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Indoor pollution as an occupational risk factor for tuberculosis among women: a population-based, gender oriented, case-control study in Southern Mexico

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ABSTRACT

Background. Indoor air pollution produced by biomass cooking fuels in developing countries has been associated with acute and chronic lower respiratory diseases, but has not been identified as an occupational exposure among women. **Objective.** To examine the relationship between the use of biomass cooking fuels (mainly wood) and tuberculosis (TB) among women living in rural areas in Southern Mexico. **Methods.** We conducted a population based case-control study in the health jurisdiction of Orizaba, Mexico. Cases were all incident female pulmonary TB patients, with Mycobacterium tuberculosis in sputum, living in communities with fewer than 15 000 inhabitants, diagnosed between March 1995 and April 2003. Woodsmoke exposure was assessed by applying a standardized questionnaire (ATS-DLD-78 questionnaire). Controls were randomly selected from sex-matched neighbors. Appropriate IRB approval was obtained. **Results.** 42 TB cases and 84 community controls were recruited. Multivariate assessment showed that more than 20 years of exposure to smoke from biomass fuels was three times more frequent among cases than among controls [Odds ratio (OR): 3.3, 95% confidence interval (CI):1.06-10.30, p = 0.03], after controlling for age, body mass, household crowding, years of formal education and tobacco use. **Conclusions.** We found a strong association between the use of biomass cooking fuels and tuberculosis among women in a community-based, case-control study. Results of this study are intended to provide evidence to policy makers, community leaders and the general public on the importance of implementing gender oriented interventions that decrease the use of biomass fuels in poor communities in developing countries.

Contaminación intradomiciliaria como un factor de riesgo ocupacional de tuberculosis entre mujeres: un estudio de casos y controles de base poblacional orientado al género, en el Sureste de México

RESUMEN

Antecedentes. *La contaminación intradomiciliaria producida por combustibles de biomateriales utilizados para cocinar en los países en desarrollo ha sido asociada con enfermedades respiratorias agudas y crónicas, pero no ha sido identificada como una exposición ocupacional en las mujeres.* ***Objetivo.*** *Determinar la relación entre uso de biomateriales utilizados para cocinar (principalmente leña) y tuberculosis (TB) en mujeres residentes de áreas rurales en el Sureste de México.* ***Material y métodos.*** *Se realizó un estudio de casos y controles de base poblacional en la jurisdicción sanitaria de Orizaba, México. Los casos fueron todas las mujeres con TB pulmonar de recién diagnóstico, con M. tuberculosis en expectoración y que residían en comunidades con menos de 15,000 habitantes, diagnosticadas entre marzo de 1995 y abril de 2003. La exposición a humo de leña fue evaluada mediante la aplicación de un cuestionario estandarizado (cuestionario ATS-DLD-78). Los controles fueron aleatoriamente seleccionados pareados por lugar de residencia del caso. Se obtuvieron las aprobaciones de los comités institucionales.* ***Resultados.*** *Se incluyeron en el estudio 42 casos de TB y 84 controles comunitarios. El análisis multivariado mostró que la exposicion a humo de biomateriales por más de 20 años fue tres veces más frecuente entre los casos que entre los controles [Razón de momios (RM): 3.3, intervalo de confianza (IC) 95%: 1.06-10.30), p = 0.03], después de controlar por edad, índice de masa corporal, hacinamiento, años de educación formal y uso de tabaco.* ***Conclusiones.***

En este estudio se encontró una asociación fuerte entre el uso de biomateriales utilizados para cocinar y TB entre mujeres mediante un estudio de casos y controles de base poblacional. Los resultados de este estudio están dirigidos a proveer evidencia a los responsables de políticas de salud, líderes comunitarios y al público en general sobre la importancia de implementar intervenciones de género para disminuir el uso de combustibles de biomateriales en comunidades pobres de los países en desarrollo.

Key words. Tuberculosis. Woodsmoke. Biomass. Indoor pollution.

Palabras clave. *Tuberculosis. Humo de leña. Biomateriales. Contaminación intradomiciliaria.*

INTRODUCTION

General recognition of the association between chronic respiratory diseases including tuberculosis with occupational exposure has increased in recent years. However, research in this area has not been gender oriented.[1,2] The World Health Organization (WHO) has encouraged studies that document health burden of indoor air pollution produced by biomass cooking fuels in developing countries and gender-specific studies that determine the impact of tuberculosis among women.

