

# Mexico



Total population*	<b>122,332,000</b>
Urban (%)	<b>79</b>
Rural (%)	<b>21</b>
% Population that uses biomass*	<b>15</b>
% rural**	<b>44.6</b>
% urban**	<b>&lt;5</b>
% Population with access to LPG and electricity**	<b>86</b>
Number of households that use biomass***	5,696,902
Number of annual deaths from HAP 2012*	<b>14,292</b>
Number of annual child deaths from HAP 2012*	<b>745</b>
Price of LPG (25 lb tank)	<b>12USD****</b>
Price of electricity (Kw/h)	<b>0.06USD****</b>
Price of Firewood	<b>nd</b>

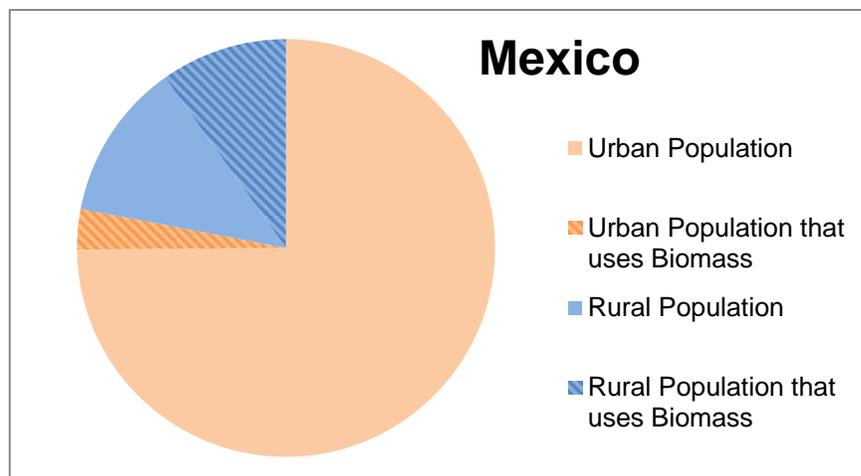
HAP: Household Air Pollution

\*WHO Global health observatory data base.

\*\*GACC (Global Alliance for Clean Cookstoves) web page

\*\*\* INEGI 2010

\*\*\*\* September 2010



## History of Cookstoves distribution

Number of efficient cookstoves distributed so far	<b>561,926</b>	
Type of technology distributed so far	<b>25 models including Onil, Mexalit, Ecocina, Patsari, Lorena</b>	
Cost of the technology	<b>100 to 200 USD</b>	
Technology performance assessment	Type of cookstove	<b>Patsari</b>
	PM concentration in kitchen	<b>40 µg/m<sup>3</sup></b>
	CO concentration in kitchen	<b>0.3 ppm</b>
Where was it evaluated?	<b>El Zamorano Laboratory</b>	
Technology performance assessment	Type of cookstove	<b>Onil</b>
	PM concentration in kitchen	<b>53µg/m<sup>3</sup></b>
	CO concentration in kitchen	<b>0.4 ppm</b>
Where was it evaluated?	<b>El Zamorano Laboratory</b>	

## National Program

Is there a national program?	Since when?
<b>Yes, between 2007 -2012</b>	<b>2007</b>
Responsible ministry	Social Development Ministry (SEDESOL)
Other ministries involved	<b>SEMARNAT, SE, INE, municipalities</b>
Non-governmental stakeholders	<b>GIRA A.C. Fundación Carso, Fundación ProMazahua,</b>
Universities involved	<b>UNAM: Bioenergy Lab, Eco-technology Unit</b>
How is the cookstove distribution prioritized?	<b>The 500 poorest municipalities in the country</b>
Which regions will be prioritized?	<b>Across the entire country</b>

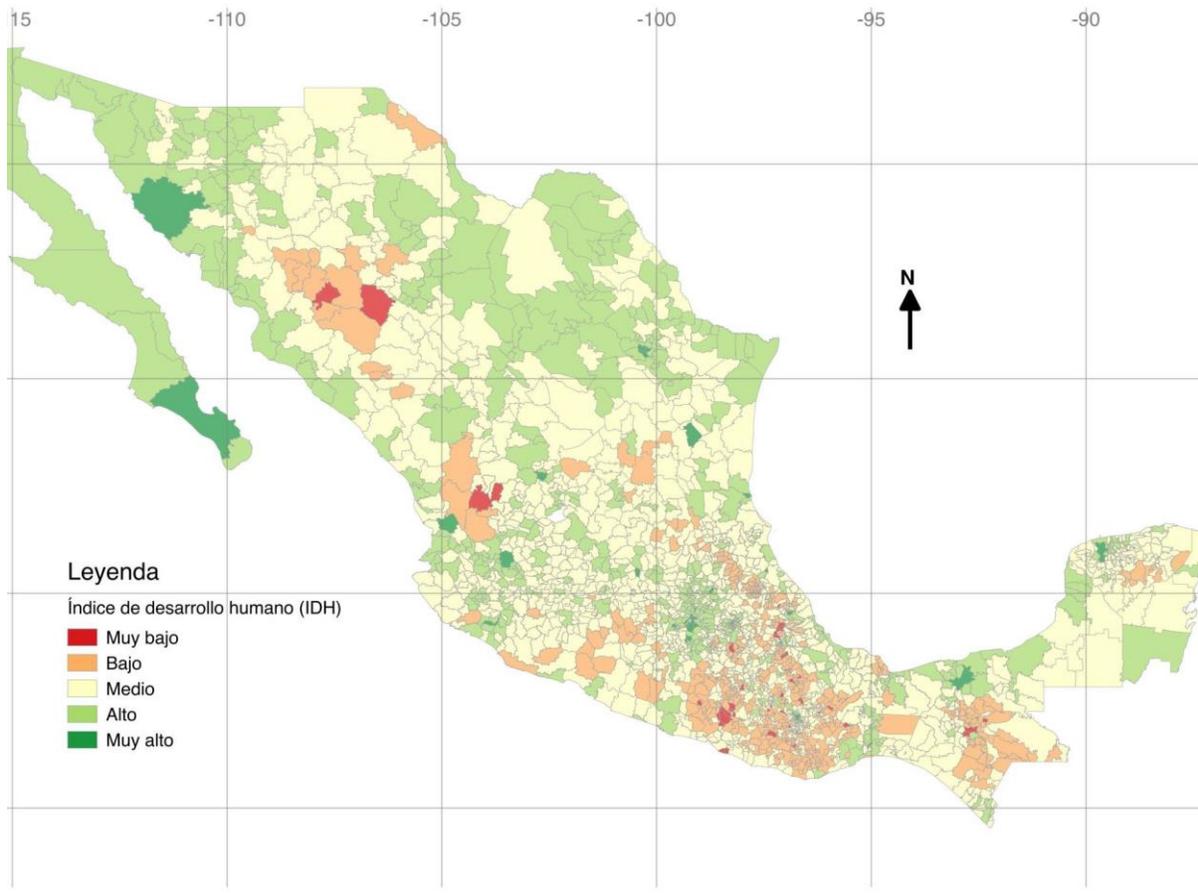
### Stoves distributed by CONAFOR 2008-2010:

