

# Neighbourhood deprivation and smoking and quit behaviour among smokers in Mexico: findings from the ITC Mexico Survey

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Received 12 December 2013

Accepted 8 August 2014

Published Online First

28 August 2014

## ABSTRACT

**Background** In high-income countries (HICs), higher neighbourhood socioeconomic deprivation is associated with higher levels of smoking. Few studies in low-income and middle-income countries (LMICs) have investigated the role of the neighbourhood environment on smoking behaviour.

**Objective** To determine whether neighbourhood socioeconomic deprivation is related to smoking intensity, quit attempts, quit success and smoking relapse among a cohort of smokers in Mexico from 2010 to 2012.

**Methods** Data were analysed from adult smokers and recent ex-smokers who participated in waves 4–6 of the International Tobacco Control (ITC) Mexico Survey. Data were linked to the Mexican government's composite index of neighbourhood socioeconomic deprivation, which is based on 2010 Mexican Census data. We used generalised estimating equations to determine associations between neighbourhood deprivation and individual smoking behaviours.

**Findings** Contrary to past findings in HICs, higher neighbourhood socioeconomic deprivation was associated with lower smoking intensity. Quit attempts showed a U-shaped pattern whereby smokers living in high/very high deprivation neighbourhoods and smokers living in very low deprivation neighbourhoods were more likely to make a quit attempt than smokers living in other neighbourhoods. We did not find significant differences in neighbourhood deprivation on relapse or successful quitting, with the possible exception of people living in medium-deprivation neighbourhoods having a higher likelihood of successful quitting than people living in very low deprivation neighbourhoods ( $p=0.06$ ).

**Conclusions** Neighbourhood socioeconomic environments in Mexico appear to operate in an opposing manner to those in HICs. Further research should investigate whether rapid implementation of strong tobacco control policies in LMICs, as occurred in Mexico during the follow-up period, avoids the concentration of tobacco-related disparities among socioeconomically disadvantaged groups.

including through socioeconomic opportunities for individuals and the resources available within neighbourhoods (eg, municipal, medical and social services; built environment).<sup>1</sup> Neighbourhood deprivation, often measured as a composite of socio-demographic census-level variables, is one way of measuring the neighbourhood socioeconomic environment.<sup>2</sup>

In HICs, living in a more socioeconomically deprived neighbourhood has been associated with higher smoking levels, above and beyond the socioeconomic position (SEP) of individuals.<sup>3–5</sup> Most of this literature compares smokers and non-smokers. Studies focusing on smokers only find similar patterns: neighbourhood deprivation is associated with a higher intensity of smoking<sup>6–7</sup> and lower likelihood of quitting.<sup>8–9</sup> Very little research, though, has explored these relationships in low-income and middle-income countries (LMICs), where tobacco use is increasing.<sup>10</sup> Understanding the relationship between neighbourhood deprivation and smoking in LMICs may inform tobacco control strategies that alleviate some of the health and socioeconomic burden by effectively promoting smoking cessation among smokers from disadvantaged settings.

The aim of this paper is to determine whether neighbourhood deprivation affects smoking intensity, quit attempts, quit success and smoking relapse among a cohort of smokers in Mexico from 2010 to 2012. Mexico has been at the forefront of tobacco control efforts in Latin America,<sup>11</sup> making it an important environment to investigate neighbourhood-level influences in LMICs.

## METHODS

### Population

We analysed data from the International Tobacco Control (ITC) Mexico Survey, a population-based, longitudinal survey of adult smokers in seven Mexican cities. ITC Mexico Survey began in 2006, and uses a stratified, multistage sampling strategy with face-to-face interviews. Within the urban limits of the seven purposefully selected major Mexican cities, census tracts (ie, Áreas Geoestadísticas Básicas, or AGEB) were selected, with likelihood of selection proportional to the number of households according to census data. At the initial wave of data collection for each city, two block groups within each census tract were selected, with selection proportional to the number of



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**To cite:** Fleischer NL, Thrasher JF, Sáenz de Miera Juárez B, et al. *Tob Control* 2015;**24**:iii56–iii63.

residents. Households were then visited in random order to enumerate household members and recruit eligible study participants.<sup>12</sup> Quotas were set for smokers per block group; if that number was not reached, another block group was selected at random and eligible participants selected according to the same protocol. To replenish the sample due to loss to follow-up, new block groups were selected each year within the originally selected census tracts that had the lowest levels of follow-up, and the same protocol was followed to find and recruit participants. At initial recruitment, eligible participants were aged 18 years or older, had smoked at least once during the previous week and had smoked at least 100 cigarettes in their lifetime. We used data from waves 4–6, conducted in January–February 2010, April–May 2011 and October–November 2012, respectively.