In 2005, indoor air pollution was the 8th-most important risk factor and was responsible for 2.7% of the global disease burden (in Disability-Adjusted Life Years or DALYs, a measure combining years of life lost due to disability and death).[3] In contrast with outdoor air pollution that affects everyone regardless of gender; indoor air pollution affects women predominantly since usage of biomass and wood to warm households and cook food in low resource settings occurs in poorly ventilated conditions and is generally performed by women. In fact, cooking is one of the most time consuming activities without being considered as a formal occupation. Indoor biomass fuel pollution due to particulate matter is greater than that occurring in the most contaminated cities.[4]

Indoor air pollution has been associated with a wide range of health issues. Specifically in developing countries, the health effects of using solid household fuels include chronic obstructive pulmonary disease, lung cancer, blindness and tuberculosis (TB) in people above 15 years of age, and acute lower respiratory infections in children below 5.[5] On the other hand, TB continues to be a major cause of death worldwide despite the fact the global epidemic seems to be on the threshold of decline.[6] In low- and middle-income countries, TB was the 8th-most common cause of mortality, with 1.59 million deaths and 3.3% of total deaths in 2001.[7]

It is therefore important to recognize gender differentials that contribute to different health risks between men and women and frequently to differential usage of health services and decrease in health care to women.[8] In contrast to other studies, this is a gender-oriented population based study that sought to determine the impact that biomass fuel production has on health of women, particularly on development of pulmonary tuberculosis in a setting where both usage of biomass fuel and tuberculosis are highly prevalent. Our hypothesis is that the indoor use of wood for cooking is associated with bacteriologically confirmed pulmonary TB among women.

MATERIAL AND METHODS

Study population and enrollment

We have been conducting a population-based prospective study of pulmonary TB in southern Mexico since 1995.[9-17] The study site and enrollment procedures have been described previously.[10] Briefly, the study area includes 12 municipalities in the Orizaba Health Jurisdiction in Veracruz State, Mexico. The study area is 618.11 km2 and has 369 235 inhabitants, 14.9% of them in rural communities.[18] The incidence rate of tuberculosis in the state of Veracruz during 2002 (25.3 cases per 100,000 population) was higher than the incidence rate nationwide (14.1 cases per 100,000 population).[19] In the state of Veracruz, 32.4% of all dwellings used firewood as fuel; exposure being both diurnal and nocturnal in approximately a third of them.[20]

We performed passive case finding supported by community-based health workers and screened persons who reported coughing for more than 15 days. Collaboration was established with local health and political authorities for recruitment of participants. The register of tuberculosis patients was reviewed periodically to identify patients with pulmonary tuberculosis who might have been missed by recruiters.

Between March 1995 and April 2003, patients with acid fast bacilli (AFB) or *M. tuberculosis* in sputa were evaluated using a standardized questionnaire, physical exam, chest radiograph, and HIV test to determine their epidemiological, clinical, and mycobacteriological characteristics. Treatment was provided using the official norms of Mexico's national tuberculosis control program.[21]

Selection and recruitment of population-based cases and controls

Cases were selected from among female TB patients with *M. tuberculosis* in sputa diagnosed in the study area between March 1995 and April 2003, residing in communities with fewer than 15 000 inhabitants. We selected as cases all tuberculosis female patients who were living in these communities. For each case, two randomly-selected controls were recruited in 2003 from the same neighborhood in which the cases resided. We selected only female individuals as exposure to biomass fuels occurs predominantly among women. Although the number of selected cases was reduced, our sample included all female cases occurring in the communities with fewer than 15,000 inhabitants. This allowed us to study all events of transmission that took place among the study population during reference period.

The controls denied having had respiratory symptoms during the prior two weeks and had no previous diagnoses of TB. Sociodemographic and clinical data were explored for cases and controls using a standardized questionnaire.

