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Association Between Type of Cooking Fuel and Body Mass Index Among Women in Cambodia

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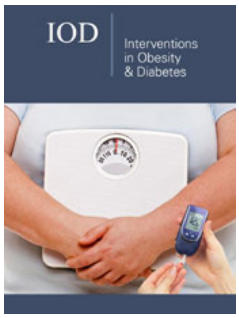

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Abstract

Introduction: Solid cooking fuel is the primary source of energy for almost half of the world's population. Studies have examined the association between solid cooking fuel and respiratory and cardiovascular disease, negative pregnancy outcomes, and shortened life expectancy. However, no study has examined the association between solid cooking fuel and Body Mass Index (BMI) among women in Cambodia.

Methods: Data was taken from the 2014 Cambodia Demographic and Health Survey (N=3249), women aged 15-49 years. Multivariable logistic regression analysis was used to determine the association between type of cooking fuel and BMI, controlling for age, education, marital status, parity, employment status, kitchen being a separate room, location of cooking food, and household wealth index.

Results: Compared to younger women, older women were more likely to be overweight/obese shown by multivariable adjusted odds ratio (95% confidence interval) for women aged 25-34 years 2.64 (1.80, 3.86), and for women aged 35-49 years 4.97 (3.20, 7.72). Compared to women who reside in poor households, the odds of being overweight/obese were higher for women residing in a middle household wealth index 2.62 (1.52, 4.52), and women residing in rich household wealth index 2.78 (1.83, 4.24). When adjusting for potential confounding variables, the association between type of cooking fuel and BMI observed in the unadjusted model disappeared (p=0.103).

Conclusion: These findings indicate that type of cooking fuel is not significantly associated with BMI in a nationally representative sample of women in Cambodia.

Keywords: Cooking fuel; Cambodia; Childhood mortality; Body mass index; Overweight; Obesity

Abbreviations: BMI: Body Mass Index; PM: Particulate Matter; CDHS: Cambodia Demographic and Health Survey

Introduction

Globally, 3 billion people use solid fuels (coal, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung) for household energy [1]. These solid fuels are commonly burned inside a house with poor ventilation, creating a large amount of health-damaging pollutants in these households [2]. Rural households use more solid fuel for cooking than urban households. Total solid fuel used for cooking was reported for 91.5% of rural households and only 38.4% of urban households in Cambodia in 2014 [3]. Electricity and gas are more widely available in urban areas and household income is higher in urban areas, resulting in the lower percentage of use of solid fuels for cooking in urban areas [2]. Particulate Matter (PM) is the byproduct of solid fuel combustion used in many developing countries as a cooking fuel. Long-term exposure to PM that measures 2.5μm in diameter or less (PM2.5) is known to cause respiratory and cardiac diseases, negative pregnancy-related outcomes, chronic physiological changes, and reduced life expectancy [4]. The WHO guidelines for PM2.5 are 25μg/m^3 daily; the average daily exposure in Cambodia in a cooking and eating environment has been calculated at 155.0μg/m^3 for households that cook inside the house [5,6]. According to the 2014 DHS Survey of Cambodia, 40.4% of households cook inside the house and 83.8%

of households use solid cooking fuel [3]. The WHO estimates that 1.45 million people (mainly women and children under 5) die each year from household air pollution caused by biomass (solid fuel) combustion [7]. The aim of Millennium Development Goal 7 (MDG7) is to ensure environmental sustainability. This goal was established to protect the environment as well as reduce the harmful effects of using solid fuels as household energy on women's health [8]. The high rate of using solid fuel for cooking in Cambodia not only causes health problems, but it is also not in alignment with MDG7. The 2014 DHS Survey of Cambodia showed there are high rates of malnutrition among women [3]. There was a significant increase in the percentage of overweight women in Cambodia from 6% in 2000 to 18% in 2014 [9]. Given the high rates of overweight and obesity and use of solid fuel for cooking in Cambodia, I sought to examine the association between using solid fuel for cooking and BMI. To my knowledge, the association between type of cooking fuel and BMI has not been explored among women in Cambodia. I hypothesized that women in Cambodia who used solid cooking fuel would have higher rates of overweight and obese BMI.