We defined three analytic samples of participants: the smoking intensity sample, the quit behaviour sample and the relapse sample. The first two samples include smokers who were still in the cohort at wave 4, in addition to smokers who were newly recruited to replenish the sample at waves 5 and 6. The smoking intensity sample included all smokers at wave 4 ( $n=1769$ ), in addition to the new recruit smokers at waves 5 ( $n=359$ ) and 6 ( $n=412$ ). The quit behaviour sample consisted of all smokers from wave 4 with data at wave 5 ( $n=1487$ ), and new recruit smokers at wave 5 with data at wave 6 ( $n=212$ ). The relapse included all quitters from wave 4 with data at wave 5 ( $n=219$ ), and all new quitters at wave 5 with data at wave 6 ( $n=146$ ). Analytic samples retained participants with data on all variables of interest, as described below.

### Smoking intensity

To characterise smoking intensity, we compared daily heavy smokers and daily light smokers to non-daily smokers. Daily heavy smokers smoked at least six cigarettes per day, and daily light smokers smoked five or fewer cigarettes per day. Smoking intensity is low in Mexico and these categories broadly represent tertiles of smoking intensity. Smoking intensity was ascertained at wave 4, and waves 5 and 6 for newly recruited smokers.

### Smoking cessation behaviour

We investigated three dependent variables related to smoking cessation behaviour: quit attempts, successful quitting and smoking relapse. A quit attempt was defined as a smoker at wave 4 or 5 answering 'yes' to the question, "In the past year, have you tried to quit smoking?" at wave 5 or 6, respectively. A smoker from wave 4 or 5 was considered to have successfully quit if he/she had made a quit attempt in the past year, and had quit for at least 1 month at wave 5 or 6. A smoker was considered to have relapsed if they had quit for any length of time at wave 4, but were currently smoking (daily or non-daily) at wave 5, or had recently quit at wave 5 (ie, not quit at wave 4), but were currently smoking at wave 6.

### Neighbourhood deprivation

Neighbourhood deprivation was measured by the marginalisation index created for urban census tracts (ie, AGEBs) by the Mexican Consejo Nacional de Población (National Population Council) using principal components analysis to reduce the dimensionality of socioeconomic indicators from the 2010 census.<sup>13</sup> The following indicators were included in the index by AGEB: percentage of 6–14-year-olds who do not attend school, percentage of people aged 15 years or older without basic (ie, primary school (6 years) and secondary school

(3 years)) education completed, percentage without entitlement to health services, percentage of deceased children among women aged 15–49 years, percentage of occupied houses without piped water inside, percentage of occupied houses without drainage connected to the public system or a septic tank, percentage of occupied houses without toilets with water connection, percentage of occupied houses with dirt floors, percentage of occupied houses with some level of overcrowding and percentage of occupied houses without a refrigerator. The first principal component was retained, as it picked up most (55.6%) of the variability of the original indicators. At the national level, all urban AGEBs were then categorised according to their level of deprivation into quintiles: very low, low, medium, high and very high. Our data set contains a subset of all urban AGEBs in Mexico. As such, the distribution for neighbourhood deprivation among the 146 AGEBs in our analyses is no longer 20% in each category that was created at the national level. In our analyses, we grouped our AGEBs into four categories, combining the very high and high categories (created from the whole distribution of urban AGEBs at the national level) due to low numbers in our sample for the very high category.

