically, the prevalence of slow gait speed ranged from 7.3% in China to 45.7% in Russia, while that of unclean cooking fuel use ranged from 1.6% in Russia to 92.8% in Ghana. Unclean cooking fuel use (vs. clean cooking fuel use) was significantly associated with higher odds for slow gait speed [OR=1.45 (95%CI=1.14-1.85)] based on a meta-analysis using country-wise estimates (**Figure 1**). The level of between-country heterogeneity was very low (I^2=0%). Cooking ventilation was not significantly associated with slow gait speed (**Table 2**). Finally, compared to clean cooking fuel use, use of agriculture/crop (OR=1.84; 95%CI=1.06-3.17) and shrubs/grass (OR=2.73; 95%CI=1.63-4.59) were significantly associated with higher odds for slow gait speed (**Table 3**).

DISCUSSION

Main findings

In our nationally representative study including nearly 15,000 people aged ≥65 years from six LMICs, we found that unclean cooking fuel use was associated with higher odds for slow gait speed. Interestingly, the level of between-country heterogeneity was very low, despite the fact that the countries included in our study were from different continents with diverse sociodemographic and economic levels. In particular, compared to clean cooking fuel, the use of shrubs/grass was associated with a nearly three-fold increase in the odds for slow gait speed. Cooking ventilation type was not significantly associated with slow gait speed. To the best of our knowledge, this study is the first study on unclean cooking fuel use and slow gait speed.

Interpretation of the findings

Findings from the present study are in line with existing literature that has identified associations between outdoor air pollution and varying measures of frailty (15,21,29–32), or indoor air pollution and weak handgrip strength (15), and adds to this literature through showing for the first time that unclean cooking fuel use is associated with higher odds for slow gait speed. There are several speculative pathways that may explain the unclean cooking fuel use/slow gait speed association. First, as previously discussed, this may be owing to the fact that fine particulate matter released by the combustion of solid fuel is a chronic source of neuro-inflammation and reactive oxygen species that contributes to neuropathology and central nervous system diseases (12). Second, particulate air pollution, especially particulate matter smaller than 2.5 µm, are known to augment systemic inflammation, insulin resistance, and oxidative stress which can lead to muscle wastage and increased body fat mass (33). Muscle wastage and increased fat mass (i.e., sarcopenia) have been found to be strongly related to slow gait speed (34). Indeed, the impaired muscular system has difficulty responding to postural correction with sufficient strength and speed subsequently leading to a lower gait speed (5,35). Interestingly, particulate matter exposure appears to alter both neurotransmitters within dopamine and glutamate systems (36). Whereas the level of dopamine has been shown to influence gait speed (37) owing to subsequent declines in motor function and postural control. For example, sensory information integration important for balance is affected by dopaminergic denervations in the ventral striatum, yielding postural control impairments (37).

The finding that the type of cooking ventilation was not associated with gait speed among those who use solid fuel for cooking is interesting and should be noted. It is possible that a high level of pollutant still enters the internal atmosphere even in the presence of cooking ventilation. For example, previous literature has shown that in kitchens using biomass for cooking, average airborne concentrations of carbon monoxide, and especially PM2.5 were higher than in those using natural gas, and that the use of a chimney stove appeared to reduce levels of carbon monoxide, but not of PM2.5 (38). Indeed, the association between unclean cooking fuel use and slow gait speed is likely driven by particulate matter and not carbon monoxide, as discussed above.

Implications of the study findings

The findings of this study provide further evidence for the importance of implementing United Nations Sustainable Goal 7, which aims to provide access to affordable, reliable, sustainable, and modern energy for all, and reduce the use of unclean cooking fuel. This could potentially improve physical function as well as other multiple health outcomes (e.g., heart diseases, stroke, cancers, chronic lung diseases, and pneumonia) (39,40). Examples of recommendations to address the widespread use of unclean cooking fuels in LMICs proposed by the WHO and other key international bodies include the following: (1) Prioritization of clean-cooking solutions via evidence-based policies; (2) Scale up of promising enterprises and increase in consumer choice and private investment via mobilization of funding; (3) Monitoring of household energy use; and (4) Encouraging cleaner and more efficient cooking solutions that meet local cultural, social, and gender needs (41). However, to clarify whether these policies can also improve indicators of physical function will require future research of longitudinal and interventional design.

