Original research

Household use of crop residues and fuelwood for cooking and newborn birth size in rural Bangladesh

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ABSTRACT

Objectives We aimed to investigate the association between type of cooking biomass fuels (crop residues vs fuelwood) and newborn birth outcomes in Bangladeshi children.

Methods In this birth cohort study, pregnant women who were 18 years or older with ultrasound confirmed singleton pregnancy of ≤16 weeks of gestation were enrolled from two Bangladesh clinics between January 2008 and June 2011. Exposure to cooking biomass fuels during pregnancy was assessed by an administered questionnaire. The newborn size metrics were measured at the time of delivery. We used multiple linear regression and logistic regression to assess the associations between the type of cooking biomass fuels and birth outcomes after adjusting for covariates.

Results A total of 1137 participants were using biomass fuels, including crop residues (30.3%) and fuelwood (69.7%), respectively, for cooking. After adjusting for covariates, the use of crop residues for cooking was associated with a 0.13 SD decrease in birth length (95% CI 0.25 to −0.01), a 0.14 SD decrease in head circumference (95% CI −0.27 to −0.02), and increased risk of low birth weight (LBW, OR 1.52, 95% CI 1.07 to 2.15) compared with the use of fuelwood.

Conclusion The use of crop residues for cooking was associated with reduced birth size and increased risk for LBW in Bangladeshi children, implying that the use of crop residues during pregnancy may have a detrimental effect on fetal growth.

Key messages

What is already known about this subject?
► More than 90% of households still use biomass for cooking in rural Bangladesh; few epidemiological studies have examined the association between the type of traditional cooking biomass fuels (crop residues vs fuelwood) and birth outcomes.

What are the new findings?
► We found that the use of crop residues for cooking was associated with reduced birth size and higher risk of low birth weight in Bangladeshi children.

How might this impact on policy or clinical practice in the foreseeable future?
► Prenatal exposure to cooking biomass fuel, crop residues in particular, may be toxic to fetal growth; switching to cleaner fuels is an important approach to reduce adverse birth outcomes.

INTRODUCTION

Of the 7.7 billion world population, about 3 billion people (41% of households) still use solid fuels, defined as coal and biomass (wood, crop residues, dung or charcoal), and kerosene for cooking, mainly in rural areas in low-income countries.[1] The combustion of household solid fuels releases various health-damaging pollutants such as respirable particulate matter (PM), black carbon, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), heavy metals and many other organic pollutants.[2–5]

Household air pollution from the use of solid fuels contributed to 3.8 million premature deaths per year.[1] In 2019, nearly two-thirds (64%) of the 500 000 neonatal deaths in the first month of their life were attributable to household use of solid fuels for cooking.[6] Especially women of reproductive age, who were mainly involved in cooking activity, and their young children under 5 years are faced with the highest PM exposure from biomass fuels in homes[7 8] and the burden of deaths from biomass exposure.[9 10]

Studies have linked cooking solid fuel use with adverse birth outcomes such as low birth weight (LBW), birth size, preterm birth, stillbirth, small for gestational age (SGA), Apgar score and neonatal mortality.[11–23] Most of previous studies have focused mainly on the association between the use of solid fuels and birth outcomes by comparing pollution fuels (wood, crop residue, animal dung, charcoal or kerosene) versus cleaner fuels (liquid petroleum gas, natural gas and/or electricity).[12 14–17 19–23] However, to our knowledge, no studies have accessed the type of cooking biomass fuels (crop residues vs fuelwood, also called 'firewood') in association with newborn birth outcomes such as birth size and LBW, even though the pollution exposure from biomass was different by type of cooking biomass fuels.[24] This research gap is more substantial in Bangladesh as well as many low-income countries in rural South Asia, the highest LBW-prevalent region[25] where these biomass fuels have been predominantly used for cooking.[26 27]

Therefore, in this birth cohort study, we assessed the association between the type of cooking biomass fuels (crop residues vs fuelwood) and neonate size

metrics (birth weight, birth length and head circumference), LBW, preterm birth, SGA and large for gestational age (LGA) in a community-based sample recruited from rural Bangladesh where over 90% of cooking energy was derived from biomass fuels.[27]