### Covariates

All sociodemographic variables were measured at the wave corresponding to the dependent variable. Age was treated as a continuous variable. Education was categorised as (1) primary education or less, (2) middle school, (3) vocational school/high school/incomplete university and (4) university/postgraduate. Monthly household income, in pesos (approximated 12.5 pesos=US\$1), was categorised as 0–3000, 3001–5000, 5001–8000,  $\geq 8001$  and unknown; income was not adjusted for number of household members due to the lack of a continuous income measure. We also controlled for intensity of smoking at wave 4 or 5 for the quit behaviour models.<sup>14</sup>

### Statistical analysis

We calculated descriptive statistics for all variables of interest, adjusting for the complex survey design. Generalised estimating equations (GEE) with robust SEs were used to determine the relationship between neighbourhood-level deprivation and individual-level smoking and quit behaviour outcomes in order to account for the nested structure of the data (individuals within neighbourhoods).<sup>15</sup> We ran two sets of log-binomial models for smoking intensity and smoking relapse, and three sets of log-binomial models for quit attempts and successful quitting. Risk ratios (RRs) using log-binomial models were calculated rather than ORs using logit models since the prevalence of the outcomes was higher than 10%. When the prevalence of an outcome is higher than 10%, ORs overestimate RRs.<sup>16</sup> The first model examined the relationship between neighbourhood deprivation and the outcome of interest (daily heavy smoking, daily light smoking, quit attempts, successful quitting or relapse). The second model included sociodemographic variables as well. The third model, for quit attempts and successful quitting, also adjusted for smoking intensity. Although intention to quit is a common covariate in models looking at quit behaviour, we decided not to include this variable since it is more likely to be on the causal pathway from neighbourhood deprivation to quit behaviour rather than a confounder. All models were weighted to account for the sampling design and rescaled to the sample size at the city level to keep the observations from the largest cities from overwhelming those in smaller cities. GEE models were run in SAS V9.3.

## RESULTS

## Sample characteristics

The smoking intensity analytic sample included a total of 2540 smokers; on average, when combining data across all three waves, 19 people lived in each AGEB (table 1). The quit behaviour sample consisted of 1699 daily or non-daily smokers from waves 4 and 5 with an average of 13 people per AGEB, while the relapse sample included 374 smokers who had quit for any amount of time at wave 4 or had newly quit at wave 5, with an average of 2 people per AGEB. In the smoking intensity sample, non-daily and daily light smokers each comprised just over 30% of the sample, while 39% of participants were daily heavy smokers. In the quit behaviour sample, over 60% of participants were daily smokers in 2010 (wave 4) or 2011 (wave 5), and more than 12% of smokers had quit by the subsequent year. Among waves 4 and 5 smokers, 17% planned to quit within the next 6 months, and more than 35% had tried to quit within the

last year. Among waves 4 and 5 quitters, 30% had relapsed by the following year. With regard to neighbourhood deprivation, more than half of each sample lived in a neighbourhood with a medium, high or very high deprivation level. Correlation was low between income, education and neighbourhood deprivation (results not shown).

## Neighbourhood deprivation and smoking intensity

Higher neighbourhood deprivation was associated with a lower prevalence of daily heavy versus non-daily smoking (table 2). Results were only slightly attenuated after adjusting for sociodemographic variables (RR=0.70, 95% CI 0.52 to 0.93 for high/very high versus very low deprivation). Individual-level socioeconomic variables (education and household income) showed no relationship with daily heavy versus non-daily smoking. The relationship between neighbourhood deprivation and daily light versus non-daily smoking was in