State	# Homes using solid fuels (2010) INEGI	# Stoves distributed by CONAFOR (2008-2010)	% coverage	Human Devel. Index (WHO)	% Indigenous population (INEGI)
CAMPECHE	61,328 (30%)	27	0.04	0.75	8-15
CHIAPAS	698,406 (58%)	14,178	2	0.66	15 - 19
CHIHUAHUA	84,659 (10%)	4,589	5	0.73	< 4
DURANGO	67,893 (17%)	3,821	6	0.73	< 4
GUANAGUATO	161,278 (12%)	293	0.2	0.71	< 4
GUERRERO	433,432 (51%)	3,197	0.7	0.67	4 - 8
HIDALGO	224,457 (34%)	4,381	2	0.72	15 - 19
JALISCO	108,766 (6%)	6,873	6	0.75	< 4
MÉXICO	340,852 (9%)	5,730	1.7	0.74	4
MICHOACAN	294,595 (27%)	8,053	2.7	0.70	4
MORELOS	59,787 (13%)	392	0.7	0.75	< 4
NAYARIT	49,873 (18%)	931	1.9	0.73	< 4
NUEVO LEÓN	30,226 (3%)	1,207	4	0.79	< 4
OAXACA	582,984 (61%)	8,792	1.5	0.67	> 19
PUEBLA	477,728 (33%)	3,665	0.8	0.72	4 - 8
QUERETARO	62,106 (13%)	3,339	5.4	0.76	< 4
QUINTANA ROO	58,354 (18%)	1,470	2.5	0.75	15 - 19
SAN LUIS POTOSÍ	198,639 (30.7%)	1722	0.9	0.73	4 - 8
SINALOA	98,811 (15%)	1,903	1.9	0.76	< 4
TABASCO	255,730 (46%)	549	0.2	0.74	< 4
TAMAULIPAS	57,208 (7%)	1,605	2.8	0.76	< 4
VERACRUZ	858,395 (44%)	2,355	0.3	0.71	4 - 8
YUCATÁN	240,679 (49%)	4,907	2	0.74	> 19
ZACATECAS	49,351 (13%)	537	1	0.72	< 4
TOTAL		84,516	1.5		

**States of the Mexican republic where CONAFOR (National Forestry Commission) has implemented its program (15 % of all stoves distributed by the federal program) between 2008 and 2010**

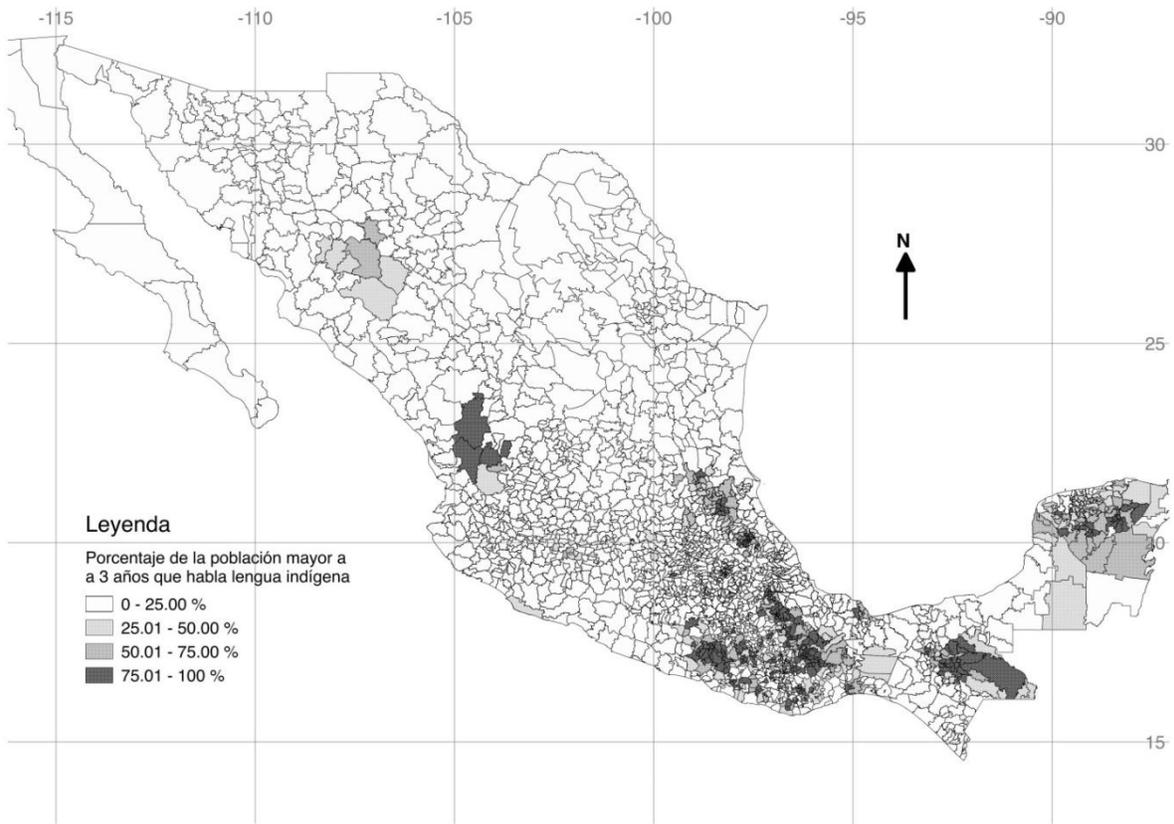
- The number of households using firewood for cooking throughout the country is 5,696,902 (INEGI 2010)
- 31% of users are mixed users (firewood and LPG) and 69% are unique users (Ghilardi et al, 2009)
- Between January 2007 and December 2011, the Ministry of Social Development has granted 384,783 ecological saving wood stoves in houses located in the target territories (SEDESOL, 6th work report).
- In 2012 SEDESOL handed 92,627 stoves. (SEDESOL, 6th work report)
- It is estimated a total of 561,926 stoves distributed by the government between 2007 and 2012
- Priority was given to the 500 poorest municipalities in the country

