Additional Information Sources

16. American Journal of Health Promotion (2011) *Secondhand Smoke Exposure Among Hispanics/Latinos Living in Multiunit Housing: Exploring Barriers to New Policies*

17. Apartment Management (2011) *Apartment Owners Benefit from Smoke-Free Housing Policies*

18. ASHRAE Journal (2014) *The Hazards of E-Cigarettes*

19. ASHRAE (2010) *Position Document on Environmental Tobacco Smoke*

20. Circulation: Journal of the American Heart Association (2014) *E-Cigarettes: A Scientific Review*

21. The Center for Tobacco Policy and Organizing (2014) *List of Municipalities that Restrict Smoking in Recreation Areas*

22. The Center for Tobacco Policy and Organizing (2014) *List of Municipalities that Restrict Smoking in Service Areas*

23. The Center for Tobacco Policy and Organizing (2011) *Understanding California's New Smokefree Housing Law*

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Tobacco Control/Underserved Populations

Secondhand Smoke Exposure Among Hispanics/ Latinos Living in Multiunit Housing: Exploring Barriers to New Policies

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Abstract

Purpose. *Despite a high prevalence of voluntary home smoking bans and laws protecting Californians from exposure to secondhand smoke (SHS) in the workplace, many Hispanic/Latino (H/L) residents of multiunit housing (MUH) are potentially exposed to SHS from neighboring apartments. An advocacy/ policy intervention was implemented to reduce tobacco-related health disparities by encouraging H/L living in MUH to implement voluntary policies that reduce exposure to SHS. This article presents findings from qualitative and quantitative data collected during development of the intervention, as well as preliminary results of the intervention.*

Design, Setting, and Subjects. *MUH residents in Southern California participated in focus groups (n = 48), door-to-door surveys (n = 142), and a telephone survey (n = 409).*

Measures. *Exposure to SHS, attitudes toward SHS, and attitudes toward policies restricting SHS in MUH were assessed.*

Results. *H/L MUH residents reported high levels of exposure to SHS and little ability to protect themselves and their families from SHS. Respondents expressed positive attitudes toward adopting antismoking policies in MUH, but they also feared retaliation by smokers. The cultural values of familismo, respeto, simpatía, and personalismo influenced their motivation to protect their families from SHS as well as their reluctance to ask their neighbors to refrain from smoking. Nonsmokers were more likely to favor complete indoor and outdoor smoking bans in MUH, whereas smokers were more likely to favor separate smoking areas. The Regale Salud advocacy/policy intervention, implemented to reduce SHS exposure, prompted the passage of seven voluntary policies in apartment complexes in Southern California to prevent smoking in MUH.*

Conclusions. *H/L in California support voluntary policies, local ordinances, and state laws that prevent exposure to SHS in MUH, especially those that are consistent with H/L cultural values and norms for interpersonal communication. (Am J Health Promot 2011;25[5 Supplement]:S82–S90.)*

Key Words: Tobacco, Secondhand Smoke, Hispanic, Latino, Multiunit Housing, Apartment, Prevention Research. Manuscript format: research; Research purpose: descriptive, program evaluation; Study design: nonexperimental; Outcome measure: cognitive, behavioral; Setting: local community; Health focus: smoking control; Strategy: policy; Target population age: adults; Target population circumstances: low income, Hispanic/Latino, California

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PURPOSE

California has been a natural laboratory and an exemplar for antismoking policies in the United States and around the world.[1–3] Although much progress has been made in the United States and California in reducing tobacco prevalence, exposure to secondhand smoke (SHS) still impacts more than 126 million nonsmoking Americans.[4] Disproportionate exposure to SHS among minority groups, including Hispanic(s)/Latino(s) (H/L), could exacerbate tobacco-related health disparities.

SHS Exposure in the H/L Community

The H/L community is the largest minority population in the United States, and nearly one-third of U.S. H/L live in California.[5] Although the prevalence of smoking among H/L adults in California is relatively low compared with that of other ethnic groups,[6] H/L are disproportionately exposed to SHS in the workplace. California's Smoke-Free Workplace Law (Law 6404.5 of the California State Labor Code) prohibits smoking in all indoor workplaces with more than five employees.[7] However, many H/L workers are not covered by this law. A disproportionately high number of H/L have jobs in small-service occupations with only a few employees (e.g., automotive shops, employment within a private home), where California's smoke-free workplace laws do not apply. Between 1990 and 2008, H/L nonsmokers have consistently reported the highest amount of exposure to

SHS in indoor work areas, compared with other ethnic and racial groups.[8,9]

Because of their lower average socioeconomic status, H/L in California are more likely than non-Hispanics to live in multiunit housing complexes (MUH; 46% of H/L vs. 37% of non-Hispanics).[10] MUH are apartment buildings, townhouses, or condominiums that share common walls and/or common areas such as hallways, laundry rooms, parking garages, stairwells, or courtyards. Although most H/L households have complete or partial smoking bans to protect children from SHS exposure,[9,11] H/L residents living in MUH are at risk for exposure to SHS from neighboring units. California's Smoke-Free Workplace Law does apply to MUH complexes that employ five or more workers, including managers and maintenance workers. The law requires that all enclosed common areas, including lobbies, halls, laundry rooms, stairways, elevators, recreation rooms, and the manager's office, in a MUH complex be smoke-free.[12] However, the law does not protect the residents in MUH from being exposed to SHS from smoke drifting into their units from neighboring units or outdoor areas. The California Division of Occupational Safety and Health reported that ''tobacco smoke travels from its point of generation in a building to all other areas of the building…through light fixtures, through ceiling crawl spaces, and into and out of doorways.''[13] In California's warm climate, windows and doors are often open, allowing unimpeded flow of smoke. Although levels of exposure to SHS have decreased by 70% between the late 1980s and 2002,[14] protection from SHS in the H/L community remains a priority in California's H/L health agenda.

Voluntary Policies

Although most California households have complete or partial smoking bans,[7,15] voluntary policies to protect MUH residents from SHS from neighboring units or outdoor areas are rare. Voluntary smoking bans in MUH could be useful not only in protecting nonsmokers from SHS exposure but also in supporting smokers in their quit attempts, helping them to continue refraining from smoking, and preventing youth from initiating smoking.[7,16,17] According to a statewide California survey in 2004 to 2005,[18] the majority of apartment residents and owner/managers favored a law requiring all apartment buildings to offer nonsmoking sections. Nearly one-half of the apartment owners and managers had received complaints from tenants about SHS exposure.

***Regale Salud*—An Advocacy/Policy Intervention to Reduce Exposure to SHS in Predominantly H/L MUH**

Regale Salud (Give the Gift of Health) is an intervention that uses the environmental change model to reduce tobacco-related health disparities by encouraging voluntary policies to control SHS exposure among H/L MUH residents. This intervention has been designated a model program by the Centers for Disease Control's National Latino Tobacco Control Network and is being implemented in California and several other states. To the authors' knowledge, it is the only SHS prevention program specifically targeted toward H/L MUH residents.

The *Regale Salud* intervention incorporates and addresses H/L cultural values, which have been described in detail elsewhere.[19,20] Some of these cultural values may make individuals reluctant to ask others not to smoke, such as *respeto*—a norm of treating others with respect or admiration and not interfering with their personal decisions; *personalismo*—relating to others on a personal, friendly level; and *simpatía*—maintaining agreeable social relationships and avoiding direct confrontation. These cultural values may make H/L residents feel that it is not appropriate to ask their neighbors to change their smoking habits or that doing so might jeopardize their relationships with neighbors who smoke. Other cultural values emphasize the importance of the immediate and extended family over the individual, which includes the responsibility to protect children from SHS. The most salient of these values is *familismo*—respect, loyalty, and unity within the immediate and extended family, including the responsibility to take care of family members. These cultural values are common to most H/L groups, but some are endorsed more strongly than others depending on acculturation, personality, and individual differences. The *Regale Salud* program attempts to educate all apartment residents, managers, and owners about the problem of SHS so that they can implement voluntary policies in a collectivist manner rather than waiting for individual residents to initiate confrontations.

Regale Salud calls for individuals in the H/L community to advocate for and adopt voluntary nonsmoking policies to protect workers, residents, and families beyond the parameters of the California Smoke-Free Workplace Law. The premise is that health is a gift that can be given by anyone, including smokers who want to protect others from the dangers of SHS. The intervention consists of multiple phases (outlined briefly in Table 1).

An essential element of *Regale Salud* involves convincing apartment owners that their tenants really are bothered by SHS and would support smoke-free policies. To gather evidence to support this claim, we conducted three phases of research, using mixed quantitative and qualitative methods. A community-based participatory research model was used, involving community members and local stakeholders throughout the process. The qualitative portion of the research consisted of focus groups to explore the issue of SHS in the home among H/L MUH tenants. The focus group findings were used to inform the development of a door-to door intercept survey and a telephone survey to assess attitudes toward implementing voluntary antismoking policies in MUH. These two survey methodologies were used to increase representativeness and generalizability of the sample; door-to-door intercept surveys are more expensive and typically cover more limited geographical areas, whereas telephone surveys can cover wider areas but are limited to residents who have landline telephones and are listed in telephone directories. After describing the findings from the three data collection phases, we present preliminary outcomes of the implementation of the *Regale Salud* intervention.

METHODS

All data collection methods described below were approved by the institutional review board.

Table 1
Phases of the *Regale Salud* Intervention

Phase	Objective	Specific Activities
1	Establish objectives and gather baseline data	Survey residents of specific apartment complexes Determine extent of problem and level of support
2	Determine level of capacity building necessary to implement program	Identify leaders in community; identify people, organizations, coalitions, and other groups that could be involved; assess their capacity and readiness to act
3	Identify allies and opposing forces	Determine level of support for advocacy/policy campaign Partner with other service providers such as California Smokers' Helpline Offer to provide information and technical assistance
4	Identify participants and develop materials	Form committees of residents, managers, owners, and business patrons Establish framework of mutual respect and equity Develop materials that are culturally acceptable and language appropriate Pilot-test the materials
5	Implement intervention	Establish effective communication systems, acknowledging culture, language, and educational levels Educate residents, managers, and owners about voluntary policies Encourage policy adoption and enforcement
6	Recognize efforts	Capitalize on local media opportunities to publicize program and acknowledge participants Place ads in local media Document results with formal evaluation

Phase 1: Focus Groups

Method. In 2005 to 2007, five focus groups were conducted with H/L in Los Angeles County, Riverside County (southeast of Los Angeles), San Bernardino County (east of Los Angeles), and Fresno County (in central California, northwest of Los Angeles). These areas were selected because of their large and rapidly growing H/L populations and because they include urban and suburban areas. The apartment complexes selected consisted of at least 93% residents of Mexican origin and had no smoking restrictions currently in place.

The protocol and focus group guide were developed by staff from the H/L Tobacco Education Network and pilot tested with one group of H/L MUH residents. Questions assessed residents' self-reported SHS exposure, opinions about the extent of the problem of SHS, perceptions of the effects of SHS, willingness to take action in favor of voluntary policies, and perceptions of potential advantages and disadvantages of voluntary policies. Verbal assent was received from each participant. The focus groups were audio-recorded, and a Spanish-speaking staff member recorded notes. Participants received educational pamphlets about tobacco and small token gifts worth approximately $5 (e.g., hats, tote bags, writing pads, water bottles imprinted with the *Regale Salud* logo).

Analyses. Audio-recordings were transcribed verbatim by a trained Spanish-speaking staff member. Two bilingual staff members translated the Spanish text into English independently, compared their translations, and agreed on a final English version. Focus group data were coded and analyzed thematically using Nud*ist qualitative software, and responses were collapsed accordingly by two senior researchers who served as focus group raters.

Phase 2: Door-to-Door Intercept Surveys

Method. To obtain a broader understanding of the feasibility of implementing voluntary policies in MUH, we conducted a door-to-door intercept survey of 142 apartment residents in Los Angeles and Riverside Counties in 2007. Apartment complexes were selected based on their high proportions of low-income H/L residents. Of the 18 apartment complexes approached, 7 agreed to participate. Surveys were conducted on weekends to maximize participation. The survey was conducted by three pairs of bilingual data collectors, who knocked on every other door of the selected complexes. The data collectors delivered an introductory script, obtained consent, and administered the 12-minute survey in the respondent's preferred language. Participants received educational pamphlets about tobacco and small token gifts worth approximately $5 (e.g., hats, tote bags, writing pads, water bottles imprinted with the *Regale Salud* logo).

Survey questions were developed from the focus group findings and from existent surveys endorsed by California's Clean Air Project of the American Lung Association and other materials available through the California Tobacco Control Program evaluation technical assistance provider. Two bilingual staff members independently translated the survey into Spanish and then compared their translations to create a final Spanish version of the survey. The Spanish survey was pilot-tested with several Spanish-speaking adults in Los Angeles to identify any ambiguous wording or unfamiliar idioms. Questions assessed residents' perceived harm of SHS, whether and where they had been exposed to SHS, and how much SHS bothered them. We also asked about their support for voluntary smoking bans in their apartment complex.

Analyses. Frequencies were calculated and compared with the focus group findings to detect similarities and differences.

Phase 3: Telephone Survey

Method. In partnership with the Center for Policy and Organizing, we conducted a telephone survey to assess knowledge and attitudes about smoke-free MUH among H/L MUH residents in 2006. The sample was obtained from a commercially available listing of apartment renters with H/L surnames who were listed in the telephone directory. Because some people with H/L surnames are not H/L, the interviewer verified that the participants self-identified as H/L before proceeding with the survey. Questions focused on living conditions, type of dwelling, household composition, SHS exposure, and attitudes about policies to prohibit smoking in MUH. Two bilingual staff members independently translated the survey into Spanish and then compared their translations to create a final Spanish version of the survey. The Spanish survey was pilot-tested with several Spanish-speaking adults in Los Angeles to identify any ambiguous wording or unfamiliar idioms. The 30-minute survey was administered by a bilingual call center. Respondents were not compensated for their participation.

Analyses. Frequencies and univariate statistics were calculated. Attitudes toward SHS and smoking bans were compared between smokers and nonsmokers with χ^2 tests.

RESULTS

Phase 1: Focus Groups

A total of 48 participants attended the focus groups, with six to eight participants per group. More than half of the participants (53.6%) were from Riverside County. Sixty-five percent of the participants were female, and 35% were male. Almost half of the participants (46%) were between the ages of 26 and 40 years, and almost one-third (29%) of the participants were 55 years and older. All participants were monolingual Spanish speakers.

All participants knew that SHS had harmful health effects. Most of the participants (71%) reported being exposed to SHS at home or work, and 65% felt that SHS was a problem where they lived. Participants reported being exposed to SHS from neighbors smoking in their units or in common areas. Some were exposed to the smell of cigarette smoke when family members came home after smoking or being with smokers. Participants expressed concern about the effects of SHS on children. Most (85%) did not have a written or verbal policy prohibiting smoking in their building, but 71% believed that it would be possible to obtain support for a written voluntary policy prohibiting smoking in common areas. Participants, including smokers, expressed support for the establishment of smoke-free policies in common areas, with appropriate signage.

Three broad themes emerged: (1) impact of SHS exposure in MUH, 2) protection of themselves and their families from SHS exposure, and (3) attitudes toward the implementation of voluntary policies that protect residents from SHS exposure.

Theme 1: Impact of Exposure to SHS. Several questions focused on how SHS affected MUH residents. Participants' responses centered on how the smoke penetrated the apartment units, regardless of whether the smoker was indoors or outdoors. They also expressed hesitancy about asking people not to smoke because they value their friendship. The value of *simpatía* was evident. One participant expressed her conflict between disliking smoke and not wanting to offend her neighbors:

> ''It affects me a lot because I don't smoke. When I open the door I can smell the cigarette. The smoker is always happy, but I'm not. See, there are three neighbors that are always smoking, but they are good people, and I like them very much. But they smoke too much. Although they are smoking outdoors the smell still comes inside my apartment.''

Theme 2: Protecting Themselves and Their Families From SHS Exposure. When asked about what they have done to avoid exposure to SHS, respondents mentioned several strategies. However, these strategies were not sufficient to protect them completely:

> ''We close the doors. We place towels or a cloth under the doors. But it doesn't matter; it is as if we had not done anything.''
>
> ''Sometimes we need to sleep with our windows open. Every night my husband opens all the windows so we can get some air because that is the only time that we can get some clean air so keep the windows open all night.''
>
> ''Whatever comes in stays in and it does not leave. Not even with the air conditioner.''

Respondents believed that it would be beneficial to educate smokers and others about SHS, but they also believed that the smokers really did not care. Respondents were reluctant to ask their neighbors not to smoke because the neighbors were paying to live there and they did not want to interfere with their decisions. Therefore, they felt disempowered and hopeless. Although the nonsmokers had tried to use the value of *familismo* to convince smokers not to smoke near children, these efforts had not been effective. Participants believed that these efforts need to be supported by something more formal, such as a clause in the rental contract and signs on the property:

> ''It should be in the contract before you move in.''
>
> ''Put up signs to remind people about the dangers of smoking.''

Theme 3: Attitudes Toward Voluntary Policies. Most respondents had never heard of voluntary policies to regulate SHS exposure in common living areas. Some expressed doubts about whether such a policy would be legal and whether it would be discriminatory. After we explained that voluntary policies were legal and that smoking was not a fundamental right, the participants were positive about the potential benefits of such a policy, highlighting the collective benefits:

> ''There would be benefits for everyone…and also for the children because I was going to let my child go outside and instead we went back inside because they were smoking outside.''

Although respondents generally favored voluntary policies, some residents were reluctant to challenge the status quo because of their *respeto* values:

> ''Even for the older people that don't listen this would be good, but they are older and who am I to tell them what to do?''
> ''We need to educate everyone in a respectful way.''
> ''There is an apartment available next door. I am glad that person left because it was a smoker but I hope I don't get another smoker. Depending on who he/she is I don't know if I can ask them not to smoke.''

Respondents listed some potential barriers to a voluntary policy. They were concerned about angering the smokers:

> ''Those that smoke might get angry.''
> ''We would be lost if the owner smoked because they might attack us.''

Some respondents were also concerned that owners would not support the policy because it would make it more difficult to fill their vacant apartments, although others disagreed:

> ''Many of the owners don't have those rules because they rent the places more easily…all the owners care is to have money and they don't want to lose anything.''
> ''I think it would be the opposite because people would then see that the place does not smell bad and it is much cleaner so people would be much happier in living in a clean area. The building would not look dirty.''

Respondents had mixed views about the extent to which their fellow residents would support a policy. In general, they believed that nonsmokers would support the policy, but smokers would not:

> ''Although they would like to be helpful they can't because they love cigarettes.''
> ''I think there would not (be much support)…because they smoke all over the place…in the garage, outside, inside, everywhere.''

Respondents believed that it would be easier to pass a voluntary policy for common areas such as patios and laundry rooms, but that this would not solve the SHS problem completely:

> ''Common areas, because I would feel bad if someone came to tell me you can't smoke in your apartment.''
> ''It does not matter if it is indoors or outdoors. The smoke still comes in either way.''

When asked if they would be willing to write a note to tell the owner about their concerns regarding SHS exposure and a possible voluntary policy as a solution, respondents were not yet ready to take action:

> ''It would not matter because we are the minority; they only listen to the majority.''
> ''At least now I don't think many would speak up. Look at this group, it is small compared to all the people that live here.''

Phase 2: Door-to-Door Intercept Surveys

A total of 142 residents participated in the survey, with an 86% participation rate. Slightly more than one-half (56%) of the respondents were female; and 29% were aged 18 to 30 years, 27% were 31 to 40 years, 33% were 41 to 64 years, and 11% were 65 years or older.

Nearly all respondents (97%) believed that SHS is harmful, and the majority (68%) believed that SHS can drift into their units from the outside. Respondents reported that SHS had drifted into their units from outside (35%) or from other units (20%). Respondents were asked if they had been exposed to SHS in specific indoor and outdoor common areas. The most specific locations of SHS exposure were the lobby/entrance (24%), balcony/patio (23%), and stairs/hallway (20%). Other areas included recreational areas and the garage/parking structure. Two-thirds of the respondents (66%) stated that they had been ''somewhat'' bothered or bothered ''a lot'' by SHS in their apartments.

Only 35% said they had taken action to address the issue of SHS. These actions included moving away from the person, asking the person to stop smoking or move away, and closing doors and windows. Among those who did not take action, reasons for not taking action included issues of disempowerment (''Because I cannot do anything,'' ''I did not know that I can do something about it,'' ''I can't control other's actions'') and discomfort with confrontation (''I didn't feel comfortable telling them,'' ''I don't want to look for trouble or problems,'' ''People might get mad,'' ''Too scared'').

We also asked about preferences for smoke-free MUH. Most respondents stated that they would like to live in a nonsmoking section of an apartment building (82%) or in a completely smoke-free building (80%). The majority (63%) believed that a tenant should be required to move if they continue to smoke after signing a nonsmoking agreement.

Phase 3: Telephone Survey

A total of 409 H/L adult renters in California participated in the telephone survey. Table 2 shows the demographic characteristics of the respondents. Participants ranged in age from 18 to 89 years (mean, 38.7 years; SD, 14.6 years). The median number of people living in their units (including the respondent) was 5, and the median number of bedrooms was 2. Most lived in small- to medium-sized apartment buildings: 40% lived in buildings with 10 or fewer units, and 24% lived in buildings with 11 to 50 units. Only 8% of the respondents had smoked in the past week (13% of the men and 4% of the women), but 17% had a smoker in the household. Nearly all (95%) had banned smoking inside their own units. Only 26% reported that their current apartment buildings restricted smoking in indoor common areas, and only 19% reported smoking restrictions in outdoor common areas.