**Table 1** Selected characteristics of study sample, 2010–2012 ITC Mexico Survey

Characteristic*	Smoking intensity sample N=2540	Quit behaviour sample N=1699	Relapse sample N=374
Age, mean (SE)	39.4 (0.5)	39.4 (0.5)	40.7 (1.1)
Sex, n (%)			
Female	916 (36.2)	624 (37.0)	149 (39.5)
Education, n (%)			
Primary education or less	818 (31.7)	553 (32.1)	113 (29.0)
Middle school	783 (31.1)	547 (31.6)	118 (33.8)
Vocational school, high school, incomplete university	709 (27.7)	436 (26.5)	99 (24.1)
University and postgraduate	230 (9.1)	163 (9.9)	44 (13.1)
Income, n (%)			
0–3000	688 (26.1)	384 (22.4)	98 (24.8)
3001–5000	743 (28.4)	609 (36.8)	105 (28.3)
5001–8000	502 (20.1)	367 (21.6)	92 (26.4)
≥8001	420 (17.7)	236 (14.4)	55 (14.5)
Unknown	187 (7.8)	103 (5.8)	24 (6.0)
Smoking intensity, n (%)†			
Non-daily smoker	794 (31.3)		
Daily light smokers (1–5 cigarettes per day)	781 (30.0)		
Daily heavy smokers (6+cigarettes per day)	957 (38.7)		
Smoking status, n (%)‡			
Quit (<30 days)		4 (0.3)	0 (0.0)
Quit (≥30 days)		208 (12.5)	260 (64.3)
Non-daily smoker		442 (27.0)	61 (18.2)
Daily smokers		1045 (60.1)	53 (15.4)
Tried to quit within last year, n (%)			
Yes		595 (37.2)	
Quit for at least 1 month, n (%)			
Yes		208 (12.5)	
Relapse, n (%)			
Yes			114 (33.6)
People per AGEB, mean (range)	18.9 (8–32)	12.9 (3–32)	1.8 (1–8)
Neighbourhood deprivation, n (%)			
Very low	546 (22.0)	317 (19.3)	69 (16.94)
Low	617 (24.7)	441 (25.7)	92 (27.51)
Medium	1025 (40.1)	712 (41.7)	154 (40.31)
High/very high	352 (13.2)	229 (13.3)	59 (15.24)

\*Percentages are weighted for appropriate characteristics. Mean and SE for age are also calculated taking into account complex survey design. The mean and range for people per AGEB are not weighted.

†Smoking intensity at wave 4 among smokers, or wave 5 or 6 for new recruit smokers.

‡Smoking status at wave 5 if smoking at wave 4 or 6 if new recruit smoker at wave 5 for quit behaviour sample; smoking status at wave 5 if quit at wave 4 or 6 if newly quit at wave 5 for relapse sample.

AGEB, Áreas Geoestadísticas Básicas; ITC, International Tobacco Control.

**Table 2** Adjusted prevalence ratios for smoking intensity associated with neighbourhood deprivation in the smoking intensity sample, 2010–2012 International Tobacco Control (ITC) Mexico Survey

	Daily heavy vs non-daily smoking Risk ratio (95% CI) (n=1751)		Daily light vs non-daily smoking Risk ratio (95% CI) (n=1575)	
	Model 1	Model 2	Model 1	Model 2
Neighbourhood deprivation				
Very low	1.00	1.00	1.00	1.00
Low	0.81 (0.66 to 1.01)	0.83 (0.67 to 1.02)	0.84 (0.67 to 1.03)	0.83 (0.67 to 1.03)
Medium	0.84 (0.69 to 1.02)	0.84 (0.70 to 1.02)	0.85 (0.70 to 1.03)	0.84 (0.69 to 1.03)
High/very high	0.65 (0.47 to 0.89)	0.70 (0.52 to 0.93)	0.88 (0.64 to 1.22)	0.89 (0.65 to 1.22)
Age (in years)		1.01 (1.00 to 1.01)		1.01 (1.00 to 1.01)
Sex				
Male		1.00		1.00
Female		0.83 (0.75 to 0.92)		1.01 (0.90 to 1.12)
Education				
Primary education or less		1.00		1.00
Middle school		0.90 (0.77 to 1.05)		0.99 (0.84 to 1.16)
Vocational school, high school, incomplete university		0.85 (0.74 to 0.98)		0.90 (0.74 to 1.10)
University and postgraduate		1.01 (0.84 to 1.21)		0.94 (0.74 to 1.20)
Income (pesos)				
0–3000		1.00		1.00
3001–5000		1.04 (0.92 to 1.18)		1.03 (0.89 to 1.19)
5001–8000		1.00 (0.85 to 1.16)		1.08 (0.90 to 1.30)
≥8001		1.03 (0.89 to 1.20)		1.01 (0.82 to 1.23)

the same direction as daily heavy smoking, although the results were not statistically significant.