**Distribution of population by: Human Development Index, Indigenous population, solid fuels users, and health risks.<sup>1</sup>**



**Human Development Index**

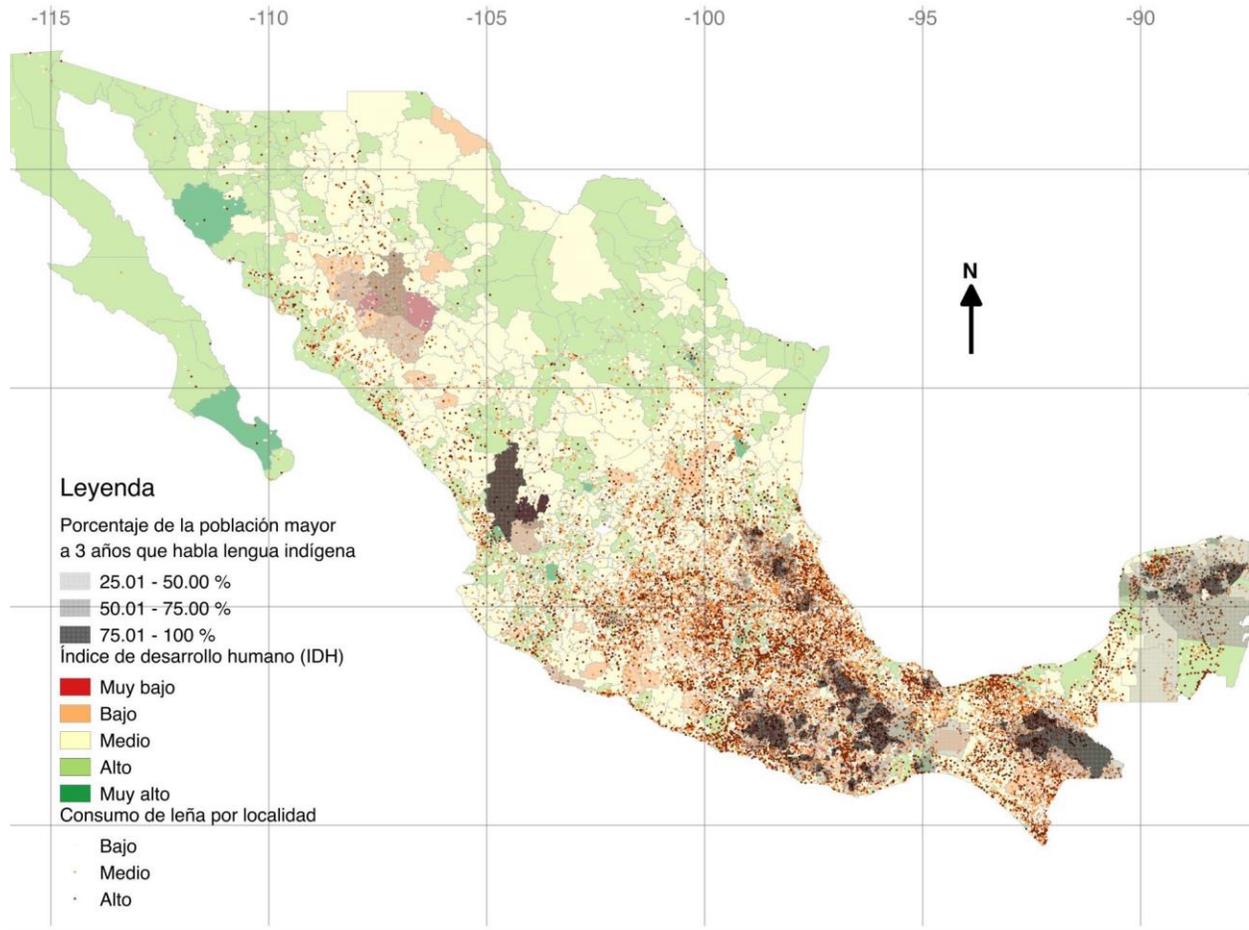
<sup>1</sup> IDH and indigenous population maps are from CONABIO-CONANP-TNC-PRONATURA. (2009, July 23). CONABIO. Retrieved April 14, 2014 from Geoportal del Sistema Nacional de Información sobre Biodiversidad: <http://www.conabio.gob.mx/informacion/gis/> The distribution of firewood users is from Ghilardi et al, 2008; with INEGI 2000 data. The health risk population map is from the Ministry of Health of Mexico [http://www.salud.gob.mx/unidades/evaluacion/publicaciones/pesc\\_2003-2006/pesc\\_2003-2006.pdf](http://www.salud.gob.mx/unidades/evaluacion/publicaciones/pesc_2003-2006/pesc_2003-2006.pdf)



**Indigenous population**

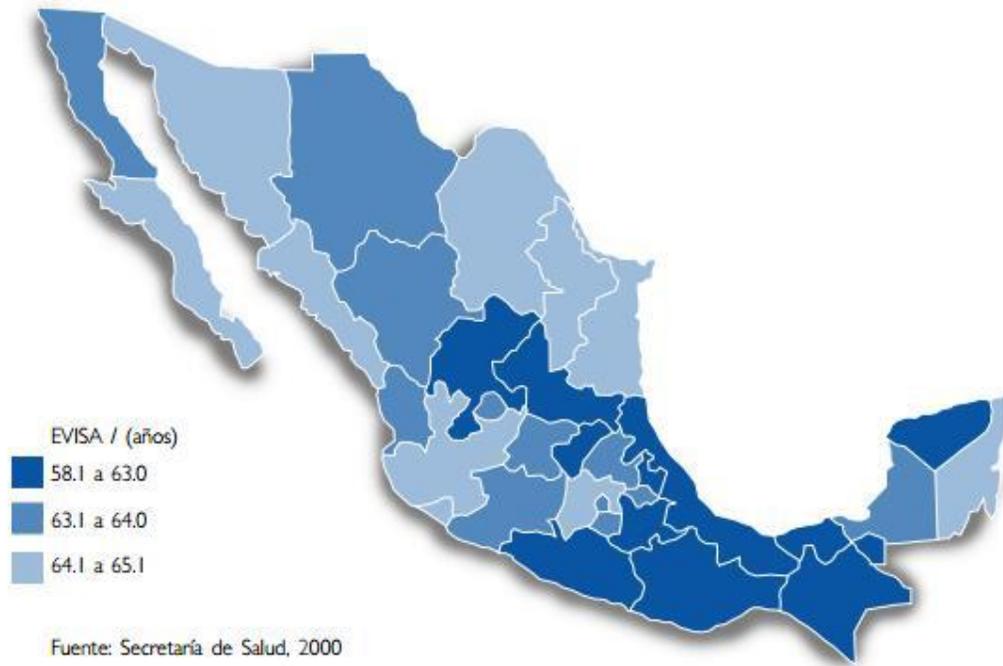


## Solid fuel Users



**Correlation between Human Development Index, Indigenous population and firewood use in Mexico**

**Figura 3.** Distribución regional del rezago en salud en México, 2000



**Health risks (Population left behind of health services)**

**Some cookstoves distributed in México:**



**Patsari model 1**



**Onil**



**Patsari bricks model**

## Papers on indoor air pollution:

1. Pine K, Edwards R, Masera O, Schilman A, Marrón-Mares A, Riojas-Rodríguez H (2011) *Adoption and use of improved biomass stoves in Rural Mexico*. Energy for Sustainable Development 15(2): 176–183