METHODS

Study design and birth cohort

The Jeebon (meaning 'life' in Bengali) cohort is a community-based, prospective birth cohort study, which was established in 2008 in two rural clinics of Dhaka Community Hospital (DCH), located in Pabna Upazila and Sirajdikhan Upazila of Bangladesh. The study population has been described.[28–31] Briefly, 1613 pregnant women with an ultrasound-confirmed singleton pregnancy ≤16 weeks of gestation that resulted in a live birth were enrolled in the cohort between January 2008 and June 2011. Women were followed up throughout their pregnancies. Participants provided sociodemographic, medical and environmental data as well as birth outcome data at delivery. The demographic and environmental information, including sociodemographic factors (age, infant gender and household income), smoking history (smoking status and secondhand smoke (SHS)) and household biomass fuel exposures was collected using a structured questionnaire at scheduled clinic visits during pregnancy. Of the 1167 participants with singleton live births, missing information on household income (n=8), SHS (n=1), and the type of biomass fuels and time spent cooking (n=8) were excluded. Of the 1150 participants, women using bottled gas and animal dung for cooking biomass fuel (n=13) were excluded. Finally, a total of 1137 participants were included in the analysis.

Figure 1 Cooking over a traditional mud stove using crop residue in Bangladesh, 2008 (photo credit: Molly L Kile).

Exposure data

In the present population, pregnant women were cooking over a traditional mud stove in a rural village home in Bangladesh (figure 1). Maternal exposure to biomass fuels from cooking was assessed in the questions at enrolment at ≤16 weeks of pregnancy: type of cooking fuels (crop residues, fuelwood, bottled gas, animal dung and kerosene) by asking 'What type of fuel do you usually use for cooking?'. The pregnant women using bottled gas (n=4), kerosene (n=0) or animal dung (n=9) for cooking were not included in the analysis due to a very small number of subjects. We compared crop residues versus fuelwood.

Birth outcomes

Newborns' anthropometric indicators (birth weight, birth length and head circumference) were assessed at the time of delivery by well-trained field staff from DCH clinics.[28] Birth weight was recorded to the nearest 10 g using calibrated digital infant scales.[32] Birth length was measured to the nearest 0.1 cm on an infantometer in a supine position with baby knees fully extended and the soles of the baby's feet held firmly against the measuring board. Head circumference was measured to the closest 0.1 cm at the maximal occipitofrontal circumference using a standard measuring tape. Birth gestational age (weeks) was estimated by ultrasound measurements taken at enrolment.[31] Maternal weight gain during pregnancy (kg/week) was calculated by subtracting weight obtained before delivery from weight measured at the time of enrolment divided by the number of weeks of follow-up.[31] We calculated z-scores for the birth size measures that were standardised to the study population mean and SD for each week of gestational age.[28]

$$Zscore = \frac{Individual\ Value - Mean}{Standard\ Deviation}.$$

Therefore, we did not adjust for gestational age when modelling associations with birth outcome z-scores. The z-scores could not be estimated for birth weight and head circumference for two births (one birth was at 22 weeks of gestation and one was at 28 weeks of gestation), or for birth length for five births (one birth at 22 weeks of gestation, one at 28 weeks of gestation and three at 29 weeks of gestation with having the same birth length). Binary adverse birth outcomes included LBW (less than 2500 g), preterm birth (before 37 weeks of pregnancy), SGA (below the 10th percentile of birthweight z-scores) and LGA (above the 90th percentile of birthweight z-scores).