Methods

Design

This is a cross-sectional study based on secondary data from the 2014 Cambodia Demographic and Health Survey (CDHS). The CDHS is a national representative, retrospective, cross-sectional household survey implemented by the Cambodia National Institute of Statistics Ministry of Planning and Ministry of Health, the Directorate General for Health, and ICF International. Data collection for the 2014 CDHS was funded by the Royal Government of Cambodia, the United States Agency for International Development, UNICEF, and other international organizations. A detailed description of the study design for the 2014 CDHS is available elsewhere [10]. The main purpose of the 2014 CDHS was to generate reliable information on population and reproductive health to make informed policy decisions for planning, monitoring, and evaluating programs.

Ethical considerations

The 2014 Cambodia Demographic and Health Survey (CDHS) received government permission to conduct the survey, used informed consent, and assured participants of confidentiality. The study was justified and approved by the DHS program after which the data used for this study was downloaded. This study was considered exempt from a full review and approved by the Ohio University Office of Research Compliance because it was based on anonymous public use of a secondary dataset with unidentifiable information about the survey participants.

Setting

The Kingdom of Cambodia is located in Southeast China, on the southern portion of the Indochina Peninsula. It is one of the poorest and least developed countries in Asia [10]. The population of Cambodia is over 15 million and approximately 95% of the population follows the Theravada Buddhist religion [11]. Over 95% of the population are of Khmer ethnicity and speak Khmer, the official language of the country [11]. Cambodia is governed by a constitutional monarchy and ruled by a prime minister. Cambodia has one of the fastest growing economies in Asia and has attained lower middle-income status. Over 50% of the population is under 22 years of age and 80% of the population lives in rural areas [10]. Phnom Penh is the capital of Cambodia and hosts a population of over 2 million people. The country's income is primarily dependent on agricultural exports, mainly rice and a growing fishing industry [10].

Sample

The 2014 CDHS survey sampled a representative sample of the population of men and women ages 15 to 49 years of age. The country was divided into 19 domains; 14 individual provinces and five groups of provinces. The 19 domains were divided into 38 sampling strata by rural and urban areas. The country was further divided into 611 clusters, based on probability proportional to size. Each cluster was an enumeration area or a segment of an enumeration area. The enumeration areas were derived from the 2008 Cambodia General Population Census provided by the NIS. This list was updated in 2012 to exclude special settlement areas and not ordinary residential areas. From each rural cluster, 28 households were selected to complete the household survey and 24 households from each urban cluster were selected. All women aged 15 to 49 years who stayed in the selected households the night before the household survey was administered were eligible for the women's survey. One-third of the men who lived in the selected households were eligible for the survey due to financial restrictions. Questionnaires were completed by 15,825 households, 17,578 women, and 5,190 men [10]. In the current study, 3,249 women who provided data for all the variables (age, education level, marital status, parity, employment, type of residence, kitchen as a separate room of the house, location of food cooked, household wealth index, type of cooking fuel, and BMI) were included in the study.

Measurement

Measurement: Standard DHS instruments that were translated into the Khmer language were utilized. The household questionnaire collected information on age, sex, education, relationship to the head of household, dwelling characteristics, accidental death and injury, physical impairment, utilization and cost of health services, disability, possession of iodized salt, height and weight of women and children, and hemoglobin measurements of women and children. The women's questionnaire included information on education, residential history, media exposure, reproductive history, knowledge and use of family planning methods, antenatal and delivery care, breastfeeding, infant and early childhood feeding practices, vaccinations and childhood illness, woman's occupation, husband's background characteristics, childhood mortality, AIDS awareness and behavior, and other health issues. The standard DHS questionnaire was pretested in February and March of 2014 and adapted to reflect health issues relevant to Cambodia. Stakeholders that include government ministries and agencies, nongovernmental organizations, and international donors participated in validating the questionnaire [10].

Outcome variable: As part of the women's questionnaire, the height and weight of two-thirds of the participants were measured to calculate the Body Mass Index (BMI). The BMI is calculated by dividing a person's weight in kilograms by the height in meters squared (BMI=kg/m^2). This variable was recoded into two groups: (1) underweight or normal weight (12.00kg/m^2 - 24.99kg/m^2) and (2) overweight or obese (≥25.00 kg/m^2).

