Lung cancer mortality and municipal marginalization in Mexico, 1998-2016

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Abstract

Objective. To analyze the mortality trend of lung cancer (LC) in Mexico, according to the municipality marginalization index (MMI) by age group and sex, during the period 1998-2016. **Materials and methods.** The information on mortality, population and MMI was obtained from the National Institute of Statistics and Geography (INEGI) and the National Council of Population (Conapo). The adjusted LC mortality rate trends were analyzed using the joinpoint regression analysis. A total of 126 132 deaths were included. **Results.** The adjusted LC mortality rate decreased from 7.83 to 4.97 100 000 inhabitants during the period from 1998-2016, but the decrease was found to be less in women and in areas with very high marginalization. **Conclusions.** Unequal reduction in LC mortality according to the degree of marginalization are related to early diagnosis, timely treatment and inequity in medical services. This inequity affects mainly the populations of women, highly marginalized groups and older populations.

Keywords: mortality; social marginalization; lung cancer; inequality; epidemiology; Mexico

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Resumen

Objetivo. Analizar la tendencia de mortalidad por cáncer de pulmón (CP) en México, según el índice de marginación municipal (IMM) por grupo de edad y sexo, de 1998 a 2016. **Material y métodos.** La información sobre mortalidad, población e IMM se obtuvo del Instituto Nacional de Estadística y Geografía (INEGI) y del Consejo Nacional de Población (Conapo). Las tendencias de la tasa de mortalidad ajustada para CP se analizaron mediante el análisis de regresión de joinpoint. Se incluyeron 126 132 defunciones. **Resultados.** La tasa de mortalidad ajustada por CP disminuyó de 7.83 a 4.97 por 100 000 habitantes durante el periodo 1998-2016. **Conclusiones.** La reducción desigual en la mortalidad por CP, de acuerdo con el grado de marginación, está relacionada con en el diagnóstico temprano, el tratamiento oportuno y la inequidad en los servicios médicos. Esta inequidad afecta principalmente a las mujeres, a los grupos altamente marginados y a las poblaciones más envejecidas.

Palabras clave: mortalidad; marginación social; cancer de pulmón; inequidad; epidemiología; México

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Lung cancer (LC) is the most common cause of cancer mortality worldwide. In 2018, ~2.09 million people were diagnosed with LC.[1] Of the multiple risk factors identified for LC, the three main modifiable and preventable risk factors are cigarette smoking, second-hand smoke (SHS) and biomass smoke exposure (BSE) resulting from cooking.[2]

In Mexico, about 20% of the Mexican population from 12 to 65 years old are current smokers.[3] In addition, 30.2% (~30 million) of the non-smoking Mexican population encounters exposure to SHS.[3] In rural zones, slight changes have been observed in the prevalence of this risk factor; between 2012 and 2013 the prevalence of this factor was 44.5%.[4] Smoking is associated with 71% of LC mortality. SHS can raise the risk of LC to up to 30% for non-smoking individuals who live with a smoker; BSE can be the only related risk factor in up to 27% of the incident cases seen at the National Cancer Institute of Mexico (*Instituto Nacional de Cancerología*, Incan), particularly among women.[3,5]

Analysis of LC mortality trend is important as changes in incidence and mortality of this tumor can be partly attributed to changes in the prevalence these and other risk factors which in turn have been reported to be unequally distributed in populations according to sex, age, socioeconomic status (SES) and other social and structural determinants such as geographical and economical environments (rural vs. urban).[2-5]

Furthermore, differences by country in LC mortality according to the level of development can be partially explained by the efficacy of health promotion interventions in well-defined targeted populations, by the access to prevention methods to increase timely diagnosis (as effective screening programs) as well as by treatment access.[6,7] For that reason, the study of marginalization and dynamic patterns of LC mortality is relevant.[6-9]

However, it is unclear how clinical and treatment differences contribute to these survival differences, but it seems that differences in treatment access might be partly explained by geographic centralization of health services, the lack of- or less access to efficient health services in rural communities or less efficient diagnostic and therapeutic approaches among low SES patients because of systematic marginalization. [6-9]