<http://www.sciencedirect.com/science/article/pii/S0973082611000238#>

### Abstract

In households that rely on biomass for a large percentage of their energy needs, adoption of improved biomass stoves can result in significant reduction of indoor air pollutants and emissions of greenhouse gasses with concurrent health co-benefits. To maximize the effectiveness of the stove dissemination process, promoters should choose target populations that are both likely to adopt the new technology and to influence the opinions of other potential adopters within a social group. In the current study a longitudinal analysis of adoption patterns and intensity of use of a Patsari improved biomass cookstove was conducted in 259 randomly selected households of a community intervention study in rural communities of Michoacan, Mexico. Health promoters classified households into one of several stove user groups during a series of monthly follow up interviews after Patsari installation, based on physical traces of use and household self-reporting by questionnaire. Multinomial logistic regression was used to develop a model of household and community characteristics associated with early adoption of the Patsari, leading to the development of a bi-level model for targeting improved stove dissemination efforts. Factors including community of residence, number of adults in household, suffering from irritated eyes, using wood scraps for fuel, and cooking with certain types of traditional fogons were associated with early adoption of Patsari cookstoves. Maximum saturation of the Patsari in the study population was reached four months after installation; after this point, stove use decreased until eight months but remained relatively steady with 55% of the sample using the Patsari regularly from month eight onwards. Results highlight the importance of utilizing effective targeting strategies to maximize NGO resources and increase the robustness of the diffusion process, resulting in more stoves in actual use. Additionally, results point to the importance of evaluating the success of an improved stove program in terms of stove use over time, rather than the total number of stoves disseminated.

2. Christoff J (2010) *Benefits and barriers: exploring complete and sustained ecological stove usage in rural Mexico*. MPhil thesis, Yale University, New Haven, Connecticut.

<http://gradworks.umi.com/14/80/1480293.html>

### Abstract:

Informal caregivers provide a substantial portion of long-term health care to the elderly in the United States, and the need and demand for informal caregiving is projected to increase as the population ages. The well-established phenomenon of “caregiver burden” suggests that caregivers are more likely to experience psychiatric and physical health morbidities as compared to noncaregivers. One of the factors behind their poorer health outcomes may be that caregivers have less time to care for themselves, and are subsequently less likely to engage in preventive health behaviors. This study sought to (1) examine the association between caregiver status and engagement in a series of routine health-promoting behaviors, (2) focus on populations of caregivers who suffer from chronic conditions and their health behaviors, and (3) assess the presence of an interaction between sex and caregiver status. Data was collected from the 2000 Behavioral Risk Factor Surveillance Survey, and analyzed using the Chi-Squared test and logistic regression. Results indicated that caregivers were more likely to engage in a number of health-promoting behaviors such as receiving an annual flu vaccination, having a routine check-up,

having a cholesterol check, participating in regular physical activity for thirty or more minutes a session for five sessions a week or in some form of leisure-time physical activity as compared to non-caregivers. Among disease-specific populations, caregivers with cardiovascular disease were more likely to engage in regular physical activity or some form of leisure-time physical activity as compared to non-caregivers with cardiovascular disease; the same trends were demonstrated among individuals with arthritis. There did not appear to be a significant interaction between caregiver status and sex for the majority of outcomes assessed, except that female caregivers seemed to demonstrate significantly higher odds of engaging in physical activity as compared to male caregivers. These results suggest that caregivers may be equally, if not more likely to engage in common health-promoting behaviors. Future efforts should be taken to understand other contributors to caregiver burden beyond engagement in prevention, such as the psychosocial stress of caregiving responsibilities, or the material disadvantages experienced by this population so as to develop interventions that minimize their risk for poor health outcomes.

**3. Velasco I (2008) *More sustainable cooking technologies – a case study in rural kitchens in Michoacan, Mexico*. MSc thesis, Lund University. Available at:**

[www.lumes.lu.se/database/alumni/06.08/thesis/Ignacio\\_Velasco.pdf](http://www.lumes.lu.se/database/alumni/06.08/thesis/Ignacio_Velasco.pdf) (accessed 12 July 2011).

#### Abstract

Currently millions of people around the globe rely on wood as a source of fuel for cooking. Although this situation not only pertains to impoverished rural communities, it is within these communities and in industrializing countries like Mexico that this is occurring the most. The burning of wood in open fires is causing a number of health problems but is also deteriorating for the rural household economy as well as for the local and global environment. Women and children are the main groups exposed to the indoor smoke produced while cooking. Illnesses as a result of this exposure take millions of lives every year. Expenses on fuel for cooking represent a significant part of the rural household income. The emissions from the cooking fires and the resulting deforestation together add up to the threat of global warming.

Currently one-fourth of the Mexican population is framed within this context. This thesis looks into the adoption of more sustainable rural cooking technologies and its consequences. The overall aim of this case study is to examine the contribution to social, economic and environmental sustainability once a new cooking technology is adopted by Mexican rural families. The particular objectives concern the process of optimizing human health and the consumption of cooking fuels within the Mexican rural household. Over a six-week period, twenty-four rural households in two rural communities from two different regions in the state of Michoacan, Mexico were visited, observed and interviewed. An improved wood-burning stove and a solar cooking device were studied. Through the adoption of these cooking technologies, reductions of indoor smoke exposure, wood fuel consumption and carbon dioxide equivalent emissions are significant. In order for a new cooking technology to be adopted it must meet certain requirements within the concept of an appropriate technology. Finally, consequences from the adoption are clearly reflected in improvements within the rural kitchen, the household and therefore the entire family.