Table 3 compares attitudes toward SHS and smoke-free policies between smokers and nonsmokers. In general, nonsmokers had stronger beliefs about the negative effects of SHS and its ability to drift into apartments, but

Table 2
Demographic Characteristics of Telephone Survey Respondents

Characteristic	Percent of Participants*
Age, y	
18–24	15
25–34	30
35–44	21
45–54	7
55–64	17
≥65	7
Gender	
Female	49
Male	51
Public housing	
Yes	19
No	74
Country of origin	
Mexico	71
Central America	23
South America	6
Caribbean (including Cuba and Dominican Republic)	2
Language spoken at home	
Primarily Spanish	73
Spanish and English equally	23
Primarily English	3
Education	
Less than high school	46
High school	32
Some college	10
College graduate	7
Postgraduate work or professional school	2
Smoking status	
Current	8
Former	17
Never	74

* The sum of the percentages is less than 100% because some respondents declined to answer some questions.

these differences were not statistically significant. Nonsmokers were significantly more likely than smokers to believe that there is a need to protect nonsmokers in apartments from SHS (85% of nonsmokers vs. 56% of smokers; $\chi^2 = 21.69$; $p < .0001$). Nonsmokers were also more likely to favor a complete smoking ban in all indoor and outdoor areas (37% of nonsmokers vs. 18% of smokers; $\chi^2 = 4.89$; $p < .05$), whereas smokers were more likely to favor separate smoking and nonsmoking areas (79% of smokers vs. 58% of nonsmokers; $\chi^2 = 5.74$; $p < .05$). Nonsmokers were significantly more likely than smokers to state that tenants who repeatedly violate nonsmoking policies should be evicted (78% of nonsmokers vs. 52% of smokers; $\chi^2 = 9.10$; $p < .005$).

Implementation of *Regale Salud*

After collecting the data described above, we presented the findings to apartment owners and managers as part of the *Regale Salud* intervention. We reviewed the benefits of smoke-free MUH, including improved health, quality of life, and economic benefits (e.g., lower cleaning costs, decreased fire hazards, and possible tax breaks). We used the findings from the qualitative and quantitative data to demonstrate that most tenants were in favor of smoke-free MUH.

One of the managers' main concerns was whether smoking bans were illegal or discriminatory. They were also concerned that smoking residents would be upset, and this would stir controversy among residents and create difficult situations for managers, who would have to enforce the new policies. Like the residents, the managers were influenced by the cultural values of *simpatía*, *respeto*, and *personalismo*; they were reluctant to cause controversy or interfere with others' lives. However, they agreed that managers, rather than individual tenants, should speak with smoking residents and that the discussions should be done in person in a respectful way. The managers felt that this approach would minimize conflicts among neighbors.

As a possible solution, managers and residents also suggested purchasing air filters for their apartments. We did not support that because previous research has established that SHS cannot be controlled by ventilation, air cleaning, or spatial separation of smokers from nonsmokers.[21] Smoke-free buildings are the only remedy for reducing SHS-related morbidity and mortality; thus, the establishment of completely smoke-free living environments is the ultimate goal.

After these meetings, five apartment complexes in Coachella Valley and two complexes in the Los Angeles area passed voluntary policies. The new policies banned smoking in common areas, playgrounds, and balconies of apartments that face each other. The H/L Tobacco Education Partnership/Network placed a congratulatory advertisement in Spanish in a local newspaper, spoke at the official policy signing, and presented awards to all parties responsible for the development and implementation of the policy. The final outcome of the program was that seven policies were passed out of the 12 attempted.

DISCUSSION

As the size and voting power of the H/L population in the United States continues to increase, the issue of SHS exposure among H/L in MUH is becoming more salient. Other states are already following California's lead

Table 3
Comparison of Attitudes Toward SHS and No-Smoking Policies Between Smokers and Nonsmokers†

Attitude/Belief	Percent Who Agreed: Overall Sample (N = 409)	Nonsmokers (n = 375)	Smokers (n = 34)	χ^2
SHS is harmful	98	98	97	5.02
SHS can drift from one apartment to another	86	86	79	1.97
SHS can drift from outside an apartment building into an apartment	82	83	76	2.86
Have experienced SHS drifting into your apartment	63	64	53	1.79
There is need for laws to protect nonsmokers in apartments from SHS	82	85	56	21.69***
Strongly favor law limiting smoking in outdoor common areas of apartment buildings	78	79	68	5.56
Favor a complete smoking ban in all indoor and outdoor areas	35	37	18	4.89*
Favor separate smoking and nonsmoking areas	60	58	79	5.74*
Favor law requiring all apartment buildings to offer sections that are completely nonsmoking	86	86	85	3.64
Tenants should be evicted for repeat violations of no-smoking policies	76	78	52	9.10**

† SHS indicates secondhand smoke; Smoker, smoked in the past week; and nonsmoker, did not smoke in the past week.
* $p < 0.05$.
** $p < 0.005$.
*** $p < 0.0005$.

in implementing smoke-free apartment initiatives. Support for such policies needs to be supplemented with local action and incentives for building owners to implement smoke-free policies.

Overcoming Barriers to Smoke-Free Environments in MUH

This study identified some potential barriers to implementing smoke-free housing policies. The cultural values of *respeto*, *personalismo*, and *simpatía* made some residents hesitant to ask their neighbors not to smoke. Many respondents empathized with the smokers, mentioning how inconvenient it would be for the smokers to be forced to refrain from smoking in common areas. Respondents also stated that it would be inappropriate and difficult for a younger person to ask an elderly person not to smoke. This indicates that voluntary policies initiated by tenants might be difficult to enforce. However, if apartment owners or managers initiated the policy and reinforced it with signage, residents would feel more empowered to ask people not to smoke. This indicates that smoke-free policies should be initiated and enforced by authority figures such as managers, apartment owners, or city ordinances.

Although some cultural values could be barriers to enforcement of voluntary policies, other cultural values may empower residents to protect their families from SHS. For example, the value of *familismo* made residents quite concerned about the effects of SHS on their family members. *Familismo* may empower residents to insist on smoke-free environments for the entire family, especially the children, the elderly, and those with chronic illnesses. Residents also could reframe the roles of *respeto* and *simpatía* to shift the focus from protecting the smokers from inconvenience to protecting the health of the whole community.

The owners' and managers' barriers to implementing policies were their concerns that nonsmoking policies might be discriminatory or illegal and that they would be unable to fill their vacant apartments. It is important to educate landlords that smoke-free policies are legal and that the majority of tenants actually favor smoke-free apartments. The present findings indicate that once landlords understand that their own tenants favor nonsmoking policies, they are more receptive to the idea. We recommend collecting data from the residents of the landlords' own apartment complexes to convince landlords that their tenants support nonsmoking policies. Our experience suggests that landlords and tenants each have unique roles in creating and maintaining smoke-free MUH: the tenants need to voice their preference for smoke-free MUH and the landlords need to create an environment where tenants feel safe and empowered to voice their preferences without fear of reprisal. As a result, tenants and landlords will be more satisfied and healthy.

The current findings in the California H/L community are consistent with findings from previous studies in other demographic groups in other states. Surveys of MUH residents in Minnesota[22–24] found that substantial proportions of residents were bothered by SHS entering their units. Most of these respondents reported that their current buildings did not have smoke-free policies, but they would prefer to live in a building with smoke-free policies. Moreover, although residents were bothered by SHS, very few had talked to owners, managers, or the smokers about their concerns. This is very similar to our findings from the door-to-door intercept survey. A study of low-income MUH residents in subsidized housing in Oregon[25] found strong support for smoke-free MUH policies among nonsmokers but much weaker support among smokers. This is consistent with the results from our telephone survey, although we found that the vast majority of residents (smokers and nonsmokers) were in favor of some type of policy to protect nonsmokers from SHS. The main difference between the smokers and nonsmokers in our study was that the nonsmokers favored a complete indoor and outdoor smoking ban, whereas the smokers favored separate smoking areas. The consistency of these findings across states with diverse demographic characteristics suggests that there is widespread support for smoke-free MUH.

Our findings from apartment owners and managers are also consistent with those documented in other states. A survey of apartment owners and managers in New York[26] found that few owners and managers had implemented smoke-free policies, but most were receptive to the idea. Their main perceived barrier to implementation was concern about vacancy rates. In a Minnesota study,[23] owners and managers were aware of SHS, but they were reluctant to implement smoke-free policies because they were concerned about increasing their vacancy rates, being accused of discriminating against smokers, or incurring additional responsibilities to enforce the policies. However, owners who had already implemented smoke-free policies reported neutral or positive effects on vacancies, apartment turnover, and management workload. It is understandable that apartment owners and managers are worried about the effect of smoke-free policies on their ability to rent out their apartments, but the evidence suggests that these policies in fact will not adversely affect their occupancy rates and are not overly burdensome.

Limitations

Although *Regale Salud* focuses on voluntary policy development, the H/L Tobacco Education Partnership/Network also collaborated with smoke-free housing coalitions in California to encourage the passage of city-level ordinances to give priority to developers who would build smoke-free affordable housing. This could have influenced support for smoke-free housing. Another limitation of this study is that encouraging the passage of policies for smoke-free common areas (indoors and outdoors) does not address the problem of smoke drifting from neighboring units because such a policy would drive smokers back into their homes and expose their families and neighbors to SHS. Therefore, we favor total smoking bans rather than partial bans. The *Regale Salud* intervention needs to evolve its advocacy and policy work further to reflect and acknowledge the disadvantages of partial vs. complete voluntary policies. Also, it is important to work with apartment owners in addition to managers and residents. Owners can establish permanent policies that can survive after managers and resident advocates leave.

Although we attempted to obtain the most comprehensive and representative data possible by using mixed qualitative and quantitative methods and using two different sampling methodologies for the quantitative surveys, our method does have several limitations. Sampling for the focus group portion of the project was only performed with two MUH facilities; thus, generalizability to other MUH facilities is limited. The door-to-door intercept surveys were limited to residents who were at home and agreed to participate. Thus, residents who spend much of their time away from home were likely underrepresented. The telephone survey was limited to people with Hispanic surnames who had landline phones and were listed in the telephone directory. Thus, cell phone–only households and Hispanics without obvious Hispanic surnames were underrepresented. Although each methodology has inherent limitations, we believe that the similar findings across the three phases of data collection support the validity of the findings.

Because we did not ask participants to divulge their smoking status in the focus group and door-to-door intercept surveys, we were unable to analyze differences between smokers and nonsmokers. The telephone survey results revealed some similarities and some differences between smokers and nonsmokers; respondents generally agreed that SHS smoke was harmful and should be avoided, but nonsmokers favored more restrictions on smoking. In future studies, it would be useful to ascertain all participants' smoking status, if this can be done without compromising participation rates.

Because of budgetary constraints, this project was unable to collect data on the sustainability of the *Regale Salud* intervention or its long-term effects on SHS exposure among MUH residents. Longitudinal studies are needed to assess these important outcomes.

Recommendations

Based on the three phases of data gathering described in this article and the preliminary outcomes of the *Regale Salud* intervention, we offer several recommendations to promote smoke-free choices in MUH. At the policy level, we encourage municipalities to pass ordinances that prohibit smoking in all new and existing residences that share walls or common areas. Outdoor common areas should be smoke-free except for designated smoking areas. Rental clauses should specify where smoking is allowed and the consequences of smoking in units or common areas. Involuntary exposure to SHS in residential housing should be declared a public nuisance, especially when it impacts children and the elderly.

Until such policies are widespread, we encourage individual apartment owners and managers to implement and enforce policies to protect their residents from SHS. The findings of this study indicate that most residents, even smokers, acknowledge the harm associated with SHS and favor at least minimal restrictions. If apartment owners are unsure about their tenants' preferences, we encourage them to ask the tenants, confidentially or anonymously if possible. We expect that they will find that protecting their residents from SHS will actually result in more satisfied, loyal, long-term tenants, rather than increased vacancies.

Although some MUH residents may feel powerless to avoid SHS, they can become empowered. MUH residents can form partnerships with community-based organizations involved in the housing industry (e.g., affordable housing); health organizations; and city, county, or state agencies that promote smoke-free housing. Coalitions of residents can educate their landlords about the hazards of SHS and the health, safety, and economic benefits of smoke-free housing. If a critical mass of tenants demands smoke-free environments, voluntary and formal policies will follow.

CONCLUSIONS

In California, apartment residents, managers, and owners are passing voluntary policies to prohibit smoking indoors and in outdoor communal areas of MUH complexes. Policies that prohibit smoking in communal areas are capable of surviving most legal challenges because smoking is not considered a fundamental right. As state and local ordinances and voluntary policies in MUH gain momentum, it is our hope that the option to choose to live in smoke-free environments will become the norm.

> **SO WHAT? Implications for Health Promotion Practitioners and Researchers**
>
> **What is already known on this topic?** Many Hispanic/Latino residents of multiunit housing in California are potentially exposed to secondhand smoke from neighboring apartments.
>
> **What does this article add?** Secondhand smoke exposure is prevalent among Hispanic/Latinos in multiunit housing. There is high support for policies to reduce secondhand smoke exposure, but certain traditional cultural values made residents hesitant to ask their neighbors not to smoke. Apartment owners and managers were also concerned about negative consequences of implementing policies. The *Regale Salud* intervention prompted the passage of several anti-smoking policies in housing units.
>
> **What are the implications for health promotion practice or research?** Municipalities should pass ordinances to prohibit smoking in multiunit housing and common areas. In the meantime, it is important to continue to educate landlords and managers about secondhand smoke and encourage them to implement voluntary policies. This could reduce health disparities in secondhand smoke exposure among Hispanic/Latinos.

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Apartment Owners Realize Benefits from Smoke-Free MULTI-UNIT HOUSING TREND

By George Cushing

Thirty-four cities and counties in California have passed ordinances prohibiting smoking in part of or all outdoor common areas of multi-unit housing since December 2010. In the Tri-County area, Santa Clara County is the most recent to pass smoke-free ordinances, following a successful vote in December to adopt laws to make all units in duplexes, condo and townhouse complexes, and apartment buildings smoke free. Santa Clara now joins Santa Cruz and San Mateo County in the smoke-free trend.

Smoke-free initiatives are gaining momentum as the health dangers of second-hand smoke become more apparent. Fortunately, what is in the best interest of residents is also in the best interest of apartment owners and their bottom lines. Smoke-free buildings are more cost-effective, safe, marketable and healthy. For property owners, the economic benefits are numerous including lower rehab costs for smoke-free units, faster turnover time due to less preparation and repainting, less wear and tear on ventilation systems, discounts on property casualty insurance, and lower fire risk.

"Property owners know that effective risk management begins with providing safe, well-maintained buildings and premises, and ends with making sure you have a sound solution for protecting your investment from all levels of liability," said Ken Stewart, products, compliance & commercial lines manager for Capital Insurance Group. "Smoke-free buildings increase the level of liability protection for property owners and also offer a unique advantage in attracting new tenants."

In addition to the physical property benefits, apartment owners realize a marketing advantage when trying to attract new residents. Research surveys indicate that over 80 percent of renters in California prefer housing with smoke-free areas. Demand for smoke-free dwellings ultimately translates to lower vacancy rates. Because smoke-free environments are becoming the norm, health-conscious renters increasingly demand non-smoking homes.

Apartment turnover costs can be two to seven times greater when smoking is allowed compared to the cost of maintaining and turning over a smoke-free unit. Tobacco smoke leaves a sticky residue on walls, curtains, cabinets, blinds, appliances, fixtures, and ceilings. The odor and toxins often stay in carpets, curtains, and walls. Dropped ashes may result in burn damage to tiles, carpets, countertops, and bathtubs. Smoke-free housing reduces the property maintenance, and therefore positively impacts an owner's bottom line.

"Smoke-free units not only contribute to the cost savings in property maintenance, but also increase the safety of tenants and welfare of the property from catastrophic circumstances," remarked Stewart.

A primary concern of property management professionals is suffering a devastating fire. According to the National Fire Protection Association (NFPA), smoking was the leading cause of death from civilian home fires in 2009. Direct property damage to duplexes, manufactured homes, apartments, townhouses and row houses was $7.9 billion that year. However, implementing a smoke-free housing program immediately cuts maintenance and repair costs, while profoundly decreasing the risk of fire caused by cigarettes.

Clearly, losses attributable to fire pose some of the greatest risks to apartment and condominium owners. Many of those fires are attributable to smokers, who:

- Improperly dispose of smoking materials inside their unit — an ashtray dumped into a trash bin or a smoldering butt thrown into a wastebasket.

- Fall asleep holding a lit cigarette, which ignites bed sheets and blankets.
- Allow unattended cigarettes to fall onto furnishings, setting a couch or chair on fire.
- Toss cigarette butts into an inappropriate container, such as a planter or dumpster.
- Let unattended children play with matches or lighters.

Apartment Size	Construction	Premium with Smoke-Free Credit	Premium without Credit Savings	Total Smoke-Free Savings
10 units	Frame	$1,574	$1,749	$175
50 units	Frame	$8,108	$9,009	$901
200 units	Frame	$29,905	$33,231	$3,326

Insurance companies who specialize in commercial and apartment insurance have an opportunity to assist apartment owners by reducing the cost of risk management through lower premiums, participating in the shared-risk decision making, and building more effective risk management programs.

"We consider our relationship with our property owners to be a partnership in which we help one another assess and mitigate risk. We initiated our smoke-free premium discount as a way to meet the growing demand for smoke-free multi-unit housing, and assist our customers with an incentive that impacts their bottom line," added Stewart.

Purchasing property insurance is one way to manage the risk of loss from a fire. Paying a monthly premium buys risk protection from an insurance carrier, who is there to assist and indemnify an owner from fire-related losses. However, the cost of that security can be reduced substantially with a smoke-free credit. This smoke-free apartment credit* can translate to significant annual savings for an apartment owner. For example see chart above.

For Tri-County area property owners, the mandate to go smoke-free can result in additional protection for your investments. Consequently, property/casualty insurance partners who give smoke-free apartment owners some breathing room on their premium costs will be viewed as forward-thinking and offering a savings to property owners when they need it most.

*Representative rates and credits provided for demonstration purposes only; your rate will vary.

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The Hazards of E-Cigarettes

BY FRANCIS (BUD) J. OFFERMANN, P.E., CIH, MEMBER ASHRAE

The prevalence of the use of e-cigarettes is increasing. E-cigarettes are marketed as an alternative to smoking tobacco that only produces harmless water vapor, with no adverse impact on indoor air quality. However, published literature seems to show that e-cigarettes are not harmless.[1] *Photo 1* shows an e-cigarette user exhaling a dense visible aerosol into the surrounding air. This visible aerosol consists of condensed submicron liquid droplets, which contain many chemicals including some that are carcinogenic, such as formaldehyde, metals (cadmium, lead, nickel), and nitrosamines.

Figure 1 is a schematic of typical e-cigarette components. E-cigarettes contain a liquid, typically propylene glycol and/or glycerol, that include varying amounts of nicotine (e.g., 0 to 36 mg/mL) as well as flavorants. A wicking material is used to transport the liquid by capillary action from a reservoir to the heater. When the user draws on the e-cigarette, a sensor detects the draw and a microprocessor activates the heater, which vaporizes the fluid to produce a saturated vapor at an elevated temperature (i.e., > 350°C [662°F] in the center of the heating unit[2]). Propylene glycol, glycerol, and nicotine are liquids with relatively high boiling points: propylene glycol (188°C [370°F]), glycerol (290°C [554°F]), and nicotine (247°C [477°F]). Consequently, the vaporized fluid immediately condenses upon leaving the heating element, forming an aerosol of submicron spherical liquid droplets with the visible appearance of smoke or fog.

PHOTO 1: E-cigarettes do not produce a vapor (gas), but rather a dense visible aerosol of liquid sub-micron droplets consisting of glycols, nicotine, and other chemicals, some of which are carcinogenic (e.g., formaldehyde, metals, nitrosamines).

While the word vapor is used to describe what e-cigarettes produce, and vaping is a term used to describe the process of inhaling from an e-cigarette, the emissions out of the mouthpiece are not actually a vapor, which is a gas, but rather they are primarily an aerosol. This aerosol consists of submicron particles of the condensed vapor of glycols containing the nicotine and flavorants. So users are not vaping, but rather they are aerosolizing.

What are the chemical emissions from e-cigarettes? We searched through the published literature for information on the chemical emissions from e-cigarettes. We then used these chemical emissions to calculate the direct exposure to users and the indirect (passive) exposure to non-users, with usage and exposure assumptions selected to produce worst-case exposure scenarios. For both the direct and indirect exposures, we calculated the hazard quotients as the ratio of the calculated exposures to both cancer and non-cancer health exposure guidelines. Hazard quotients in excess of 1.0 indicate a health risk.

The paper by Goniewicz et. al.[3] contained the largest study of chemical emissions from e-cigarettes and forms the primary basis for our analyses. In this paper the chemical emissions of 11 chemicals, including carbonyl compounds, volatile organic compounds, tobacco specific nitrosamines, and heavy metals were measured from 12 different e-cigarettes. Each e-cigarette was tested three times. A total of 150 puffs (70 mL/puff) were directly vaporized into the analytical samplers from an e-cigarette attached to a mechanical smoking machine. For our exposure analyses we included seven of the 11 chemicals studied by Goniewicz

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et.al.,[3] that had both significant emission rates and relevant health-based exposure guidelines. Schripp et. al.[2] measured the emission rates of propylene glycol from three e-cigarettes.

Table 1 summarizes the minimum and maximum chemical emissions rates for nine chemicals in terms of mass (µg) of chemical per 150 puffs (70 mL/puff). The dominant chemical emitted was propylene glycol, with a range of 250,950 to 828,750 µg/150 puffs. The chemical with the next highest emission rate was nicotine, for which we assumed a concentration of 24 mg/mL of nicotine in propylene glycol, yielding 5,770 to 19,060 µg/150 puffs.

Are the chemical emissions from e-cigarettes a health risk? We used the maximum chemical emissions in *Table 1* to calculate the direct exposure to users and the indirect (passive) exposure to non-users, with the following usage and exposure assumptions, which were selected to produce worst-case exposure scenarios.