Marginalization is a complex, multidimensional and dynamic phenomena described as the existence of populations, communities or individuals that have been peripheralized from society with their needs oftentimes ignored.[10] Studying and identifying marginalized groups represents a challenge and considerations on geographic scales, timeliness of data and population dynamics are needed to be taken into account.[9,10] In Mexico the National council of population and housing (*Consejo Nacional de Población y Vivienda,* Conapo*)* has been estimating the marginalization index (MI) since 1990.[11]

The MI is a statistical parameter that sums up the shortcomings and deficiencies of the population in states, municipalities, and localities. This index summarizes marginalization by evaluating intensity and forms of marginalization across four dimensions: access to education, living conditions (housing), household income and population size.[11] Marginalized groups are in a vulnerable position that potentially threaten their well-being. Populations inhabiting marginalized environments may experience poorer health outcomes, inequalities in health care access, and deficiencies in available health care resources.[9,10]

Therefore, although the trend of cancer mortality (including LC), has been previously analyzed in the country; the analysis by level of marginalization could be relevant and pertinent since many of the previous analyses reported or do not consider the level of marginalization or were made in years prior to the implementation of the tobacco tax and SHS law. Further, the analysis by level of marginalization might help to highlight the negative effect of the economic disparity between regions regardless of the geographical area, underlining also disparities in therapeutic approaches across the country. Thus, the objective of this article was to analyze LC mortality trends using the municipality marginalization index (MMI) as a proxy for effectiveness of prevention and health promotion awareness interventions, timely diagnosis and treatment services in Mexico from 1998 to 2016.

Materials and methods

An epidemiological study of trend analysis was carried out, using the national death certificate database. This database is validated by the National Statistics and Geography Institute (*Instituto Nacional de Estadística y Geografía*, INEGI) and is available on the Secretary of Health (SSA) National Health Information System (*Sistema Nacional de Información en Salud*, Sinais) webpage.[12]

The deaths between 1998 and 2016 were those identified with codes C33-34 of the International Classification of Diseases (ICD-X), corresponding to deaths due to LC (C34) and tracheal and bronchial cancer (C-33).[13] The population denominators were obtained from populations published on Conapo webpage.[11]

A total of 126 309 deaths were included in the final dataset, of these, 177 deaths (0.14%) were excluded because of incomplete information. The information on municipal marginalization level (MMI) were taken from the 1990s, 2000s and 2010s Conapo estimations and corresponded to the municipality of habitual residence

which divides place of residence into five categories: "very low marginalization", "low marginalization", "medium marginalization", "high marginalization" and "very high marginalization".[11]

The middle years of the MMI were interpolated and extrapolated based on the methodology of Conapo[11] with a linear interpolation for performed in order, to have complete data for the study period. This method was carried out under the assumption that marginalization has a low annual variation, that is, there are no extraordinary annual changes in the MMI in Mexico. The linear interpolation of the degree of MMI was carried out with 126 132 deaths for 2 454 municipalities. The mean overall MMI was of 0.8096 with a standard deviation of 0.58 and 0.57 among the municipalities.

The global mortality rates, adjusted for age and sex, were estimated for the study period using the direct method. The 2010 Mexican population reported by the 2010 Conapo was used as standard population for rate adjustment.[11]

The percentage of change and the increase or average annual decrease in specific rates and stratified mortality rates were constructed for the age groups of 30 to 59 years old and 60 years old and over.

The municipalities were grouped according to their level of marginalization and subsequently, the mortality rates were calculated for each of the marginalization strata.

Finally, to determine the significant changes in LC mortality rates standardized by age, sex, and degree of marginalization and for the previously established age groups, over time (increase or decease), the annual percent change (APC) was obtained using a joinpoint analysis.

The statistical analysis was perfomed with the statistical program Stata v.14.0 and Joinpoint Regression Program v.4.6.0.0.