**4. Masera O, Díaz R, Berrueta V (2005) *From cookstoves to cooking systems: the integrated program on sustainable household energy use in Mexico*. Energy for Sustainable Development 9(1): 25–36.**

<http://ecotec.cieco.unam.mx/Ecotec/wp-content/uploads/From-cookstoves-to-cooking-systems.-The-integrated-program-on-sustainable-household-energy-use-in-Mexico.pdf>

#### Abstract

Interest in household energy use and improved cookstoves is growing again, prompted this time by a breadth of concerns that range from local environmental, socio-cultural and, very particularly, health issues to global aspects related to the emissions of greenhouse gases. To face these challenges, improved cookstove programs are evolving from projects narrowly targeting stove construction or sales to more integrated “systemic” approaches. This paper discusses one such approach: a multiinstitutional effort directed to improve the sustainability of household energy use in rural Mexico. The program is based in the highlands of central Mexico, and seeks to set up a model that can be scaled up and replicated in other regions. The program has five main components that are highly integrated: technology innovation and market development, a cookstove dissemination package, support to micro-enterprise development, monitoring and evaluation and outreach activities. One of the program’s salient features is the development and dissemination of a new efficient wood-burning cookstove named “Patsari”. Results of the first year and a half of project implementation and the main challenges and lessons learned by the program are presented and discussed.

5. Troncoso K, Castillo A, Masera O, Merino L (2007) *Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico*. Energy Policy 35(5): 2799–2810.

[http://www.oikos.unam.mx/Bioenergia/images/PDF/Bioenergia/EEL/social\\_perceptions\\_about\\_a\\_technological\\_innovation.pdf](http://www.oikos.unam.mx/Bioenergia/images/PDF/Bioenergia/EEL/social_perceptions_about_a_technological_innovation.pdf)

#### Abstract

The widespread use of traditional biomass fuels in open fires in developing countries brings about serious health effects, besides high fuelwood consumption. A technological innovation—i.e., improved cookstoves—reduce fuel consumption and address the health effects of indoor air pollution. Implementation projects have been conducted worldwide, but have frequently faced very low success rates. Different demographic and socio-economic factors have been analyzed to explain low rates but there are almost no studies that try to understand, from the users’ perspective, the factors involved when choosing among different cooking technologies. Through a qualitative methodological approach we documented the adoption of improved cookstoves through the implementation program of a Mexican NGO. Results showed that although the program raised public awareness, the improved cookstoves did not reach the poorest sector. The socioeconomic level was found positively correlated with the adoption of the improved cookstoves, but neither the age nor the educational levels were. Payment of the stove did not seem to be an adoption factor. Differences among individual users were more significant than differences between communities. Finally as men are the principal fuelwood harvesters, they should be considered as an important group in diffusion programs.

6. Troncoso K, Castillo A, Merino L, Lazos E, Masera OR (2011) *Understanding an improved cookstove program in rural Mexico: an analysis from the implementers' perspective*. Energy Policy 39(12): 7600–7608.

<http://www.oikos.unam.mx/Bioenergia/images/PDF/Bioenergia/EEL/understanding-an-improved-cookstove.pdf>

The adoption of innovations in rural areas depends, among many different factors, on the way development workers approach a community. Through a qualitative research methodology this study documented the adoption of a new technology, by following an improved cookstove implementation program carried out by a Mexican NGO. This technology reduces fuel consumption and addresses health impacts of indoor air pollution caused by the widespread use of traditional biomass fuels in open fires in developing countries. Different demographic and socio-economic factors have been analyzed to explain the low success rates implementation projects have faced worldwide, but there are almost no studies that

examine the problem from the perspective of implementers. The aim of this study was to understand how the different visions of the individuals involved in an implementation program affect its outcome. Findings showed that the NGO work was constrained by the need to meet the commitment with sponsors. The adoption rates did not change between the first and the second stage of the project, even though the approach towards users was very different. A lack of a shared vision among the work team towards the project was found and the existence of two main perspectives among program workers—broadly described as people-centered and technology-centered—, gave place to differences in attitudes towards the program.

7. Troncoso K., Armendáriz C., Alatorre S. (2013). *Improved Cookstove Adoption and Impact Assessment: a proposed methodology*. Energy Policy 62: 637-645.

<http://www.sciencedirect.com/science/article/pii/S0301421513007179>

#### Abstract

Until now, the success of improved cook stoves (ICS) implementation programs has usually been measured by the number of ICS distributed. Some important research has been conducted to try to determine the effects of the use of an ICS in the user's health, but these studies are expensive and time consuming. Moreover, no evaluations show the impact of the technology in the user's lives. This study seeks to contribute to fill this gap. By applying cluster analysis techniques to survey data, the most relevant variables that explain adoption and impact were identified. Using these variables, two qualitative indexes are proposed: The adoption index considers the use of the new technology, the level of satisfaction, and the conditions of the stove. The impact index considers the changes in cooking practices and life quality brought about by the ICS. Both indexes are then applied to two implementation programs. The indexes show the differences between the program results and the user's perceptions of each technology. The proposed indexes can be used to measure the success of an ICS implementation program in terms of the benefits perceived by the users of these technologies.

8. Herrera Portugal C., Franco Sánchez G., Pelayes Cruz M., Schlottfeldt Trujillo Y., Pérez Solís B.L. *Daño al ADN en mujeres expuestas al humo de la leña en Chiapas, México / DNA damage in women exposed to firewood fuel smoke in Chiapas, Mexico*. Acta toxicol. Argent; 17(2): 56-61, dic. 2009. tab. Artículo en Español | LILACS | ID: lil-564760

[http://www.scielo.org.ar/scielo.php?script=sci\\_arttext&pid=S1851-37432009000200004](http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1851-37432009000200004)

#### Abstract/Resumen

Actualmente alrededor de la cuarta parte de la población mexicana, entre 25 y 28 millones de habitantes, cocina con leña. Sin embargo, el humo de la leña contiene una amplia gama de sustancias tóxicas, entre ellas el monóxido de carbono (CO) cuyo impacto en la salud de la población rural debe ser estudiado. Por esto, el potencial daño al ADN asociado con la exposición a CO de 30 mujeres que cocinaban con leña en Chiapas, México, fue evaluado por el ensayo cometa. Los resultados se compararon con 30 controles comparables en edad y condiciones socioeconómicas, quienes cocinaban con gas licuado de petróleo (GLP). Se obtuvieron muestras de sangre total para medir carboxihemoglobina (COHb) y llevar a cabo el ensayo cometa. Se encontró diferencia significativa ( $P < 0,001$ ) en las concentraciones de COHb entre las mujeres que cocinaban con leña (media= 6,6%) y las que lo hacían con GLP (media= 1,8%), siendo 3,6 veces más elevadas en las primeras antes citadas que en las segundas. Se encontraron diferencias significativas en la longitud de cola (media  $\pm$  DE = 18,5  $\pm$  4,21 contra 5,97  $\pm$  1,0  $\mu$ m,  $P < 0,001$ ) y en el momento de cola (media  $\pm$  DE = 4,55  $\pm$  1,5 contra 1,5  $\pm$  0,40,  $P < 0,001$ ) del cometa entre los dos grupos examinados. Los resultados del presente estudio sugieren fuertemente que la

exposición a CO y componentes presentes en el humo de la leña, puede causar daño genotóxico a las mujeres que hacen uso de este combustible, por lo que es necesario implementar medidas que disminuyan esta exposición.(AU)