Strengths and limitations

The analysis of large representative samples of older adults from six LMICs is a clear strength of the present study. However, findings must be interpreted in light of the study's limitations. First, the study was cross-sectional in nature. Therefore, the direction of the association (causality) is unknown. However, it could be unlikely that slow gait speed leads to unclean cooking fuel use. Second, there was no detailed information on personal exposure (including length of time or frequency) and smoke composition of different cooking fuels. Future studies should take these factors into consideration to provide more insight. Next, while we did adjust for lifestyle factors such as physical activity, alcohol consumption, and smoking, the variables used in our study do not necessarily reflect the past long-term trajectory of these behaviours. Thus, it is possible that adjustment for these factors is incomplete and that the association observed in our study is partly explained by factors such as health literacy. Finally, the institutionalized and homeless were not included in the study. Thus, the study results cannot be generalized to this population.

Conclusion

The present study using large representative samples of older adults from six LMICs found that unclean cooking fuel use was associated with slower gait speed and that the combustion of agriculture/crops or shrubs/grass may be particularly harmful. Future studies of longitudinal design are warranted to assess whether interventions to reduce unclean cooking fuel including the implementation of Sustainable Development Goal 7 can also have a positive influence on physical function in older people from LMICs.

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Table 1 Sample characteristics (overall and by country)

Characteristic		Total (n=14585)	China (n=5360)	Ghana (n=1975)	India (n=2441)	Mexico (n=1375)	Russia (n=1950)	South Africa (n=1484)
Slow gait speed	Yes	19.2	7.3	39.0	18.5	20.9	45.7	39.3
Unclean cooking fuel use	Yes	45.9	42.1	92.8	79.3	11.2	1.6	24.2
Age (years)	Mean (SD)	72.6 (11.4)	72.3 (11.0)	74.1 (14.1)	71.6 (10.0)	74.7 (15.9)	74.2 (10.4)	72.8 (14.6)
Sex	Male	45.0	46.6	52.0	52.0	45.1	31.8	39.4
Education	≤Primary	63.7	72.6	85.3	82.4	87.1	16.5	77.8
	Secondary	29.9	21.2	12.4	14.2	6.7	71.3	19.1
	Tertiary	6.4	6.2	2.3	3.4	6.2	12.2	3.1
Marital status	Married/cohabiting	61.0	73.4	50.8	60.9	54.2	42.1	48.4
	Never married	1.2	0.8	1.2	0.7	7.0	1.6	8.3
	Else[a]	37.8	25.8	48.0	38.4	38.7	56.3	43.3
Setting	Urban	50.6	54.9	40.5	29.5	78.6	74.0	62.4
Smoking	Never	62.2	67.8	73.5	42.8	60.1	80.3	68.5
	Current	29.3	23.4	11.7	51.0	17.7	9.3	19.8
	Quit	8.5	8.9	14.8	6.2	22.2	10.4	11.6
Physical activity	High	35.2	32.0	53.5	35.9	25.2	40.8	18.2
	Moderate	25.2	30.3	12.7	25.5	24.1	18.4	13.8
	Low	39.6	37.6	33.8	38.6	50.7	40.9	67.9
Smoking	Never	67.7	71.5	46.8	85.3	54.5	33.4	77.3
	Non-heavy	29.9	24.5	52.0	14.3	43.4	64.1	20.1
	Heavy	2.3	4.0	1.2	0.4	2.0	2.5	2.6
Body mass index (kg/m^2)	<18.5	19.3	6.3	20.8	46.0	1.1	1.7	4.7
	18.5-24.9	46.4	60.1	55.6	44.0	31.9	27.1	23.5
	25.0-29.9	23.9	28.3	16.5	7.8	43.8	42.4	28.3
	≥30	10.4	5.4	7.2	2.2	23.2	28.8	43.5
Disability	Yes	11.9	3.2	11.7	19.0	11.2	15.9	15.2

Abbreviation: SD Standard deviation

[a] Else includes divorced/separated/widowed.

Data are % unless otherwise stated.

Table 2 Association between cooking ventilation and hearing problems (outcome) estimated by multivariable logistic regression

Cooking ventilation		OR	95%CI	P-value
Stove	Closed stove	1.00		
	Open stove or fire	0.77	[0.54,1.10]	0.145
Chimney/hood	Chimney or hood	1.00		
	Without chimney or hood	1.18	[0.81,1.72]	0.380
Cooking place	In a separate room/building used as kitchen or outdoor	1.00		
	In a room used for living or sleeping	0.90	[0.46,1.75]	0.748

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, education, wealth, marital status, setting, smoking, physical activity, alcohol consumption, body mass index, disability, and country.