Results

Between 1998 and 2016, the number of LC deaths, increased annually during the period 1998 to 2016 from 6 145 to 6 867 deaths respectively in 2016. The number of deaths predominated in the male sex during the entire study period.

There was an decreasing trend in LC mortality rates. The LC mortality rate, adjusted decreased from 7.83 per 100 000 inhabitants in 1998 to 4.97 per 100 000 inhabitants in 2016. In men, the highest rate was recorded at the beginning of the period (10.70) (table I).

The distribution by degree of marginalization showed that, on average, 63% of deaths occurred in municipalities with very low marginalization and only 1.4% of deaths corresponded to municipalities with very high marginalization.

In men residents of municipalities with very low marginalization there were three significant changes observed. First, there was a 1.80%, annual decrease between 1998 and 2005 (jointpoint= -0.27); second, there was a 5.73% decrease between 2005 and 2008 (jointpoint= -0.76) and third, there was a 3.22% decrease (jointpoint= -0.31) between 2008 and 2015. As a result of this situation, the LC mortality rate decreased by 44.8% between the beginning of the period and the end of the period (14.2 in 1998 vs. 7.84 in 2016) (figure 1, table II).

In male residents of municipalities with low marginalization there was a stable trend at the beginning of the period (1998-2004) (jointpoint= 0.0), followed by an annual decrease of 6% between 2004 and 2008 (jointpoint= -0.80), and an annual decrease of 3.41% (jointpoint= -0.25) between 2009 and 2016. In this population, the LC mortality rate decreased a 44.1% in the study period (11.43 in 1998 vs. 6.39 in 2016) (figure 1, table II).

In male residents of municipalities with medium, high and very high marginalization, there were no changes significantly over the last 19 years. However, the LC mortality rate annual decrease 2.5, 2.5 and 1.6%, respectively (joinpoint = -0.29, -0.19 and -0.04, respectively). The LC mortality rate decrease a 44.4, 45.7 and 27.9% in the period, respectively. As can be seen, the reduction in the mortality rate in the municipalities with very high marginalization was 36% lower than that reported in the rest of the municipalities (table II, figure 1).

In women residents of municipalities with very low marginalization, low marginalization and high marginalization, the annual decrease was 1.5, 1.4, and 2.5%, respectively (joinpoint= -0.06, -0.09 and -0.10). At the end of the study period there was a decrease, in mortality rates, of 28, 25 and 25%, respectively (table II, figure 1).

The LC mortality rate in women residents of the municipalities with medium marginalization there was two significant changes observed. Fists, there was a 2.7% annual decrease between 1998 and 2011 (joinpoint= -0.14); later there was an 8% increase between 2012 and 2016 (joinpoint= 0.10). As a result of this situation, the LC mortality rate decrease a 37.5% between 1998-2012 and there was an increase of 8% between 2012 and 2016 (table II, figure 1).

Finally, in women residents of the municipalities with very high marginalization, the trend showed an annual decrease of 1.9% (joinpoint= -0.09). There was a reduction of 35% in the LC rate at the end of the period (2.78 in 1998 vs. 1.81 in 2016) (table II, figure 1).

Table I

Lung cancer mortality rate,* age-adjusted, in men and women, according to the degree of municipality marginalization. México, 1998-2016

