Effect of clean indoor air laws on smokers: the clean air module of the SimSmoke computer simulation model

David T Levy, Karen Friend, Eugene Polishchuk

Abstract

Objectives—To develop a simulation model to examine the effects of clean indoor air laws on prevalence rates and smoking attributable deaths.

Methods—Based on empirical and theoretical research, the effects of clean air laws are modelled by type of law. The model considers clean air laws at the state levels between 1993 and 2000, and projects the number of smokers and smoking attributable deaths in the USA under different scenarios from 2000 onward.

Results—The model predicts that comprehensive clean air laws have the potential to reduce substantially the number of smokers and smoking attributable deaths, and these effects are predicted to grow over time. The predicted impact of new worksite laws are reduced when previously implemented private and public worksite restrictions are taken into account.

Conclusions—Clean indoor air laws have the ability to reduce smoking rates substantially and save lives, but their impact is likely to depend on their comprehensiveness and prior private worksite restrictions in place.

Keywords: policy; clean indoor air laws; prevalence rates; smoking attributable deaths

Clean indoor air laws, such as laws against smoking in restaurants and workplaces, are often justified in terms of reducing the harmful effects of second hand smoke on nonsmokers. They may, however, directly influence the behaviours of smokers themselves. A large empirical literature finds that restrictions on smoking in work and public places have been associated with both decreased consumption and prevalence rates. They reduce opportunities to smoke and shape smoking behaviour through changes in social norms. Restrictions on smoking are generally a key element in comprehensive tobacco control strategies.

The purpose of this paper is to present a model that predicts the effects of clean indoor air laws on prevalence rates and deaths caused by smoking. We address the effects of clean air laws on different sociodemographic groups, and the role of social norms and reduced opportunities to smoke. In addition, the model is used to trace the impact of laws and of private restrictions that have already been implemented, and the effect of implementing stronger laws than those that presently exist throughout the USA.

Methods

THE SIMSMOKE MODEL

The clean air module is part of a larger computer simulation model of tobacco control policies, known as SimSmoke. That model predicts future prevalence rates and smoking attributable deaths across the US population and by age, sex, and racial/ethnic group.

Discussed at greater length elsewhere, SimSmoke begins with the number of smokers, never smokers, and six categories of ex-smokers (<1, 1–2, 3–5, 6–10, 11–15, >15 years) distinguished by age, sex, and racial/ethnic group in the baseline year 1993. As each cohort moves through time, the population model allows for births and deaths, and the smoking model allows for initiation, cessation, and relapse. A first order discrete Markov process is employed.

Smokers are defined as individuals who have smoked at least 100 cigarettes in their lifetime and are currently smoking. Individuals are classified as never smokers from birth until they initiate smoking or die. Since initiation generally occurs before the age of 25 years, initiation is modelled to occur until age 25. Initiation rates at a particular age are measured as the change in prevalence rate between those smoking at one age and those smoking at the previous age. This method insures that the number of smokers equals the number of actual smokers at age 25, rather than relying on separate, unstable measures of initiation and cessation for those under age 25.

Ex-smokers are defined as those who have smoked at least 100 cigarettes, and are not currently smoking. The rate at which smokers become ex-smokers depends on the first year quit rate (net of relapse). The first year average quit rate is calculated by the quit rate model with adjusters for the age, sex, and racial/ethnic groups. Smokers may relapse in future years.