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Currently, about a quarter of the Mexican population, between 25 and 28 million people, cook with firewood. However, wood smoke contains a wide range of toxic substances, including carbon monoxide (CO) whose impact on health of the rural population should be studied. Therefore, the potential DNA damage associated with the exposition to CO of 30 women who cooked with wood in Chiapas, Mexico, was assessed using Comet Assay. Results were compared with 30 controls of similar age and socioeconomic status, who cooked with liquefied petroleum gas (LPG). We obtained whole blood samples to measure carboxyhemoglobin (% COHb) and perform the comet assay. There was a significant difference ( $P < 0.001$ ) in the percentages of COHb between women who cooked with wood (mean= 6.6%) and those who did it with LPG (mean=1.8%) being 3.6 times higher in the former compared with the latter. There was a significant difference in comet tail length between the two groups examined (mean 18.5 +/- 4.21 versus 5.97 +/- 1.0  $\mu\text{m}$ ,  $P < 0.001$ ) and tail moment (mean 4.55 +/- 1.5 versus 1.5 +/- 0.40,  $P < 0.001$ ). The results of this study strongly suggest that exposure to carbon monoxide and compounds present in wood smoke can cause genotoxic damage to women who use this fuel, so it is necessary to implement measures to reduce this exposure.(AU)

9. González-García M., Maldonado Gomez D., Torres-Duque C.A., Barrero M., Jaramillo Villegas C., Pérez J.R., Varon H. *Diferencias tomográficas y funcionales entre la EPOC severa relacionada con humo de leña y con cigarrillo/ Comparison between the wood smoke-related and smoking-related disease / Tomographic and functional findings in severe COPD*. J Bras Pneumol; 39(2): 147-154, marzo-abr. 2013. ilus, tab | LILACS | ID: lil-673305

[http://www.scielo.br/scielo.php?script=sci\\_arttext&pid=S1806-37132013000200005](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-37132013000200005)

Abstract/Resumen

OBJETIVO: La exposición a humo de leña es factor de riesgo para EPOC. A diferencia de la EPOC por cigarrillo (EPOC-C), para un mismo nivel de obstrucción, en la EPOC por leña (EPOC-L), la DLCO está menos disminuida, sugiriendo menos enfisema. Por tanto, el objetivo de este estudio fue comparar los hallazgos en la TCAR en mujeres con EPOC-L y con EPOC-C. MÉTODOS: Veintidós mujeres con EPOC severa ( $\text{VEF1}/\text{CVF} < 70\%$  y  $\text{VEF1} < 50\%$ ) fueron divididas en dos grupos: las expuestas a leña (EPOC-L;  $n = 12$ ) y las expuestas a cigarrillo (EPOC-C;  $n = 10$ ). Se compararon los dos grupos con respecto al puntaje de enfisema y el compromiso de la vía aérea en la TCAR, las anomalías funcionales en la espirometría, la DLCO, los volúmenes pulmonares y la resistencia específica de la vía aérea (sRaw). RESULTADOS: Los dos grupos tuvieron VEF1, sRaw e hiperinflación pulmonar similares. En el grupo EPOC-C, hubo mayor disminución de la DLCO y de la DLCO/VA y mayor puntaje de enfisema. En el grupo EPOC-L, no encontramos enfisema significativo en la TCAR. Los hallazgos principales fueron engrosamiento peribronquial, dilataciones bronquiales y atelectasias subsegmentarias. CONCLUSIONES: En pacientes con EPOC-L severa no hay enfisema en la TCAR. El hallazgo más importante es el compromiso severo de la vía aérea. La disminución de la DLCO y del VA con DLCO/VA normal es probablemente determinada por la obstrucción bronquial severa y la mezcla incompleta del gas inspirado en la maniobra de la respiración única de la prueba de difusión.(AU)

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**OBJECTIVE:** Wood smoke exposure is a risk factor for COPD. For a given degree of airway obstruction, the reduction in DLCO is smaller in individuals with wood smoke-related COPD than in those with smoking-related COPD, suggesting that there is less emphysema in the former. The objective of this study was to compare HRCT findings between women with wood smoke-related COPD and women with smoking-related COPD. **METHODS:** Twenty-two women with severe COPD (FEV1/FVC ratio < 70% and FEV1 < 50%) were divided into two groups: those with wood smoke-related COPD (n = 12) and those with smoking-related COPD (n = 10). The two groups were compared regarding emphysema scores and airway involvement (as determined by HRCT); and functional abnormalities-spirometry results, DLCO, alveolar volume (VA), the DLCO/VA ratio, lung volumes, and specific airway resistance (sRaw). **Results:** There were no significant differences between the two groups in terms of FEV1, sRaw, or lung hyperinflation. Decreases in DLCO and in the DLCO/VA ratio were greater in the smoking-related COPD group subjects, who also had higher emphysema scores, in comparison with the wood smoke-related COPD group subjects. In the wood smoke-related COPD group, HRCT scans showed no significant emphysema, the main findings being peribronchial thickening, bronchial dilation, and subsegmental atelectasis. **CONCLUSIONS:** Female patients with severe wood smoke-related COPD do not appear to develop emphysema, although they do show severe airway involvement. The reduction in DLCO and VA, with a normal DLCO/VA ratio, is probably due to severe bronchial obstruction and incomplete mixing of inspired gas during the determination of single-breath DLCO.(AU)

10. Riojas-Rodríguez H., Escamilla-Cejudo J.A., González-Hermosillo J.A., Téllez-Rojo, Maite Vallejo M.M., Santos-Burgoa C. and Rojas-Bracho L. *Personal PM 2.5 and CO exposures and heart rate variability in subjects with known ischemic heart disease in Mexico City.* J EXPO ANAL ENVIRON EPIDEMIOL, Vol. 16, Nom. 2, Pags. 131- 137, Año 2006