Covariates

Trained DCH healthcare workers who lived in the local area administered questionnaires to collect information on participants' sociodemographic, lifestyle and environmental information at their first clinical visit at enrolment at ≤16 weeks of pregnancy. Maternal weight and height were measured at scheduled clinic visits during pregnancy. Covariates were selected a priori based on previous literature and plausible associations with birth outcomes[28–30] including maternal age (years), maternal body mass index (BMI) at enrolment (kg/m²), infant sex, monthly household income (taka), SHS exposure during pregnancy (yes or no), study site (Pabna vs Sirajdikhan) and time spent cooking per day (hour/day). None of the participants smoked during pregnancy, but 42% reported SHS exposure.[28 29] We also adjusted for gestational age at birth (weeks) for analyses of unstandardised (raw) birth size measures (birth weight (g), birth length (cm) and head circumference (cm)) to provide absolute changes in birth outcomes.

Table 1	Characteristics of the study population, N=1137
Variables	**n (%) or mean±SD**
Maternal characteristics	
Age at delivery (years)	23.0±4.2
BMI at enrolment (kg/m^2)	20.4±3.2
Monthly household income (taka)	
≤3000	193 (17.0)
3001–4000	304 (26.7)
4001–5000	340 (29.9)
5001–6000	169 (14.9)
>6000	131 (11.5)
Secondhand smoke exposure during pregnancy	
Yes	478 (42.0)
No	659 (58.0)
Study site	
Pabna	560 (49.2)
Sirajdikhan	577 (50.8)
Type of cooking biomass fuel	
Crop residues	344 (30.3)
Fuelwood	793 (69.7)
Time spent cooking, per day	2.5±0.7
Neonatal characteristics	
Gestational age at birth (weeks)	38.0±1.9
Birth weight (g)	2837±408
Birth length (cm)	46.6±2.4
Head circumference (cm)*	32.7±1.2
Birth gender	
Male	571 (50.2)
Female	566 (49.8)
Low birth weight	
Yes	187 (16.5)
No	950 (83.5)
Preterm birth	
Yes	250 (22.0)
No	887 (78.0)
SGA	
Yes	213 (20.1)
No	846 (79.9)
LGA	
Yes	74 (8.0)
No	846 (92.0)

SGA excludes LGA, and LGA excludes SGA.
*N=1136 due to missing data.
LGA, large for gestational age; SGA, small for gestational age.

Statistical analysis

Descriptive statistics were examined for all variables. Demographic differences between the type of cooking biomass fuels (crop residues vs fuelwood) were tested using logistic regression. Adjusted associations between the type of cooking biomass fuels and birth size z-scores and raw birth size measures were estimated using multiple linear regression. For the analysis of the raw value of birth size measures (birth weight (g), birth length (cm), and head circumference (cm)), gestational age (weeks) was additionally included. Associations between the type of cooking biomass fuels and adverse birth outcomes, including LBW, preterm birth, SGA and LGA, were analysed using logistic regression. All models were adjusted for maternal age (years), infant gender, maternal BMI at enrolment (kg/m^2), monthly household income (taka), SHS exposure (yes vs no), time spent cooking (hour/day)

and study site (Pabna vs Siradikhan). As a sensitivity analysis, we additionally adjusted for pregnancy weight gain in the regression models to examine the robustness of our results. To assess the potential effect modification by time spent cooking and SHS, we assessed the association between the type of cooking fuel and birth size outcomes, stratified by time spent cooking (median 2.5 hours, ≤2.5 vs >2.5) and SHS (yes vs no). The p values for interaction were estimated using the interaction terms, the product of type of cooking fuel (crop residues vs fuelwood) and time spent cooking (≤2.5 vs >2.5) or SHS (yes vs no) in the multiple regression model along with the main effects. Statistical analyses were performed using SAS V.9.4. The p value for significance was <0.05.

RESULTS

Demographic and clinical characteristics stratified by type of cooking biomass fuel are given in table 1. The overall study population included 1137 participants (mean age at delivery 23.0 (SD 4.2) years, mean BMI at enrolment 20.4 (SD 3.2), 571 (SD 50.2%) male baby). Average infant sizes at birth were 2837 g (SD 408) for birth weight, 46.6 cm (SD 2.4) for birth length and 32.7 cm (SD 1.2) for head circumference. Overall, 187 (16.5%) newborns had LBW and 250 (22%), 213 (20%) and 74 (8%) had preterm birth, SGA and LGA. Overall, 344 (30.3%) and 793 (69.7%) women used crop residues and fuelwood for cooking during pregnancy.