Direct Exposure Assessment. The median puffs/day by e-cigarette users was assumed to be 175 puffs/day with a puff volume of 70 mL/puff. The respiratory absorption of the inhaled vapor was assumed to be 100% for all compounds. We assumed a zero exposure other than the vapor that was directly inhaled (i.e., no indirect exposure).

Indirect (Passive) Exposure Assessment. We modeled exposures for a small office space (i.e., 20.9 m^2 [225 ft], 2.4 m [7.9 ft] ceiling), with a low outdoor air ventilation rate of 0.3 h-1 (assuming openable windows closed and no mechanical ventilation, so there is only outdoor air infiltration) and no contaminant removal other than ventilation. We assumed continuous occupancy for eight hours by two occupants; one e-cigarette user (125 puffs in 8 hours, 70 mL/puff) and one non-user. For this assessment we assumed that 100% of the inhaled vapor by the user was exhaled into the indoor air and the respiratory absorption by occupants of the exhaled vapor in the indoor air was 100% for all compounds. We assumed a zero exposure when away from work.

For cancer health effects we used the California Office of Environmental Health Hazard Assessment,[4] No

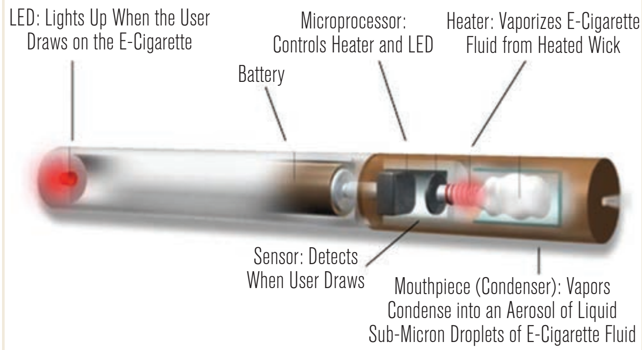

FIGURE 1: Schematic of the typical components found in an e-cigarette.

TABLE 1 Chemical emissions of selected compounds from e-cigarettes for exposure analyses.

CHEMICAL	CHEMICAL EMISSIONS (µG/150 PUFFS – 70 ML/PUFF) INDIRECT EXPOSURE	
	Minimum	Maximum
ACETALDEHYDE	2.0	13.6
ACROLEIN	<0.02	41.9
FORMALDEHYDE	3.2	56.1
CADMIUM	<0.04	0.22
LEAD	0.03	0.57
NICKEL	0.11	0.29
NICOTINE	5,770	19,060
NNK[a]	<0.0001	0.028
PROPYLENE GLYCOL	250,950	828,750

[a]NNK, 4-(n-nitrosomethylamino)-1-(3-pyridyl)1-butanone.

TABLE 2 Hazard quotients associated with the direct exposures of e-cigarette users and the indirect (passive) exposures of non-users.

CHEMICAL	EXPOSURE CRITERIA		DIRECT EXPOSURE		INDIRECT EXPOSURE	
	NSRL (µg/day)	CREL ($\mu g/m^3$)	HQ [a] NSRL	HQ [a] CREL	HQ [a] NSRL	HQ [a] CREL
ACETALDEHYDE	90	140	0.18	0.01	0.004	0.0001
ACROLEIN	N/A	0.35	N/A	**7.0**	N/A	0.17
FORMALDEHYDE	40	9	**1.64**	0.36	0.04	0.009
CADMIUM	0.05	0.02	**5.13**	0.64	0.12	0.015
LEAD	0.5	0.15	**1.33**	0.22	0.03	0.005
NICKEL	0.8	0.05	0.42	0.34	0.008	0.007
NICOTINE	N/A	5	N/A	**222**	N/A	**5.4**
NNK[b]	0.014	N/A	**2.36**	N/A	0.05	N/A
PROPYLENE GLYCOL	N/A	50	N/A	**967**	N/A	**23**

[a]Hazard quotients expressed as the ratio of the calculated exposure to the NSRL and CREL health exposure guidelines, with values above 1.0 **bolded**.
[b]NNK, 4-(n-nitrosomethylamino)-1-(3-pyridyl)1-butanone.

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Significant Risk Levels (NSRLs). The NSRL is the 70 year average daily intake level calculated to result in one excess case of cancer in an exposed population of 100,000. For non-cancer health effects, we used the California Office of Environmental Health Hazard Assessment[5] Chronic Reference Exposure Guidelines (CRELs).

For propylene glycol and nicotine, which do not have established CRELs, we used 1% of the California OSHA[6] occupational eight-hour Permissible Exposure Guideline, and for lead we used the Environmental Protection Agency[7] National Ambient Air Quality Standards (NAAQS), three-month average requirement.

For both the direct and indirect exposures, we calculated the hazard quotients as the ratio of the calculated exposures to the cancer (NSRL) and non-cancer (CREL) health exposure guidelines. Hazard quotients in excess of 1.0 indicate a health risk.

Table 2 summarizes the hazard quotients associated with the direct exposures of e-cigarette users and the indirect (passive) exposures of non-users.

With respect to the NSRL hazard quotients for cancer related health effects, four of the nine chemicals analyzed exceeded 1.0 for the direct exposure to users; lead (1.33), formaldehyde (1.64), NNK (2.36), and cadmium (5.13). For the indirect exposure to non-users, the NSRL hazard quotients were all less than 1.0, with the highest, cadmium (0.12). With respect to the CREL hazard quotients for non-cancer related health effects, three of the nine chemicals analyzed exceeded 1.0 for the direct exposure to users; acrolein (7.0), nicotine (222), and propylene glycol (967). For the indirect exposure to non-users, the CREL hazard quotients also exceeded 1.0 for nicotine (5.4) and propylene glycol (23).

If we use the minimum rather than the maximum chemical emissions in *Table 1*, the modeled direct and indirect CREL hazard quotients still exceed 1.0 for propylene glycol (293 direct and 7.0 indirect) and nicotine (65 direct and 1.6 indirect).

With respect to the modeled indirect exposures, we note that while this was a worst-case exposure scenario with a low ventilation rate of 0.3 h-1, even if ventilation rates are tripled to 0.9 h-1, which exceeds ASHRAE Standard 62.1[8] default minimum ventilation of 0.78 h-1 for the modeled office space, the indirect exposures still present a significant health risk. Ventilation rates would have to be increased by a factor of 23 to mitigate the health risks for each of the nine chemicals modeled. Clearly, ventilation is not a solution and e-cigarette use will have to be regulated indoors in the same manner as is done for tobacco smoking, which is prohibited indoors.

We also note that there has been little research into the emissions of the flavorants that are added into the e-cigarette fluids. Some flavorant chemicals, such as diacetal, while having no apparent adverse effects when ingested, when aerosolized and inhaled can cause lung irritation.

Like the flavorants, the propylene glycol carrier, while used as a preservative in food products without apparent adverse health effects, are themselves a potential airborne respiratory irritant. Wieslander et.al.[9] conducted experimental studies of 27 individuals exposed to propylene glycol aerosol for a one-minute period with airborne concentrations ranging from 176 to 851 mg/m^3 (geometric mean of 309 mg/m^3). Results of post-exposure measurements of tear film stability and forced expiratory respiratory volume indicated that short-term exposures to propylene glycol aerosol can cause acute eye and upper respiratory irritation in non-asthmatic patients.

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Conclusions

We conclude that e-cigarettes emit harmful chemicals into the air and need to be regulated in the same manner as tobacco smoking. There is evidence that nitrosamines, a group of carcinogens found specifically in tobacco, are carried over into the e-cigarette fluid from the nicotine extraction process.[10] There is also evidence that the glycol carriers can by oxidized by the heating elements used in e-cigarettes to vaporize the liquids, creating aldehydes such as formaldehyde.[11] Consumers should be warned that, while the health risks associated with the usage of e-cigarettes are less than those associated with tobacco smoking, there remain substantial health risks associated with the use of e-cigarettes.

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Executive Summary

This position document has been written to provide the membership of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and other interested persons with information on the health consequences of exposure of nonsmokers to tobacco smoke in indoor environments, and on the implications of this knowledge for the design, installation and operation of heating, ventilating, and air-conditioning (HVAC) systems. ASHRAE's sole objective is to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and their allied arts and sciences and related human factors, for the benefit of the public. Therefore, the health effects of indoor exposure to emissions from cigarettes, cigars, pipes, and other tobacco products have long been relevant to ASHRAE.

For more than three decades, researchers have investigated the health and irritant effects among non-smokers exposed to tobacco smoke in indoor environments. The preponderance of credible evidence links passive smoking to specific diseases and other adverse health effects in people. A number of national and global review groups and agencies have concluded that exposure of nonsmokers to tobacco smoke causes adverse effects to human health. No cognizant authorities have identified an acceptable level of environmental tobacco smoke (ETS) exposure, nor is there any expectation that further research will identify such a level.

International experience has been gained over several decades with using various strategies to reduce ETS exposure, including separation of smokers from nonsmokers, ventilation, air cleaning and filtration, and smoking bans. Only the last provides the lowest achievable exposures for nonsmokers and is the only effective control method recognized by cognizant authorities (see *Findings of Cognizant Authorities* below). At the time of this writing, several nations[1,2], 30 states[3] in the U.S. and hundreds of municipalities and other jurisdictions have banned tobacco smoking completely in all public buildings and workspaces. The U.S. government has banned smoking in its workplaces. Experience with such bans documents that they can be effective, practically eliminating ETS exposure of non-smokers. The benefits of bans, including exposure reduction and benefits to public health are well documented[4,5]. While exposure is decreasing internationally because of these smoking bans in public and private buildings, and a decrease in the prevalence of smoking, substantial portions of the population are still regularly exposed in workplaces, homes and public places, such as entertainment venues.

ASHRAE concludes that:

- It is the consensus of the medical community and its cognizant authorities that ETS is a health risk, causing lung cancer and heart disease in adults, and exacerbation of asthma, lower respiratory illnesses and other adverse effects on the respiratory health of children.
- At present, the only means of effectively eliminating health risk associated with indoor exposure is to ban smoking activity.
- Although complete separation and isolation of smoking rooms can control ETS exposure in non-smoking spaces in the same building, adverse health effects for the occupants of the smoking room cannot be controlled by ventilation.

- No other engineering approaches, including current and advanced dilution ventilation or air cleaning technologies, have been demonstrated or should be relied upon to control health risks from ETS exposure in spaces where smoking occurs. Some engineering measures may reduce that exposure and the corresponding risk to some degree while also addressing to some extent the comfort issues of odor and some forms of irritation. However, the public now expects smoke-free air which cannot be accomplished with any engineering or other approaches.
- An increasing number of local, state, and national governments, as well as many private building owners, are adopting and implementing bans on indoor smoking.
- At a minimum, ASHRAE members must abide by local regulations and building codes and stay aware of changes in areas where they practice, and should educate and inform their clients of the substantial limitations and the available benefits of engineering controls.
- Because of ASHRAE's mission to act for the benefit of the public, it encourages elimination of smoking in the indoor environment as the optimal way to minimize ETS exposure.

1.0 Introduction

Providing healthful and comfortable indoor environments through the control of indoor air quality is a fundamental goal of building and HVAC design and operation. ASHRAE has long been active in providing engineering technology, standards and design guidance in support of this goal. These activities are consistent with the society's Certificate of Consolidation, which states that ASHRAE's sole objective is "… to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and their allied arts and sciences and related human factors, for the benefit of the public."

This position document has been written to provide the membership of ASHRAE and other interested persons with information on what is known about the health consequences to nonsmokers from exposure to tobacco smoke in indoor environments and on the implications of this knowledge for the design, installation and operation of HVAC systems. Because tobacco smoke is a source of both gaseous and particulate contaminants, the health effects of inhaling smoke from cigarettes, cigars, pipes, or other tobacco products in indoor environments have long been relevant to ASHRAE, and specifically to ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*[6].ASHRAE continues to re-affirm its policy stating that while "ASHRAE does not make findings as to the health and safety impacts of environmental exposures," its document and activities "shall consider health and safety impacts."[7,8] Therefore, it is important for ASHRAE to identify these impacts as they relate to the activities of its members and then to consider them in its documents, as it has done in ASHRAE Standard 62.1. ASHRAE also adopted a policy stating that ASHRAE standards and guidelines will not set ventilation requirements and will not claim to provide acceptable indoor air quality in smoking spaces. Note that this policy does not prevent ASHRAE from providing guidance for designing smoking spaces in other documents, but these documents would only address odor and other comfort goals.

Concerns regarding tobacco smoke in indoor environments have arisen from evidence of adverse health and irritation effects caused among nonsmokers exposed to tobacco smoke indoors. The relevant evidence comes from information on tobacco smoke and its components; from toxicologic studies of tobacco smoke and some of its specific components; from the substantial epidemiologic, pathologic, and clinical evidence that shows the health effects of active smoking; and from epidemiologic studies that have assessed the risks of passive smoking. The latter studies, carried out over the last three decades, have linked passive smoking to specific diseases and other adverse health effects in children and adults.

There are now several decades of international experience with the use of various strategies to reduce ETS exposure, including separation of smokers and nonsmokers, ventilation, air cleaning and filtration, and bans. Only the last provides the lowest achievable exposures for nonsmokers and experience with such bans documents that they can be effective[2,9]. While exposure is decreasing nationally because of these smoking bans in public and private buildings, and because of decreases in the prevalence of smoking, substantial portions of the population are still regularly exposed in workplaces, homes, and public places, such as entertainment venues.

2.0 Tobacco Smoke in Indoor Spaces: Characteristics and Concentrations

2.1 Characteristics of tobacco smoke in indoor spaces

While tobacco may be smoked in other forms (e.g., pipes and cigars), the cigarette is the principal source of exposure of nonsmokers to tobacco smoke in the United States and other countries. The burning cigarette produces smoke primarily in the form of mainstream smoke (MS) -- that smoke inhaled by the smoker during puffing -- and sidestream smoke (SS) -- that smoke released by the smoldering cigarette while not being actively smoked. Because of the lower temperature in the burning cone of the smoldering cigarette, many tobacco combustion products are enriched in SS compared to MS.

Nonsmokers are exposed to the combination of diluted SS that is released from the cigarette's burning end and the MS exhaled by the active smoker[8]. This mixture of diluted SS and exhaled MS has been referred to as secondhand smoke or environmental tobacco smoke (ETS); the term used in this position document. Exposure to ETS is also commonly referred to as passive or involuntary smoking.

Tobacco smoke consists of a complex mixture of particles and gases, with thousands of individual chemical components. The particles in ETS are in the submicron size range, and as such, penetrate deeply into the lung when inhaled. The respiratory tract (which extends from the nose to the alveoli) absorbs the gases in a manner dependent on their chemical and physical characteristics. For example, reactive and highly soluble gases, such as formaldehyde, are adsorbed in the upper respiratory tract, while less soluble and more inert gases, such as carbon monoxide, reach the alveoli and may be systemically absorbed. Additionally, these particles and gases also impact the mucous membranes of the eyes. While exposures of involuntary and active smoking differ quantitatively and, to some extent, qualitatively [9, 11-16], involuntary smoking results in exposure to multiple toxic agents including known human carcinogens generated by tobacco combustion[9,11-17].

2.2 Exposure to tobacco smoke in indoor spaces

The concentration of the various ETS constituents in an indoor space depends on the number of smokers and their pattern of smoking, the volume of the space, the ventilation rate and the effectiveness of the air distribution, the rate of removal of ETS from the indoor air by air cleaners, deposition of particles onto surfaces, and surface adsorption and re-emission of gaseous components. Because ETS is a complex mixture, measurements of single components are of varying specificity and none alone is considered to indicate the potential toxicity of ETS at a particular concentration. Therefore, measurements of multiple surrogates have been used as indicators of the concentration of the mixture for research and public health purposes. These measures include respirable suspended particles (RSP), nicotine, benzene, solanesol, 3-ethenyl pyridine (3-EP) and carbon monoxide. Such measurements have demonstrated contamination of indoor air wherever smoking takes place. Biomarkers of ETS exposure, i.e., indicators in biological materials such as nicotine in saliva and blood, have also been measured; measurable concentrations of these biomarkers (e.g. cotinine) have been found in the bodies of exposed nonsmokers, indicating uptake of ETS.

3.0 Health Effects of Involuntary Smoking

3.1 Cognizant authorities

Following the same approach used in the landmark 1964 report of the U.S. Surgeon General on smoking and health, the finding that involuntary smoking causes disease or other adverse effects has been based in systematic review of the evidence and the application of criteria for evaluating the strength of evidence in support of causality. The principles for causal inference were set out in the 1964 report and revisited in the subsequent reports of the Surgeon General[9,18,19]. This approach for evidence evaluation involves systematically gathering and assessing the quality of individual research studies, and then evaluating the overall strength of evidence using accepted causal criteria as guidelines. The term *causal criteria* refers to a set of principles for evaluating evidence for causal inference. These criteria include the consistency of the evidence, the strength of the association of involuntary smoking with the health outcome of concern, the specificity of that association, proper temporality of the association (i.e., involuntary smoking proceeds onset of the health outcome), and the coherence of the evidence.

Using this general approach, the scientific evidence on the health consequences of exposure to ETS has been extensively reviewed by a number of independent expert groups (cognizant authorities) in the United States and internationally, with similar conclusions over the last two decades (Table 1). In the United States, five major cognizant authorities have examined the evidence, including the U.S. Surgeon General[9,15], the U.S. Environmental Protection Agency[16], the National Research Council[13], the California Environmental Protection Agency[20-22] , and the National Toxicology Program[23]. The first major reviews were published in 1986[15,32]. As the evidence has expanded, further reviews have been carried out in the United States and internationally. These conclusions are also supported by positions of major health organizations, such as the American Cancer Society, the American Heart Association, the American Lung Association, the American Medical Association, and the British Medical Association, and many professional societies, such as the American Public Health Association, the American Thoracic Society, the American College of Preventive Medicine, the American Academy of Pediatrics and others.

The validity of the conclusions from these cognizant authorities is largely based on the integrity of the processes used to ensure that the reviews and conclusions are free of bias. Factors used to assess the potential role of bias in these processes include the expertise and independence of the report's authors and reviewers, the comprehensiveness of the approach to reviewing the scientific evidence, and the process for peer-review of the report.

3.2 Findings of Cognizant Authorities

Scientific evidence indicates adverse health effects from passive smoking throughout the life-span (Table 1). Some of the first epidemiological studies on ETS and health were reported in the late 1960s[24-26] and since then there have been hundreds of scientific papers on the health effects of ETS exposure. Exposure to ETS in actual indoor spaces has since been linked to numerous adverse effects in infants and children. The adverse effects may even extend to gestation, as ETS components and metabolites reach the fetus of pregnant mothers who are exposed. There is evidence suggesting that ETS exposure of the mother reduces birth weight and that child development and behavior are adversely affected by parental smoking[27,28]. ETS exposure causes increased risk for more severe lower respiratory infections, middle ear disease, chronic respiratory symptoms and asthma, and reduces the rate of lung function growth during childhood. There is no strong evidence at present that ETS exposure increases childhood cancer risk[29].

The first major studies on passive smoking and lung cancer in non-smoking adults were reported in 1981 [30,31] and by 1986[15,32] the evidence supported the conclusion that passive smoking was a cause of lung cancer in non-smokers. Subsequent evidence has continued to identify other diseases and adverse effects of passive smoking in adults, and the conclusion has been reached that coronary heart disease is caused by ETS exposure (Table 1). The number of coronary heart disease deaths caused by ETS greatly exceeds the number of ETS-caused lung cancer deaths.

Thus, the epidemiological evidence, along with the other relevant lines of evidence, has been reviewed periodically by cognizant authorities with an increasingly lengthy list of diseases and other adverse effects associated with ETS exposure in the nearly two decades since the first causal conclusions were reached in 1986[15,32]. Notably, conclusions offered by the cognizant authorities have converged and no conclusions have ever been reversed. The conclusions of these studies refer to ETS exposure in general since the biological action does not depend on the particular type of indoor environments.

The reports and their conclusions have not indicated that thresholds can be identified below which effects would not be anticipated, and in general, risks tend to increase with the level of exposure and conversely to decrease with a reduction in exposure. On a biological basis, a threshold would not be anticipated for the carcinogens in ETS [(22;25).] Additionally, the scientific evidence recognizes substantial subpopulations potentially susceptible to ETS, such as children and adults with asthma or heart disease, whose disease may be exacerbated by ETS exposure.

In the absence of a quantitative criterion for acceptable exposure, the only protective measure for effective control that has been recognized by cognizant authorities is an indoor smoking ban, leading to near zero exposure.

4.0 Considerations Related to HVAC System Design and Operation

4.1 General principles

Societal recognition of the public health risks to children and adults of ETS exposure has motivated the use of strategies to reduce or eliminate exposure to ETS. Exposure to ETS has been reduced through a variety of strategies, including those that reduce, but do not eliminate, exposure to ETS. Others, such as banning or restricting smoking, result in a complete or nearly complete reduction of exposure to ETS. The specific strategies may be regulatory or voluntary in their application. Because smoking is a strong localized source of a complex mixture of hazardous agents with different physical and chemical characteristics, multiple engineering techniques need to be employed to minimize ETS exposure in non-smoking areas, absent a smoking ban. There is no target for such reduction, as no cognizant authority has defined a safe level of ETS exposure because of the complex nature of ETS, the multiple health and irritation hazards, and varying individual susceptibility to ETS.

Practitioners must always follow the laws and regulations in laws, regulations and directives at all levels of government, as well as industry codes and standards. Even where permitted by law, many developers, building owners, and operators do not allow smoking. For instance, the Building Owners and Managers Association (BOMA) International has taken the position that secondhand smoke should not be allowed in buildings and supports legislation to ban smoking in buildings[33]. In the U.S. and many other countries as well, smoking has been banned in most office buildings, shopping center common areas and in most retail sales areas. Many operators of restaurants and other hospitality venues have voluntarily done the same. Therefore, it is recommended that engineers work with their clients to define their intent for addressing ETS exposure in their building. In working with their clients, engineers need to take account of all laws and regulations relevant to ETS, and with their clients develop a strategy that will result in the lowest ETS exposure to building occupants within the context of a building's intended use.