The source of data on prevalence, initiation, and cessation rates by demographic group for those ages 15 and above is the 1992/3 tobacco supplement of the Current Population Survey, and for those below age 15, the 1993 Teenage Attitudes and Practices Survey. Relapse rates are based on various sources. Population data are from the 1993 Census of Population, fertility rates are from the US Census vital rate inputs tables, and mortality rates are from the 1993 multiple cause-of-death file.
Based on prevalence and cessation rates and on risks of smokers and ex-smokers relative to non-smokers, deaths attributable to smoking are predicted. Excess risk caused by smoking is calculated as the difference between death rates of a smoking category and the death rate of never smokers (where death rates are standardised to preserve the overall population death rate). Excess risk is multiplied by the population of the relevant demographic/smoking group projected for a particular year to obtain smoking attributable deaths. Deaths are distinguished by age, sex, and smoking groups, based on the Cancer Prevention Study II.14

ASSUMPTIONS AND STRUCTURE OF THE CLEAN AIR MODULE
In developing the clean air module, simplifications and estimates were developed with our expert advisers based on: (1) policy relevance, (2) empirical support, and (3) tractability.

Focus on clean air laws
Because SimSmoke is a public policy model, we consider the passage of laws requiring smoking bans. Instead of passing laws, public action may be taken to exhort businesses or homes to impose their own smoking bans voluntarily. We do not consider these public policies, because they are not commonly employed by government or empirically studied.

Laws implemented at the state level
Since SimSmoke uses US prevalence rates, we examine the policy effects at a national level. We assume, however, that policies are implemented by individual states, which commonly implement most clean air laws and are the subject of most empirical studies.3,4

Categories of clean air laws
The module includes four categories of clean air laws: workplaces, restaurants, schools, and other public places. Worksites are designated as a separate entity because smokers spend many waking hours at their places of employment. Although the number of hours an individual may spend in a restaurant per day or week is small, eating and smoking are often linked, and these laws typically generate much media attention. School clean air policies are included because they reduce opportunities to smoke and affect norms when they are actively publicised and enforced. In the model, they influence those below the age of 18 (for example, college bans are not considered).

“Other public places” denotes public places besides restaurants and schools, and includes shopping malls, retail stores (including grocery stores), enclosed arenas, and public transit.17 28 Restrictions in government buildings, hospitals and childcare centres are subsumed under workplace laws, and elevators, prisons, and hotels/motels were considered to have limited exposure. Although “other public places” are typically less controversial than restaurant bans, they further limit the places in which a smoker can smoke. In addition, they are often the first laws that states implement. They are classified as a single group rather than as separate sites for simplicity, and because there was little basis to distinguish their effects.

The effect of laws is likely to depend on how broadly they apply. We assume that the laws ban all smoking in the designated area, except for workplace laws. The partial workplace ban disallows smoking in work areas, but allows smoking in some designated common areas.

Publicity and enforcing the law
Efforts to pass clean air laws are generally accompanied by media publicity and community organisation. Media publicity after the law is enacted may be important in informing and getting business and other establishments to comply with the law and may shape social norms. Active enforcement may also increase the perception that smoking is not condoned and may be necessary to insure compliance with the laws in less politically mobilised communities.7 Empirical studies suggest that enforcement and publicity have an impact,19-22 but the magnitude could not be ascertained from studies.7 Publicity and enforcement are considered part of the policy.

Impact on smoking initiation and cessation
Prior studies of smoking restrictions4 have found the greatest effects on the amount smoked per smoker within six months, with some tendency for these effects to dissipate over time. Reductions in prevalence rates and increases in quit rates become more pronounced over time.4

Like other policy modules in SimSmoke, the effects of each clean air law are developed in terms of the percentage change in prevalence rates from their initial rate. The effects are assumed to occur directly through the prevalence rate, and indirectly through initiation and quit rates. For a particular demographic group, we apply the same percentage effect to each of these rates. The effect on the prevalence rate is applied in equal increments (one third of the total effect) to each of the first three years in which the law is implemented. This represents the immediate cessation that occurs in response to the laws. Decreases in the average amount smoked by those who continue smoking are expected to increase cessation further each year that a law is in effect.13 Increases in the one year quit rate each year that the law is in effect lead to further reductions in prevalence after the first three years. Reductions in prevalence during the first three years in which the policy is in effect are sustained through decreases in the initiation rate.