Exposure variable: Participants in the women's questionnaire were asked, "What type of fuel does your household mainly use for cooking?" The response variables were recoded so that electricity, liquid petroleum gas, natural gas, biogas, and kerosene were coded as "liquid fuel" and coal, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung were coded as "solid fuel".

Covariates: Based on previous studies, the following variables were adjusted in the multivariable model: woman's age (15-24, 25-34, 35-49), woman's education level (no education, primary, secondary or above), marital status (never married, married or living together, widowed/separated/divorced), parity (0 children, 1-3 children, more than 3 children), employment (currently working, unemployed), type of residence (rural, urban), kitchen is a separate room of the house (separate room, not separate room), location of food cooked (in house, outside of house), and household wealth index (poor, middle, rich).

Statistical analysis: The household and women's survey data sets from the 2014 CDHS were merged to include only the women's body mass index in the current study. Descriptive statistics were used to describe and summarize the data. Rao-Scott chi-square test statistic ($\chi 2$) was used to compare differences in Body Mass Index (BMI) by the type of cooking fuel used in the household and each of the covariates. Multivariable logistic regression analysis was performed to determine the association between the type of cooking fuel and BMI. As each covariate had been associated with BMI in prior studies, covariates were retained in the multivariable model regardless of their statistical significance in the bivariate analysis. The corresponding odds ratio, 95% confidence interval, and p value for the association between type of cooking fuel and BMI were determined. P value <0.05 was considered statistically significant. As recommended, sampling weights that accounted for complex survey design were incorporated in all analyses. All analyses were performed using SAS University Edition (SAS Institute, Inc., Cary, NC).

Results

Overall, 46% of the study participants were aged 15-24 years of age, 46% had secondary or higher education level, 57% were married or living together, 50% had at least one child, 69% were employed, 70% lived in a rural area, 62% had a kitchen that was not a separate room in the house, 100% cooked inside the house, 52% were considered rich, 18% were overweight or obese, and 67% used solid fuel for cooking (Table 1). Two-way comparisons using a Rao-Scott Chi-square test between type of cooking fuel used and BMI showed significance statistically significant association ($p<0.001$). Additionally, Chi-square tests showed statistically significant associations ($p<0.05$) between BMI and women's age, education level, marital status, parity, employment status, type of residence, whether the kitchen is a separate room in the house, whether food is cooked inside or outside the house, and household wealth index. Chi-square tests also showed statistically significant associations ($p<0.05$) between the type of cooking fuel and each of these covariates. Table 2 contains the results of the bivariate analysis using the Rao-Scott chi-square test statistic ($\chi 2$), showing statistically significant results comparing BMI to covariates with a p value <0.05. The covariates with a statistically significant association to BMI were type of cooking fuel (0.026), age (<0.001), education (<0.001), parity (<0.001), and household wealth index (<0.001). A higher proportion of women who used liquid fuel were overweight or obese than women who used solid cooking fuel. Women who were 25-49 years old had a higher proportion of overweight and obese BMI than women 15-24 years of age. Women who had no education had a higher proportion of overweight or obese BMI than women who had primary or higher level of education. Women who were married or widowed/separate/divorced were more likely to be overweight or obese as compared to women who have never married. Women who had at least one child were more likely to be overweight or obese than women who had no children. Women who had middle- or high-income levels were more likely to be overweight or obese BMI than women who were poor.

Table 1: Descriptive statistics of the survey sample (N=3249). Abbreviations: wt.%: weighted percent.

	Overall n (wt.%)
Body Mass Index	
Normal/underweight	2702 (82.3)
Overweight/obese	547 (17.7)
Type of Cooking Fuel	
Liquid fuel	1085 (32.9)
Solid fuel	2164 (67.1)
Woman's Age	
15-24	1516 (45.5)
25-34	858 (26.0)
35-49	875 (28.5)
Woman's Education	

None	396 (12.7)
Primary	1302 (41.4)
Secondary or above	1551 (45.9)
Place of Residence	
Urban	1365 (30.4)
Rural	1884 (69.6)
Marital Status	
Never married	1318 (39.7)
Married or living together	1839 (57.4)
Widowed/separated/divorced	92 (2.9)
Parity	
No children	1632 (49.9)
1-3 children	771 (22.9)
More than 3 children	846 (27.2)
Employment Status	
Not employed	972 (30.1)
Employed	2277 (69.9)
Household Wealth Index	
Poor	1050 (34.4)
Middle Income	360 (13.5)
Wealthy	1839 (52.1)
Kitchen is a Separate Room	
Kitchen not a separate room	1980 (61.8)
Kitchen is a separate room	1269 (38.2)

Table 2: Characteristics of the study sample by body mass index (N=3249). Abbreviations: wt.%: weighted percent. P-values are derived from Rao-Scott Chi-square test.