### Neighbourhood deprivation and quit behaviours

For quit attempts, neighbourhood deprivation showed a U-shaped relationship whereby smokers in low-deprivation or medium-deprivation neighbourhoods had a lower probability of attempting to quit in the past year compared with smokers living in neighbourhoods with very low deprivation (table 3). Results were not attenuated with the addition of sociodemographic variables (RR=0.56, 95% CI 0.40 to 0.78 for low vs very low deprivation neighbourhoods and RR=0.73, 95% CI 0.54 to 0.98 for medium vs very low-deprivation neighbourhoods, in model 2) and smoking intensity from the prior wave (model 3). Smokers in high/very high deprivation neighbourhood had similar levels of quit attempts when compared with smokers in very low deprivation neighbourhoods.

When looking at successful quitting, there was limited evidence that living in a more deprived neighbourhood was associated with a higher likelihood of successful quitting, although results were attenuated with the addition of sociodemographic variables. In the multivariable model, only living in a medium-deprivation neighbourhood was marginally associated with higher levels of successful quitting compared with living in a very low deprivation neighbourhood ( $p=0.0617$ ; RR=1.65, 95% CI 0.98 to 2.78; model 2). Results were slightly attenuated with the addition of smoking intensity from the prior wave (model 3), although this may be on the causal pathway between neighbourhood deprivation and successful quitting, which may explain the attenuation. Point estimates for low and high/very high versus very low neighbourhood deprivation were in the same direction, although the CIs were wide. Again, individual-level socioeconomic variables were not associated with either quit attempts or successful quitting.

### Neighbourhood deprivation and relapse

Neighbourhood deprivation was not associated with relapse (table 4). Although point estimates for living in low and medium versus very low neighbourhoods in multivariable analysis suggest that higher deprivation may be associated with higher likelihood of relapse, CIs were wide (RR=1.42, 95% CI 0.79 to 2.56 for low vs very low deprivation neighbourhoods and RR=1.40, 95% CI 0.82 to 2.39 for medium vs very low deprivation neighbourhoods, in model 2). Results were closer to the null for quitters living in high/very high versus very low deprivation neighbourhoods (RR=1.10, 95% CI 0.57 to 2.15 in model 2).

### DISCUSSION

Contrary to the findings from HICs, higher neighbourhood deprivation was associated with lower smoking intensity among a cohort of smokers in Mexico between 2010 and 2012. Quit attempts showed a U-shaped pattern whereby smokers in high/very high deprivation neighbourhoods were at the same level as smokers in very low deprivation neighbourhoods, although those in low or medium deprivation neighbourhoods had a lower prevalence of quit attempts. Point estimates for successful quitting suggested that higher deprivation may be associated with higher probability of successful quitting, although only the results for medium versus very low deprivation neighbourhoods was marginally statistically significant ( $p=0.0617$ ). Neighbourhood deprivation was not associated with relapse in our small sample.

Our analyses suggest that living in more deprived areas was associated with lower intensity of smoking in Mexico. These results are in contrast to most studies of smoking prevalence and intensity in HICs. Studies from France,<sup>6 17</sup> the Netherlands,<sup>18–20</sup> Sweden,<sup>21–23</sup> the UK<sup>24–28</sup> and the USA<sup>7 9 29–36</sup> have all found that living in more deprived (ie, less socioeconomically advantaged) areas was associated with higher

**Table 3** Adjusted risk ratios of quit attempts and successful quitting associated with neighbourhood deprivation in the quit behaviour sample, 2010–2012 International Tobacco Control (ITC) Mexico Survey