4.2 Design and Operation Approaches

There are four general cases of space-use and smoking activity that lead to different engineering approaches to addressing ETS exposure in buildings: 1) banning smoking indoors; 2) allowing smoking only in isolated rooms; 3) allowing smoking in separate but not isolated spaces; and 4) totally mixing occupancy of smokers and nonsmokers. These approaches do not necessarily account for all circumstances, but are in a sequence from most to least effective in controlling ETS exposure.

1. **Banning Smoking Indoors:** A total ban on indoor smoking is the only effective means of controlling the health risks associated with ETS exposure. This approach has been implemented by many governments and private building owners. While there are no system design issues related to this approach, the existence of outdoor smoking areas near the building and their potential impacts on entryway exposure and outdoor air intake locations should be discussed with the developer, building owner, and/or building operator.

2. **Smoking Only in Isolated Rooms:** Allowing smoking only in separate and isolated rooms, typically dedicated to smoking, can control ETS exposure in non-smoking spaces in the same building. Effective isolation is achievable through airflow and pressure control including location of supply outlets and return and exhaust air inlets to preserve desirable airflow directions at doorways, as well as the use of separate ventilation systems serving the smoking spaces. When using this approach, the design and operation need to address entrainment of exhaust air containing ETS into the non-smoking area's system through the air intake, windows, and other

airflow paths. In addition, the airtightness of the physical barriers between the smoking and nonsmoking areas, as well as of the connecting doorways, requires special attention. Some smoking lounges in airports or office buildings exemplify use of this control approach. The risk of adverse health effects for the occupants of the smoking room cannot be controlled by ventilation. Engineering techniques to reduce odor and irritation in the smoking room include dilution ventilation, and air cleaning and filtration techniques.

3. **Smoking in Separate But Not Isolated Spaces:** In the third situation, smoking is allowed in separate spaces that are not physically isolated from non-smoking areas. This approach includes spaces where smokers and non-smokers are separated but still occupy a single space or a collection of smoking and non-smoking spaces served by the same air handler. Examples can be found in restaurants and bars with smoking and non-smoking areas, or buildings where smoking is restricted to specific rooms but a common, recirculating air handler serves both the smoking and non-smoking rooms. This situation also includes spaces where a common air handler does not recirculate from the smoking to the nonsmoking area and spaces with multiple air handlers.

Engineering techniques to reduce odor and irritation include, directional airflow patterns achieved through selective location of supply and exhaust vents, and air cleaning and filtration. These techniques may reduce ETS exposure in non-smoking areas but limited evidence is available on their effectiveness. Movement of people between non-smoking and smoking areas may disrupt intended airflow patterns, degrading the effectiveness of exposure reduction for the non-smoking occupants (including workers).

4. **Mixed Occupancy of Smokers and Nonsmokers:** If smoking is allowed throughout a space or a collection of spaces served by the same air handler, with no effort to isolate or separate the smokers and nonsmokers, there is no currently available or reasonably anticipated ventilation or air cleaning system that can adequately control or significantly reduce the health risks of ETS. For example, this situation includes unrestricted smoking in homes, dormitories, casinos, bingo parlors, small workplaces, and open plan office spaces. Air cleaning, ordinary dilution ventilation and displacement ventilation can provide some reduction in exposure but they cannot minimize adverse health effects, nor odor and sensory irritation for nonsmokers in general.

5.0 Conclusions

- There is a consensus among cognizant medical authorities that ETS is a health risk, causing lung cancer and heart disease in adults, and causing adverse effects on the respiratory health of children, including exacerbating asthma and increasing risk for lower respiratory tract infection.
- At present, the only means of eliminating health risks associated with indoor exposure is to ban all smoking activity.
- Although complete separation and isolation of smoking rooms can control ETS exposure in non-smoking spaces in the same building, adverse health effects for the occupants of the smoking room cannot be controlled by ventilation.

- No other engineering approaches, including current and advanced dilution ventilation, "air curtains" or air cleaning technologies, have been demonstrated or should be relied upon to control health risks from ETS exposure in spaces where smoking occurs, though some approaches may reduce that exposure and address odor and some forms of irritation.
- An increasing number of local and national governments, as well as many private building owners, are implementing/adopting bans on indoor smoking.
- At a minimum, ASHRAE members must abide by local regulations and building codes and stay aware of changes where they practice; they should also educate/inform their clients of the limits of engineering controls in regard to ETS.
- Because of ASHRAE's mission to act for the benefit of the public, it encourages elimination of smoking in the indoor environment as the optimal way to control ETS exposure.

Table 1. Adverse Effects from ETS Throughout the Life Span

Health Effect	SG 1984[14]	SG 2006[9]	EPA 1992[16]	CalEPA 2005[22]	UK 1998[34]	WHO 1999[35]	IARC 2002[29]
Children							
Risk factor for SIDS		Yes/c		Yes/c	Yes/a	Yes/c	
Increased prevalence of respiratory illnesses	Yes/a	Yes/c	Yes/c	Yes/c	Yes/c	Yes/c	
Decrement in pulmonary function	Yes/a	Yes/c	Yes/a	Yes/c		Yes/c	
Increased frequency of bronchitis, pneumonia	Yes/a	Yes/c	Yes/a	Yes/c		Yes/c	
Increase in chronic cough, phlegm		Yes/c		Yes/c		Yes/c	
Increased frequency of middle ear effusion		Yes/c	Yes/c	Yes/c	Yes/c	Yes/c	
Increased severity of asthma episodes and symptoms		Yes/c	Yes/c	Yes/c		Yes/c	
Risk factor for new asthma		Yes/a	Yes/a	Yes/c			
Low Birth Weight		Yes/c		Yes/c			
Adults							
Risk factor for lung cancer		Yes/c	Yes/c	Yes/c	Yes/c	Not addressed	Yes/c
Risk factor for breast cancer		Yes/a		Yes/c			
Risk factor for heart disease		Yes/c		Yes/c	Yes/c	Yes/a	
Respiratory symptoms and lung function	Yes/a	Yes/a		Yes/c			
Increased severity of asthma episodes and symptoms		Yes/a		Yes/c			

Yes/a = association

Yes/c = cause

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E-Cigarettes
A Scientific Review

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Electronic cigarettes (e-cigarettes) are products that deliver a nicotine-containing aerosol (commonly called vapor) to users by heating a solution typically made up of propylene glycol or glycerol (glycerin), nicotine, and flavoring agents (Figure 1) invented in their current form by Chinese pharmacist Hon Lik in the early 2000s.[1] The US patent application describes the e-cigarette device as "an electronic atomization cigarette that functions as substitutes [sic] for quitting smoking and cigarette substitutes" (patent No. 8,490,628 B2). By 2013, the major multinational tobacco companies had entered the e-cigarette market. E-cigarettes are marketed via television, the Internet, and print advertisements (that often feature celebrities)[2] as healthier alternatives to tobacco smoking, as useful for quitting smoking and reducing cigarette consumption, and as a way to circumvent smoke-free laws by enabling users to "smoke anywhere."[3]

There has been rapid market penetration of e-cigarettes despite many unanswered questions about their safety, efficacy for harm reduction and cessation, and total impact on public health. E-cigarette products are changing quickly, and many of the findings from studies of older products may not be relevant to the assessment of newer products that could be safer and more effective as nicotine delivery devices. In addition, marketing and other environmental influences may vary from country to country, so patterns of use and the ultimate impact on public health may differ. The individual risks and benefits and the total impact of these products occur in the context of the widespread and continuing availability of conventional cigarettes and other tobacco products, with high levels of dual use of e-cigarettes and conventional cigarettes at the same time among adults[4–8] and youth.[9–11] It is important to assess e-cigarette toxicant exposure and individual risk, as well as the health effects, of e-cigarettes as they are actually used to ensure safety and to develop an evidence-based regulatory scheme that protects the entire population—children and adults, smokers and nonsmokers—in the context of how the tobacco industry is marketing and promoting these products. Health claims and claims of efficacy for quitting smoking are unsupported by the scientific evidence to date. To minimize the potential negative impacts on prevention and cessation and the undermining of existing tobacco control measures, e-cigarette use should be prohibited where tobacco cigarette use is prohibited, and the products should be subject to the same marketing restrictions as tobacco cigarettes.

Methods

Initial searches conducted via PubMed using the key words electronic cigarette, e-cigarette, and electronic nicotine delivery systems yielded 151 studies (Figure 2). Seventy-one articles presented original data and were included. Eighty articles were excluded because they were not relevant, were not in English, or were reviews or commentaries that did not provide original data, although some are cited for background and context. Searches using the same search terms were conducted using World Health Organization regional databases; only BIBLIOTECA Virtual em Salude Latin America and Caribbean included relevant papers, all of which had already been located with PubMed. Working with the World Health Organization, we also contacted investigators to locate other studies, some of which had not yet been published (submitted or in press). We also reviewed technical reports prepared by health organizations,[12–15] news articles, and relevant Web sites. The results of these searches were used to prepare a report commissioned by the World Health Organization Tobacco Free Initiative, which provides details of individual studies, including some studies that are not discussed in this article because of length constraints.[1] After the manuscript was submitted for peer review, 5 more articles became available, resulting in a total of 82 articles forming the basis for this review.

The Product

E-cigarette devices are manufactured mainly in China. As of late 2013, there was wide variability in e-cigarette product engineering, including varying nicotine concentrations in the solution used to generate the nicotine aerosol (also called e-liquid), varying volumes of solution in the product, different carrier compounds (most commonly propylene glycol with or without glycerol [glycerin]), a wide range of additives and flavors, and battery voltage. Quality control is variable,[16] and users can modify many of the products, including using them to deliver other drugs such as marijuana.[17,18] These engineering differences result in variability in how e-cigarettes heat and convert the nicotine solution to an aerosol and consequently the levels of nicotine and other

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Product	Description	Some Brands
Disposable e-cigarette 	Cigarette-shaped device consisting of a battery and a cartridge containing an atomizer to heat a solution (with or without nicotine). Not rechargeable or refillable and is intended to be discarded after product stops producing aerosol. Sometimes called an e-hookah.	NJOY OneJoy, Aer Disposable, Flavorvapes
Rechargeable e-cigarette 	Cigarette-shaped device consisting of a battery that connects to an atomizer used to heat a solution typically containing nicotine. Often contains an element that regulates puff duration and /or how many puffs may be taken consecutively.	Blu, GreenSmoke, EonSmoke
Pen-style, medium-sized rechargeable e-cigarette 	Larger than a cigarette, often with a higher capacity battery, may contain a prefilled cartridge or a refillable cartridge (often called a clearomizer). These devices often come with a manual switch allowing to regulate length and frequency of puffs.	Vapor King Storm, Totally Wicked Tornado
Tank-style, large-sized rechargeable e-cigarette 	Much larger than a cigarette with a higher capacity battery and typically contains a large, refillable cartridge. Often contains manual switches and a battery casing for customizing battery capacity. Can be easily modified.	Volcano Lavatube

Figure 1. Examples of different electronic cigarette (e-cigarette) products. Reproduced from Grana et al.[1]

chemicals delivered to users and the air pollution generated by the exhaled aerosol.[19]

E-liquids are flavored, including tobacco, menthol, coffee, fruit, candy, and alcohol flavors, as well as unusual flavors such as cola and Belgian waffle.[3] Flavored (conventional) tobacco products are used disproportionately by youth and initiators,[20] and cigarettes with characterizing flavors (except menthol) have been banned in the United States.

Marketing and Media Research

Consumer perceptions of the risks and benefits and decisions to use e-cigarettes are heavily influenced by how they are marketed. Celebrities have been used to market e-cigarettes since at least 2009.[21] Grana and Ling[3] reviewed 59 single-brand e-cigarette retail Web sites in 2012 and found that the most popular claims were that the products are healthier (95%), cheaper (93%), and cleaner (95%) than cigarettes; can be smoked anywhere (88%); can be used to circumvent smoke-free policies (71%); do not produce secondhand smoke (76%); and are modern (73%). Health claims made through text and pictorial and video representations of doctors were present on 22% of sites. Cessation-related claims (direct and indirect statements) were found on 64% of sites. Marketing on the sites commonly stated that e-cigarettes produce only "harmless water vapor." Similar messaging strategies were being used in the United Kingdom.[22]

These marketing messages have been repeated in the media. A thematic analysis of newspaper and online media coverage about e-cigarettes in the United Kingdom and Scotland from July 2007 to June 2012 found 5 themes: healthier choice, circumventing smoke-free restrictions, celebrity use, price, and risk and uncertainty.[23] Coverage often included anecdotes about having tried nicotine replacement therapies (NRTs), failing to quit, and then trying the e-cigarette (such as the celebrity endorsement by actress Katherine Heigl on the US David Letterman television program[21]), implying that e-cigarettes are a more effective form of NRT.

E-cigarette companies also have a strong presence in social media, which reinforces their marketing messages, including repeating the use of celebrity endorsements (eg, Heigl) and spreading images of the UK musical group Girls Aloud "puffing on e-cigarettes to cope with the stress of their 10th anniversary tour."[22]

Cigarette and other tobacco companies have been unable to market their products on television and radio since the 1970s. E-cigarette advertising on television and radio is mass marketing of an addictive nicotine product for use in a recreational manner to new generations who have never experienced such marketing. In an online convenience sample of 519 adult

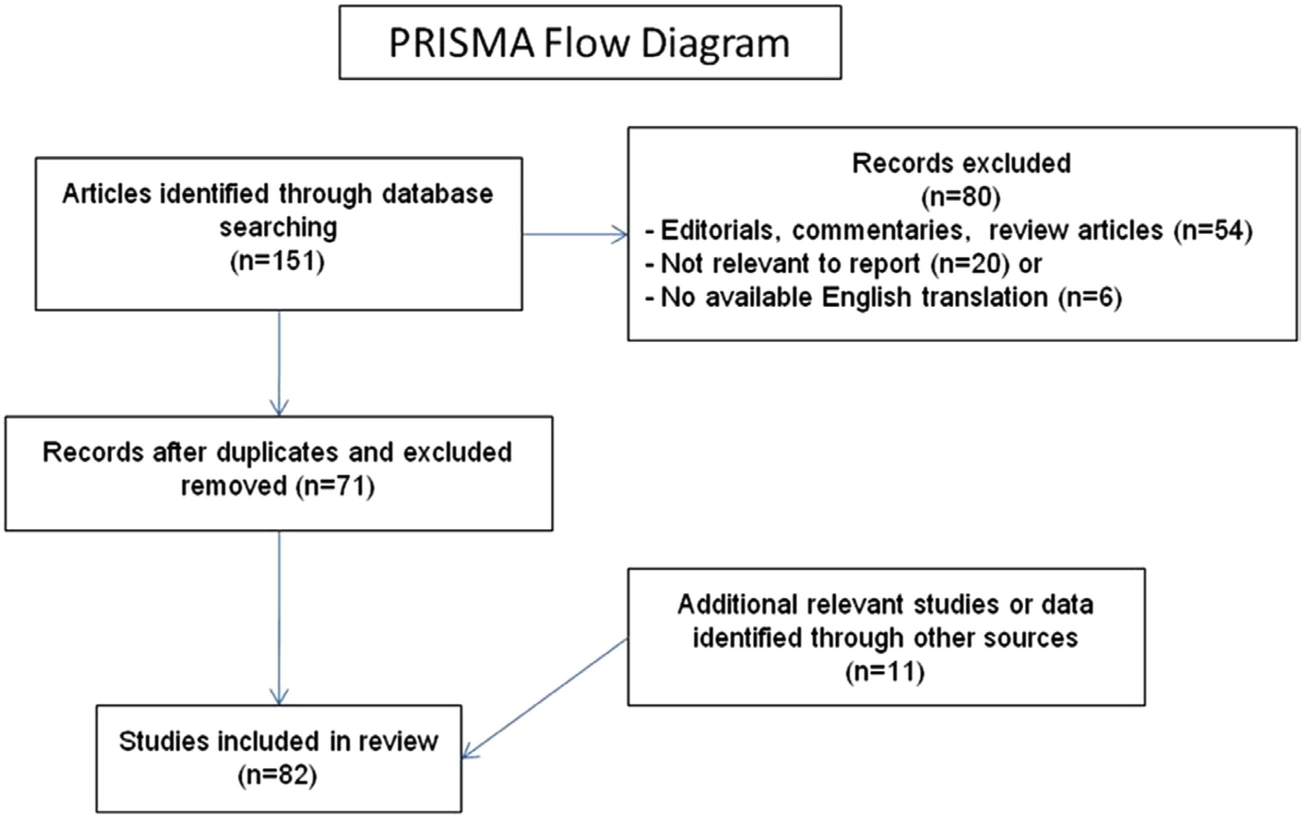

Figure 2. Studies screened and selected for inclusion. PRISMA indicates Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

smokers and recent quitters who viewed a television commercial for Blu e-cigarettes, 76% of current smokers reported that the ad made them think about smoking cigarettes, 74% reported it made them think about quitting, and 66% said it made them likely to try an e-cigarette in the future.[24] The 34% of participants who had used e-cigarettes were significantly more likely to think about smoking cigarettes after viewing the ad than nonusers (83% and 72%, respectively), suggesting that viewing an e-cigarette commercial may induce thoughts about smoking and cue the urge to smoke.[24]

Prevalence

Awareness of e-cigarettes and e-cigarette trial have at least doubled among both adults and adolescents in several countries from 2008 to 2012. In the United States, awareness is more prevalent among men, but trying e-cigarettes is more prevalent among women. Almost the same percent of European Union and US adult respondents to national surveys reported having tried e-cigarettes (7% in 2012 versus 6.2% in 2011, respectively).[5,25] All population-based studies of adult use show the highest rate of e-cigarette use among current smokers, followed by former smokers, with little use among nonsmokers, although e-cigarette trial and use rose in all of these categories.[4–6] Etter and Bullen[26] followed up a sample of e-cigarette users recruited from Web sites dedicated to e-cigarettes and smoking cessation, most (72%) of whom were former smokers at baseline. At the 1-year follow up, 6% of former smokers who were daily e-cigarette users at baseline relapsed to smoking cigarettes, and almost all (92%) of the former smokers using e-cigarettes daily at baseline were still using e-cigarettes daily at follow-up. Among 36 dual users at baseline, 16 (44%) had stopped smoking after 1 year. The epidemiological, population-based studies indicate that, across countries, e-cigarettes are most commonly being used concurrently with conventional tobacco cigarettes (dual use). Consistent with marketing messages, the most common reasons given for trying e-cigarettes are for use in places where smoking is restricted, to cut down on smoking, and for help with quitting smoking.[6,27–30]

Choi and Forster[31] followed up a cohort of Midwestern young adults (mean age, 24.1 years) who had never used e-cigarettes from 2010 to 2011 and found that 21.6% of baseline current smokers, 11.9% of baseline former smokers, and 2.9% of baseline nonsmokers reported having ever used e-cigarettes at follow-up. Those who believed at baseline that e-cigarettes could help with quitting smoking and perceived e-cigarettes to be less harmful than cigarettes were more likely to report experimenting with e-cigarettes at follow-up (adjusted odds ratio [OR], 1.98; 95% confidence interval [CI], 1.29–3.04; and adjusted OR, 2.34; 95% CI, 1.49–3.69, respectively).

Data on e-cigarette use among adolescents are more limited but, like for adults, show rapid increases in awareness and use in 5 countries (United States, Poland, Latvia, Finland, and Korea), with higher rates of trial and current use in European countries than the United States or Korea.[9,10,32,33] In Korea, youth ever use of e-cigarettes rose from 0.5% in 2008 to 9.4% in 2011,[10] and in the United States, it rose from 3.3% in 2011 to 6.8% in 2012.[9] As with adult population-based studies, data suggest that e-cigarette use is most appealing and prevalent among youth who are also experimenting with or are current users of tobacco cigarettes. Dual use with conventional cigarettes is the predominant pattern of e-cigarette use: 61% in US middle school students and 80% among US high school students in 2011.[9] These results indicate rapid market penetration of e-cigarettes among youth, with trial among US high school students (10.0%) in 2012 even higher than the 2011 rate for adults (6.2%).[5] Despite a law prohibiting e-cigarette sales to minors, e-cigarette use among Utah youth (grades 8, 10, and 12) tripled between 2011 and 2013, with youth 3 times more likely to report current e-cigarette use than adults.[34]

Although dual use with cigarettes is high, some youth experimenting with e-cigarettes have never tried a tobacco cigarette, which indicates that some youth are initiating use of nicotine, an addictive drug, with e-cigarettes. In 2012, 20.3% of middle school and 7.2% of high school ever e-cigarette users reported never smoking conventional cigarettes.[9] Similarly, in 2011 in Korea, 15% of students in grades 7 through 12 who had ever used e-cigarettes had never smoked a cigarette.[10] The Utah Department of Health found that 32% of ever e-cigarette users reported that they had never smoked conventional cigarettes.[34]

E-Cigarette E-Fluid and Vapor

Chemical Constituents

The nicotine content of the cartridge e-liquid from some brands revealed poor concordance of labeled and actual nicotine content.[35–39] Simulated e-cigarette use revealed that individual puffs contained from 0 to 35 μg nicotine per puff.[37] Assuming a high nicotine delivery of 30 μg per puff, it would take ≈30 puffs to deliver the 1 mg nicotine typically delivered by smoking a conventional cigarette. A puff of the e-cigarette with the highest nicotine content contained 20% of the nicotine contained in a puff of a conventional cigarette.[37] Actual nicotine delivery from an e-cigarette would likely be affected by users' smoking behavior. An analysis of UK brand e-cigarettes and the resulting aerosol demonstrated that, across brands, nicotine content of the e-liquid in the cartridges was not significantly correlated with the amount found in the resulting aerosol, indicating differences in the engineering characteristics of the device that strongly influence nicotine delivery even with a consistent puffing protocol.[40]

Goniewicz et al[41] analyzed the aerosol from 12 brands of e-cigarettes, a conventional cigarette, and a nicotine inhaler for toxic and carcinogenic compounds. The levels of toxicants in the aerosol were 1 to 2 orders of magnitude lower than in cigarette smoke but higher than with a nicotine inhaler (Table 1).