	Body Mass Index		P
	Normal/Underweight n(wt.%)	Overweight/Obese n(wt.%)	
Type of Cooking Fuel			
Liquid fuel	873 (79.3)	212 (20.7)	0.026
Solid fuel	1829 (83.8)	335 (16.2)	
Woman's Age			
15-24	1427 (93.8)	89 (6.2)	<0.001
25-34	701 (80.5)	157 (19.5)	
35-49	574 (65.7)	301 (34.3)	
Woman's Education			
None	315 (77.3)	81 (22.7)	<0.001
Primary	1047 (79.4)	255 (20.6)	
Secondary or above	1340 (86.4)	211 (13.6)	
Marital Status			
Never married	1219 (92.4)	99 (7.6)	<0.001
Married or living together	1413 (76.0)	426 (24.0)	
Widowed/separated/divorced	70 (69.3)	22 (30.7)	
Parity			
No children	1492 (91.0)	140 (9.0)	<0.001
1-3 children	634 (81.8)	137 (18.2)	
More than 3 children	576 (67.0)	270 (33.0)	

Household Wealth Index			
Poor	943 (88.1)	107 (11.9)	<0.001
Middle Income	289 (77.7)	71 (22.3)	
Wealthy	1470 (79.7)	369 (20.3)	

Multivariable logistic regression analysis was used to test the association between type of cooking fuel and BMI. After adjusting for potential confounding variables, the association between type of cooking fuel and BMI was not statistically significant (p=0.103). However, the multivariable logistic regression analysis showed a significant association between BMI with age (<0.001) where a higher proportion of women who were 25-49 years of age were overweight or obese compared to women 15-24 years old, and household wealth index (<0.001), where women who had middle- or high-income levels had a higher proportion of being overweight or obese compared to women who were poor. Multivariate analysis results (Table 3) showed adjusted multivariable odds ratio (95% confidence interval) for the variables that had statistically significant associations with BMI. Compared to younger women, older women were more likely to be overweight/obese with multivariable adjusted odds ratio (95% confidence interval) for women aged 25-34 years 2.64 (1.80, 3.86) and for women aged 35-49 years 4.97 (3.20, 7.72). Compared to women who reside in poor households, the odds of being overweight/obese were higher for women residing in a middle household wealth index 2.62 (1.52, 4.52), and women residing in rich household wealth index 2.78 (1.83, 4.24).

Table 3: Association between type of cooking fuel and body mass index (N=3249). Abbreviations: wt.%: weighted percent; OR: Odds Ratio; CI: Confidence Interval.

	Unadjusted OR (95% CI)	P	Adjusted OR (95% CI)	P
Type of Cooking Fuel				
Liquid fuel	Reference		Reference	
Solid fuel	0.74 (0.57, 0.97)	0.027	0.73 (050, 1.06)	0.103
Woman's Age				
15-24	Reference		Reference	
25-34	3.63 (2.56, 5.16)	<0.001	2.64 (1.80, 3.86)	<0.001
35-49	7.85 (5.63, 10.95)	<0.001	4.97 (3.20, 7.72)	<0.001
Woman's Education				
None	Reference		Reference	
Primary	0.88 (0.62, 1.24)	0.475	0.92 (0.63, 1.35)	0.663
Secondary or above	0.54 (0.36, 0.80)	0.002	0.78 (0.47, 1.29)	0.329
Marital Status				
Never married	Reference		Reference	
Married or living together	3.82 (2.90, 5.04)	<0.001	1.89 (1.09, 3.01)	0.023
Widowed/separated/ divorced	5.37 (2.84, 10.14)	<0.001	1.65 (0.78, 3.50)	0.194
Parity				
No children	Reference		Reference	
1-3 children	2.25 (1.63, 3.10)	<0.001	1.19 (0.70, 2.04)	0.515
More than 3 children	4.96 (3.76, 6.53)	<0.001	1.54 (0.93, 2.57)	0.095
Household Wealth Index				
Poor	Reference		Reference	
Middle	2.12 (1.30, 3.45)	0.003	2.62 (1.52, 4.52)	<0.001
Rich	1.88 (1.35, 2.61)	<0.001	2.78 (1.83, 4.24)	<0.001