	Quit attempts Risk ratio (95% CI) (n=1699)			Successful quitting Risk ratio (95% CI) (n=595)		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Neighbourhood deprivation						
Very low	1.00	1.00	1.00	1.00	1.00	1.00
Low	0.56 (0.41 to 0.78)	0.56 (0.40 to 0.78)	0.59 (0.43 to 0.82)	1.53 (0.85 to 2.74)	1.50 (0.82 to 2.76)	1.29 (0.73 to 2.29)
Medium	0.73 (0.55 to 0.96)	0.73 (0.54 to 0.98)	0.74 (0.56 to 0.97)	1.67 (1.03 to 2.72)	1.65 (0.98 to 2.78)	1.43 (0.90 to 2.28)
High/very high	0.99 (0.72 to 1.37)	0.98 (0.70 to 1.36)	0.93 (0.68 to 1.28)	1.83 (1.04 to 3.22)	1.55 (0.80 to 2.98)	1.35 (0.72 to 2.51)
Age (in years)		1.00 (0.99 to 1.00)	1.00 (1.00 to 1.01)		1.00 (0.99 to 1.01)	1.00 (0.99 to 1.01)
Sex						
Male		1.00	1.00		1.00	1.00
Female		1.06 (0.90 to 1.25)	1.01 (0.86 to 1.18)		0.85 (0.64 to 1.13)	0.80 (0.59 to 1.07)
Education						
Primary education or less		1.00	1.00		1.00	1.00
Middle school		1.09 (0.89 to 1.33)	1.04 (0.86 to 1.27)		0.89 (0.65 to 1.22)	0.94 (0.68 to 1.32)
Vocational school, high school, incomplete university		1.10 (0.87 to 1.39)	1.04 (0.83 to 1.29)		0.94 (0.62 to 1.43)	0.94 (0.61 to 1.44)
University and postgraduate		0.98 (0.72 to 1.32)	0.93 (0.69 to 1.26)		1.10 (0.59 to 2.04)	1.12 (0.61 to 2.04)
Income						
0–3000		1.00	1.00		1.00	1.00
3001–5000		1.03 (0.87 to 1.23)	1.04 (0.87 to 1.24)		1.23 (0.91 to 1.66)	1.24 (0.92 to 1.67)
5001–8000		0.91 (0.74 to 1.13)	0.91 (0.74 to 1.12)		0.72 (0.47 to 1.10)	0.74 (0.49 to 1.11)
≥8001		0.93 (0.69 to 1.24)	0.96 (0.72 to 1.28)		0.68 (0.42 to 1.10)	0.70 (0.45 to 1.10)
Smoking intensity						
Non-daily			1.00			1.00
Daily light			0.75 (0.63 to 0.90)			0.70 (0.49 to 0.99)
Daily heavy			0.58 (0.48 to 0.70)			0.62 (0.44 to 0.87)

levels of smoking even after adjusting for individual-level SEP. Although most of these studies looked at smoking prevalence, studies looking at smoking intensity among smokers only (as our study did) also found that living in more deprived areas was associated with a higher intensity of smoking.<sup>6,7</sup> In contrast, a recent study in the Netherlands found no relationship between deprived urban areas and smoking status or smoking initiation, except that younger and more educated people living in deprived areas were more likely to initiate smoking than younger and more educated people living in non-deprived areas.<sup>37</sup> Likewise, some studies found differences in the usual relationship between neighbourhood deprivation and smoking by gender, with one study in the US A finding no effect among women.<sup>35</sup> Other studies found no relationship.<sup>9,38</sup> Similar studies in LMICs are limited. In Argentina, neighbourhood deprivation was not associated with current smoking among adolescents,<sup>39</sup> nor among adults in Buenos Aires.<sup>40</sup>

Very few studies have examined the relationship between neighbourhood deprivation and quit behaviour or smoking relapse. In a longitudinal study from the Netherlands, smokers living in the most deprived areas were less likely to quit compared with those in the most advantaged areas.<sup>8</sup> A cross-sectional Dutch study, though, found no relationship between living in deprived urban areas and smoking continuation (ie, not quitting).<sup>37</sup> A study in the USA found that people living in more disadvantaged areas were more likely to continue smoking.<sup>9</sup> Our results showed a mixture of relationships between neighbourhood deprivation with quit behaviour and relapse in Mexico. Smokers in the most deprived areas had the same likelihood of making a quit attempt as smokers in the least deprived neighbourhoods, although those living in low-deprivation or medium-

deprivation neighbourhoods were less likely to make a quit attempt. We cannot directly compare these results to the studies above, since they did not investigate quit attempts. When looking at quit success, we found limited evidence that people living in higher deprivation neighbourhoods may have a higher probability of successfully quitting, although only the results for medium versus very low deprivation neighbourhoods were marginally statistically significant ( $p=0.0617$ ). If this relationship proves accurate, this would be in the opposite direction of findings from the Netherlands and the USA, as aforementioned. Neighbourhood deprivation was not associated with relapse in our sample; this relationship has not been studied in HICs to our knowledge, but should be explored in future research.