Year	*1998*	*2000*	*2005*	*2010*	*2015*	*2016*
Adjusted rate						
Men	10.7	10.28	9.91	7.89	6.66	6.35
Women	4.97	4.78	4.48	4.06	3.74	3.69
Both	7.83	7.52	7.15	5.93	5.15	4.97
Marginalization grade						
Very low						
Men	14.19	13.27	12.4	9.60	7.95	7.84
Women	6.12	5.69	5.5	4.78	4.44	4.42
Both	9.91	9.25	8.77	7.06	6.10	6.04
Ratio M:W	2.32	2.33	2.25	2.01	1.79	1.77
Low						
Men	11.43	12.1	11.02	7.82	7.05	6.39
Women	4.96	5.19	4.45	4.24	3.83	3.72
Both	8.21	8.66	7.74	6.03	5.43	5.04
Ratio M:W	2.30	2.33	2.47	1.84	1.84	1.71
Medium						
Men	9.98	10.20	9.12	6.81	5.90	5.55
Women	5.14	5.14	4.04	3.43	3.48	3.47
Both	7.62	7.72	6.61	5.15	4.69	4.51
Ratio M:W	1.94	1.98	2.26	1.99	1.69	1.60
High						
Men	6.85	6.86	6.46	5.06	4.29	3.72
Women	2.98	3.43	2.66	2.57	2.34	2.23
Both	4.99	5.22	4.60	3.84	3.32	2.98
Ratio M:W	2.30	2.00	2.43	1.97	1.83	1.67
Very high						
Men	3.33	2.85	3.38	2.97	3.07	2.40
Women	2.78	1.84	2.28	1.92	0.96	1.81
Both	3.08	2.37	2.85	2.45	2.00	2.10
Ratio M:W	1.20	1.55	1.48	1.55	3.18	1.33

*Rate per 100 000 inhabitants
Source: Dirección General de Información en Salud[12]

The LC mortality rates decrease by 45% in men from 30 to 59 years old in the period (6.6 in 1998 to 3.6 in 2016). However, there were no significant changes in the jointpoint regression analysis by degree of marginalization in the municipalities with very low, low, medium and high marginalization (joinpoint= between -0.14 to -0.19). In municipalities with very high marginalization, the trend remained stable (joinpoint= -0.03). In the case of women, the decrease in the mortality rate was 3.3 in 1998 to 2.5 in 2016, which represented a decrease of 25%. The joinpoint regression analysis no showed significatives changes (tables III and IV).

In male 60 years old and over, the highest mortality rates with a downward trend were recorded. Thus, the mortality rate went from 106.1 to 62.8 from 1998 to 2016. As a result of this situation, the LC mortality rate decrease a 40.8% between the beginning and the end of the period (tables III and IV).

The decrease in the trends according to the degree of marginalization was very noticeable in the municipali-

Table II

JOINPOINT REGRESSION ANALYSIS OF THE LUNG CANCER MORTALITY RATES, BY SEX AND DEGREE OF MUNICIPALITY MARGINALIZATION. MÉXICO, 1998-2016

Degree of Marginalization	*Period*	*Men*	*Confidence interval 95%*	*Period*	*Women*	*95% Confidence interval*	*Period*	*Total*	*95% Confidence interval*
Very low	1998-2005	-0.27	(-0.35,-0.19)	1998-2016	-0.10	(-0.12,-0.08)	1998-2005	-0.16	(-0.22,-0.10)
	2005-2008	-0.76	(-1.37,-0.15)				2005-2008	-0.48	(-0.95,-0.01)
	2008-2016	-0.31	(-0.37,-0.25)	1998-2016			2008-2016	-0.18	(-0.24,-0.12)
Low	1998-2004	0.00	(-0.12,0.12)		-0.09	(-0.11,-0.07)	1998-2004	-0.01	(-0.09,0.07)
	2004-2008	-0.80	(-1.11,-0.49)				2004-2009	-0.43	(-0.59,-0.27)
	2008-2016	-0.25	(-0.33,-0.17)	1998-2012			2009-2016	-0.15	(-0.21,-0.09)
Medium	1998-2016	-0.29	(-0.33,-0.25)	2012-2016	-0.14	(-0.16,-0.12)	1998-2011	-0.24	(-0.28,-0.20)
				1998-2016	0.10	(-0.10,0.30)	2011-2016	-0.05	(-0.21,0.11)
High	1998-2016	-0.19	(-0.23,-0.15)	1998-2016	-0.06	(-0.08,-0.04)	1998-2016	-0.13	(-0.15,-0.11)
Very high	1998-2016	-0.04	(-0.08,0.00)	1998-2016	-0.01	(-0.05,0.03)	1998-2016	-0.03	(-0.07,0.01)

Source: Consejo Nacional de Población.[11]