Table 2 shows covariates and outcomes, stratified by crop residues and fuelwood. Statistically significant differences between users of crop residues and fuelwood were found in maternal age, BMI, household income, SHS, and study site.

The adjusted associations of type of cooking biomass fuels (crop residues vs fuelwood) with birth size outcomes are shown in table 3. When adjusted for covariates, the use of crop residues was associated with a 0.11 SD decrease in birth weight (95% CI −0.24 to 0.02), 0.13 SD decrease in birth length (95% CI −0.25 to –0.01) and a 0.14 SD decrease in head circumference (95% CI −0.27 to –0.02) compared with women using fuelwood. Similar associations were observed with the raw value of birth size outcomes.

Table 4 presents the associations between cooking biomass fuels and adverse birth outcomes. The use of crop residues was associated with increased risk for LBW (OR: 1.52, 95% CI: 1.07, 2.15) compared with fuelwood users. No associations for preterm birth (OR: 0.81, 95% CI: 0.58, 1.13), SGA (OR: 1.13, 95% CI: 0.80, 1.59) and LGA (OR: 1.01, 95% CI: 0.58, 1.75) were observed in crop residue users compared with fuelwood users.

As a sensitivity analysis, we analysed the data with additional adjustment for pregnancy weight gain as a potential confounder in the regression models and found similar associations (online supplemental table 1). We also assessed the potential effect modification by time spent cooking and the SHS and found there were no significant effect modifications (online supplemental table 2, p value for interactions >0.05).

DISCUSSION

In this birth cohort study, we found the association between the use of crop residues for cooking and decreases in birth length and head circumference and increased risk of LBW. These associations remain robust when we adjusted additionally for maternal weight gain during pregnancy.

To our knowledge, no studies have examined the association between type of cooking biomass fuels (crop residues vs fuelwood)

Table 2 Characteristics of the study population by type of cooking biomass fuels, N=1137

Variables	Crop residues (n=344) n (%) or mean±SD	Fuelwood (n=793) n (%) or mean±SD	P value*
Age at delivery (years)	23.4±4.5	22.8±4.1	0.03
Birth gender			
Male	177 (51.4)	394 (49.7)	0.58
Female	167 (48.6)	399 (50.3)	
BMI at enrolment (kg/m^2)	19.8±2.9	20.8±3.3	<0.001
Monthly household income (taka)			
≤3000	85 (24.7)	108 (13.6)	<0.01
3001–4000	95 (27.6)	209 (26.4)	0.40
4001–5000	94 (27.3)	246 (31.0)	0.54
5001–6000	45 (13.1)	124 (15.6)	0.42
>6000	25 (7.3)	106 (13.4)	Reference
Secondhand smoke exposure			
Yes	166 (48.3)	312 (39.3)	0.01
No	178 (51.7)	481 (60.7)	Reference
Study site			
Pabna	218 (63.4)	342 (39.3)	<0.001
Sirajdikhan	126 (36.6)	451 (60.7)	Reference
Time spent cooking (hour/day)	2.5±0.8	2.4±0.7	0.68
Low birth weight	83 (24.1)	104 (13.1)	<0.01
Preterm birth	82 (23.8)	168 (21.2)	0.32
SGA	72 (23.0)	140 (18.9)	0.13
LGA	25 (9.3)	49 (7.5)	0.38

SGA excludes LGA, and LGA excludes SGA.
*P value for comparing the difference between users of crop residues versus fuelwood, given by logistic regression analysis.
LGA, large for gestational age; SGA, small for gestational age.