In our study, higher neighbourhood deprivation was associated with less intense smoking, above and beyond individual-level SEP. In fact, for smoking intensity, quit attempts and quit success, neither individual-level education nor income was associated with the outcomes. For relapse, there was some evidence that higher education and higher income were associated with a higher likelihood of relapse. In many Mexican studies, higher individual-level SEP is associated with higher smoking prevalence.<sup>41–44</sup> Considering the level of development in Mexico, a middle-income country, the relationships between individual-level SEP and smoking behaviour appear to counter trends in other countries. Most LMICs, and countries with high levels of urbanicity, such as Mexico, show inverse relationships between individual-level SEP and smoking.<sup>41,42</sup> Since Mexico is an outlier in terms of the relationship between individual-level SEP and smoking, it may not be surprising that our neighbourhood-level results show the opposite relationship of previous studies of neighbourhood deprivation and smoking in HICs.

**Table 4** Adjusted risk ratios for smoking relapse associated with neighbourhood deprivation in the relapse sample, 2010–2012 International Tobacco Control (ITC) Mexico Survey

	Relapse Risk ratio (95% CI) (n=374)	
	Model 1	Model 2
Neighbourhood deprivation		
Very low	1.00	1.00
Low	1.37 (0.75 to 2.52)	1.42 (0.79 to 2.56)
Medium	1.31 (0.78 to 2.18)	1.40 (0.82 to 2.39)
High/very high	1.19 (0.66 to 2.14)	1.10 (0.57 to 2.15)
Age (in years)		0.99 (0.98 to 1.00)
Sex		
Male		1.00
Female		0.92 (0.74 to 1.13)
Education		
Primary education or less		1.00
Middle school		1.56 (0.88 to 2.74)
Vocational school, high school, incomplete university		1.30 (0.75 to 2.27)
University and postgraduate		2.26 (1.33 to 3.85)
Income		
0–3000		1.00
3001–5000		1.62 (1.12 to 2.35)
5001–8000		1.26 (0.88 to 1.79)
≥8001		0.68 (0.32 to 1.43)

In HICs, various pathways have been hypothesised and explored for understanding how neighbourhood deprivation impacts smoking. The neighbourhood socioeconomic environment may influence the area's social fabric, including factors such as social capital or crime and disorder, which could contribute to more smoking.<sup>45</sup> Likewise, tobacco control policies, including smoking cessation policies, the availability of tobacco products and tobacco advertising may represent ways in which the neighbourhood environment affects smoking.<sup>45</sup>

Without further research into the pathways through which neighbourhood deprivation influences smoking behaviour, it remains unclear why we see opposite or no relationships between neighbourhood deprivation and smoking outcomes in Mexico compared with HICs. The Mexican context, though, may be particularly important in this regard. For instance, Mexican smokers have a much lower intensity, and less frequent, consumption of cigarettes compared with smokers in HICs.<sup>46–47</sup> In addition, prior to and during this study period, Mexico implemented several Framework Convention on Tobacco Control policies, including introduction of pictorial health warnings<sup>48–49</sup>; implementation of smoke-free laws at the local level<sup>12–50</sup>; increased taxes on tobacco products<sup>51–53</sup> and prohibition of most tobacco advertising, promotion and sponsorship.<sup>54</sup> The relatively simultaneous implementation of a comprehensive set of tobacco control policies, along with lower levels of addiction, may have provided the broader context for potentially inverting the commonly found relationship between neighbourhood deprivation and smoking outcomes.