Kim and Shin[42] analyzed the tobacco-specific nitrosamines NNN, NNK, and NAT and total tobacco-specific nitrosamines in 105 refill fluids from 11 companies in the Korean market and found nearly a 3-order-of-magnitude variation in tobacco-specific nitrosamine concentrations, with total tobacco-specific nitrosamine concentration ranging from 330 to 8600 μg/mL.

Cytotoxicity

Bahl et al[43] screened 41 e-cigarette refill fluids from 4 companies for cytotoxicity using 3 cell types: human pulmonary fibroblasts, human embryonic stem cells, and mouse neural stem cells. Cytotoxicity varied among products from highly toxic to low or no cytotoxicity. The authors determined that nicotine did not cause cytotoxicity, that some products were noncytotoxic to pulmonary fibroblasts but cytotoxic to both types of stem cells, and that cytotoxicity was related to the concentration and number of flavorings used. The finding that the stem cells are more sensitive than the differentiated adult pulmonary fibroblasts cells suggests that adult lungs are probably not the most sensitive system to assess the effects of exposure to e-cigarette aerosol. These findings also raise concerns about pregnant women who use e-cigarettes or are exposed to secondhand e-cigarette aerosol.

In a study funded by the FlavorArt e-cigarette liquid manufacturers, Romagna et al[44] compared the cytotoxicity of aerosol produced from 21 nicotine-containing, flavored (12 tobacco flavored and 9 fruit or candied flavored) brands of e-cigarette liquid with smoke from a conventional cigarette using embryonic mouse fibroblast cells. Only aerosol from coffee-flavored e-liquid produced a cytotoxic effect (average, 51% viability at 100% concentration of solution).

Table 1. Levels of Toxicants in E-Cigarette Aerosol Compared With Nicotine Inhaler and Cigarette Smoke

Toxicant	Range in Content in Aerosol From 12 E-Cigarette Samples per 15 Puffs*	Range in Content in Conventional Cigarette Micrograms in Mainstream Smoke From 1 Cigarette	Content in Nicotine Inhaler Mist per 15 Puffs*
Formaldehyde, μg	0.2–5.61	1.6–52	0.2
Acetaldehyde, μg	0.11–1.36	52–140	0.11
Acrolein, μg	0.07–4.19	2.4–62	ND
o-Methylbenzaldehyde, μg	0.13–0.71	…	0.07
Toluene, μg	ND–0.63	8.3–70	ND
p,m-xylene, μg	ND–0.2	…	ND
NNN, ng	ND–0.00043	0.0005–0.19	ND
NNK, ng	ND–0.00283	0.012–0.11	ND
Cadmium, ng	ND–0.022	…	0.003
Nickel, ng	0.011–0.029	…	0.019
Lead, ng	0.003–0.057	…	0.004

Prepared using data from Goniewicz et al.[41] E-cigarette indicates electronic cigarette; and ND, not determined.

Farsalinos et al[45] tested cytotoxicity in cultured rat cardiac myoblasts of exposure to aerosol generated from 20 refill solutions from 5 manufacturers containing 6 to 24 mg/mL nicotine in various flavors, a "base"-only solution (50% propylene glycol and 50% glycerol), and conventional cigarette smoke. The aerosol from 3 fluids was cytotoxic at 100% and 50% dilution; 2 were tobacco flavored and 1 was cinnamon cookie flavored. Cigarette smoke was cytotoxic at 100% and all dilutions except 6.25%.

Secondhand Exposure

E-cigarettes do not burn or smolder the way conventional cigarettes do, so they do not emit side-stream smoke; however, bystanders are exposed to aerosol exhaled by the user. Schripp et al[46] conducted chamber studies in which subjects used 3 e-liquids (0 mg nicotine, apple flavor; 18 mg nicotine, apple flavor; 18 mg nicotine, tobacco flavor) and 1 tobacco cigarette and measured levels of several toxins and nicotine in the resulting aerosol. Three e-cigarette devices were used for these experiments: 2 that used a tank system that is directly filled with e-liquid and one that used a cartridge with a cotton fiber on which to drip the liquid. They found low levels of formaldehyde, acetaldehyde, isoprene, acetic acid, 2-butanodione, acetone, propanol, propylene glycol, and diacetin (from flavoring), traces of apple oil (3- methylbutyl-3-methylbutanoate), and nicotine (with differing levels depending on the specific protocols) emitted into the air. Toxins in the e-cigarette aerosol were at much lower levels compared with the conventional cigarette emissions.[46]

In another chamber study, Flouris et al[47] compared emissions of conventional cigarettes and e-cigarettes in conditions designed to approximate a smoky bar (target air CO of 23 ppm) using machine-smoked e-cigarettes and cigarettes. E-cigarette aerosol (using a single brand of e-cigarette made in Greece and a single e-liquid with at least 60% propylene glycol, 11 mg/mL nicotine) was generated with a pump that operated for the same duration as the cigarette smoking, and aerosol was released into the room. (A person inhaling a nicotine aerosol usually absorbs 80% of the nicotine,[48] whereas the pump discharges all nicotine into the environment, so the nicotine exposure may be higher in this study than would be the case with actual secondhand aerosol exposure.) Serum cotinine in nonsmokers sitting in the chamber was similar for cigarette smoke and e-cigarette aerosol exposure (average, 0.8 ng/mL for tobacco cigarette and 0.5 ng/mL for e-cigarette).

Schober et al[39] measured indoor pollution from 3 people using e-cigarettes over a 2-hour period in a realistic environment modeled on a café. They found elevated nicotine, 1,2-propanediol, glycerin, aluminum, and 7 polycyclic aromatic hydrocarbons classified as probable carcinogens by the International Agency for Research on Cancer in the room air.

Czogala et al[49] conducted a chamber study of secondhand exposure to e-cigarette aerosol compared with cigarette smoke, finding that, on average, bystanders would be exposed to nicotine but at levels 1/10th that of cigarette smoke (e-cigarette aerosol, 3.32±2.49 μg/m³; cigarette smoke, 31.60±6.91 μg/m³; P=0.008). Both e-cigarette aerosol and cigarette smoke contained fine particles ($PM_{2.5}$), with e-cigarette aerosol particle concentrations ranging from 6.6 to 85.0 μg/m³. E-cigarette aerosol was not a source of exposure to carbon monoxide, a key combustion element of conventional cigarette smoke.

Particulate Matter

E-cigarettes deliver nicotine by creating an aerosol of ultrafine particles. Fine particles can be variable and chemically complex, and the specific components responsible for toxicity and the relative importance of particle size and particle composition are generally not known.[50] Given these uncertainties, it is not clear whether the ultrafine particles delivered by e-cigarettes have health effects and toxicity similar to the ambient fine particles generated by conventional cigarette smoke or secondhand smoke. There is strong evidence, however, that frequent low or short-term levels of exposure to fine and ultrafine particles from tobacco smoke or air pollution can contribute to pulmonary and systemic inflammatory processes and increase the risk of cardiovascular and respiratory disease and death.[51–54]

Fuoco et al[55] examined particle number concentration and distribution and performed a volatility analysis of the e-cigarette aerosol generated from 3 devices (2 rechargeable and 1 disposable) using 4 refill e-liquids with varying levels of nicotine and flavorants. They found that higher e-liquid nicotine content was associated with higher particle numbers in the resulting aerosol, with little effect on the particle size distribution. Longer puffing time resulted in more particles. Flavor was not associated with differences in particle number or size distribution. Consistent with other studies,[46,56–58] the particle size distribution (range of modes, ≈120–165 nm) was similar to that of conventional cigarettes, with some e-cigarettes delivering more particles than conventional cigarettes (Figure 3).

Zhang et al[57] examined the size of e-cigarette aerosol particles and likely deposition in the human body (using a single brand, BloogMaxXFusion) with both propylene glycol and vegetable glycerin-based liquids. Using particle size and lung ventilation rates (1 for a "reference worker" and 1 for a "heavy worker": 1.2 and 1.688 m³/h, respectively), their human deposition model estimated that 73% to 80% of particles would be distributed into the exhaled aerosol, whereas 9% to 18% of particles would be deposited in alveoli resulting in arterial delivery, and 9% to 17% would be deposited in the head and airways, resulting in venous delivery. As expected, the heavy worker model showed more alveolar delivery across puffs compared with the reference worker, who would have more head and airway delivery. In total, ≈20% to 27% of particles are estimated to be deposited in the circulatory system and into organs from e-cigarette aerosol, which is comparable to the 25% to 35% for conventional cigarette smoke.

In their study of passive exposure to exhaled e-cigarette aerosol in a simulated café, Schober et al[39] found that concentrations of fine particles in the air increased from a median of 400 particles per 1 cm³ with people simply sitting in the room for 2 hours to medians of 49 000 to 88 000 particles per 1 cm³ (depending on the e-cigarette fluid used) after 2 hours of e-cigarette use in the same room

Both the e-liquid and the Poly-fil fibers that are used to absorb the e-liquid for heating and conversion to an aerosol come into contact with heating elements that contain heavy

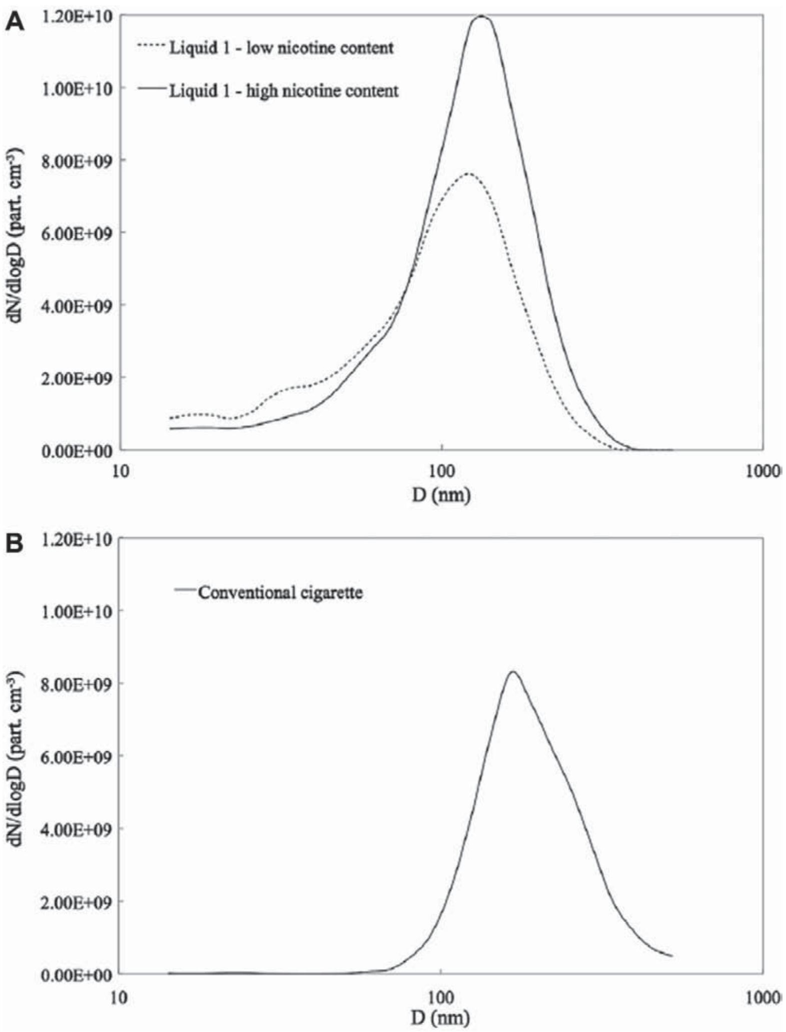

Figure 3. Particle number distribution from (**A**) mainstream aerosol in e-liquid 1 and from (**B**) conventional cigarette. Reproduced from Fuoco et al[55] with permission from the publisher. Copyright © 2013 Elsevier Ltd.

metals (tin, nickel, copper, lead, chromium). Williams et al[58] found heavy metals in samples of e-cigarette liquids and aerosol. Tin, which appeared to originate from solder joints, was found as both particles and tin whiskers in the fluid and Poly-fil, and e-cigarette fluid containing tin was cytotoxic to human pulmonary fibroblasts. E-cigarette aerosol also contained other metals, including nickel, 2 to 100 times higher than found in Marlboro cigarette smoke. The nickel and chromium nanoparticles (<100 nm) possibly originated from the heating element. It is likely that engineering features, including the nature of the battery, the heating temperature of the liquid, and the type of heating element and reservoir, will influence the nature, number, and size of particles produced. These metal nanoparticles can deposit into alveolar sacs in the lungs, potentially causing local respiratory toxicity and entering the bloodstream.

In summary, the particle size distribution and number of particles delivered by e-cigarettes are similar to those of conventional cigarettes, with most particles in the ultrafine range (modes, ≈100–200 nm). Particle delivery appears to depend on the nicotine level in the e-cigarette fluid but not the presence of flavors. Smokers exhale some of these particles, which exposes bystanders to "passive vaping." Like cigarettes, e-cigarette particles are small enough to reach deep into the lungs and cross into the systemic circulation. At a minimum, these studies show that e-cigarette aerosol is not merely "water vapor" as is often claimed in the marketing for these products. Tests on e-cigarettes show much lower levels of most toxicants, but not particles, than conventional cigarettes. The thresholds for human toxicity of potential toxicants in e-cigarette vapor are not known, and the possibility of health risks to primary users of the products and those exposed passively to their emissions must be considered.

Nicotine Absorption

Early studies of nicotine absorption in 2010 found that e-cigarettes delivered much lower levels of plasma nicotine than conventional cigarettes,[59,60] whereas a more recent study demonstrated that more experienced users using their own product who engaged in more puff intervals have nicotine absorption similar to that with conventional cigarettes,[61–63] perhaps as a result of a combination of characteristics of the devices and user vaping topography.[63] Another study of smokers smoking e-cigarettes using a specified protocol found a similar rise in serum cotinine immediately after use (mean increase, ≈20 ng/mL).[47] Several studies reported that regardless of nicotine delivery, e-cigarettes can modestly alleviate some symptoms of withdrawal, and participants positively appraised the use of e-cigarettes.[62–65] In a study comparing the nicotine inhalator and e-cigarettes,[60] the nicotine inhalator delivered an amount of nicotine similar to that in the 16-mg e-cigarette; however, the authors noted that the e-cigarette malfunctioned and did not deliver any nicotine in a third of participants. These results highlight the need for product regulation in terms of drug delivery and effects, as well as device functioning and labeling.

Health Effects

Propylene glycol and glycerin are the main base ingredients of the e-liquid. Exposure to propylene glycol can cause eye and respiratory irritation, and prolonged or repeated inhalation in industrial settings may affect the central nervous system, behavior, and the spleen.[66] In its product safety materials, Dow Chemical Company states that "inhalation exposure to [propylene glycol] mists should be avoided,"[67] and the American Chemistry Council warns against its use in theater fogs because of the potential for eye and respiratory irritation.[68] When heated and vaporized, propylene glycol can form propylene oxide, an International Agency for Research on Cancer class 2B carcinogen,[69] and glycerol forms acrolein, which can cause upper respiratory tract irritation.[70,71]

Major injuries and illness have resulted from e-cigarette use,[72] including explosions and fires.[73,74] Less serious adverse events include throat and mouth irritation, cough, nausea, and vomiting.[72]

A study[75] of healthy smokers' pulmonary function after acute ad lib puffing of an e-cigarette (Nobacco, medium, 11 mg) for 5 minutes (after refraining from smoking tobacco cigarettes for 4 hours) found no effect on spirometry but did find significantly increased dynamic airway resistance (18%) and decreased expired nitric oxide (16%). Sham e-cigarette use had no significant effect. This study is limited by the small sample size, the short period of tobacco use abstinence before protocol execution, the short length of exposure to e-cigarette aerosol, and the lack of comparison with smoking conventional cigarettes. In addition, smokers in general have high airway resistance with dynamic testing and lower expired nitric oxide, likely as a result of oxidant stress. Despite these limitations, this study suggests that e-cigarette use constricts peripheral airways, possibly as a result of the irritant effects of propylene glycol, which could be of particular concern in people with chronic lung disease such as asthma, emphysema, or chronic bronchitis.

Flouris et al[47] assessed the short-term effects of e-cigarette use on pulmonary function in 15 cigarette smokers who puffed an e-cigarette (>60% propylene glycol, 11 mg/mL nicotine) and a conventional cigarette according to a specified protocol, and passive exposure to e-cigarette aerosol and conventional cigarette smoke with 15 never smokers. Active cigarette smoking resulted in a significant decrease in expired lung volume (forced expiratory volume in the first second of expiration/forced inspiratory vital capacity) that was not seen with active e-cigarette use or with passive tobacco cigarette or e-cigarette exposure. Additional analysis of the data collected in this study[76] found that white cell count increased after cigarette smoking, reflecting inflammatory process–associated risk for acute cardiovascular events. Active e-cigarette use and passive exposure to e-cigarette vapor did not result in a significant increase in these biomarkers over 1 hour of exposure.

Schober et al[39] found elevated levels of exhaled nitric oxide in people using a nicotine e-cigarette (but not a nicotine-free e-cigarette), which the authors attributed to pulmonary inflammation.

National Vaper's Club, a pro–e-cigarette advocacy group, published a "risk assessment" of e-cigarette and cigarette use that concluded that "neither vapor from e-liquids or cigarette smoke analytes posed a condition of 'significant risk' of harm to human health via the inhalation route of exposure."[77] The authors failed to detect benzo(a)pyrene in conventional cigarette smoke despite the fact that it is an established carcinogen in cigarette smoke, and their assessment of conventional cigarettes concluded that they did not pose significant risk, both of which point to fatal errors in the data, data analysis, or both. Another report[15] funded by the Consumer Advocates for Smoke-free Alternatives Association and published on the Internet used occupational threshold limit values to evaluate the potential risk posed by several toxins in e-cigarettes, concluding that "there is no evidence that vaping produces inhalable exposures to contaminants of the aerosol that would warrant health concerns by the standards that are used to ensure safety of workplaces." Threshold limit values are an approach to assessing health effects for occupational chemical exposures that are generally much higher (often orders of magnitude higher) than levels considered acceptable for ambient or population-level exposures. Occupational exposures also do not consider exposure to sensitive subgroups such as people with medical conditions, children, and infants who might be exposed to secondhand e-cigarette emissions, most notably nicotine.

In summary, only a few studies have directly investigated the health effects of exposure to e-cigarette aerosol, but some demonstrate the ability of e-cigarette aerosol exposure to result in biological effects. Long-term biological effects are unknown at this time because e-cigarettes have not been in widespread use long enough for assessment.

Effects on Cessation of Conventional Cigarettes

E-cigarettes are promoted as smoking cessation aids, and many individuals who use e-cigarettes believe that they will help them quit smoking conventional cigarettes.[7,29,30] The assumption that e-cigarettes will be as effective as or more effective than pharmaceutical NRTs has also motivated support for e-cigarettes among some public health researchers and policy makers[78] and (as discussed later) formed the basis for some public policies on the regulation of e-cigarettes.

Population-Based Studies

There are 4 longitudinal studies[4,79–81] and 1 cross-sectional study[82] of the association between e-cigarette use and quitting conventional cigarettes (Table 2).

Adkison et al[4] studied current and former smokers in the *International Tobacco Control* study in the United States, Canada, the United Kingdom, and Australia at baseline and 1 year later and found that e-cigarette users had a statistically significant greater reduction in cigarettes per day (e-cigarette users, 20.1 to 16.3 cigarettes per day; nonusers, 16.9 to 15.0

Table 2. Population Studies of the Association Between E-Cigarette Use and Cessation of Conventional Cigarette Smoking

Study	Location and Study Design	Odds of Quitting (95% CI)
Longitudinal studies		
Adkison et al[4] (2013)	US, UK, Canada, Australia (ITC), surveyed, 1 y apart	0.81 (0.43–1.53)*
Vickerman et al[80] (2013)	US quit-line callers from 6 states surveyed at enrollment and 7 mo later	0.50 (0.40–0.63)†
Grana et al[79] (2014)	US sample drawn from a nationally representative Internet panel, 1 y apart	0.76 (0.36–1.60)
Choi and Forster[81] (2014)	Midwestern young adults, 1 y apart	0.93 (0.19–4.63)
Cross-sectional study		
Popova and Ling[82] (2013)	US sample drawn from a nationally represented Internet panel	0.69 (0.52–0.94) *
All studies		
Pooled‡		0.61 (0.50–0.75)

CI indicates confidence interval; E-cigarette, electronic cigarette; and ITC, International Tobacco Control.

*Odds ratios obtained by contacting authors.

†Computed by authors of this report on the basis of the numbers reported.

‡Estimated with a random-effects meta-analysis using Stata 12.1 metan. There was no evidence of heterogeneity (*P*=0.28) or evidence of publication bias with the use of a funnel plot.

cigarettes per day). Although 85% of e-cigarette users reported they were using the product to quit smoking at the initial wave, e-cigarette users were no more likely to have quit 1 year later than nonusers (OR, 0.81; 95% CI, 0.43–1.53; *P*=0.52).

Vickerman et al[80] found that ≈31% of quit-line callers surveyed 7 months after enrollment reported that they had ever tried e-cigarettes. The majority used them for <1 month (67.1%), and 9.2% were using them at the 7-month survey. The main reason for e-cigarette use was tobacco cessation (51.3%), but it is not known whether ever use occurred as part of a quit attempt in the preceding 7 months. Although quit-line callers represent a small population of smokers motivated to quit, these data present a real-world estimate of the potential effectiveness of using e-cigarettes for cessation in a population of smokers motivated to quit. Although this study had a low response rate (34.6%) and may be subject to recall bias because e-cigarette use and perceptions were assessed only at the 7-month follow-up, those who reported using e-cigarettes were statistically significantly less likely to quit than those who had not used e-cigarettes (21.7% among callers who used for ≥1 month, 16.6% among those who used for <1 month, and 31.4% among never users; *P*<0.001). The unadjusted odds of quitting were statistically significantly lower for e-cigarette users compared with nonusers (OR, 0.50; 95% CI, 0.40–0.63).