The structure of the model is shown in fig 1. The number of smokers is decreased directly through reductions in prevalence rates, and indirectly through higher cessation rates and lower initiation rates. As the number of smokers declines, fewer deaths are attributable to smoking.

Effects of policies are independent
Knowledge about the interactive effects of other tobacco control policies, such as media
policies and taxes, with clean air laws is limited. There may be a synergistic relationship of different policies on social norms and/or smoking behaviours. Alternatively, if other policies (for example, taxes) already reduce smoking opportunities, clean air laws may have less impact. In accordance with other policy modules, we make the neutral assumption that the effects of policies are independent of each other—that is, the effects of clean air laws on prevalence rates are unaffected by other policies in place.

Prior studies also do not explicitly consider interactive effects between each type of clean air law. While there may be synergistic effects of the laws on social norms, a restaurant law alone may have a greater effect on norms than its incremental impact with a worksite ban already in place. We assume that the effects of different clean air laws are independent.

Health impacts limited to smokers

Considerable evidence links exposure to smoke with health and even deaths to non-smokers, and this evidence provides a strong justification for the passage of clean air laws. The current version of SimSmoke, however, is limited to considering only the deaths of smokers. The effects of clean air laws on non-smokers will be considered separately when deaths from environmental tobacco smoke are incorporated into SimSmoke.

MAGNITUDE OF EFFECTS

In comparing an extensive law (including worksite, restaurant and other public places) to a minimal clean air law, Emont et al and Ohsfeldt et al found 12–14% reductions in prevalence rates. Chaloupka and Saffer, Wasserman et al, and Yurekli and Zhang found 4–20% reductions in per capita consumption, which includes changes in quantity smoked by continuing smokers and prevalence, and thus serves as an upper bound. Based on these studies, Levy and Friend estimate a 10% reduction in prevalence rates, with a range of 6–14%, as a result of extensive laws within three years after implementation.

Prior literature provides limited evidence on the effects of separate clean air laws, except worksite laws. To distinguish the effects, we considered how laws affect social norms and smoking opportunities.

Workplace laws

Ohsfeldt et al found that 60–70% of the effects of clean air laws were attributable to worksite laws. Using the 10% reduction for extensive laws, a 6–7% reduction in prevalence rates was attributable to worksite laws. Both individual worksite and population based studies indicated that workplace restrictions implemented by private entities reduced prevalence rates by 10–20%, with most population based studies finding effects closer to 20%. Since only 63% of the adult population worked in 1993 and 67% of workers worked indoors, the effects would be applied to 42% (67% of 63%) of the adult population. Thus, the 10–20% reductions found in studies of workers would imply a 4–8% reduction for the overall adult smoking population. These results are consistent with the 6–7% estimate from Ohsfeldt et al. We estimate a total reduction of a 7% in the average prevalence rate for the adult population.

A less than a complete ban provides the worker greater opportunity to smoke at work. Farrelly et al and other studies have found that partial bans had about half or less than half the effect of a complete ban. In addition, partial bans may not be readily enforceable. We estimate that partial bans have one third the impact of a full ban (that is, a 2% reduction in prevalence rates).

The effects of worksite laws may vary by demographic group, because of different reactions to worksite laws or variations in labour participation rates. Based on labour force participation rates, prevalence rates in SimSmoke, and results from Farrelly et al, we multiplied the effect of workplace laws by a factor of 1.06 for whites, Asians, and others and by a factor of 0.65 for African Americans and Hispanics. Farrelly et al do not find differences in reactions by males and females; female participation rates are on average 80% that of males and females. We scaled the effect on males by a factor of 1.10 and the effect on females by a factor of 0.91. Conflicting effects by age group were found by Farrelly et al and by Ohsfeldt et al. Correcting only for differences in labour participation rates, we scaled the effects of those ages 18–29 by a factor of 0.9, those ages 20–25 by 1.05, those ages 26–35 by 1.11, those ages 36–49 by 1.10, those ages 50–59 by 0.90, those ages 60–79 by 0.5, and those ages 80–89 by 0%. We estimated that smokers below 18 years of age do not reduce their prevalence rates except through reductions in initiation rates. They are much less likely to work a significant number of hours, but initiation rates are affected through norms and the reduced availability through parents and older peer smokers.
Table 1 Percentage change in prevalence rates from clean air laws with no prior policies