Exposure

Exposure to biomass fuel stoves was assessed by a validated questionnaire [American Thoracic Society (ATS) and National Heart and Lung Institute (NHLI) questionnaire (ATS-DLD-78 questionnaire)],[22] which was modified to include additional questions concerning the fuels used for cooking and background information on exposure to dust and gases in the workplace, smoking, fuels used for cooking, ventilation, characteristics of the kitchen and dwelling, respiratory symptoms and associated pulmonary illnesses. This questionnaire has been shown to be highly correlated with the concentration of particles in the dwelling.[23] A home visit was conducted to confirm the current use of biomass stoves.

We obtained written, informed consent from each participating individual prior to enrolment, and the study was approved by the institutional review boards of appropriate institutions.

Bacteriology

Ziehl Neelsen staining, mycobacteriological culture, species identification and susceptibility testing were performed following standardized procedures.[24]

Statistical analysis

Univariate and bivariate analyses were performed to examine association with TB: years of exposure to woodsmoke, age, body mass index, household crowding, tobacco use, passive smoking, previous exposure to dust and gases in the workplace, respiratory co-morbidity and years of formal education. Associations between the use of woodsmoke and diagnoses of TB were tested by multivariate conditional logistic regression with the neighborhood of residence as the matching variable. Variables were entered into the models according to their statistical significance in the bivariate analysis ($p < 0.2$) and their biological relevance, and were retained based on the Chi square test of the log likelihood ratios. Analyses were performed using STATA (version 9, Stata Corporation, College Station, TX).

Sensitivity analysis

We considered several sources of biases. We compared characteristics of included and not included patients. Since poverty and usage of biomass occur in rural low socioeconomic levels, we evaluated the association between wood smoke and being a case in several subsamples according to formal education, work outside the home, body mass index and number of economic dependents. We assessed the association using Chi square tests and Mantel-Haenszel stratified analyses. Odds ratio (ORs) and 95% confidence intervals (CIs) were calculated.

RESULTS

Fifty female tuberculosis patients residing in rural areas were diagnosed with *M. tuberculosis* in sputa during the study period but only on 42 was it possible to obtain information and are thus the study cases. Comparison between these two groups revealed that the only difference was that patients with complete information lived closer to the local health center [873 (± 813) *vs.* 1377 m. (± 964) m. $p = 0.03$].

Table 1. Characteristics of patients with pulmonary tuberculosis and controls

Characteristic	PTB cases (n = 42) (N)	(%)	Controls (n = 84) (N)	(%)	p
• Age, years [mean, (± SD)]	42.9	±18.3	39 9	±15.0	0.3
• Body mass index [mean, (± SD)]	25	±5.3	26.5	±16.1	0.1
• Formal education ≤ 6 years	30	71.4	67	79.8	0.3
• Number of persons per room in household [mean, (± SD)]	2.8	1.9	2.5	±2.0	0.4
• Time of residence in area of study [mean, (± SD)]	22	±17.0	20.4	±16.1	0.6
• Community with < 2,500 inhabitants	15	35.7	30	35.7	1.0

Table 2. Results of multivariate analysis with bacteriologically-confirmed TB as outcome.

Variable	Crude analysis Crude OR* (95%CI)	p	Multivariate analysis Adjusted OR (95%CI)	p
Exposure to biomass smoke > 20 years	1.4 (0.6-3.1)	0.4	3.3 (1.06-10.30)	0.03
Age ≤ 20 years	1.8 (0.5-6.2)	0.4	1.9 (0.30-11.72)	0.5
Body mass index ≤ 20	1.8 (0.5-6.2)	0.4	5.8 (0.89-37.62)	0.06
One-room Household	6.4 (2.1-19.2)	0.001	15.4 (3.30-72.08)	< 0.0001
Formal education ≤ 6 years.	0.6 (0.3-1.5)	0.3	0.36 (0.10-1.24)	0.1
Current smoking	3.6 (1.09-12.1)	0.03	4.1 (0.91-18.58)	0.06

* OR: Odds ratio, 95%CI: 95% confidence intervals.

Forty-two cases and 84 community controls were recruited. Comparison between cases and controls is shown in table 1. The proportion of cases and controls who referred use of biomass as a cooking fuel at the time of the study was 71.4% (30/42) *vs.* 66.7% (56/84), p = 0.5 and during the past 20 years 50.0%, (21/42) *vs.* 41.7%, (35/84), p = 0.4. The proportion of one-room dwellings and tobacco use was significantly higher among cases than among controls (p = 0.001 y 0.03, respectively).