Grana et al[79] explored predictors of quitting among a national sample of smokers who participated in a study in 2011 and follow-up in 2012. Current e-cigarette use (past 30 days) at baseline did not predict a greater likelihood of having quit at the follow-up (OR, 0.71; 95% CI, 0.35–1.46). In a second logistic regression model that included baseline cigarettes per day, time to first cigarette, and intention to quit, in addition to baseline current e-cigarette use, only intention to quit (OR, 5.59; 95% CI, 2.41–12.98) and cigarettes per day (OR, 0.97; 95% CI, 0.94–0.99) were significant predictors of having quit at follow-up; current e-cigarette use remained nonsignificant (OR, 0.76; 95% CI, 0.36–1.60).

Choi and Forster[81] followed up a cohort of young adults in Midwestern (recruited October 2010–March 2011 and followed up for 1 year). Among those who were smoking cigarettes at baseline, 11% of those who used e-cigarettes at least 1 day in the past 30 days at baseline quit smoking at follow-up compared with 17% of smokers who never used e-cigarettes. In a logistic regression controlling for demographics and baseline cigarettes per day, baseline past 30-day e-cigarette use was not a significant predictor of having quit at follow-up (OR, 0.93; 95% CI, 0.19–4.63; *P*=0.93). There was also no significant change in the number of conventional cigarettes smoked per day between those who did and did not use e-cigarettes (difference, 0.2 cigarettes per day; 95% CI, −3.72 to 4.18; *P*=0.91).

In a national cross-sectional sample, Popova and Ling[82] found that adult smokers who ever used e-cigarettes were significantly less likely to be former smokers compared to those who never used e-cigarettes (OR, 0.69; 95% CI, 0.52–0.94), controlling for demographics (Lucy Popova, personal communication). In an examination of only those who tried to quit, those who ever used e-cigarettes were significantly less likely to be former smokers than never users (adjusted OR, 0.61; 95% CI, 0.45–0.83).

Combining these results in a random-effects meta-analysis (Table 2) yields a pooled OR of 0.61 (95% CI, 0.50–0.75), indicating that e-cigarette use in the real world is associated with significantly lower odds of quitting smoking cigarettes. A limitation of 3 of these studies[4,80,82] is that they did not control for level of nicotine dependence. It is possible that more dependent smokers, who would have more difficulty quitting in general, would be the ones who would be more likely to experiment with e-cigarettes, which could contribute to the finding that e-cigarette use is associated with a lower quit rate.

Clinical Trials

Four clinical trials (2 with very small samples) examined the efficacy of e-cigarettes for smoking cessation.[83–86] Three trials[83-85] did not have a control group who were not using e-cigarettes. The other study[86] compared e-cigarette efficacy to a standard-of-care regimen with a 21-mg nicotine patch. None of the trials were conducted with the level of behavioral support that accompanies most pharmaceutical trials for smoking cessation.

Polosa et al[83] conducted a proof-of-concept study in Italy in 2010 with smokers18 to 60 years of age not intending to quit in the next 30 days. Subjects were offered Categoria e-cigarettes and instructed to use up to 4 cartridges (7.4-mg nicotine content) per day as desired to reduce smoking and to keep a log of cigarettes per day, cartridges per day, and adverse events. Six-month follow-up was completed with 68% of participants (27 of 40): 13 were using both e-cigarettes and tobacco cigarettes, 5 maintained exclusive tobacco cigarette smoking, and 9 stopped using tobacco cigarettes while continuing to use e-cigarettes. Cigarette consumption was reduced by at least 50% in the 13 dual users (25 cigarettes per day at baseline to 6 cigarettes per day at 6 months; $P<0.001$). Polosa et al[87] continued follow-up of this sample at 18 and 24 months with 23 subjects (58% of the original 40 enrolled). Among the 23 participants who completed a 24-month visit, 18 continued to smoke, and 11 had reduced cigarette consumption by ≥50% with a statistically significant reduction from an average of 24 to 4 cigarettes per day ($P=0.003$). Five participants had quit tobacco cigarettes at 24 months. Study limitations included the use of a poor-quality product and the lack of a comparison or control group, which could make it difficult to determine whether quit rates achieved were not due to chance.

Caponnetto et al[85] conducted a similar study with 14 smokers with schizophrenia not intending to quit in the next 30 days. Participants were provided the same Categoria e-cigarette, and carbon monoxide, product use, number of cigarettes smoked, and positive and negative symptoms of schizophrenia were assessed at baseline and 4, 8, 12, 24, and 52 weeks. Seven of 14 participants (50%) sustained a 50% reduction in the number of cigarettes per day smoked at week 52, and the median of 30 cigarettes per day decreased to 15 cigarettes per day ($P=0.018$). Sustained abstinence from smoking occurred with 2 participants (14.3%) by week 52. Positive and negative aspects of schizophrenia were not increased after smoking cessation. The most common outcome was dual use of e-cigarettes with conventional cigarettes. Study findings are not generalizable to smokers with mental illness because of the very small sample size and lack of a control group.

Caponnetto et al[84] also conducted a randomized, quasi-controlled trial to examine the efficacy of e-cigarettes of different strengths for smoking cessation and reduction in 3 study arms: 12 weeks of treatment with the 7.2-mg nicotine e-cigarette, a 12-week nicotine-tapering regimen (6 weeks of treatment with a 7.2-mg e-cigarette and 6 weeks with a 5.4-mg e-cigarette), and a 12-week treatment with a nonnicotine e-cigarette. Similar reductions in the median cigarettes per day were seen at all study visits for all 3 treatment arms (7–10 cigarettes per day at 1 year). There was no statistically significant difference in 6-month or 1-year quit rate among the 3 conditions (1-year rates: 4% for placebo e-cigarette users, 9% for low-nicotine e-cigarette users, and 13% for high-nicotine e-cigarette users). The authors noted that those who initiated quitting in the first few weeks of the study stayed quitters, whereas those who did not remained dual users throughout the study. Twenty-six percent of quitters continued to use e-cigarettes at 1 year. Problems with the study include the lack of a control group not using e-cigarettes and noted lack of product quality (the devices malfunctioned often, and new ones had to be sent frequently). An author on all of these studies, R. Polosa, served as a consultant for the Arbi Group SRL, the manufacturer of the Categoria e-cigarette used in the study, beginning in February 2011.

Bullen et al[86] conducted a randomized, controlled, clinical trial of e-cigarettes compared with medicinal NRT in Auckland, New Zealand. Adult smokers motivated to quit were randomized to the 3 study arms (16-mg e-cigarette, 21-mg NRT patch, no-nicotine e-cigarette). Voluntary telephone counseling was offered to all subjects. Subjects were observed at baseline, 1 week (quit day), 12 weeks, and 6 months. Fifty-seven percent of participants in the nicotine e-cigarettes group reduced their cigarettes per day by ≥50% at 6 months compared with 41% in the patch group ($P=0.002$) and 45% in the nonnicotine e-cigarette group ($P=0.08$). Those randomized to the nicotine patch group were less adherent to the treatment (46%) than the 16-mg e-cigarette group (78%) and the no-nicotine e-cigarette group (82%). Of note, the study methodology may have introduced bias against success in the nicotine patch group because e-cigarettes were mailed for free directly to participants randomized to either the nicotine or no-nicotine e-cigarette group, whereas participants in the patch group were mailed cards redeemable for nicotine patches at a pharmacy and vouchers to cover the modest fee. Therefore, although the protocol for providing the patches represented "usual care" for New Zealand quit-line callers, this procedure may have introduced bias against NRT, making it difficult to view the study as a head-to-head comparison of e-cigarettes and NRT for cessation. There were no statistically significant differences in biochemically confirmed (breath CO) self-reported continuous abstinence from quit day to the 6-month follow-up between the nicotine e-cigarette (7.3%), nicotine patch (5.8%), and nonnicotine e-cigarette (4.1%).

Neither Capponnetto et al[84] nor Bullen et al[86] found effects of e-cigarette use on quitting beyond what is seen in unassisted or low-assistance studies of smokers using NRT to quit.[88] In determining the effectiveness of smoking cessation therapy, active drug is considered efficacious when it outperforms placebo; therefore, the evidence to date from clinical trials does not demonstrate that e-cigarettes are efficacious for cessation. However, it is possible that e-cigarettes even without nicotine act as substitutes for the sensory and behavioral effects of conventional cigarettes. If this is the case, the nonnicotine placebo e-cigarette would be considered an active treatment condition and, as discussed previously, has been shown to reduce withdrawal symptoms.[59,60,63,89] Important limitations of the current research include the use of e-cigarettes that deliver relatively low levels of nicotine and the provision of minimal behavioral counseling. Another important limitation of studies assessing the effectiveness of e-cigarettes for smoking cessation is that, because they are not approved as cessation therapy, there are no therapeutic instructions for using them as replacements or to quit smoking (eg, dosage tapering, duration of use, how to combine them with behavioral strategies, guidance for discontinuation).

In contrast to the assumption that e-cigarettes would function as a better form of NRT, population-based studies that reflect real-world e-cigarette use found that e-cigarette use is not associated with successful quitting; all[4,79,80,82] had point estimates of the odds of quitting of <1.0. The 1 clinical trial examining the effectiveness of e-cigarettes (both with and without nicotine) compared with the medicinal nicotine patch found that e-cigarettes are no better than the nicotine patch and that all treatments produced very modest quit rates without counseling.[86] Taken together, these studies suggest that e-cigarettes are not associated with successful quitting in general population-based samples of smokers.

Health Implications of Cigarette Reduction in the Context of Dual Use

Among adults, reductions in cigarettes per day were observed in several of the clinical studies[83,84,86] and in 1 population-based study[4] among those who did not quit. Reduction in cigarettes smoked per day could have benefit if it promotes subsequent cessation, as has been found with NRT,[90] but this pattern has not yet been seen with e-cigarettes. In the cigarette reduction analyses presented in some of the studies, many participants were still smoking about half a pack cigarettes per day at the end of the study.

Both duration (years of cigarette use) and intensity (cigarettes per day) determine the negative health effects of smoking.[91] People who stop smoking at younger ages have lower age-adjusted mortality compared with those who continued to smoke later into adulthood.[92] Findings for decreased smoking intensity have been less consistent, with some studies showing lower mortality with reduced daily cigarette consumption[93] and others not finding a significant overall survival benefit.[94] The 2014 report of the US Surgeon General concluded that "reducing the number of cigarettes smoked per day is much less effective than quitting entirely for avoiding the risks of premature death from all smoking-related causes of death."[95] Use of electronic cigarettes by cigarette smokers to cut down on the number of cigarettes smoked per day is likely to have much smaller beneficial effects on overall survival compared with quitting smoking completely.

This situation is particularly likely to exist for cardiovascular disease because of the highly nonlinear dose-response relationship between exposure to fine particles and the risk of cardiovascular disease.[53,96] Light smoking, even 1 to 4 cigarettes per day, is associated with markedly elevated risk of cardiovascular disease.[97] In addition, e-cigarettes deliver loads of fine particles similar to those of conventional cigarettes.

The relative risk of death from lung cancer increases with years smoked and cigarettes per day,[98] as well as pancreatic cancer[99] and esophageal cancer.[100] The relative risk of both lung cancer and bladder cancer levels off after a certain number of cigarettes per day,[101] suggesting that above a certain intensity, the specific levels of exposure may not cause significant differences in risk for these cancers. Doll and Peto[102] found a dose-response relationship between duration of smoking and number of cigarettes smoked per day and risk of lung cancer, with models suggesting the impact of duration to be greater than that of intensity. Using participants from the Cancer Prevention Study II, Flanders et al[103] found a greater increase in lung cancer mortality with a greater duration of cigarette smoking compared with a greater intensity of smoking. Overall, these data suggest that lung cancer mortality increases more with additional years of smoking than additional cigarettes per day. Thus, if dual use of e-cigarettes and cigarettes results in reductions in the number of cigarettes per day for current smokers, any reduction malignancy risk will be less than proportional to the reduction in cigarette consumption because of the (likely larger) importance of duration of smoking.

What to Tell Patients About E-Cigarettes and Cessation

First and foremost, clinicians must support a smoker's quit attempt and try to ensure any that advice given does not undermine their motivation to quit. Clinicians should follow the 5 A's of evidence-based treatment: ask, advise, assess, assist, and arrange.[104] They should assess their patient's motivation and readiness to quit and recommend a treatment plan that should include setting a quit date and obtaining cessation counseling and, if appropriate, conventional smoking cessation medications. The safest and most proven smoking cessation pharmacotherapies are the nicotine replacement medications varenicline and bupropion, which have been approved by the US Food and Drug Administration (FDA). Referral to a free telephone quit line (eg, 1-800-QUIT-NOW) or another counseling support program enhances the effectiveness of smoking cessation medications.[104]

If a patient has failed initial treatment, has been intolerant of or refuses to use conventional smoking cessation medication, and wishes to use e-cigarettes to aid quitting, it is reasonable to support the attempt. However, subjects should be informed that, although e-cigarette aerosol is likely to be much less toxic than cigarette smoking, the products are unregulated, contain toxic chemicals, and have not been proven as cessation devices. The patient should also be advised not to use the product indoors or around children because studies show that bystanders may be exposed to nicotine and other toxins (at levels much lower than cigarettes) through passive exposure to the e-cigarette aerosol. Because there are no long-term safety studies of e-cigarette use, patients should be urged to set a quit date for their e-cigarette use and not plan to use it indefinitely. It is also important to stress that patients should quit smoking cigarettes entirely as soon as possible because continued cigarette smoking, even at reduced levels, continues to impose tobacco-induced health risks (particularly for cardiovascular disease).

Tobacco Industry and Involvement

By 2013, the major tobacco companies had purchased or developed e-cigarette products (Table 3).

There is no evidence that the cigarette companies are acquiring or producing e-cigarettes as part of a strategy to phase out regular cigarettes, even though some claim to want to participate in "harm reduction." Lorillard CEO Murray Kessler stated in an interview with the *Wall Street Journal* that e-cigarettes will provide smokers an unprecedented chance to reduce their risk from cigarettes.[105] He also published an op-ed in *USA Today* on September 23, 2013, stating: "E-cigarettes might be the most significant harm-reduction option ever made available to smokers."[106] Shortly before this op-ed was published, however, Lorillard won approval from the US FDA to market new nonmentholated Newport conventional

Table 3. Tobacco Companies That Have Acquired or Created E-Cigarette Companies and Brands (as of January 2014)

Tobacco Company	Acquired E-Cigarette Company	E-Cigarette Brand(s)
Altria Inc	GreenSmoke	Mark Ten
Reynolds American Inc	No	Vuse
Lorillard	Blu Cigs, Inc	Blu
British American Tobacco	CN Creative	Vype
Imperial Tobacco	Dragonite Holdings Ltd	Ruyan
Swisher	No	E-Swisher

E-cigarette indicates electronic cigarette.

cigarettes, expanding their cigarette line while touting their ability to offer a product they claim reduces harm from cigarettes. This allows the cigarette companies to have it both ways. (Likewise, after evaluating the cigarette companies' internal documents and public positions on snus [a form of moist snuff tobacco in a pouch popular in Sweden] as "harm reduction" in Europe, Gilmore et al[107] found that they were entering the snus market[107] and adopting "harm reduction" rhetoric[108] to protect their cigarette business as long as possible.) As noted in the 2010 Surgeon General's report,[109] the tobacco industry has used every iteration of cigarette design to undermine cessation and prevention.

The tobacco companies address e-cigarette issues as part of their policy agenda. As they did beginning in the 1980s,[110,111] they continue to engage in creating and supporting "smokers' rights" groups, seemingly independent groups that interact with consumers directly on political involvement in support of their agenda.[111] Altria and R.J. Reynolds Tobacco Company maintain Web sites called Citizens for Tobacco Rights and Transform Tobacco. E-cigarette news and action alerts are featured on the home pages of these websites and include instructions for taking action against bills designed to include e-cigarette use in smoke-free laws. E-cigarette companies engage in similar tactics, using the same political and public relations strategies as the tobacco companies (most notably featuring organized "vapers" like the organized smokers). They also use social media that is tightly integrated with their product marketing campaigns to press their policy agenda.[22] These strategies were successfully deployed in Europe to convince the European Parliament to substantially weaken the proposed EU Tobacco Product Directive in October 2013.[112]

Current State of Global Regulation (March 2014)

Like e-cigarette products, the policy environment related to e-cigarettes is rapidly developing despite the fact that the science is just emerging. Policy makers in many countries are under considerable pressure to provide regulatory guidance regarding e-cigarettes, often on the basis of the assumption that e-cigarettes will contribute to reducing the harms of smoking either by serving as a smoking cessation aid or by replacing combusted cigarettes. The data reviewed here, together with evidence of dual use and youth initiation of e-cigarette use, do not demonstrate any hypothesized harm-reducing effect.

Some countries (including Brazil, Singapore, Canada, the Seychelles, and Uruguay) have prohibited the sale of e-cigarettes, and many others are developing policies.[1] The United States, European Union, and United Kingdom illustrate the range of regulatory approaches being developed.

The United States

In the United States, as of March 2014, e-cigarette products remained unregulated by any federal authority, particularly the US FDA. The Sottera Inc case ruling that was upheld on appeal in the US court found that e-cigarettes could be regulated as tobacco products unless they are marketed with health and therapeutic claims.[113] The US FDA has stated its intent to assert ("deem") authority over e-cigarettes but has yet to act. The US FDA does not have the authority to regulate where e-cigarettes are used; that is the domain of state and local governments, where almost all activity on smoke-free laws has occurred.

Since e-cigarettes entered the US market in 2008, there has been a rapid increase in the number of municipalities and states that have adopted legislation regulating where e-cigarettes can be used and laws restricting sales to minors. As of March 2014, 27 states had laws restricting sales to minors, 1 state (Minnesota) taxed e-cigarettes as tobacco products, and 3 states (New Jersey, North Dakota, and Utah) and >100 municipalities (including New York, Los Angeles, San Francisco, and Chicago) prohibited the use of e-cigarettes in 100% smoke-free indoor environments.[114] An additional 9 states restricted e-cigarettes in other venues such as school district property, Department of Corrections/prisons, public educational facilities and grounds, and commuter transit systems.[114] Some local and statewide smoke-free laws enacted before the introduction of e-cigarettes include language that could be interpreted as including e-cigarettes.

European Union Tobacco Product Directive

In February 2014, the European Parliament approved a revised European Union Tobacco Product Directive that regulates e-cigarettes with nicotine concentrations up to 20 mg/mL (an amount equal to that in a pack of cigarettes) as tobacco products.[115] E-cigarettes with higher nicotine concentrations or intended therapeutic uses will be regulated as medical devices.[116] The directive stipulates that e-cigarettes must be childproof and that packaging must include information about ingredients, adverse effects, and health warnings.[115] Refillable cartridges are allowed as long as their volume does not exceed 2 mL (but could be banned by the European Commission if at least 3 member states prohibit them on the basis of risks to human health).[115] Marketing and advertising restrictions will mirror those of tobacco products.[115]

The United Kingdom

In the United Kingdom, the Medicines and Healthcare Products Regulatory Agency announced a plan to regulate e-cigarettes as medicines on the basis of the assumption that e-cigarettes function like NRTs for smokers wishing to cut down or quit.[78] As of January 2014, Medicines and Healthcare Products Regulatory Agency policies did not include any restrictions on e-cigarette marketing.[117] The antismoking advocacy group Action on Smoking and Health UK has announced that it "does not consider it appropriate to include e-cigarettes under smokefree regulations,"[118] supporting one of the e-cigarette companies' key marketing messages that e-cigarettes can be used everywhere without the restrictions and social stigma of smoking.[3,119]

Policy Recommendations

E-cigarettes deliver lower levels of some of the toxins found in cigarette smoke. Main concerns about the potential of e-cigarettes to make a contribution to reducing the harm caused by cigarette smoking arise from effects on youth, dual use with cigarettes resulting in delayed or deferred quitting (among both adults and youth), and renormalization of smoking behavior.

The ultimate effect of e-cigarettes on public health will depend on what happens in the policy environment. These policies should be implemented to protect public health:

- Prohibit the use of e-cigarettes anywhere that use of conventional cigarettes is prohibited.
- Prohibit the sale of e-cigarettes to anyone who cannot legally buy cigarettes or in any venues where sale of conventional cigarettes is prohibited.
- Subject e-cigarette marketing to the same level of restrictions that apply to conventional cigarettes (including no television or radio advertising).
- Prohibit cobranding e-cigarettes with cigarettes or marketing in a way that promotes dual use.
- Prohibit the use of characterizing flavors in e-cigarettes, particularly candy and alcohol flavors.
- Prohibit claims that e-cigarettes are effective smoking cessation aids until e-cigarette manufacturers and companies provide sufficient evidence that e-cigarettes can be used effectively for smoking cessation.
- Prohibit any health claims for e-cigarette products until and unless approved by regulatory agencies to scientific and regulatory standards.
- Establish standards for regulating product ingredients and functioning.

In addition to being important in their own right, should these policies be put in place together with polices designed to make combustible tobacco products (eg, cigarettes, cigars, cigarillos) less desirable and available, it is possible that current conventional cigarette smokers who will not quit nicotine would shift to e-cigarettes without major dual use or youth initiation to nicotine addiction with e-cigarettes. Absent this change in the policy environment, it is reasonable to assume that the behavior patterns that have been observed for e-cigarettes will persist, which makes it unlikely that they will contribute to reducing the harm of tobacco use and could increase harm by perpetuating the life of conventional cigarettes.