<table>
<thead>
<tr>
<th>Year</th>
<th>BAU (%)</th>
<th>WP (%)</th>
<th>WP partial (%)</th>
<th>Restaurant (%)</th>
<th>Other places (%)</th>
<th>Schools (%)</th>
<th>All policies (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>18.5</td>
<td>-2.3</td>
<td>-0.7</td>
<td>-0.7</td>
<td>-0.3</td>
<td>0.0</td>
<td>-3.3</td>
</tr>
<tr>
<td>2001</td>
<td>18.4</td>
<td>-4.2</td>
<td>-1.4</td>
<td>-1.2</td>
<td>-0.6</td>
<td>-0.1</td>
<td>-6.1</td>
</tr>
<tr>
<td>2002</td>
<td>18.3</td>
<td>-6.0</td>
<td>-2.0</td>
<td>-1.8</td>
<td>-0.9</td>
<td>-0.1</td>
<td>-7.1</td>
</tr>
<tr>
<td>2003</td>
<td>18.2</td>
<td>-6.0</td>
<td>-2.0</td>
<td>-1.8</td>
<td>-0.9</td>
<td>-0.1</td>
<td>-7.2</td>
</tr>
<tr>
<td>2004</td>
<td>18.1</td>
<td>-6.0</td>
<td>-2.0</td>
<td>-1.8</td>
<td>-0.9</td>
<td>-0.1</td>
<td>-7.4</td>
</tr>
<tr>
<td>2005</td>
<td>18.0</td>
<td>-6.1</td>
<td>-2.1</td>
<td>-1.8</td>
<td>-0.9</td>
<td>-0.1</td>
<td>-7.5</td>
</tr>
<tr>
<td>2006</td>
<td>17.6</td>
<td>-6.3</td>
<td>-2.1</td>
<td>-1.9</td>
<td>-0.9</td>
<td>-0.2</td>
<td>-8.1</td>
</tr>
<tr>
<td>2015</td>
<td>17.1</td>
<td>-6.6</td>
<td>-2.2</td>
<td>-2.0</td>
<td>-1.0</td>
<td>-0.2</td>
<td>-8.7</td>
</tr>
<tr>
<td>2020</td>
<td>16.6</td>
<td>-6.7</td>
<td>-2.3</td>
<td>-2.1</td>
<td>-1.0</td>
<td>-0.3</td>
<td>-9.2</td>
</tr>
<tr>
<td>2025</td>
<td>16.0</td>
<td>-6.9</td>
<td>-2.4</td>
<td>-2.2</td>
<td>-1.1</td>
<td>-0.3</td>
<td>-9.7</td>
</tr>
<tr>
<td>2030</td>
<td>15.5</td>
<td>-7.1</td>
<td>-2.4</td>
<td>-2.3</td>
<td>-1.1</td>
<td>-0.4</td>
<td>-10.1</td>
</tr>
<tr>
<td>2035</td>
<td>15.2</td>
<td>-7.2</td>
<td>-2.5</td>
<td>-2.3</td>
<td>-1.1</td>
<td>-0.4</td>
<td>-10.5</td>
</tr>
<tr>
<td>2040</td>
<td>15.0</td>
<td>-7.3</td>
<td>-2.5</td>
<td>-2.3</td>
<td>-1.1</td>
<td>-0.5</td>
<td>-10.8</td>
</tr>
</tbody>
</table>

Percent change = (BAU prevalence rate – prevalence rate under policy)/BAU prevalence rate. BAU, business as usual; WP, workplace.
Table 2  Lives saved under clean air policies with no prior policies