and newborn size and adverse birth outcomes. Although direct comparison is limited, most of the previous studies have reported associations of solid fuel use with LBW and/or reduced birth weight in Bangladesh,[15 17] Pakistan,[22] Zimbabwe[23] and India[20 21] when they compared with non-biomass fuels. In Bangladesh, an increased risk of LBW was found in coal or wood fuel users compared with electric/gas users.[17] Similarly, indoor use of cooking solid fuel versus no use of indoor solid fuel was associated with increased risk for LBW (OR 1.33, 95% CI 1.14 to 1.56), but no association was found with the fuel type (solid fuel vs clean fuel).[15] In pregnant women from a semirural area of Pakistan, cooking with wood fuel during pregnancy was associated with LBW compared with using natural gas.[22] In a study from rural Zimbabwe, cooking with biomass fuels (wood, dung and straw) was associated with a 175 g (95% CI −300 to −50) decrease in mean birth weight compared with using low-pollution fuels (liquefied petroleum gas (LPG), natural gas or electricity).[23] In a cross-sectional data from India's National Family Health Survey-3, the use of coal or biomass was associated with an increased risk of LBW and decrease in mean birth weight compared with using low-pollution fuel (LPG, natural gas and biogas).[20] In the Demographic Health Survey in Malawi, a decrease in mean birth weight (92 g) was observed with the use of high-pollution fuels (charcoal, wood, crops, straw and dung), but it was not statistically significant.[16] By contrast, findings were inconsistent in pregnant women in Ghana[14] and central and east India.[19] The use of high-pollution fuels (wood, charcoal, crop residues and kerosene) was associated with Apgar score below 7 at 5 min, but no associations were found with LBW, preterm birth and SGA, probably due to the small number of cases.[14] The use of wood for cooking was associated with an increased risk of preterm birth (OR 2.3, 95% CI 1.2 to 4.2), but no associations were found with LBW, stillbirth and SGA.[19] The aforementioned studies compared cooking fuels according to high-pollution fuels (wood, crop residue, animal dung, charcoal or kerosene) versus low-pollution fuels (LPG, natural gas or electricity), suggesting potential effect of biomass on adverse birth outcomes. Specifically, the present study compared the effect by type of cooking biomass fuels (crop residues vs fuelwood) and found that pregnant women using crop residues for cooking over a traditional mud stove during pregnancy had lighter (by 41 g) and lower length (by 0.26 cm) and smaller head circumference (by 0.17 cm) of newborn babies and a higher risk of LBW (52%) than women using fuelwood.

Although the greater effect of crop residues than fuelwood is not fully explainable, cooking activity, fuel mass, time, and composition of toxic chemicals from biomass burning may contribute to adverse birth outcomes. Crop residues are generally available at no or low cost, and the burning of crop residues is shorter than wood fuels, resulting in frequent refuelling in the cooking process. The burning of crop residues contributed to excessive pollution of $PM_{2.5}$[2 33] and PAHs[3] that has been linked with birth outcomes.[34 35] In addition, crop residues typically have a higher content of ash and volatile matter, higher PM formation potential, black carbon, photochemical oxidant formation,

Table 3 Adjusted effect estimates (β and 95% CIs) for birth size outcomes in association with type of cooking biomass fuels

	Birth size z-score*			Untransformed birth size measures†		
	Birth weight (N=1135) β (95% CI)	Birth length (N=1132) β (95% CI)	Head circumference (N=1134) β (95% CI)	Birth weight (g) (N=1137) β (95% CI)	Birth length (cm) (N=1137) β (95% CI)	Head circumference (cm) (N=1136) β (95% CI)
Crop residues	−0.11 (−0.24 to 0.02) p=0.09	−0.13 (−0.25 to 0.01) p=0.03	−0.14 (−0.27 to 0.02) p=0.03	−41.49 (−89.45 to 6.48) p=0.09	−0.26 (−0.57 to 0.04) p=0.09	−0.17 (−0.32 to 0.01) p=0.03
Fuelwood	Reference	Reference	Reference	Reference	Reference	Reference

The n's differ in z-score outcomes: missing in birthweight z-score (n=2) and head circumference z-score (n=2) due to 22 weeks of gestation (n=1) and 28 weeks of gestation (n=1), respectively, and missing in birth length z-score (n=5) due to 22 weeks of gestation (n=1), 28 weeks of gestation (n=1) and 29 weeks of gestation (n=3) with having the same value of birth length.
*Models adjusted for maternal age, maternal enrolment BMI, infant gender, income, SHS exposure, study site and time spent cooking per day.
†Models adjusted for maternal age, maternal enrolment BMI, infant gender, income, SHS exposure, study site, time spent cooking per day and gestational age.
BMI, body mass index; SHS, secondhand smoke.