Table 3 Association between different types of unclean cooking fuels and slow gait speed (outcome) estimated by multivariable logistic regression

	OR	95%CI	P-value
Clean[a]	1.00		
Kerosene/paraffin	1.63	[0.80,3.34]	0.181
Coal/charcoal	1.68	[0.99,2.86]	0.056
Wood	1.26	[0.83,1.93]	0.278
Agriculture/crop	1.84	[1.06,3.17]	0.029
Animal dung	1.94	[0.87,4.31]	0.105
Shrubs/grass	2.73	[1.63,4.59]	<0.001

Abbreviation: OR Odds ratio; CI Confidence interval

[a] Clean cooking fuel referred to gas and electricity.

Models are adjusted for age, sex, education, wealth, marital status, setting, smoking, physical activity, alcohol consumption, body mass index, disability, and country.

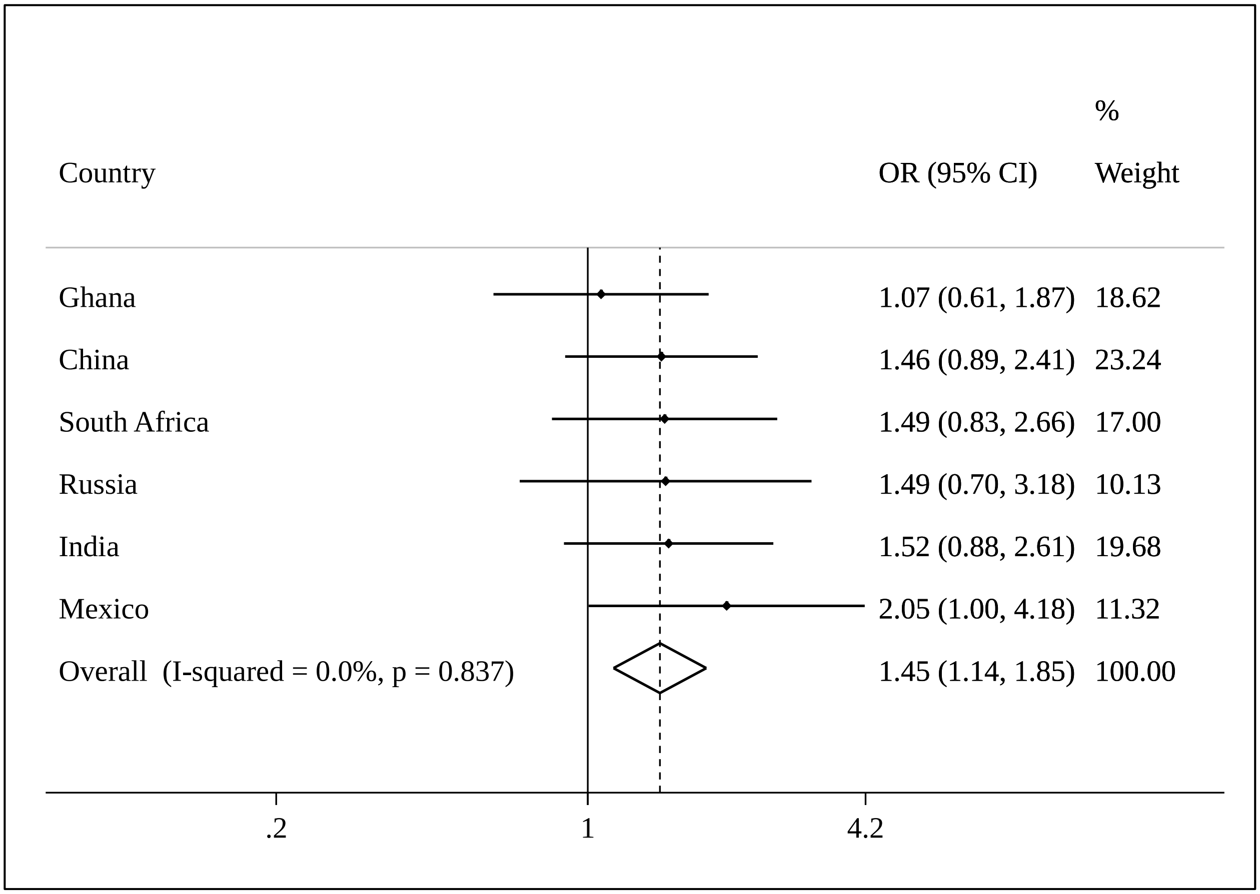

Figure 1 Association between unclean cooking fuel use and slow gait speed estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models were adjusted for age, sex, education, wealth, marital status, setting, smoking, physical activity, alcohol consumption, body mass index, and disability.

Overall estimate was based on meta-analysis with fixed effects.