### Strengths and limitations

Our study is one of few studies in LMICs to explore the relationship between neighbourhood environment and smoking intensity, and, as far as we know, is the first to explore the relationship

with cessation behaviours. With respect to cessation, many of our estimates have wide CIs due to a limited sample size at the neighbourhood level (n=146 for smoking intensity and quit attempts, n=141 for quit success and n=136 for relapse), which limits power in nested studies such as ours. Since we are using Census data to describe neighbourhood deprivation, we may not be capturing the specific surroundings that are important to all of the study participants. Other limitations include specific aspects of the study design. Sampling from seven cities limits generalisability to rural areas or other cities in Mexico, although most Mexicans live in urban areas. Self-reporting bias may be an issue with some of the smoking behaviour measures, although previous validation studies in Mexico showed that salivary cotinine levels were highly correlated with the reported number of cigarettes smoked per day.<sup>55</sup> The study suffered from some loss to follow-up, with 83% follow-up from waves 4 to 5 and 79% follow-up from waves 5 to 6, which reduced our available sample size. Loss to follow-up may have introduced selection bias if it were related to the exposure and outcome measures. We do not expect that this was an issue with our data since it was not related to the two most consistent predictors of quit behaviour, intention to quit and addiction,<sup>56</sup> nor was it related to the exposure in the relapse sample. Also, the analytic samples included outcome measures from individuals at different waves. However, we do not expect that there were large changes from 2010 to 2012 (the years of the survey data) in how the proximal neighbourhood socioeconomic environment would have impacted smoking behaviour. In addition, our sample only includes smokers; investigating the influence of neighbourhood environments on a broader Mexican population that includes non-smokers will be another important future direction for this research. As a first step, this research can direct more in-depth studies of relevant geographical areas and specific pathways through which the place where Mexican smokers live may impact their smoking intensity and quit behaviour.

### CONCLUSIONS

Our study found that higher neighbourhood deprivation was associated with lower smoking intensity among a cohort of smokers in Mexico between 2010 and 2012. These findings are in contrast to results from HICs. The next step in this research will be to understand which specific characteristics of more deprived neighbourhoods are acting as buffers against worse smoking outcomes. In addition, it is unclear if these patterns will hold in other LMICs. If so, understanding these environments may help reduce and prevent smoking-related health disparities around the world.

### What this paper adds

- ▶ Our study is one of few studies in low-income and middle-income countries to explore the relationship between neighbourhood environment and smoking intensity, and, as far as we know, is the first to explore the relationship with cessation behaviours.
- ▶ In contrast to high-income countries, we found that living in higher deprivation neighbourhoods is associated with lower intensity of smoking among a cohort of smokers in Mexico.
- ▶ Results for cessation behaviours were more mixed.

**Contributors** NLF conceived the research, conducted the analyses and drafted the article. JFT conceived the research, assisted with data interpretation and critically

revised the article. BsdMJ, AO, LMR-S, EAS, MS and GTF assisted with data interpretation and critically revised the article. All authors approved the final version for publication.

**Funding** Funding for data collection came from the Mexican Consejo Nacional de Ciencia y Tecnología (Salud-2007-C01-70032), with additional funding for analysis provided by the National Cancer Institute at the National Institutes of Health (P01 CA138389), Canadian Institutes for Health (57897, 79551, and 115016). Additional support was provided to Geoffrey T Fong from a Senior Investigator Award from the Ontario Institute for Cancer Research and a Prevention Scientist Award from the Canadian Cancer Society Research Institute.

**Competing interests** None declared.

**Ethics approval** The ITC Mexico Survey was cleared for ethics by Research Ethics Boards or International Review Boards at the Instituto Nacional de Salud Pública (Mexico) and the University of Waterloo (Canada).

**Provenance and peer review** Not commissioned; externally peer reviewed.

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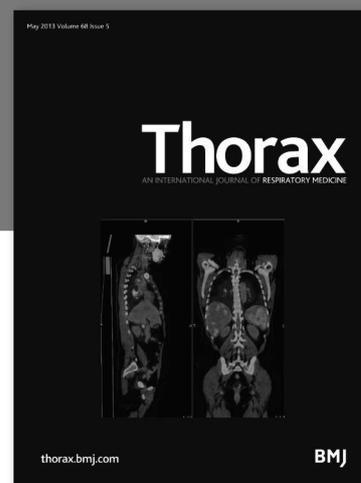
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