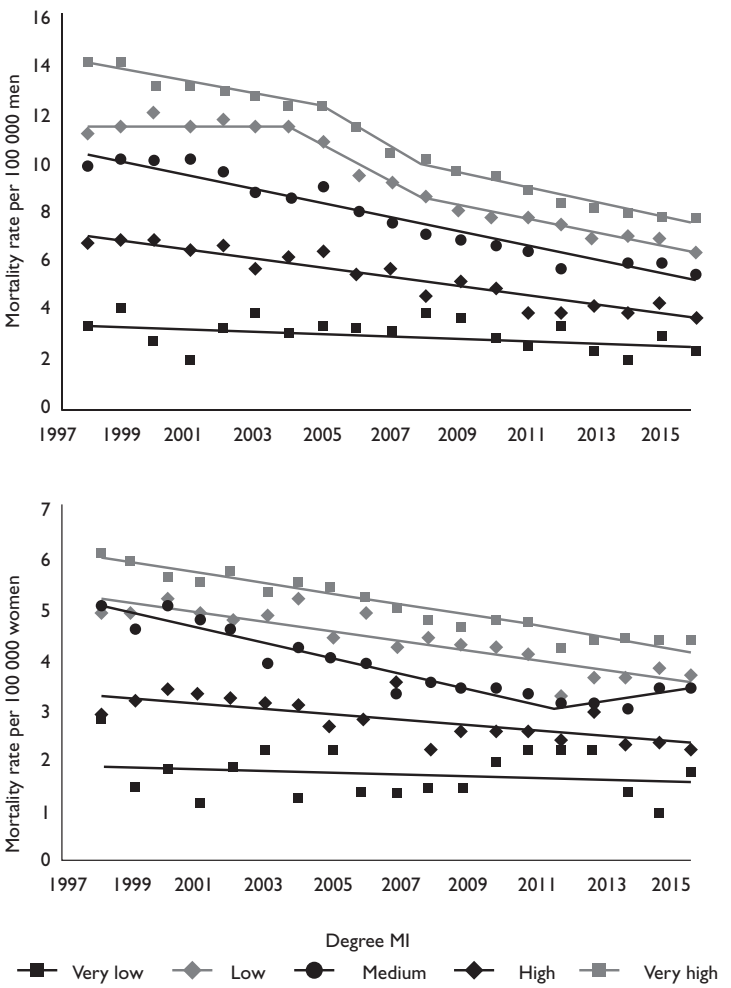

FIGURE 1. JOINPOINT REGRESSION ANALYSIS OF THE LUNG CANCER MORTALITY RATES,1 AGE-ADJUSTED, IN MEN AND WOMEN, ACCORDING TO THE DEGREE OF MUNICIPALITY MARGINALIZATION INDEX. MEXICO, 1998-2016

ties with very low and low marginalization, between 2005 and 2009 and later between 2004 and 2008 (joinpoint= -6.86 and -7.99, respectively). In the case of the municipalities with medium degree of marginalization the mortality rate decresead (joinpoint= -2.64). Finally, in municipalities with high and very high marginalization, there were no significatives changes (joinpoint= -1.67 and -0.34 respectively) (tables III and IV).

In the case of women aged 60 and over, the trend observed in municipalities with very low and low marginalization was similar (joinpoint= -0.95 and -0.82), unlike municipalities with medium marginalization, where the decrease was greater between 1998 and 2013 (joinpoint= -1.20). However, in the period 2013-2016 an increase in the trend is observed (joinpoint= 2.35). Finally, the mortality rates corresponding to municipalities with high and very high marginalization are those that showed, as in men of this age group, the lowest decrease in trends (joinpoint= -0.49 and -0.06) (table III and IV).