<table>
<thead>
<tr>
<th>Year</th>
<th>Business as usual</th>
<th>Total WP</th>
<th>WP partial,</th>
<th>Restaurant,</th>
<th>Other places,</th>
<th>Schools,</th>
<th>All policies,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>lives saved</td>
<td></td>
<td></td>
<td>lives saved</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>421494</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>440990</td>
<td>21124</td>
<td>7089</td>
<td>6190</td>
<td>3107</td>
<td>0</td>
<td>24251</td>
</tr>
<tr>
<td>2010</td>
<td>469959</td>
<td>24217</td>
<td>8136</td>
<td>7227</td>
<td>3628</td>
<td>0</td>
<td>28120</td>
</tr>
<tr>
<td>2015</td>
<td>479987</td>
<td>27122</td>
<td>9124</td>
<td>8221</td>
<td>4128</td>
<td>0</td>
<td>31901</td>
</tr>
<tr>
<td>2020</td>
<td>499887</td>
<td>29893</td>
<td>10075</td>
<td>9160</td>
<td>4602</td>
<td>33</td>
<td>35658</td>
</tr>
<tr>
<td>2025</td>
<td>511831</td>
<td>32431</td>
<td>10954</td>
<td>10024</td>
<td>5037</td>
<td>98</td>
<td>39296</td>
</tr>
<tr>
<td>2030</td>
<td>517068</td>
<td>34718</td>
<td>11570</td>
<td>10626</td>
<td>5341</td>
<td>172</td>
<td>41997</td>
</tr>
<tr>
<td>2035</td>
<td>504823</td>
<td>34741</td>
<td>11789</td>
<td>10847</td>
<td>5443</td>
<td>280</td>
<td>43318</td>
</tr>
<tr>
<td>2040</td>
<td>475440</td>
<td>34095</td>
<td>11602</td>
<td>10665</td>
<td>5361</td>
<td>442</td>
<td>43268</td>
</tr>
</tbody>
</table>

Lives saved = business as usual lives lost − lives lost under policy.
WP, workplace.

Table 3  Indices of clean air policies in existence from 1993-2000 in percentage terms

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Worksite full</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private firms</td>
<td>59.5</td>
<td>63.5</td>
<td>67.5</td>
<td>71.5</td>
<td>72.9</td>
<td>74.3</td>
<td>75.8</td>
<td>75.8</td>
</tr>
<tr>
<td>Laws</td>
<td>11.3</td>
<td>15.5</td>
<td>15.8</td>
<td>15.8</td>
<td>16.7</td>
<td>17.2</td>
<td>17.2</td>
<td>17.2</td>
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<tr>
<td>Final index</td>
<td>50.9</td>
<td>55.3</td>
<td>57.4</td>
<td>60.2</td>
<td>61.0</td>
<td>61.9</td>
<td>62.5</td>
<td>62.3</td>
</tr>
<tr>
<td>Worksite partial</td>
<td>81.7</td>
<td>83.7</td>
<td>84.8</td>
<td>86.2</td>
<td>87.3</td>
<td>88.5</td>
<td>89.6</td>
<td>89.5</td>
</tr>
<tr>
<td>Restaurant</td>
<td>17.2</td>
<td>19.0</td>
<td>19.5</td>
<td>19.7</td>
<td>19.9</td>
<td>20.8</td>
<td>20.8</td>
<td>20.8</td>
</tr>
<tr>
<td>Other places</td>
<td>12.8</td>
<td>13.1</td>
<td>13.5</td>
<td>13.5</td>
<td>13.0</td>
<td>13.7</td>
<td>13.7</td>
<td>13.7</td>
</tr>
<tr>
<td>School</td>
<td>38.5</td>
<td>45.7</td>
<td>45.7</td>
<td>45.7</td>
<td>45.7</td>
<td>45.7</td>
<td>48.2</td>
<td>48.2</td>
</tr>
</tbody>
</table>

Indices are weighted averages of state and local laws multiplied by 100, except for worksite which is a the law index multiplied by a private index of the percent of workers in firms that have total or partial ban smoking bans. See text for details.