Multivariable assessment showed that more than 20 years of exposure to smoke from biomass fuels was three times more frequent among cases than among controls [OR: 3.3 (95%CI: 1.06-10.30) p = 0.03], after controlling for age, body mass, one-room household crowding, years of formal education and tobacco use (Table 2).

SENSITIVITY ANALYSES

On bivariate analysis, association between exposure to woodsmoke for more than 20 years and tuberculosis was greater than the unity for several subsamples: age ≤ 30 OR 2.5 CI95% (0.02-199); age ≤ 30 OR 1.3 (CI95% 0.5-3.6); body mass index < 29.9 OR 1.09 (CI95% 0.5-2.7); ≥ 29.9 OR 6.5 (CI95% 0.5-101); unemployed OR 2.5 (CI95% 0.9-7), employed OR 0.5 (CI95% 0.08-2.1); one-room household OR 1.7 (CI95% 0.4-7.3); more than one room household OR 1.2 (CI95% 0,4-3.8).

DISCUSSION

Few studies have evaluated the impact of indoor air pollution on women's health. Tuberculosis has been identified as an occupational exposure, but not

as such within the household. [25] Our results show that chronic exposure to indoor biomass fuels among women represents a risk for development of tuberculosis. Our population-based case-control study, has documented an association between > 20 years of exposure to woodsmoke and the diagnosis of bacteriologically-confirmed tuberculosis. Indeed, exposure to woodsmoke was three times more frequent among cases than among controls.

These results are consistent with those encountered in previous epidemiological studies which explored the association between biomass smoke exposure and TB. As in our study, the probability of suffering from tuberculosis among individuals exposed to biomass smoke has doubled or tripled that observed among non-exposed.[26-30] In contrast to our study, main limitations of published studies are TB diagnoses based on clinical grounds or patient recall, scarcity of control variables and non-population based designs.[26-30] Additional limitations of previous studies include that exposure, disease, or both, have been assessed through non-standardized questionnaires. Our study has the advantage that we evaluated exposure by means of a questionnaire that has been shown to be highly correlated with the concentration of particles in the dwelling.[23] Moreover, all our cases were bacteriologically confirmed. We evaluated the consistency of the association between exposure to woodsmoke and being a case by testing if it persisted in different subsamples of our population. Although sample size limited significant associations, odds ratio were greater than the unity in most of the studied subsamples.

We chose to study only women living in rural areas as the effect of this exposure apparently is higher, as shown by the findings of India's National Family Health Survey, where the prevalence rate of TB is 2.4 times higher for men but 2.7 times higher for women. The effect was also greater in rural areas.[27] We considered that limiting our study to female individuals living in rural areas would provide control of confounding variables, particularly those related to sociodemographic and economic aspects.

This study demonstrated the association between exposure to woodsmoke and bacteriologically-confirmed TB. Results of toxicological studies in experimental animals have described a direct alteration of the local immunological defense mechanisms in response to exposure to woodsmoke.[5,31,32] Inhaled woodsmoke produces a direct toxic effect on the alveolar macrophages that alters their anti-bacterial properties by inhibiting their ability to adhere to surfaces, their capacity to phagocyte bacteria and the intracellular bactericide process.[5,31,32] These results provide biological plausibility to the findings of our study.

Our study has some potential biases which are inherent to observational studies that evaluate indoor pollution and respiratory health and that do not allow controlling for all socio-economic variables and other potential confounders that are associated with TB.[33,34] Additionally we were unable to include patients who lived farther away from the health center. Finally, although selection of control subjects allowed us to control for community exposure to tuberculosis, we did not collect information regarding additional tuberculosis cases that may have occurred in the household of either cases or controls. Prospective studies based on well-evaluated interventions will make it possible to control for some of these factors.

Mexico's has initiated advances toward gender equality in health care. The 2006-2012 administration set the ambitious goal of having by 2015 Mexican health programs and services designed, budgeted, and evaluated with a gender perspective. An innovative National Program on Women and Health (PROMSA) has been created which includes meeting women's health-care needs throughout life, addressing the challenges women face as health-care professionals, and as caregivers in the family and community.[8] Therefore, results of this study are intended to provide evidence to policy makers, community leaders and the general public on the importance of implementing interventions that decrease the use of biomass fuels in poor communities and mainly affect women's health in developing countries.