Table III
Lung cancer mortality rate[1-6] by age group and sex. México, 1998-2016

Year	Men		Women		Total	
	30-59 years old*	≥60 years old‡	30-59 years old§	≥60 years old#	30-59 years old&	≥60 years old≠
1998	6.60	106.11	3.33	42.10	4.87	72.14
1999	6.24	108.78	3.26	41.50	4.67	73.02
2000	6.15	103.68	3.10	41.18	4.56	70.43
2001	5.99	103.17	2.85	40.16	4.35	69.64
2002	5.77	103.93	3.04	40.50	4.34	70.15
2003	6.01	99.98	2.90	38.74	4.38	67.35
2004	5.16	100.18	2.94	39.69	3.99	67.94
2005	5.51	98.72	2.85	37.92	4.12	66.30
2006	5.09	90.49	3.19	36.40	4.10	61.64
2007	4.89	83.74	2.81	35.37	3.80	57.92
2008	4.62	81.69	2.76	33.94	3.65	56.19
2009	4.64	77.81	2.45	33.86	3.49	54.33
2010	4.44	75.84	2.81	32.96	3.59	52.92
2011	4.17	71.13	2.89	32.50	3.50	50.46
2012	3.96	67.89	2.41	29.85	3.15	47.51
2013	3.90	67.17	2.87	30.47	3.36	47.49
2014	3.71	65.94	2.64	30.59	3.14	46.97
2015	3.75	65.22	2.79	30.53	3.24	46.59
2016	3.56	62.77	2.50	31.50	3.00	45.96

* Rate per 100 000 men 30 to 59 years old
‡ Rate per 100 000 men ≥60 years old
§ Rate per 100 000 women 30 to 59 years old
# Rate per 100 000 women ≥60 years old
& Rate per 100 000 inhabitants 30 to 59 years old
≠ Rate per 100 000 inhabitants ≥ 60 years old

Discussion

Worldwide, substantial changes have been achieved in the overall survival of patients with LC.[14] Particularly, after the advent of targeted therapies, or personalized medicine, the therapeutic approach and the range of possible therapeutic options has increased and has laid the development of new clinical practice guidelines for the care of this pathology.[5,14]

However, the scarcity of resources coupled with the poor distribution of them has helped to generate large disparities in the therapeutic approach of the LC despite having trained and updated specialist physicians in the new treatments.[6-8]

Furthermore, studies in different populations (e.g., Asiatic and Anglo-Saxon) document how the diagnosis and treatment may be different by socioeconomic and educational level.[15-18] For instance, a study showed that LC patients with lower SES compared to those with higher SES had a lower probability of undergoing surgery or chemotherapy.[15] Likewise, as the level of poverty of the community increased, the median survival decreased, concluding that extreme community poverty (> 15%) behaves as a factor of poor prognosis even after adjusting the for comorbidities, clinical characteristics or even the treatment received.[15]

In the present study, we observed that the adjusted LC mortality rate decreased in Mexico and particularly in men, which is consistent with previous reports.[18] However, the decrease in the mortality rate was not uniform throughout the country. Therefore, resident populations of municipalities with high and very high marginalization showed a tendency with less decrease or even no decrease in both men and women.

Among the possible explanations of our results, it can be mentioned that in marginalized populations the educational level is lower and more accentuated in women. This, in turn, limits access to medical care, therefore diagnosis and treatment are not timely. In addition, if we consider the unequal and unfavorable distribution of the economic income of both the patient and the health services, reflected, the latter, in the lack of human and material resources (laboratory and molecular studies, medicines, etc.), the result is the limitation of the navigation of these patients within the health system and therefore their poor prognosis.[9,10,16,17]

Another aspect to be considered is the geographical barriers of highly marginalized groups, a situation that prevents access to health services, resulting in the lack

Table IV

JOINPOINT REGRESSION ANALYSIS OF THE LUNG CANCER MORTALITY RATES,[1] BY AGE GROUP, SEX AND DEGREE OF MUNICIPALITY MARGINALIZATION MÉXICO, 1998-2016