Results

EFFECTS OF CLEAN AIR LAWS IN THE ABSENCE OF PRIOR POLICIES

We first examined the effects of clean air laws in the absence of prior laws and restrictions by private firms. These results may be used to gauge the potential effect of the laws.

As shown in table 1, prevalence rates as a percentage of the total population (including those age 18) in the absence of new laws are projected to fall from 18.5% in the year 2000 to 15.0% in the year 2040. With a smoke-free workplace law alone, prevalence rates fall by slightly more than 2% relative to its initial rate in the first year of the policy, and about an additional 2% each of the next two years. The effects continue over time reaching a 7.3% reduction in prevalence rates by the year 2040 as young adults enter the work force and cessation rates are maintained at higher levels. We suggested above that the range of effects for worksite laws would be 4–8% within three years, translating to a range of 4.5–9% reductions in the prevalence rate over longer periods.

When partial workplace laws are implemented (allowing smoking in common, but not work areas), we project that prevalence rates are reduced by about one third that of a complete ban, peaking at 2.5%.

Laws prohibiting smoking in restaurants, schools, and other places show similar patterns, but are predicted to have smaller effects than workplace laws. By the year 2040, a restaurant ban and laws banning smoking in three or more public places are, respectively, predicted to yield a 2.3% and 1.1% reduction in prevalence rates relative to their initial value.

While laws banning smoking in schools are estimated to reduce prevalence rates of youth by 1%, they are predicted to have smaller effects on the smoking population as a whole. In the first four years, they have less than a 0.1% effect, but their effects reach 0.5% by the year 2040 as youth smokers age.

A 7.2% effect is predicted after the first three years when all laws are simultaneously implemented, and a relative reduction in the prevalence rate of 10.8% is predicted by 2040. We suggested above that the range of effects for comprehensive laws lie between 6–14% within three years, translating to a range of 6.5–15% reductions in the prevalence rate over longer periods.

As shown in table 2, the number of deaths attributable to smoking in the year 2000 are 421 494 and increase to 517 068 by the year 2030 and then fall. The effects of clean air laws on death rates build more slowly over time than on prevalence rates. A worksite law is predicted to save over 20 000 lives per year within five years and 34 095 lives per year by 2040. Except for the effect of school laws, public area laws lead to slightly slower growth patterns than worksite laws (since the effects are less concentrated on older smokers). Since school laws affect youth, who generally do not die from smoking until they reach age 40, lives are not saved until the year 2020 and reach about 450 in the year 2040.

Adding each of the other laws leads to a saving of 43 268 lives per year by 2040. Given a range of reductions of 6–14% within three years, the range of effects for comprehensive laws is between about 26 000–60 100 lives saved per year by 2040.

POLICIES IMPLEMENTED IN 1993-2000

The indices of prior worksite and other clean air policies for the years 1993 through 2000 are shown in table 3. The index of state workplace laws increases from about 11% in 1993 to 17% in 2000, mostly because of new laws in the states of California, Massachusetts, Maryland, and Washington. The index of private workplace restrictions increases from about 60% to 75% between 1993 and 2000. After incorporating labour participation, the combined index of past laws and private practices increases from about 51% to 62% between 1993 and 2000. We estimated that 81% of the firms had implemented at least partial bans in 1993, with an increase to 90% by the year 2000. From 1993 to 2000, we estimated an increase in the states with strong restaurant laws from 17% to 21%, schools from 39% to 48%, and of other public places from 13% to 14%.