CONCLUSIONS

Exposure to smoke produced by biomass fuels is one of the ten most important risk factors in the world's disease burden, and it is believed that at least 30% of the total global burden of disease (as measured by DALYs) during 2002 occurred in developing countries. In our study, this risk was strongly and directly associated with pulmonary tuberculosis among women, arguably the most important airborne transmitted infection. The study of the possible effects of exposure to smoke produced by biomaterials is thus not only a high priority in the search for preventive strategies for chronic lung disease, but also an important topic for gender oriented control strategies of respiratory infections.

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COMPETING INTEREST STATEMENT

All authors declare that they have no competing interests.

ABBREVIATIONS

- WHO: World Health Organization
- HIV: Human immunodeficiency virus
- SD: Standard deviation
- M tuberculosis: Mycobacterium tuberculosis
- TB: Tuberculosis
- ATS-DLD-78: American Thoracic Society (ATS) and National Heart and Lung Institute (NHLI) questionnaire
- IRB: Institutional Review Board
- OR: Odds ratio
- CI: 95% confidence intervals 95%
- NIH: National Institutes of Health
- HHMI: Howard Hughes Medical Institute
- CONACyT: Council of Science and Technology

REFERENCES

1. Kennedy SM, Chambers R, Du W, Dimich-Ward H. Environmental and occupational exposures: do they affect chronic obstructive pulmonary disease differently in women and men? *Proc Am Thorac Soc* 2007; 4: 692-4.
2. Camp PG, Dimich-Ward H, Kennedy SM. Women and occupational lung disease: sex differences and gender influences on research and disease outcomes. *Clin Chest Med* 2004; 25: 269-79.
3. WHO. Indoor air pollution and health. *Fact Sheet No. 292*. Geneve: World Health Organization; 2005.
4. Smith K. Fuel combustion air pollution exposure and health: the situation in devoloping countries. *Annu Rev Energy Environ* 1993; 18: 529.
5. Naeher LP, Brauer M, Lipsett M, et al. Woodsmoke health effects: a review. *Inhal Toxicol* 2007; 19: 67-106.
6. Global tuberculosis control: surveillance, planning, financing. WHO report 2007. Geneva, World Health Organization (WHO/HTM/TB/2007.376).
7. Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *Lancet* 2006; 367: 1747-57.
8. Langer A, Catino J. A gendered look at Mexico's health-sector reform. *Lancet* 2006; 368: 1753-5.
9. DeRiemer K, Garcia-Garcia L, Bobadilla-del-Valle M, et al. Does DOTS work in populations with drug-resistant tuberculosis? *Lancet* 2005; 365: 1239-45.
10. Garcia-Garcia M, Palacios-Martinez M, Ponce-de-Leon A, et al. The role of core groups in transmitting Mycobacterium tuberculosis in a high prevalence community in Southern Mexico. *Int J Tuberc Lung Dis* 2000; 4: 12-7.
11. Garcia-Garcia M de L, Ponce-De-Leon A, Garcia-Sancho MC, et al. Tuberculosis-related deaths within a well-functioning DOTS control program. *Emerg Infect Dis* 2002; 8: 1327-33.
12. Garcia-Garcia ML, Jimenez-Corona ME, Ponce-de-Leon A, et al. Mycobacterium tuberculosis drug resistance in a suburban community in southern Mexico. *Int J Tuberc Lung Dis* 2000; 4: S168-S170.
13. Garcia-Garcia ML, Ponce de Leon A, Jimenez-Corona ME, et al. Clinical consequences and transmissibility of drug-resistant tuberculosis in southern Mexico. *Arch Intern Med* 2000; 160: 630-6.
14. Garcia-Sancho FM, Garcia-Garcia L, Jimenez-Corona ME, et al. Is tuberculin skin testing useful to diagnose latent tuberculosis in BCG-vaccinated children? *Int J Epidemiol* 2006;35:1447-54.
15. Jacobson LM, de Lourdes Garcia-Garcia M, Hernandez-Avila JE, et al. Changes in the geographical distribution of tuberculosis patients in Veracruz, Mexico, after reinforcement of a tuberculosis control programme. *Trop Med Int Health* 2005; 10: 305-11.
16. Ponce-De-Leon A, Garcia-Garcia Md Mde L, Garcia-Sancho MC, et al. Tuberculosis and diabetes in southern Mexico. *Diabetes Care* 2004; 27: 1584-90.
17. Jimenez-Corona ME, Garcia-Garcia L, DeRiemer K, et al. Gender differentials of pulmonary tuberculosis transmission and reactivation in an endemic area. *Thorax* 2006; 61: 348-53.
18. Instituto Nacional de Estadística, Geografía e Informática. Estados Unidos Mexicanos. XII Censo General de Población y Vivienda 2000. Resultados preliminares. Aguascalientes; Ags; Instituto Nacional de Estadística, Geografía e Informática; 2000; 10.
19. SSA. Direccion General de Epidemiología. Sistema Unico de Información para la Vigilancia Epidemiológica. México: Secretaría de Salud (SSA); 2005.
20. Instituto Nacional de Estadística, Geografía e Informática (INEGI). Viviendas particulares habitadas por municipio, combustible utilizado para cocinar y número de cuartos, y su distribución según disponibilidad y uso de cocina. Available at: http://www.inegi.gob.mx).
21. Anonymous. Norma Oficial Mexicana NOM-006-SSA2 1993. Para la prevención y control de la tuberculosis en la atención primaria a la salud. Diario Oficial de la Federación; 1995, p. 20-9.
22. Bellia V, Pistelli F, Giannini D, et al. Questionnaires, spirometry and PEF monitoring in epidemiological studies on elderly respiratory patients. *Eur Respir J Suppl* 2003; 40: 21s-27s.
23. Brauer MBK, Regalado-Pineda J, Perez-Padilla R. Assessment of Particulate Concentrations from Domestic Biomass Combustion in Rural Mexico. *Environ Sci Technol* 1995; 30(1): 104-9.
24. Metchock B, Nolte F, Wallace RJ. Mycobacterium. In: Murray P, Baron E, Pfaller M, Tenover F, Yolken R (eds.). Manual of clinical microbiology. 7th. Ed. Washington: ASM Press; 1999, p. 399-437.