[http://www.researchgate.net/publication/7589108\\_Personal\\_PM2.5\\_and\\_CO\\_exposures\\_and\\_heart\\_rate\\_variability\\_in\\_subjects\\_with\\_known\\_ischemic\\_heart\\_disease\\_in\\_Mexico\\_City](http://www.researchgate.net/publication/7589108_Personal_PM2.5_and_CO_exposures_and_heart_rate_variability_in_subjects_with_known_ischemic_heart_disease_in_Mexico_City)

**Abstract** Cardiovascular diseases are the main cause of death in Mexico City and have shown a rising trend over the past 20 years. Various epidemiological studies have reported an association between respirable particles and carbon monoxide (CO), with cardiorespiratory outcomes. The purpose of this study was to assess the effect of particulate matter with aerodynamic diameters of less than 2.5  $\mu$ m (PM2.5), also known as respirable or fine particles and CO on heart rate variability (HRV) in 5-min periods in patients with known ischemic heart disease. 30 patients were selected from the outpatient clinic of the National Institute of Cardiology of Mexico and followed during 11 h, using electrocardiography (ECG) ambulatory electrocardiograms and personal monitors for CO and PM2.5. We calculated frequency-domain measurements using power spectral analysis and assessed the association with pollutants using mixed models analysis in 5-min periods. We found a decrease in HRV measured as high frequency (Ln) (coefficient=-0.008, 95% confidence interval (CI), -0.015, 0.0004) for each 10 g/m<sup>3</sup> (micrograms per cubic meter) increase of personal PM2.5 exposure. We also found a decrease of low (Ln) (coefficient=-0.024, 95% CI, -0.041, -0.007) and very low frequencies (Ln) (coefficient=-0.034, 95% CI, -0.061, -0.007) for 1 parts per million (p.p.m.) increase in CO personal exposure after adjustment for potential confounding factors. These results show that for this high-risk population, the alteration of the cardiac autonomic regulation was significantly associated with both PM2.5 and CO personal exposures.

11. Ruiz-Mercado I., Masera O.R., Zamora H., Smith K.R. (2011). *Adoption and Sustained use of improved cookstoves.* Energy Policy 39: 7557-7566.

<http://www.tractionproject.org/sites/default/files/Adoption%20and%20Sustained%20Use%20of%20improved%20cookstoves.pdf>

## Abstract

The adoption and sustained use of improved cookstoves are critical performance parameters of the cooking system that must be monitored just like the rest of the stove technical requirements to ensure the sustainability of their benefits. No stove program can achieve its goals unless people initially accept the stoves and continue using them on a long-term basis. When a new stove is brought into a household, commonly a stacking of stoves and fuels takes place with each device being used for the cooking practices where it fits best. Therefore, to better understand the adoption process and assess the impacts of introducing a new stove it is necessary to examine the relative advantages of each device in terms of each of the main cooking practices and available fuels. An emerging generation of sensor based tools is making possible continuous and objective monitoring of the stove adoption process (from acceptance to sustained use or disadoption), and has enabled its scalability. Such monitoring is also needed for transparent verification in carbon projects and for improved dissemination by strategically targeting the users with the highest adoption potential and the substitution of cooking practices with the highest indoor air pollution or greenhouse gas contributions.

12. Zuk M., Rojas L., Blanco S., Serrano P., Cruz J., Angeles F., Tzintzun G., Armendariz C., Edwards R.E., Johnson M., Riojas-Rodriguez H., Masera O. *The impact of improved wood-burning stoves on fine particulate matter concentrations in rural Mexican homes*. J EXPO ANAL ENVIRON EPIDEMIOLOG, Vol. 1, Nom. , Pags. 1- 9, Año 2006

<http://www.oikos.unam.mx/Bioenergia/images/PDF/Bioenergia/EEL/the-impact-wood-burning-stoves.pdf>

## Abstract

To evaluate the impact of improved wood burning stoves on indoor air pollution 53 homes in a rural town in Michoacan, Mexico, were selected from a health intervention study and monitored before and after receiving improved wood-burning stoves. Fine particulate matter - particles with aerodynamic diameter less than 2.5  $\mu\text{m}$  (PM<sub>2.5</sub>) - concentrations were measured in the central plaza of the community and in three microenvironments in the home (next to the stove, in the kitchen away from the stove, and outdoor patio).

13. Masera O.R., Edwards R., Armendáriz-Arnez C., Berrueta V., Jhonson M., Rojas-Bracho L., Riojas-Rodríguez H., Smith K.R. *Impact of Patsari improved cookstoves on indoor air quality in Michoacán, Mexico*. ENERGY SUSTAIN DEV, Vol. 11, Nom. 2, Pags. 45- 56, Año 2007

[http://www.m-publichealth.med.uni-muenchen.de/download/mph/mph\\_sommersemester\\_2012/global/day\\_six/masera\\_et\\_al.pdf](http://www.m-publichealth.med.uni-muenchen.de/download/mph/mph_sommersemester_2012/global/day_six/masera_et_al.pdf)

## Abstract

Little quantitative monitoring and evaluation of the impacts of improved stoves have been performed in Mexico. Grupo Interdisciplinario de Tecnología Rural Apropiada (GIRA) has recently disseminated 4,000 improved Patsari cookstoves, most of them in the Purépecha region of Michoacán state, Mexico. In paired comparisons in a subset of kitchens in a single community before and after installation of an improved Patsari cookstove, 48-hour average kitchen concentrations of carbon monoxide (CO) and fine particulate matter (PM<sub>2.5</sub>) were reduced by 66 % (n = 32) and 67 % (n = 33), respectively. Kitchens that had more elevated concentrations during the baseline measurements demonstrated more dramatic reductions, as the overall variability was reduced when the improved stove was used. Thus, the Patsari stove provides an effective means of reducing kitchen air pollution and potential benefits of installing these stoves are considerable. Although requiring significant additional resources, the Household Energy

and Health (HEH) Project catalyzed a much broader investigation into health, climate, environment and societal impacts of Patsari stoves, which has had a greater impact on public policy than the direct impact of the number of improved stoves installed in these communities.