Table 4 Adjusted ORs and 95% CIs for adverse birth outcomes in association with type of cooking biomass fuels

	LBW* (187 vs 950)	Preterm birth* (250 vs 887)	SGA* (213 vs 846)	LGA* (74 vs 846)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Cooking biomass fuel†				
Crop residues	1.52 (1.07 to 2.15)	0.81 (0.58 to 1.13)	1.13 (0.80 to 1.59)	1.01 (0.58 to 1.75)
Fuelwood	Reference	Reference	Reference	Reference

SGA excludes LGA, and LGA excludes SGA.

*Cases versus non-cases.

†Models adjusted for maternal age, maternal enrolment body mass index, infant gender, income, secondhand smoke exposure, time spent cooking and study site.

LGA, large for gestational age; SGA, small for gestational age.

lower stove efficiency and lower energy values compared with fuelwood.[24 36]

We observed no significant associations with preterm birth, SGA and LGA, similar to previous studies.[14 19] It is likely that possibility of residual confounding could not be ruled out or the impact of crop residue may vary, depending on emission profile of cooking biomass fuels, cooking behaviours and birth outcomes. These findings need to be confirmed in larger observational studies.

In Bangladesh, almost all rural households use biomass fuels such as crop residues (jute, rice straw, etc) and fuelwood as their main source of cooking fuel as there is no commercial supply of gas in the rural areas.[27 37] Although further research for risk assessment, experiment interventions and policy development are needed, given that more than 90% of households are still using biomass for cooking in rural Bangladesh, switching to cleaner fuels in the sustainable energy policy may be the promising approach to prevent the excess burden of adverse birth outcomes in Bangladesh.

We acknowledge several limitations. First, household biomass fuel exposure assessment was based on a questionnaire, like many prior observational studies, potentially introducing exposure misclassification. Non-differential misclassification might dilute the true association. Second, we did not have information on the possible use of secondary fuels, cooking behaviours (eg, type of stoves uses), place of cooking, availability of separate kitchen, ventilation and anaemia status of mothers which were not accounted in the models. The potential for uncontrolled confounding cannot be ruled out in the present study. Third, the use of fuelwood as a comparison may have led to the underestimation of the effect of using biomass for cooking, as fuelwood is also biomass. However, this would bias towards null so that the actual effect size may be larger. Lastly, we recruited participants from two health clinics. These clinics are representative of this region but may not represent the general rural population in Bangladesh. Further studies with larger sample sizes are warranted to confirm our findings.

CONCLUSIONS

In conclusion, the use of crop residues versus fuelwood for cooking was associated with reduced newborn birth size and increased risk of LBW in rural Bangladeshi children.

Our findings suggest that prenatal exposure to traditional cooking biomass fuel, crop residues in particular, may be more toxic to fetal growth than fuelwood in terms of birth size outcomes.

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Supplementary Table 1. Adjusted effect estimates (β and 95% CIs) for birth size outcomes in association with cooking biomass fuels

	Birth size z-score [a]			Untransformed birth size measures [b]		
	Birth weight (*n*=1,135)	Birth length (*n*=1,132)	Head circumference (*n*=1,134)	Birth weight, g (*n*=1,137)	Birth length, cm (*n*=1,137)	Head circumference, cm (*n*=1,136)
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Cooking fuels						
Crop residues	-0.11 (-0.23, 0.02) *p*=0.09	-0.13 (-0.25, -0.01) *p*=0.03	-0.14 (-0.27, -0.02) *p*=0.03	-40.16 (-87.75, 7.44) *p*=0.10	-0.26 (-0.56, 0.04) *p*=0.09	-0.17 (-0.32, -0.01) *p*=0.03
Fuelwood	Reference	Reference	Reference	Reference	Reference	Reference