25. Rodriguez BMJ, Madrid SMF. [Pulmonary tuberculosis as an occupational disease]. *Arch Bronconeumol* 2004; 40: 463-72.
26. Gupta B, Mathur N, Mahendra P. A study of household environmental risk factors pertaining to respiratory diseases. *Energy Environ Monitor* 1997; 13: 61-7.
27. Mishra VK, Retherford RD, Smith KR. Biomass cooking fuels and prevalence of tuberculosis in India. *Int J Infect Dis* 1999; 3: 119-29.
28. Perez-Padilla R, Perez-Guzman C, Baez-Saldana R, Torres-Cruz A. Cooking with biomass stoves and tuberculosis: a case control study. *Int J Tuberc Lung Dis* 2001; 5: 441-7.
29. Crampin AC, Glynn JR, Floyd S, et al. Tuberculosis and gender: exploring the patterns in a case control study in Malawi. *Int J Tuberc Lung Dis* 2004; 8: 194-203.
30. Shetty N, Shemko M, Vaz M, D'Souza G. An epidemiological evaluation of risk factors for tuberculosis in South India: a matched case control study. *Int J Tuberc Lung Dis* 2006; 10: 80-6.
31. Houtmeyers E, Gosselink R, Gayan-Ramirez G, Decramer M. Regulation of mucociliary clearance in health and disease. *Eur Respir J* 1999; 13: 1177-88.
32. Fick RB Jr, Paul ES, Merrill WW, Reynolds HY, Loke JS. Alterations in the antibacterial properties of rabbit pulmonary macrophages exposed to wood smoke. *Am Rev Respir Dis* 1984; 129: 76-81.
33. Bruce N, Neufeld L, Boy E, West C. Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala. *Int J Epidemiol* 1998; 27: 454-8.
34. Perez-Padilla R, Regalado J, Vedal S, et al. Exposure to biomass smoke and chronic airway disease in Mexican women. A case-control study. *Am J Respir Crit Care Med* 1996; 154: 701-6.

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