Discussion

This study was conducted to determine the association between the use of solid cooking fuel and BMI among women in Cambodia. In the bivariate analysis, there was a statistically significant association between type of cooking fuel used in a household and BMI. However, when controlling for potential confounding variables, the association between type of cooking fuel and BMI disappeared. Overweight and obesity is an increasing trend among women and is the fifth leading risk for death globally [12]. Women in developing countries are experiencing a disparity

in increasing BMI measurements as compared to men of similar ages [13,14]. Rates of overweight and obesity are increasing globally and have been shown in the US, in 17 of 24 countries in Africa, and in Spain, Sweden, England, France, Ireland, and Finland [15-17]. Cambodia has experienced an increase in overweight and obese status in women from 6% in 2000 to 18% in 2014 [9,18]. Studies have shown that as women increase in age, the rate of overweight and obesity increases [12,19-21]. Other demographic studies have shown a positive association between overweight and obesity in women with age, marital status, education level, and high socioeconomic status [15,21]. Solid cooking fuel, especially when used indoors, contributes to health problems such as respiratory and cardiovascular disease, negative pregnancy outcomes, and reduced life expectancy [22-24]. However, in the current study I did not find association between type of cooking fuel and BMI. This analysis contributes to the extant literature by being the first to examine the association between type of cooking fuel and BMI among women in Cambodia.

No previous study has examined the association between type of cooking fuel and BMI in Cambodia. Other variables that showed statistically significant associations with BMI include age, education level, marital status, parity, employment status, type of residence, location of kitchen, and household wealth index. Women between the ages of 25 and 49 from middle- or high-income households are more likely to be overweight or obese than women aged 15-24 from poor households. The association between overweight and obesity with older age and middle- to high-household wealth index has been well established and shown in this analysis of the 2014 CDHS [14,25,26]. Type of cooking fuel was not independently associated with BMI in Cambodian women. Using solid cooking fuel has been associated with elevated serum levels of C-Reactive Protein (CRP) [27,28]. Elevated serum levels of CRP have been associated with steep weight-gain trajectories [29]. Using solid cooking fuel could put women at risk for overweight and obesity due to the associated risk of weight gain and elevated serum CRP levels from solid cooking fuel. Additionally, no associations were observed between type of residence, parity, and marital status and BMI. Rural residence, multiparity, and being married or living with a partner have been shown to have a positive association with BMI in women [30-33]. While overweight and obesity among women in Cambodia are a public health concern, public health programs aimed at reducing obesity should not focus on the type of cooking fuel used according to the results of this study. Public health programs aimed at fighting the obesity epidemic should focus on women aged 25 to 49 years of age and women who live in households with middle or high household wealth indices. Strengths of this study are that the data collected from the CDHS is from households that are nationally representative of the Cambodian population and based on a validated questionnaire. This study was limited to the data collected from households participating in the 2014 CDHS. The rate of cooking inside the house for this study sample was 100% whereas for the entire 2014 CDHS sample, only 61% of urban households cook inside the house and only 37% of rural households cook inside the house [10]. The failure to reach a statistical significance between type of cooking fuel and BMI in this study may indicate that the study sample is not a true cross-sectional representation of the general population of adult women in Cambodia. Future studies to investigate associations between type of cooking fuel and BMI should be based on larger sample sizes and surveys only including women.

Conclusion

In conclusion, I found no association between type of cooking fuel and BMI in a representative sample of Cambodian women. Future research should be conducted to confirm or refute my results. There is a pressing need for research into solid cooking fuel and weight gain as the rate of overweight and obesity is a global health epidemic and an increasing public health problem in Cambodia.

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