Age	*Degree of Marginalization*	*Period*	*Men*	*95% Confidence interval*	*Period*	*Women*	*95% Confidence interval*
30-59 years	Very low	1998-2016	-0.19	(-0.21, -0.17)	1998-2016	-0.03	(-0.05, -0.02)
	Low	1998-2016	-0.18	(-0.21, -0.15)	1998-2016	-0.04	(-0.07. -0.01)
	Medium	1998-2016	-0.18	(-0.21, -0.15)	1998-2016	-0.07	(-0.09, -0.04)
	High	1998-2016	-0.14	(-0.19, -0.09)	1998-2016	-0.02	(-0.06, 0.01)
	Very high	1998-2016	-0.03	(-0.10, 0.04)	1998-2016	-0.02	(-0.08, 0.03)
≥60 years	Very low	1998-2005	-2.44	(-3.46, -1.42)	1998-2016	-0.95	(-1.07-0.82)
		2005-2009	-6.86	(-10.68, -3.05)			
		2009-2016	-2.57	(3.59, -1.55)			
	Low	1998-2004	0.37	(-1.18, 1.93)	1998-2016	-0.82	(-1.02, -0.62)
		2004-2008	-7.99	(-12.59, -3.39)			
		2008-2016	-2.25	(-3.25, -1.25)			
		1998-2016	-2.64	(-2.99, -2.28)	1998-2013		
	Medim					-1.2	(-1.49, -0.91)
						2.35	(-1.05, 5.75)
					2013-2016		
	High	1998-2016	-1.67	(-1.95, -1.39)	1998-2016	-0.49	(-0.67, -0.31)
	Very high	1998-2016	-0.34	(-0.75, 0.07)	1998-2016	-0.06	(-0.31, 0.19)

of diagnosis of new cases and deaths with LC, thus increasing the under-registration of the disease in this areas. In addition, the misclassification of the disease, resulting from the mis-filling of death certificates, may also increase the lack of notification for this disease in among highly marginalized environments.[6,10,16,17]

The lack of a national registry of cancer is another aspect to be considered to be limiting the registration of the disease and mortality among LC patients. Likewise, this factor, limit the information we can get to describe the availability of resources for early diagnosis and treatments access, in order to improve the survival of these patients.[19,20]

On the other hand, a risk factor associated with the presence of LC is tobacco, as mentioned in multiple studies. This exposure has decreased over time, both globally and in our country.[2,18,19] However, the assessment of this factor on LC incidence in our country remains limited derived from the lack of a national cancer registry.

In spite of the above, there are national addiction surveys (ENA) for the years 2002 and 2016-2017, which have allowed to determine the prevalence of tobacco consumption. Therefore, according to these, for the years 2002 and 2016-2017 the overall prevalence of current smokers for Mexican adults aged 18 to 65 years went from 27% in 2002 to 20.1% in 2016-2017. By gender, among males, smoking prevalence went from 42.3% to 31.3% which meant a 26.0% reduction and among women smoking prevalence went from 15.1% to 9.8% which meant a 35.1% reduction.[11]

As previously reports suggest, this decreasing trend in tobacco consumption could be associated with the implementation of the increase in the cigarette tax in 2007 and with the legislation that protects non-smokers of SHS published in 2008.[21,22]

Another risk factor mentioned in more recently literature is the exposure to wood smoke, a situation that is very frequent in populations with high and very high marginalization. However, so far there are lack of studies that evaluate the national prevalence at individual level of this exposure and its evolution over time, in these populations.[4,5]

Based on the above, it is important to point out that although the control and reduction of preventable risk factors are important to reduce the mortality burden attributable to LC, these are not the only means to reduce incidence and mortality for LC, unless accompanied by measures that ensure access to an opportune diagnosis and treatment, especially of the most vulnerable groups given their unfavorable social determinants.[9,16,17]

The main advantage of this study is the national representativeness and the disaggregation of the IM at municipal level which highlights inequalities that can be difficult to identify with the analysis of the level of marginalization by federal entity. Additionally, the study has the advantage of summarizing LC mortality for two decades after the application of tobacco taxes and the law to avoid SHS.

Finally, the challenge for the health system is to recognize the deficiencies in material and human resources, as well as to consider the ethnic, socio-economic and cultural differences of the population, in order to establish, evaluate and configure the best strategies for attention to the more vulnerable populations and thus close gaps in access to timely diagnosis and treatment services that determine LC mortality.

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