**14.** Armendáriz-Arnez C., Edwards R., Johnson M., Zuk M., Rojas L., Díaz-Jiménez R., Riojas-Rodriguez H., Masera O. *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, Vol. 18, Nom. 2, Pags. 93- 105, Año 2008

<http://onlinelibrary.wiley.com/doi/10.1111/j.1600-0668.2007.00509.x/full>

#### Abstract

The impact of an improved wood burning stove (Patsari) in reducing personal exposures and indoor concentrations of particulate matter (PM<sub>2.5</sub>) and carbon monoxide (CO) was evaluated in 60 homes in a rural community of Michoacan, Mexico. Average PM<sub>2.5</sub> 24-h personal exposure was 0.29 mg/m<sup>3</sup> and mean 48-h kitchen concentration was 1.269 mg/m<sup>3</sup> for participating women using the traditional open fire (fogon). If these concentrations are typical of rural conditions in Mexico, a large fraction of the population is chronically exposed to levels of pollution far higher than ambient concentrations found by the Mexican government to be harmful to human health. Installation of an improved Patsari stove in these homes resulted in 74% reduction in median 48-h PM<sub>2.5</sub> concentrations in kitchens and 35% reduction in median 24-h PM<sub>2.5</sub> personal exposures. Corresponding reductions in CO were 77% and 78% for median 48-h kitchen concentrations and median 24-h personal exposures, respectively. The relationship between reductions in median kitchen concentrations and reductions in median personal exposures not only changed for different pollutants, but also differed between traditional and improved stove type, and by stove adoption category. If these reductions are typical, significant bias in the relationship between reductions in particle concentrations and reductions in health impacts may result, if reductions in kitchen concentrations are used as a proxy for personal exposure reductions when evaluating stove interventions. In addition, personal exposure reductions for CO may not reflect similar reductions for PM<sub>2.5</sub>. This implies that PM<sub>2.5</sub> personal exposure measurements should be collected or indoor measurements should be combined with better time–activity estimates, which would more accurately reflect the contributions of indoor concentrations to personal exposures.

**15.** Romieu I., Riojas-Rodríguez H., Marrón-Mares A.T., Schilman A., Perez-Padilla R., and Masera O. *Improved Biomass Stove Intervention in Rural Mexico: Impact on the Respiratory Health of Women*. AM J RESP CRIT CARE, Vol. 180, Nom. 7, Pags. 649- 656, Año 2009

<http://www.pubfacts.com/detail/19556519/Improved-biomass-stove-intervention-in-rural-Mexico:-impact-on-the-respiratory-health-of-women>

**Abstract:** Exposure to biomass smoke has been related to adverse health effects. In Mexico, one household in four still cooks with biomass fuel, but there has been no evaluation of the health impact of reducing indoor air pollution. Objectives: To evaluate the health impact of the introduction of an improved biomass stove (Patsari; Interdisciplinary Group for Appropriate Rural Technology [GIRA], Patzcuaro, Mexico) in Mexican women. Methods: A randomized controlled trial was conducted in the Central Mexican state of Michoacán. Households were randomized to receive the Patsari stove or keep their traditional open fire. A total of 552 women were followed with monthly visits over 10 months to assess stove use, inquire about respiratory and other symptoms, and obtain lung function measurements. Statistical analysis was conducted using longitudinal models. Measurements and Main Results: Adherence to the intervention was low (50%). Women who reported using the Patsari stove most of the

time compared with those using the open fire had significantly lower risk of respiratory symptoms (relative risk [RR], 0.77;95%confidence interval [CI], 0.62–0.95 for cough and RR, 0.29; 95% CI, 0.11–0.77 for wheezing) adjusted for confounders. Similar results were found for other respiratory symptoms as well as for eye discomfort, headache, and back pain. Actual use of the Patsari stove was associated with a lower FEV1 decline (31 ml) compared with the open fire use (62 ml) over 1 year of follow-up (P 5 0.012) for women 20 years of age and older, adjusting for confounders. Conclusions: The use of the Patsari stove was significantly associated with a reduction of symptoms and of lung function decline comparable to smoking cessation.

**16.** Perez-Padilla R., Schilman A., Riojas-Rodriguez H. *Respiratory health effects of indoor air pollution.* INT J TUBERC LUNG D, Vol. 14, Nom. 9, Pags. 1079- 1086, Año 2010

<http://www.ncbi.nlm.nih.gov/pubmed/22790916>

#### Abstract

Domestic pollution is relevant to health because people spend most of their time indoors. One half of the world's population is exposed to high concentrations of solid fuel smoke (biomass and coal) that are produced by inefficient open fires, mainly in the rural areas of developing countries. Concentrations of particulate matter in kitchens increase to the range of milligrams per cubic meter during cooking. Solid fuel smoke possesses the majority of the toxins found in tobacco smoke and has also been associated with a variety of diseases, such as chronic obstructive pulmonary disease in women, acute respiratory infection in children and lung cancer in women (if exposed to coal smoke). Other tobacco smoke-associated diseases, such as tuberculosis, asthma, respiratory tract cancer and interstitial lung diseases, may also be associated with solid fuel smoke inhalation, but evidence is limited. As the desirable change to clean fuels is unlikely, efforts have been made to use efficient, vented wood or coal stoves, with varied success due to inconsistent acceptance by the community.

**17.** Riojas-Rodriguez H., Schilman A., Marron-Mares A.T., Masera O., Li Z., Romanoff L., Sjödin A., Rojas-Bracho L., Needham L.L., Romieu I. *Impact of the Improved Patsari Biomass Stove on Urinary Polycyclic Aromatic Hydrocarbon Biomarkers and Carbon Monoxide Exposures in Rural Mexican Women.* ENVIRON HEALTH PERSPECT, Vol. 119, Nom. 9, Pags. 1301- 1307, Año 2011

<http://www.ncbi.nlm.nih.gov/pubmed/21622083>

#### Abstract

Background: Cooking with biomass fuels on open fires results in exposure to health-damaging pollutants such as carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs), and particulate matter. Objective: Compare CO exposures and urinary PAHs biomarkers pre- and post-intervention with an improved biomass stove – the Patsari stove. Methods: A sub-sample of 63 women participating in a randomized controlled trial in central Mexico was selected. Personal CO exposure was measured for 8 hours during the day using continuous monitors and passive samplers, and first morning urine samples obtained the following day were analyzed for monohydroxylated PAH metabolites by gas chromatography isotope dilution high resolution mass spectrometry. Exposure data were collected during the use of an open fire (pre-intervention) and after installation of the improved stove (post-intervention) for 47 women, enabling paired comparisons. Results: Median pre- and post-intervention values were 4 ppm and 1 ppm for continuous personal CO and 3 ppm and 1 ppm for passive sampler CO, respectively. Post intervention measurements indicated an average reduction of 42% for hydroxylated metabolites of naphthalene, fluorene, phenanthrene and pyrene on a whole weight concentration ( $\mu\text{g/L}$  urine), and a 34% reduction on a creatinine adjusted basis ( $\mu\text{g/g}$  creatinine). Pre- and post-intervention geometric mean values for 1-

hydroxypyrene were 3.2 and 2.0  $\mu\text{g/g}$  creatinine, respectively. Conclusion: Use of the Patsari stove significantly reduced CO and PAH exposures in women. However, levels of many PAH biomarkers remained higher than those reported among smokers.