Conclusions

Although most of the discussion of e-cigarettes among health authorities has concentrated on the product itself, its potential toxicity, and use of e-cigarettes to help people quit smoking, the e-cigarette companies have been rapidly expanding using aggressive marketing messages similar to those used to promote cigarettes in the 1950s and 1960s. E-cigarette advertising is on television and radio in many countries that have long banned similar advertising for cigarettes and other tobacco products and may be indirectly promoting smoking conventional cigarettes. Although it is reasonable to assume that, if existing smokers switched completely from conventional cigarettes (with no other changes in use patterns) to e-cigarettes, there would be a lower disease burden caused by nicotine addiction, the evidence available at this time, although limited, points to high levels of dual use of e-cigarettes with conventional cigarettes, no proven cessation benefits, and rapidly increasing youth initiation with e-cigarettes. Although some cite a desire to quit smoking by using the e-cigarette, other common reasons for using the products are to circumvent smoke-free laws and to cut down on conventional cigarettes, which may reinforce dual use patterns and delay or deter quitting.

The trajectory of the dual use pattern among adults or children is unclear, but studies of youth find that as many as one third of youth who use e-cigarettes have never smoked a conventional cigarette. Nicotine is a highly addictive substance with negative effects on animal and human brain development, which is still ongoing in adolescence.[120–123] Furthermore, high rates of dual use may result in greater total public health burden and possibly increased individual risk if a smoker maintains an even low-level tobacco cigarette addiction for many years instead of quitting.

Although data are limited, it is clear that e-cigarette emissions are not merely "harmless water vapor," as is frequently claimed, and can be a source of indoor air pollution. Smoke-free policies protect nonsmokers from exposure to toxins and encourage smoking cessation.[124] One hundred percent smoke-free policies have larger effects on consumption and smoking prevalence,[125] as well as hospital admissions for myocardial infarction, stroke, and other cardiovascular and pulmonary emergencies,[126] than weaker policies. Introducing e-cigarettes into clean air environments may result in population harm if use of the product reinforces the act of smoking as socially acceptable or if use undermines the benefits of smoke-free policies.

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KEY WORDS: adolescent ■ particulate matter ■ public policy ■ smoking

AMERICAN LUNG ASSOCIATION IN CALIFORNIA
THE CENTER for Tobacco Policy & Organizing

List of Municipalities that Restrict Smoking in Recreation Areas

MARCH 2014

According to the U.S. Surgeon General, secondhand smoke exposure is harmful at any level. Therefore, many cities and counties in California have taken steps to protect their residents from this danger by passing ordinances that restrict smoking in recreation areas, including parks, beaches and trails. While California state law only restricts smoking within 25 feet of tot lots and playgrounds, municipalities are specifically authorized to pass stronger laws to prohibit smoking within all recreation areas.

There are 328 municipalities in California that have restricted smoking in at least some recreation areas beyond state law. The table below lists all of these cities and counties and divides the policies into three categories:

1. **Municipalities that restrict smoking in all recreation areas with no designated smoking areas**
   There are 175 municipalities with this type of policy. This is the strongest type of restriction because no designated smoking areas are allowed, ensuring that residents will not be exposed to secondhand smoke in all recreation areas.

2. **Municipalities that restrict smoking in all recreation areas but allow designated smoking areas**
   There are 39 municipalities with this type of policy. Examples of this type of policy include allowing designated smoking areas that meet certain conditions in all parks or only in specific areas of certain parks. The policies do a lot to protect people from secondhand smoke, but mean that people can continue to be exposed to secondhand smoke in certain parts of recreation areas.

3. **Municipalities that restrict smoking in some recreation areas**
   There are 114 municipalities with this type of policy. These policies range from only restricting smoking at beaches to restricting smoking within certain recreation areas during fire season to only restricting smoking at specific parks or skate parks. While these ordinances do protect people from secondhand smoke exposure in some recreation areas, there is still more that can be done to restrict smoking at and protect residents from secondhand smoke in all recreation areas.

For more information about smokefree recreation areas and other restrictions on smoking in outdoor areas, visit http://center4tobaccopolicy.org/smokefree-outdoor-areas. These resources include information on the need for and benefits of these policies, a list of cities and counties that have adopted comprehensive outdoor secondhand smoke ordinances and answers to tough questions about smokefree outdoor policies.

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County	Restricts Smoking in All Recreation Areas	Restricts Smoking in All Recreation Areas But Allows Designated Smoking Areas	Restricts Smoking in Some Recreation Areas
Alameda County	Alameda Alameda County Albany Dublin Emeryville Fremont Hayward Oakland San Leandro Union City	Berkeley	Livermore
Alpine County			Alpine County
Amador County	Plymouth		Ione Jackson
Butte County	Chico		Paradise
Colusa County	Colusa Williams		Colusa County
Contra Costa County	Clayton Contra Costa County Danville Lafayette Martinez Pinole Pleasant Hill Richmond San Ramon Walnut Creek		Concord
Del Norte County	Crescent City		
El Dorado County			El Dorado County Placerville
Fresno County	Clovis Firebaugh Fresno Mendota Orange Cove Reedley		Coalinga Fresno County Kerman Kingsburg Selma
Glenn County		Orland	
Humboldt County	Arcata Blue Lake Eureka		
Imperial County	Calexico	Imperial	Imperial County
Inyo County			Bishop Inyo County
Kern County	Tehachapi		California City Delano Shafter
Kings County			Lemoore
Lake County	Clearlake Lakeport		
Lassen County	Susanville		
Los Angeles County	Alhambra Arcadia Baldwin Park Beverly Hills Calabasas Carson Cerritos Claremont Compton Covina Culver City Duarte El Monte Gardena Glendale Glendora Hawthorne Hermosa Beach Huntington Park Inglewood La Habra Heights La Verne Lomita Long Beach Los Angeles County Manhattan Beach Monterey Park Pasadena Redondo Beach Rosemead San Dimas San Fernando Santa Clarita Santa Monica South Pasadena Temple City Torrance Walnut Whittier	Burbank Downey Los Angeles Palmdale Rancho Palos Verdes Santa Fe Springs South Gate	Avalon Azusa Diamond Bar El Segundo Irwindale La Puente Malibu Maywood Monrovia Palos Verdes Estates Pico Rivera Pomona Sierra Madre West Covina
Madera County			Chowchilla Madera Madera County

County	Restricts Smoking in All Recreation Areas	Restricts Smoking in All Recreation Areas But Allows Designated Smoking Areas	Restricts Smoking in Some Recreation Areas
Marin County	Corte Madera Fairfax Larkspur Marin County Mill Valley Novato Ross San Anselmo San Rafael Sausalito Tiburon		
Mariposa County			Mariposa County
Mendocino County	Fort Bragg Ukiah		
Merced County			Atwater Merced
Mono County	Mammoth Lakes		Mono County
Monterey County	Carmel-by-the-Sea Gonzales Pacific Grove		Monterey Sand City
Napa County	Napa St. Helena	Napa County	American Canyon
Nevada County	Nevada City	Grass Valley	Nevada County Truckee
Orange County	Costa Mesa Fountain Valley Laguna Beach Laguna Hills Laguna Woods Newport Beach Santa Ana Seal Beach	Dana Point Irvine San Clemente	Cypress Fullerton Garden Grove Huntington Beach Laguna Nigel Lake Forest La Palma Los Alamitos Mission Viejo Orange County
Placer County	Roseville		Placer County Auburn
Plumas County			Plumas County
Riverside County	Banning Beaumont Corona Murrieta Palm Desert Palm Springs Temecula	Eastvale Jurupa Valley Moreno Valley Riverside Riverside County Wildomar	Coachella Desert Hot Springs Indio La Quinta Norco Perris
Sacramento County		Elk Grove Sacramento	Folsom Rancho Cordova Sacramento County
San Bernardino County	Adelanto Colton Loma Linda Rancho Cucamonga Redlands Yucaipa		Chino Chino Hills Fontana Montclair San Bernardino San Bernardino County Upland Yucca Valley
San Diego County	Chula Vista Coronado Del Mar El Cajon Encinitas Escondido Imperial Beach Lemon Grove National City San Diego County Solana Beach Vista	Carlsbad La Mesa Oceanside Poway San Diego San Marcos	
San Francisco County	San Francisco		
San Joaquin County			Lathrop Lodi San Joaquin County
San Luis Obispo County	Arroyo Grande Atascadero Grover Beach Morro Bay Pismo Beach San Luis Obispo		Paso Robles San Luis Obispo County
San Mateo County	Belmont Daly City Hillsborough Menlo Park Pacifica Redwood City San Carlos San Mateo County South San Francisco	Burlingame	Brisbane Woodside

County	Restricts Smoking in All Recreation Areas	Restricts Smoking in All Recreation Areas But Allows Designated Smoking Areas	Restricts Smoking in Some Recreation Areas
Santa Barbara County	Carpinteria Buellton		Santa Barbara Santa Barbara County
Santa Clara County	Campbell Cupertino Los Altos Los Gatos Milpitas Palo Alto San Jose Santa Clara County Saratoga Sunnyvale	Morgan Hill	Gilroy Mountain View
Santa Cruz County	Capitola Watsonville	Santa Cruz Scotts Valley Watsonville	Santa Cruz County
Shasta County	Redding		Anderson Shasta County
Sierra County			Sierra County
Siskiyou County			Mount Shasta Siskiyou County Weed
Solano County	Vallejo	Vacaville	Fairfield Solano County
Sonoma County	Healdsburg Petaluma Santa Rosa Sebastopol Windsor	Sonoma County	Cotati
Stanislaus County			Ceres Hughson Modesto Oakdale Riverbank Turlock
Sutter County	Yuba City		Live Oak
Tehama County			Red Bluff
Trinity County			Trinity County
Tulare County	Exeter		Dinuba Lindsay Tulare Tulare County
Ventura County	Camarillo Moorpark Simi Valley	Ojai	Thousand Oaks Ventura
Yolo County	Winters	Woodland	Davis
Yuba County		Yuba County	

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THE CENTER for Tobacco Policy & Organizing

List of Municipalities that Restrict Smoking in Service Areas

MARCH 2014

According to the U.S. Surgeon General, secondhand smoke exposure is harmful at any level. Therefore, many cities and counties in California have taken steps to protect their residents from this danger by passing ordinances that restrict smoking in outdoor service areas where people congregate, such as ATM lines, public transit stops, taxi stands and ticket lines.

There are 111 municipalities in California that have restricted smoking in service areas. The table below lists all of these cities and counties and divides the policies into two categories:

1. **Municipalities that prohibit smoking at all service areas**
   There are 85 municipalities with this type of policy. This is the strongest type of restriction because smoking is not permitted in any type of service area, ensuring that residents will not be exposed to secondhand smoke while waiting for buses, movies or any other service.
2. **Municipalities that prohibit smoking at some types of service areas but not all service areas**
   There are 26 municipalities with this type of policy. For example, some cities only prohibit smoking at bus stops but not other service areas. Such policies help to protect people from secondhand smoke, but mean that people can continue to be exposed to secondhand smoke in other types of service areas where smoking is not restricted.

For more information about smokefree service areas and other restrictions on smoking in outdoor areas, visit www.Center4TobaccoPolicy.org/smokefree-outdoor-areas. Resources available on this page include information on the need for and benefits of these policies, a list of cities and counties that have adopted comprehensive outdoor secondhand smoke ordinances and answers to tough questions about smokefree outdoor policies.

County	Prohibits Smoking at All Service Areas		Prohibits Smoking at Some Types of Service Areas But Not All Service Areas
Alameda County	Alameda Alameda County Albany Berkeley Dublin Emeryville Fremont	Hayward Newark Oakland Pleasanton San Leandro Union City	
Contra Costa County	Contra Costa County Lafayette Martinez Pinole	Pleasant Hill Richmond San Ramon Walnut Creek	Concord
Glenn County	Orland		
Humboldt County	Arcata Blue Lake	Eureka	

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County	Prohibits Smoking at All Service Areas	Prohibits Smoking at Some Types of Service Areas But Not All Service Areas
Los Angeles County	Avalon Baldwin Park Burbank Calabasas Carson Compton Glendale Huntington Park Pasadena San Fernando San Gabriel Santa Monica South Pasadena Temple City West Hollywood	Duarte Hermosa Beach Long Beach
Marin County	Larkspur Marin County Mill Valley Novato Ross San Rafael Sausalito	
Mono County	Mammoth Lakes	
Monterey County	Monterey	
Orange County	Laguna Hills Laguna Woods	
Riverside County	Murrieta Palm Desert Temecula	
Sacramento County		Sacramento County
San Bernardino County	Loma Linda Rancho Cucamonga	San Bernardino County
San Diego County	Coronado El Cajon Solana Beach	Carlsbad Chula Vista Del Mar Encinitas Escondido Imperial Beach La Mesa Lemon Grove National City Oceanside Poway San Diego San Diego County San Marcos Santee Vista
San Francisco County	San Francisco	
San Luis Obispo County	Morro Bay San Luis Obispo	
San Mateo County	Belmont Daly City Menlo Park	
Santa Barbara County	Carpinteria Santa Barbara Santa Barbara County	Buellton
Santa Clara County	Campbell Morgan Hill Palo Alto San Jose Santa Clara County	
Santa Cruz County	Capitola Santa Cruz Scotts Valley Watsonville	
Sonoma County	Petaluma Rohnert Park Sebastopol Sonoma County	Santa Rosa
Ventura County	Camarillo Moorpark Thousand Oaks	Port Hueneme
Yolo County	Davis	

Understanding California's New Smokefree Housing Law

November 2011

On September 6, 2011 Governor Jerry Brown signed Senate Bill 332 into law making it explicit that landlords have the right to make their rental properties smokefree. SB 332 was authored by Senator Alex Padilla (D-San Fernando Valley) and goes into effect on January 1, 2012. The new law simply places an existing authority into state law. In fact, many landlords throughout California have already prohibited smoking on their properties. More importantly, many cities and counties in California have gone much further than this new state law and prohibit smoking in multi-unit housing through local ordinances and housing authority policies.

This new state law has generated many questions from advocates, tenants, landlords and elected officials. This document serves to answer those questions by providing an overview of California's new smokefree housing law and how it impacts the different types of smokefree housing policies. For more smokefree housing resources, visit www.center4tobaccopolicy.org/localpolicies-smokefreehousing.

Common Questions about the New State Smokefree Housing Law

What specifically does this new law do?

While it has always been legal for landlords to prohibit smoking in the apartments they own and manage, this law specifically spells out that authority in state law. Moving forward, landlords who adopt a smoking restriction for anywhere on their property would need to include a provision in all leases and rental agreements specifying where smoking is prohibited and provide adequate notice for these changes in accordance with federal, state and local notice requirements.

What does this new law mean for smokefree housing policies for condominiums or housing authorities?

It was legal to prohibit smoking in condominiums and housing authority properties prior to this law and it remains legal to do so. Homeowners' associations and housing authorities can continue to adopt smokefree housing policies. Homeowners' associations and housing authorities were likely already providing adequate notice for changes and including information in leases and rental agreements when implementing nonsmoking policies, which this new law requires landlords to do. For more information about how to implement these types of policies, see the fact sheets from the Technical Assistance Legal Center on creating smokefree policies for affordable housing and condo complexes.

What does this new law mean for existing and future local smokefree housing ordinances?

The state law specifically does not preempt any local ordinance in effect on or before January 1, 2012, including ordinances that grandfather tenants who smoke, and it does not preempt any provision of a local ordinance in effect after January 1, 2012 that restricts smoking. This means that cities and counties can continue to adopt ordinances that create nonsmoking units in multi-unit housing. Landlords implementing a local ordinance will need to include a provision in all leases and rental agreements specifying where smoking is prohibited and provide adequate notice for these changes in accordance with federal, state and local notice requirements. These requirements are standard for any sort of changes in terms for tenants and mostly already included in ordinances passed prior to this law.

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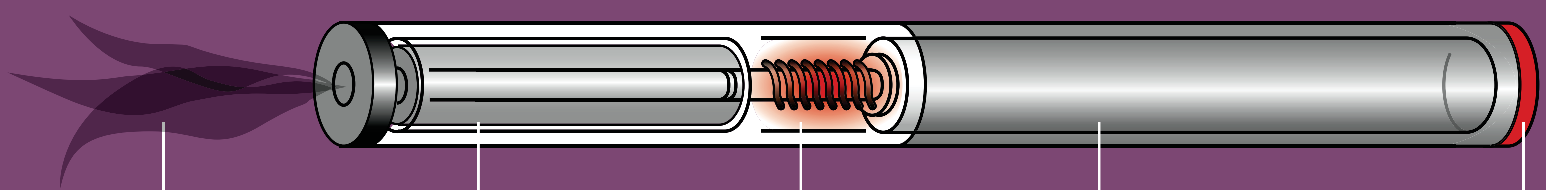
This fact sheet provides information about the public health concerns related to electronic smoking devices, the steps that have been taken to regulate electronic smoking devices, and what additional measures communities can take to limit access to and the availability of electronic smoking devices.

Regulating Toxic Vapor

A Policy Guide to Electronic Smoking Devices

Electronic smoking devices (also known as "electronic cigarettes," "e-cigarettes," "electronic nicotine delivery systems," "e-cigars," "e-cigarillos," "e-pipes," "e-hookahs," "hookah pens," etc.) are battery operated devices often designed to look like and be used in a similar manner to conventional tobacco products.[1] Electronic smoking devices are used to inhale a vaporized liquid solution that frequently, though not always, contains nicotine. Because the liquid solution is converted into vapor, electronic smoking device use is sometimes referred to as "vaping," rather than smoking. The increasing popularity of electronic smoking devices, combined with loopholes in some existing tobacco control laws, have the potential to renormalize tobacco use.[2]



Vapor is inhaled by the user and exhaled into the environment putting bystanders at risk of secondhand vapor exposure

Cartridge contains liquid that is converted into vapor

Note: This liquid often comes in flavors that are appealing to youth like chocolate or mint

Atomizer creates vapor from the nicotine solution in the cartridge

Note: More recent designs have combined the atomizer and flavor cartridge

Battery is often rechargeable, typically lithium-ion

LED light comes on during inhalation to mimic the glow of a traditional tobacco product

Policy Rationales for Restricting the Availability & Use of Electronic Smoking Devices

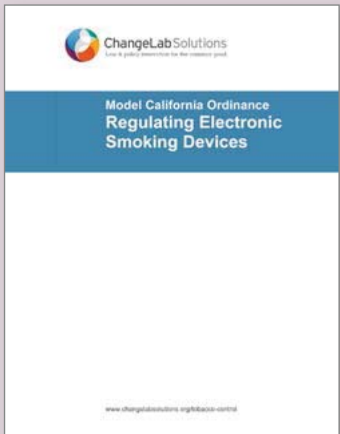
Hazardous Contents

Liquid solutions have addictive levels of nicotine sometimes 20 mg or higher[3] and contain potentially life-threatening carcinogens and toxic chemicals.[4,5] More than one study, including one conducted by the U.S. Food and Drug Administration (FDA), have found that electronic smoking devices contain a number of dangerous substances including tobacco-specific nitrosamines, which are human carcinogens;[6] tobacco-specific impurities suspected of being harmful to humans like anabasine, myosmine, and ß-nicotyrine;[7,8] and inconsistent labeling of nicotine levels in electronic smoking device products.[9,10] In one instance, diethylene glycol, an ingredient used in antifreeze and toxic to humans, was found.[11]

ChangeLab Solutions
Law & policy innovation for the common good.

This fact sheet includes information about model language ChangLab Solutions has developed to assist California cities and counties interested in regulating electronic smoking devices. ChangeLab Solutions' model ordinances offer a variety of policy options that can be tailored to the specific goals and needs of a particular community. For more information, please visit *www.changelabsolutions.org/landing-page/model-policies.*

While ChangeLab Solutions' *Model California Ordinance Regulating Electronic Smoking Devices* was designed for California communities, it can be adapted for use in other states. It is important to carefully review the existing law in your state, to understand the allowable regulations of other tobacco products, like electronic smoking devices. The best way to do this is to consult with an attorney licensed in your jurisdiction.



Exposure to Secondhand Vapor

The composition of the vapor emitted by an electronic smoking device has been found to contain several carcinogens, such as formaldehyde, acetaldehyde, lead, nickel, and chromium.[12,13,14] Additionally, electronic smoking devices have been found to contain other hazardous substances such as $PM_{2.5}$, acrolein, tin, toluene, and aluminum,[15,16,17] which are associated with a range of negative health effects such as skin, eye, and respiratory irritation,[18,19,20,21] neurological effects,[22] damage to reproductive systems,[23] and even premature death from heart attacks and stroke.[24]

Though the quantity of these harmful compounds contained in the vapor emitted by electronic smoking devices is often less than what is found in traditional cigarette smoke,[25,26] at least sodium, iron, aluminum, and nickel have been found in *higher* concentrations in emitted vapor than in cigarette smoke.[27,28]

This is especially troubling given that more than one peer reviewed study has concluded that exposure to vapor from a electronic smoking devices may cause passive or secondhand vaping.[29,30,31]

Rapid Growth in Popularity

There are over 400 brands of electronic smoking devices on the market.[32] Awareness levels of electronic smoking device products among the general population has increased dramatically, from between 40.8 and 44.1 percent in 2010, to 60.9 percent in 2011.[33] Further, the number of current smokers who have ever used an electronic smoking device more than doubled between 2010 and 2011, with 21.2 percent of current smokers reporting they have tried electronic smoking devices in 2011.[34]

Youth Appeal

The increase in use of electronic smoking devices among youth grades 6 to 12 is troubling. In 2012, 6.8 percent of all youth between 6th and 12th grade reported trying electronic smoking devices and 10 percent of high school students have tried them.[35]

Between 2011 and 2012, the percentage of all youth in grades 6 to 12 who had tried electronic smoking devices doubled.[36]

The solutions used in electronic smoking devices are often made in tempting flavors like chocolate and mint and are promoted as being healthy and environmentally friendly,[37] making them especially alluring to youth.[38] Recent national analyses of electronic smoking device users have indicated that young adults tend to be more likely to have tried them,[39] and that the perception of electronic smoking devices among smokers is that they are a safe alternative to cigarettes.[40]

Some Electronic Smoking Devices Do Not Contain Tobacco

While many electronic smoking devices contain nicotine, some devices claim to be 100 percent nicotine and tobacco free.