Table 4 presents the predicted effects of clean air laws after taking into account the effect of current laws and policies and of private workplaces with smoking restrictions. Comparing the business as usual levels of policy already in place by 33%. Further adjustments incorporate changes in labour participation rates, which increased by 6% between 1993 and 2000. We assume that effects of a law are randomly distributed over existing firms independent of their worksite practices. The final index for the worksite laws was obtained by multiplying (1 − state laws index) by (1 − private worksite ban index) and by the labour participation index.
prevailing rates in the year 2000 of tables 1 and 3, policies implemented between 1993 and 2000 were only predicted to have reduced relative prevalence rates by 0.5% in the year 2000 (18.5% relative to 18.4%). We predict a total of 2042 lives per year in the year 2000 (not shown in table) are saved as a result of laws implemented between 1993 and 2000, with deaths reduced from 421 494 to 419 452.

Implementation of comprehensive laws in the year 2000 is predicted to reduce the prevalence rate by about 5.7% by the year 2003 and by almost 6% in 2040 (table 4). The effects of a comprehensive law are almost equally distributed between worksite laws and the other laws. The total reduction is just more than half of the 11% predicted in the absence of any prior restrictions (table 1), because a large percentage of firms already had worksite bans by 2000. Lives saved (not shown) are correspondingly reduced when prior restrictions are taken into account.

Discussion

The simulation model predicted that comprehensive clean air laws with active enforcement and publicity reduce prevalence rates by 11% relative to their initial rate in states without prior public and private restrictions. The model predicts that over 20 000 lives are saved each year within five years after the laws are implemented. The predicted effects of a comprehensive law in a state without any prior laws are larger than those predicted from a large scale media campaign or a $0.50 tax hike. Unlike other policies, such as youth access interventions and even taxes, the effects of clean air laws are greatest on those aged 25–50, when work participation is highest. The effects on health are more immediate than other policies, because the number of smoking attributable deaths are greatest at the ages of 45–65 when deaths from smoking are more imminent.

The model predicts that worksite laws have the largest effect of the clean air laws and lead to a 7% reduction in the prevalence rate. Smaller effects are predicted for restaurant, schools, and other public places, with greater uncertainty placed on the estimates. While past studies provide a strong basis for claiming that clean air laws affect smoking behaviours of the adult smoking population, the ability to determine estimates of the effects of specific types of clean air laws is limited.

Our review of studies suggests that there is uncertainty about the effects of clean air laws. Knowledge of the effects on different sociodemographic groups is also incomplete. In particular, better information is needed on the effects on youth and young adults.

When the effect of laws and private policies already implemented in the USA is taken into account, the effects of newly implemented laws are predicted to be smaller, especially for worksite laws. Unfortunately, past empirical studies of clean air laws do not consider the role of private workplace restrictions that are already in effect, and studies of private restrictions do not consider the effect of clean air laws. Clean air laws are likely to have greater effects on workers in firms that have not previously had clean air restrictions, but even prevalence rates in those firms may be reduced if the laws increase anti-smoking sentiment or make it more difficult for workers to switch jobs to firms without smoking bans. Enforcement and publicity surrounding clean air laws may influence these effects, but have also received little attention in empirical studies.

The model predicts that the effects occur most in the first three years after a new law and then grow at much slower rates in future years. While empirical studies indicated that smoking restrictions first affect the quantity of cigarettes and later lead to cessation, knowledge about the interaction between reductions in quantity smoked and future quits is lacking. Knowledge about the effects on smoking initiation is also limited.
The model examines policies at the state level. Local laws may have greater community support, and thus may more strongly reinforce norms. However, laws at a local level may be more easily circumvented by smokers working for an employer or going to a restaurant without smoking restrictions, and are also subject to different enforcement mechanisms. Further information is needed on local as compared to state policies.

Finally, past studies have not considered how the effects of clean air laws depend on other types of tobacco control policies. Because clean air laws reduce secondhand smoke, they may play an important role in garnering support for other policies. Knowledge of the effects of tobacco control policies, alone and in combination, and how they affect different sociodemographic groups, will be important in developing comprehensive strategies to reduce prevalence rates.

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David T Levy, Karen Friend and Eugene Polishchuk

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