Note: The n's differ in z-score outcomes: missing in birth weight z-score (n=2) and head circumference z-score (n=2) due to 22 weeks of gestation (n=1) and 28 weeks of gestation (n=1), respectively, and missing in birth length z-score (n=5) due to 22 weeks of gestation (n=1), 28 weeks of gestation (n=1), and 29 weeks of gestation (n=3) with having the same value of birth length.
[a] Models adjusted for maternal age, maternal enrollment BMI, infant gender, income, secondhand smoke exposure, study site, time spent cooking and maternal weight gain.
[b] Models adjusted for maternal age, maternal enrollment BMI, infant gender, income, secondhand smoke exposure, study site, time spent cooking, gestational age, and maternal weight gain.

Supplemental material

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Supplementary Table 2. Adjusted effect estimates (β and 95% CIs) for birth size outcomes in association with type of cooking fuels (crop residues vs. fuelwood), stratified by time spent cooking per day (≤ 2.5 vs. > 2.5) and secondhand smoke (yes vs. no)

	Birth size z-score			Untransformed birth size measures [c]		
	Birth weight (*n*=1,135)	Birth length (*n*=1,132)	Head circumference (*n*=1,134)	Birth weight, g (*n*=1,135)	Birth length, cm (*n*=1,132)	Head circumference, cm (*n*=1,134)
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Time spent cooking [a]						
≤ 2.5 hour	-0.09 (-0.27 to 0.09) *p*=0.32	-0.13 (-0.30 to 0.05) *p*=0.17	-0.22 (-0.41 to -0.04) *p*=0.02	-18.09 (-85.55 to 49.37) *p*=0.60	-0.22 (-0.68 to 0.23) *p*=0.33	-0.23 (-0.45 to -0.004) *p*=0.05
> 2.5 hour	-0.11 (-0.29 to 0.08) *p*=0.25	-0.12 (-0.28 to 0.05) *p*=0.16	-0.04 (-0.21 to 0.14) *p*=0.67	-52.34 (-121.52 to 16.84) *p*=0.14	-0.22 (-0.62 to 0.18) *p*=0.28	-0.06 (-0.28 to 0.16) *p*=0.58
P for interaction	0.59	0.90	0.07	0.38	0.94	0.15
Secondhand smoke [b]						
Yes	-0.09 (-0.28 to 0.11) *p*=0.37	-0.11 (-0.28 to -0.06) *p*=0.20	-0.08 (-0.28 to -.12) *p*=0.42	-36.41 (-110.69 to 37.86) *p*=0.34	-0.23 (-0.66 to 0.21) *p*=0.31	-0.07 (-0.32 to 0.17) *p*=0.55
No	-0.14 (-0.32 to 0.03) *p*=0.09	-0.17 (-0.34 to 0.001) *p*=0.05	-0.19 (-0.36 to -0.02) *p*=0.03	-56.00 (-120.32 to 8.31) *p*=0.09	-0.36 (-0.78 to 0.06) *p*=0.10	-0.23 (-0.44 to -0.03) *p*=0.02
P for interaction	0.93	0.69	0.61	0.98	0.78	0.56

Note: The n's differ in z-score outcomes: missing in birth weight z-score (n=2) and head circumference z-score (n=2) due to 22 weeks of gestation (n=1) and 28 weeks of gestation (n=1), respectively, and missing in birth length z-score (n=5) due to 22 weeks of gestation (n=1), 28 weeks of gestation (n=1), and 29 weeks of gestation (n=3) with having the same value of birth length.

[a] Models adjusted for maternal age, maternal enrollment BMI, infant gender, income, secondhand smoke, and study site.
[b] Models adjusted for maternal age, maternal enrollment BMI, infant gender, income, time spent cooking, and study site.
[c] Models additionally adjusted for gestational age.