Modeling Variability in Kitchen Time-Activity of Adult Guatemalan Women Cooking with Biomass

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Abstract

Background/Aims: The dissemination of high efficiency cooking and heating systems is among the most cost-effective interventions to educe the burden of disease caused by the exposure to indoor air pollution (IAP). Measuring the population dynamics of time-location and personal activity behavior that affect IAP exposure is critical to quantify the effectiveness of such interventions. We obtained estimates by stove type (improved/open fire) of the time that Guatemalan adult women in the CRECER study spent in the kitchen. Methods: We used a novel sensor technology developed at UC Berkeley: the Time-Activity Monitoring System (TAMS) to collect minute-by-minute accounts of the kitchen time budgets. The devices were worn by the women for 48-hr periods quarterly over two years. 24-hr samples of 55 women were analyzed to obtained marginal estimates using a linear GEE model with time changing covariates. The variance components were estimated using a random effects model, and the inferences from both approaches were compared. Results and Conclusions: There were not significant differences in the kitchen time budgets of the open fire and improved stove groups. The partitioning of variances (ρ=0.14) and the inference obtained with both models indicate that the correlation between repeated measures of time-activity collected quarterly in this population is not high.

Introduction

• Traditional methods for the assessment of personal time-activity in microenvironments (questionnaires, recall diaries, surveys) are often obtrusive, subject to bias and inaccuracies.

• Assessing the exposure to pollutants from indoor cooking with biomass requires precise estimates of the time spent in the kitchen (see figure to the right).

• Whether or not household members change their kitchen time budgets when they receive a stove and what are the contributions of the between- and within-person variances to the total variability in population time budgets are two important issues to understand the household dynamics of IAP exposure.

• Assessing the correlation among observations on the same subject is critical to ensure the accuracy of the estimates of the variability of the effects of stove type and other covariates to the time spent in the kitchen.

Objectives

• Obtain marginal estimates by stove type (improved/open fire) of time spent in the kitchen of 67 adult mothers enrolled in the CRECER Guatemala stove trial.
• Estimate the variance components of their individual time budgets to compare the between- and within-person variance contributions in the two stove groups and to identify the main sources of variability.

Study Design

Study Population

• 55 adult women, enrolled in the CRECER Guatemala study. 32 cooking with an open fire (78% had electricity in the kitchen) and 23 with a chimney stove (61% had electricity in the kitchen)

Measurements

• 24-hr samples of minute by minute time spent in the kitchen, collected quarterly over two years using the Time-Activity Monitoring System (TAMS).
• 254 total observations

Analytical Models

Covariates

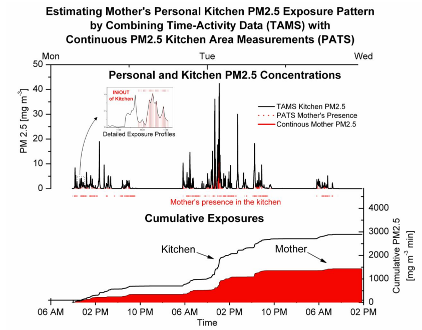
Baseline and time-changing variables in the models were chosen based on previous observational studies in the population and the results of univariate analyses.

GEE Model

Weighted OLS method with robust standard errors. Exchangeable correlation structure to account for correlation within repeated measures and to improve inference estimates.

Mixed Model

Random intercept with robust standard errors.



Results

GEE Model

$$E(Y_{i,j} \mid X_{i,j}) = \beta_0 + \beta_{stove}(x_i) + \beta_e(x_i) + \beta_p(x_{ij}) + \beta_{exp}(x_{ij})$$

β_{stove}- Chimney stove present
B_e - Electricity in kitchen
β_p - Number of person-meals cooked for during the day
β_{exp} - Interaction of electricity and person meals

Variable	Coeff.	SE	*z*	P >|*z*|	95% CI
stove	-0.21	1.40	-0.15	0.881	(-2.97, 2.55)
Electricity	1.38	2.57	0.54	0.591	(-3.65, 6.41)
Person-meals	0.58	0.12	4.76	0.000	(0.34, 0.82)
Electricity x Person meals	-0.35	0.14	-2.53	0.011	(-0.63, -0.08)
_cons	9.94	2.01	4.95	0.000	(6.00, 13,89)

Mixed Model

$$E(Y_{i,j} \mid X_{i,j}, \alpha_{i,j}) = \beta_0 + \beta_{0,i} + \beta_{stove}(x_i) + \beta_e(x_i) + \beta_p(x_{ij}) + \beta_{exp}(x_{ij}) + e_{i,j}$$

$\beta_{0,i}$ - Mother specific random intercept
$e_{i,j}$ – Residual random error

Variable	Coeff.	SE	P >|*z*|	95% CI
stove	-0.19	1.68	0.912	(-3.49, 3.12)
Electricity	0.86	4.05	0.830	(-7.07, 8.81)
Person-meals	0.54	0.19	0.005	(0.16, 0.92)
Electricity x Person meals	-0.32	0.21	0.033	(-0.73, -0.10)
_cons	10.48	3.43	0.002	(3.74, 17.22)

σ_u = 3.95
σ_e = 9.86
ρ = 0.14

Typical home: cook for 20 person-meals through day

Electricity	Average Time in the Kitchen	extra person-meal
NO	5.15 hrs	9.0 mins (4.9, 11.8)
YES	3.82 hrs	3.2 mins (1.1, 5.3)

• The presence of a chimney stove in the kitchen was not an important predictor of time spent in the kitchen for adult women in this population.

• The strongest predictors of kitchen time are the number of people fed daily and interaction with electricity in the kitchen.

• Robust standard errors are slightly smaller than naïve for both the weighted and unweighted models. This may be due to the low correlation between repeated measures (exchangeable correlation matrix R=0.078), which causes the naïve estimates to overestimate variability.

• Estimates from the GEE and mixed effects models are similar. The robust standard errors from the mixed model are more similar to the naïve GEE estimates, reinforcing that the independent correlation structure is adequate.

• The partitioning of variances in mixed models for each stove type are similar. When pooling the data, the intraclass correlation ρ=14%, indicating that most of the variability is found within subjects.

Conclusions

• The lack of a significant differences in total kitchen time-budgets across stove types suggests that if there are differences in personal IAP exposure associated with changes in kitchen time-activity, these differences arise from the re-distribution of the exposure times through the day, not from modifications in the total time-budget.

• A similar conclusion can be drawn with respect to the partitioning of variances by stove type .

• Our models indicate that the number of person meals cooked per day and the interaction of that variable with electricity are good predictors of time spent in the kitchen for exposure models, when direct measurements are not available .

• The correlation between repeated measures of time-activity collected quarterly in this population is not high.

References

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We thank NIEHS/NIS for financial support through grant #5R01ES10178, the Guatemalan Ministry of Health, the study participants and their families. Visit the Chronic Respiratory Effects of Early Childhood Exposure to Respirable Particulate Matter Study (CRECER) website:
http://ehs.sph.berkeley.edu/guat