Determining which electronic smoking devices are truly nicotine free may be difficult for local tobacco control enforcement, given that manufacturers are not required to disclose the ingredients that make up the liquid solution used in electronic smoking devices. Further, product testing has revealed that the information and ingredients listed on the packaging of electronic smoking devices can be misleading or incorrect.[41]

In some cases, vapor lounges or individuals create their own liquid solutions, and there is no way to be sure these homemade solutions are properly labeled or even safe for consumption. For these reasons, local jurisdictions may wish to regulate all electronic smoking devices, whether or not they contain nicotine. If so, communities will need to craft their policies carefully to ensure that all the products they wish to regulate are adequately covered (see the section, *Policy Options for Regulating the Use & Sale of Electronic Smoking Devices,* on page 5).

Renormalization of Tobacco Use

As electronic smoking devices are used in places where tobacco products' use has previously been prohibited, such as workplaces, restaurants, and bars, and as marketing of electronic smoking devices expands into outlets where other tobacco products are prohibited such as television commercials,[42] electronic smoking devices have the potential to renormalize tobacco use. By encouraging experimentation with tobacco, especially among youth, electronic smoking devices have the potential to increase nicotine addiction among young people[43] and serve as a gateway to other tobacco products.[44]

Lack of Regulations Ensuring Safety & Quality Control

Electronic smoking devices have often been represented as a safe alternative to cigarettes. However, there are significant concerns about the safety of these products. For example, the vapor inhaled by electronic smoking device users often contains nicotine levels that are inconsistent with their labeling. Two separate studies found that the nicotine levels of two individual products from different manufacturers were over 20 percent higher than what their labeling indicated.[45,46]

Additionally, some cartridges can be refilled with liquid nicotine solution, creating the potential for exposure to dangerous concentrations of nicotine.[47] A recent analysis of electronic smoking device refill liquids found that "[t]he bottles of e-liquid are dangerous as they contain up to 720 mg of nicotine," which is a potentially lethal amount of nicotine.[48]

Poisonings from electronic smoking devices have increased dramatically in the last three and half years from "one [a month] in September 2010 to 215 a month in February 2014."[49]

Analysis of reports of poisonings from electronic smoking devices finds that people are more likely to report adverse health effects when compared to traditional cigarettes.[50]

Clinical studies about the safety and efficacy of electronic smoking devices for their intended use have not been submitted to the FDA.[51] This means that consumers have no way of knowing whether electronic smoking devices are safe for their intended use, what types or concentrations of potentially harmful chemicals the products contain, and what dose of nicotine the products deliver.

Public Health Support for the Regulation of Electronic Smoking Devices

The World Health Organization has strongly advised consumers against the use of electronic smoking devices until they are "deemed safe and effective and of acceptable quality by a competent national regulatory body."[52] The World Medical Association has determined electronic smoking devices "are not comparable to scientifically-proven methods of smoking cessation" and that "neither their value as therapeutic aids for smoking cessation nor their safety as cigarette replacements is established.[53]

Moreover, the State of California's Tobacco Education and Research Oversight Committee (TEROC) "opposes the use of [electronic smoking devices] in all areas where other tobacco products are banned."[54]

The Legal & Regulatory Landscape

In many places, electronic smoking devices are completely unregulated. However, there is a growing patchwork of laws throughout the U.S. that regulate how electronic smoking devices are sold and, in some cases, where they are used. Here is an overview of the laws governing electronic smoking devices, as of May 2014. The current gaps in regulation are highlighted and the policy options available to local governments are explained.

At the Federal Level

As of February, 2014, the only existing federal restrictions on electronic smoking device use are as follows:

- The U.S. Department of Transportation interprets existing federal regulations against smoking on airplanes to apply to electronic smoking devices.[55]
- The U.S. Air Force and U.S. Navy have both stated that their existing regulations governing tobacco use will apply to electronic smoking devices.[56, 57]

The 2009 Family Smoking Prevention and Tobacco Control Act ("the Tobacco Control Act"), which regulates the manufacturing and marketing of tobacco products, does not apply to electronic smoking devices, nor are electronic smoking devices subject to federal taxes. Therefore, no federal regulations currently exist for electronic smoking devices. There are also no federal regulatory standards for safety or quality control for electronic smoking devices before they can be sold to consumers. Under federal law, it is entirely legal to sell electronic smoking devices to children. Electronic smoking device advertisements are routinely seen on television, where conventional tobacco advertisements have not been seen for decades, and electronic smoking device manufacturers may freely introduce new products that have not been evaluated for safety.

The FDA issues the "deeming rule"

On April 25, 2014, the FDA took a significant step toward regulating these products by releasing its proposed "deeming rule," which would extend the agency's regulatory authority to a variety of tobacco products, including electronic smoking devices.[58] Although the Tobacco Control Act does not explicitly list all tobacco products by name, Congress gave FDA authority to issue a regulation deeming that any or all tobacco products are covered by the Tobacco Control Act. If the proposed deeming rule is finalized, it would extend several provisions of the Tobacco Control Act to electronic smoking devices. These provisions include the federal prohibition on sales to minors, the federal prohibition on free sampling, federal warning label requirements, and the requirement that tobacco manufacturers register with the FDA and seek the agency's review of new tobacco products.

Until such time as the deeming rule is adopted, the FDA's Center for Tobacco Products does not have authority to regulate the sale or use of electronic smoking devices as tobacco products. The FDA Center for Drug Evaluation and Research has limited authority to regulate electronic smoking devices as drugs or devices, but only if they are marketed for therapeutic purposes.[59]

The popularity of electronic smoking devices has boomed, and calls to regulate them have increased at all jurisdictional levels.

The FDA's proposed deeming rule must go through a public notice and comment process before the agency can implement the rule, and the FDA will likely make changes to the rule in response to this process. Given the large volume of comments the agency has received, it will take at least a year, if not longer, for the FDA to implement the final rule. Thus, it is unclear when the FDA will release final regulations on electronic smoking devices.

The Deeming Rule & Preemption

Many jurisdictions have questions about whether the FDA deeming rule would affect state or local laws. The proposed deeming rule makes clear that state and local governments can continue to adopt and enforce laws relating to tobacco product sales, use, distribution, and advertising (within constitutional limitations). According to the deeming rule, these state and local laws can be "in addition to, or more stringent, than the requirements of the Tobacco Control Act and its implementing regulations."[60] For example, the deeming rule would not affect states' and localities' ability to pass laws regulating where electronic smoking devices can be used, taxing electronic smoking devices, or requiring retailers to obtain a local license to sell electronic smoking devices. The deeming rule does identify some areas where local and state action could be preempted if the rule is finalized as written, including laws relating to manufacturing standards and labeling.

At the State Level

In California, it is illegal to sell or otherwise furnish an electronic smoking device to a person under 18 years of age. For purposes of this state law, an electronic device is defined as a device that can deliver a dose of nicotine to the user through a vaporized solution.[61] Local law enforcement agencies have the general authority to enforce this law under California Penal Code Section 830.1. Violators are subject to a fine of up to $200 for a first violation; $500 for a second violation; and $1,000 for a third or subsequent violation.

The California smokefree workplace law, by contrast, does not expressly prohibit the use of electronic smoking devices in enclosed workplaces.[62]

Local Policy Options for Regulating the Use & Sale of Electronic Smoking Devices

Regulating Use

Because the California state smokefree workplace law does not expressly prohibit the use of electronic smoking devices in places covered by that law,[63] many California communities are interested in prohibiting electronic smoking device use wherever conventional smoking is already prohibited. As discussed, it has been found that electronic smoking device vapor contains a variety of substances that are known to be toxic or carcinogenic. When electronic smoking devices are used in public places, bystanders may be involuntarily exposed to those chemicals resulting from secondhand vapor.

There is also considerable concern that the use of electronic smoking devices in places that are covered by a smokefree air law hinders enforcement of those laws.[64] Certain types of electronic smoking devices are often hard to distinguish from conventional cigarettes, and the confusion that results from inconsistently allowing their use in places where smoking is prohibited could have a chilling effect on enforcement of those laws altogether.[65] Relaxed enforcement of smokefree air laws could open the door for people to smoke conventional tobacco products in violation of smokefree laws without fear of consequences. Allowing electronic smoking device use in places that are otherwise smokefree also bears the risk of "re-normalizing" tobacco use, giving the mistaken impression that electronic smoking devices are safe or healthy rather than simply "less dangerous" than conventional cigarettes.[66]

There are different ways for local governments to regulate electronic smoking device use. The most appropriate solution depends on whether there is an existing law in the jurisdiction that regulates smoking, and what the scope of any such law is.

The first step in regulating electronic smoking device use is therefore to review your local laws that govern smoking. In some cases, electronic smoking devices may actually be covered by an existing smokefree law.

To determine whether electronic smoking devices are covered by an existing smokefree law, look to see if the ordinances definition of "smoke" is broad enough to cover vapor or aerosol, or if the definition of "smoking" expressly includes the use of electronic smoking devices, electronic cigarettes, electronic nicotine delivery systems, personal vaporizers, etc.

If it is determined that a jurisdiction's existing smokefree air law already applies to electronic smoking devices, the next step is to determine if that law is being enforced. It's possible that law enforcement may not be aware that the law applies to electronic smoking devices.

Amending an existing smokefree air law

More than one peer reviewed study has concluded that exposure to vapor from a electronic smoking devices may cause passive or secondhand vaping.[67,68,69]

For California jurisdictions that already have a local smokefree air law, one way to address electronic smoking devices is to amend the definitions of "smoke" and "smoking" in the law to explicitly include "electronic smoking device vapor" and "electronic smoking device use." For model definitions of "smoke" and "smoking" that cover electronic smoking devices, see ChangeLab Solutions' *Model Comprehensive Smokefree Places Ordinance*.[70] Advocates who take this approach should be mindful of the fact that opening up any law to add an amendment gives potential opponents the opportunity to weaken it. For example, opponents might try to narrow the scope of places where smoking is prohibited.

In California, many cities and counties have smokefree air laws that cover some outdoor areas, but do not cover indoor workplaces, which are smokefree under state law. If one of these cities were to amend its ordinance to cover electronic smoking devices merely by updating its definitions of "smoke" and "smoking", it would still not cover electronic smoking device use in indoor workplaces because the change still only applies to those places covered by *local* law. For this reason, in addition to updating its definitions of "smoke" and "smoking," the jurisdiction would also need to amend its local smokefree air law to expressly prohibit the use of electronic cigarettes in those places of employment covered by the state smokefree workplace law.

Adopting a stand-alone law

Another option is to pass a stand-alone law specifically to prohibit electronic smoking device use in any place where smoking is prohibited by law. The advantage of this approach is that it provides a catch-all to regulate electronic smoking device use in exactly the same way as conventional tobacco use, regardless of whether existing smokefree air laws are local, state, or federal, and would apply prospectively to any future smokefree air laws passed in that jurisdiction. This approach does not require any existing law to be amended, reducing the likelihood that opponents could use the opportunity to weaken or repeal it. For model language prohibiting electronic smoking device use in places where smoking is prohibited, see ChangeLab Solutions' *Model California Ordinance Regulating Electronic Smoking Devices.*[71]

Adopting a new smokefree air law & working with private companies

Finally, there are some jurisdictions where there may not yet be a local smokefree air law. These jurisdictions are completely free to include electronic smoking devices in any smokefree air law drafted in the future.

It's important to remember that many locations are also subject to voluntary smokefree policies created by individual property owners/managers or businesses. For example, the Starbucks Coffee Company prohibits smoking in all outdoor seating areas in its cafes.[72] Many hotel chains, such as Marriot and Westin, have also adopted policies to prohibit smoking entirely on their premises.[73] Private entities have a free hand to prohibit electronic smoking device use, and communities can work with them to develop or enhance such policies.

To help determine the most appropriate solution for a specific community to address electronic smoking device use, ChangeLab Solutions has developed a visual flow chart, which is available on our website at: *www.changelabsolutions.org/publications/e-cig-ord.*

Regulating Sales

In California, localities can regulate how electronic smoking devices are sold in a variety of ways, up to and including prohibiting the sale of electronic smoking devices altogether. In practice, when deciding precisely how to regulate electronic smoking devices, many jurisdictions seek to achieve consistency with existing laws governing conventional cigarettes and other tobacco products.

For example, jurisdictions may: prohibit the sale of electronic smoking devices to minors and require retailers to check ID; require retailers to keep electronic smoking device paraphernalia/accessories behind the counter; and prohibit the distribution of free samples of electronic smoking devices.

As of May 2014 "71 cities and counties in California [require] retailers to obtain a license to sell e-cigarettes."[74]

Any jurisdiction wishing to regulate sales of electronic smoking devices should first become familiar with the scope of existing laws regarding tobacco. It is possible that existing laws regulating tobacco sales (e.g. a local tobacco retailer licensing law) already apply to electronic smoking devices. To determine whether an existing sales restriction applies to electronic smoking devices, look to the definitions in the law ("tobacco," "tobacco product," etc.). In many cases, a law has a very inclusive definition of tobacco that includes all products that contain nicotine (and would therefore apply to electronic smoking devices that contain nicotine, or that are packaged with cartridges or e-liquid containing nicotine). In other cases, electronic smoking devices may be mentioned directly. If it is determined that existing tobacco laws in a jurisdiction already apply to electronic smoking devices, the next step is to determine if those laws are being enforced. It's possible that law enforcement may not be aware that the law(s) apply to electronic smoking devices.

Amending an existing tobacco retailer licensing law

In cases where a local jurisdiction has an existing law governing tobacco sales that does not apply to electronic smoking devices, it is possible to amend that law to cover those products. One way to do this is to broaden the definitions of "tobacco product" and "tobacco paraphernalia," to cover electronic smoking devices and their associated products, such as e-liquid. This can be done simply by referencing these products by name in the definitions.

For model definitions that cover electronic smoking devices in this way, contact ChangeLab Solutions for assistance.* The advantage of this approach is that it is a simple way to uniformly and consistently apply a variety of tobacco laws to electronic smoking devices.

However, there are some reasons to be cautious with this approach. For example, opening up an existing law to the amendment process creates an opportunity for opponents of the law to limit the law's scope to (for instance) exempt certain types of products from the definition of "tobacco product" like new dissolvable tobacco or nicotine lozenges. This approach is also problematic in that it only affects the laws of the specific jurisdiction. If a city or county has a law prohibiting tobacco vending machines, and they amend the definition of "tobacco product" in their municipal code so that it includes electronic smoking devices, it would not address regulatory gaps at the state level, e.g. a state law like California's which prohibits self-service displays of tobacco products but does not prohibit self-service displays of electronic smoking devices.

Adopting a stand-alone law

In lieu of amending an existing tobacco retailer licensing law, a jurisdiction can adopt a stand-alone ordinance that regulates electronic smoking device in all the same ways that conventional tobacco products are regulated. For example, local governments can require retailers to check the ID of people who purchase electronic smoking device, prohibit self-service displays of electronic smoking devices, and prohibit retailers from giving out free samples to the public. Several states including California[75] have passed stand-alone laws that prohibit the sale of electronic smoking devices to minors. Many local governments in jurisdictions around the country have passed similar laws.[76] For communities that are interested in stand-alone laws such as these, see ChangeLab Solutions' *Model California Ordinance Regulating Electronic Smoking Devices* as a reference.[77]

Adopting a new tobacco retailer licensing (TRL) law

Local jurisdictions that don't already have a tobacco retailer licensing law might consider adopting one that covers both traditional tobacco products and electronic smoking devices and the various liquids sold with them as tobacco products and tobacco or smoking paraphernalia. Tobacco retailer licensing laws require retailers to abide by all applicable local, state and federal tobacco laws in order to maintain their license, and can contain a wide variety of additional conditions. For example, a TRL law may require retailers to agree not to sell electronic smoking devices to minors, to keep all electronic smoking devices behind the counter, or to agree not to give out electronic smoking device samples to prospective customers.

The advantage of including electronic smoking devices in a TRL law is that the requirements for tobacco retailing can be consistently applied to electronic smoking devices and other tobacco products in a uniform way, simplifying and streamlining enforcement. There are numerous city and county governments which have enacted TRL laws that apply to electronic smoking devices along with all other tobacco products.[78] For more information about tobacco retailer licensing, see *License to Kill? Tobacco Retailer Licensing as an Effective Enforcement Tool*, as well as ChangeLab Solutions' *Model Tobacco Retailer Licensing Ordinance.*[79]

* *Note, in some cases a jurisdiction may wish to regulate only those electronic smoking devices that contain nicotine or that can be used to deliver nicotine. This can be done by amending the definition of "tobacco product" to include all products containing nicotine that is either derived from tobacco or synthetically produced, and by changing the definition of tobacco or smoking-related "paraphernalia" to include devices that can be used to deliver a tobacco or nicotine product. For more on this approach, see ChangeLab Solutions' Model Tobacco Retailer Licensing Ordinance at: www.changelabsolutions.org/publications/model-TRL-Ordinance*

Taxing Electronic Smoking Devices

Finally, it may be possible for state and/or local governments to levy taxes on electronic smoking devices. In most jurisdictions, electronic smoking devices are currently not taxed the way that cigarettes and other tobacco products are, and federal law does not preempt state or local governments from taxing electronic smoking devices.

Numerous studies have shown that one of the most clearly effective ways of reducing tobacco use, particularly among minors, is to increase the price of those products.[80] Not only do higher excise taxes on tobacco products lower rates of use, but they also create a source of revenue that can be used to offset health costs related to tobacco and to fund public health efforts.[81]

If there is not an existing state or local law that levies a tax on electronic smoking devices, it may be possible to enact one in order to bring taxes on these products more in line with the taxes on conventional cigarettes and/or other tobacco products. Policy questions that may arise include how to set the taxation rate given the many different forms in which electronic smoking devices and their components are sold, and whether the taxation rate should be lower than the rate for conventional tobacco products. Minnesota is the first state in the country to tax electronic smoking devices as a tobacco product. Although the law itself does not explicitly mention electronic smoking devices, the definition of "tobacco products" is broad enough to cover any product that contains or is derived from tobacco.[82] The Minnesota Department of Revenue has issued a notice clarifying that in its opinion the tobacco products tax applies to electronic smoking devices.[83] As of January 2014, several other states are considering this strategy, for example Delaware, Maine, Massachusetts, New Mexico, Oklahoma, and Utah.[84]

Electronic Smoking Devices & the Minnesota Department of Revenue

In October, 2012, the Minnesota Department of Revenue clarified its position that the state's tobacco products tax applies to electronic smoking devices. More specifically, the notice states that electronic smoking devices (or any components thereof) that contain nicotine constitute tobacco products under the assumption that all nicotine is derived from tobacco. Products containing nicotine that are not derived from tobacco are exempt from the tax; however, the burden is on the taxpayer to prove this to the department. Furthermore, the sales price of an entire electronic smoking device "kit" or package is subject to the tax unless a wholesaler sells the nicotine-containing component (such as a cartridge or liquid bottle) separately and can isolate the cost of the product.

How We Can Help

Additional materials related to electronic smoking devices are available on our *website* including our *Model California Ordinance Regulating Electronic Smoking Devices.*

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Photos by ChangeLab Solutions and Douglas Litchfield/iStock (p.4).

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Smoke & Mirrors

Why Smokefree Air Laws Can Address Electronic Smoking Devices' Vapor

Eighty-eight percent of websites for electronic smoking devices claim that these devices give users the freedom to smoke anywhere. This fact sheet highlights why smokefree air laws can cover the vapor emitted from electronic smoking devices.

Electronic smoking devices (also known as "electronic cigarettes," "e-cigarettes," or "electronic nicotine delivery systems") are battery operated devices designed to be used in a manner similar to conventional tobacco products.[1] The use of electronic smoking devices is referred to as "vaping." Despite emerging research showing that electronic smoking devices contain hazardous substances and may expose bystanders to secondhand vapor,[2,3,4] the popularity of these devices is soaring.[5,6]

As electronic smoking devices are used in places where the use of traditional cigarettes has previously been prohibited – such as workplaces, restaurants, and bars – they are threatening to renormalize tobacco use. The tobacco industry is encouraging this behavior. Many advertisements, including 88 percent of websites for electronic smoking devices, claim electronic smoking devices give users the freedom to smoke anywhere.[7] For example, recent ads proclaim:

- "You control when and where you want to smoke."[8]
- "Smoke this! Anytime. Anywhere."[9]
- "Smoking permitted."[10]
- "Smoke in restaurants, work, cars, trucks, and around other people."[11]

Despite this clear invitation to smoke, proponents of electronic smoking devices often claim that vaping is not the same as smoking and that smokefree air laws do not apply to people who vape.

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They make this argument in spite of their own advertisements and in spite of the fact that common definitions of "smoke" include vapor. For example, the Merriam-Webster Dictionary defines smoke as:

> "**1 a:** the gaseous products of burning materials especially of organic origin made visible by the presence of small particles of carbon **b:** a suspension of particles in a gas; **2 a:** a mass or column of smoke **b:** smudge; **3:** ***fume or vapor often resulting from the action of heat on moisture;*** **4:** something of little substance, permanence, or value; **5:** something that obscures; **6 a(1):** something (as a cigarette) to smoke (2): marijuana **b:** an act of smoking tobacco; especially: a smoking break; **7 a:** a pale blue **b:** any of the colors of smoke; **8:** pitches that are fastballs."[12]

By making the argument that smoking is somehow different from vaping, opponents of electronic smoking device regulation are simply attempting to cloud the issue, create confusion among policymakers, and deter local communities from restricting the use of electronic smoking devices.

Although many smokefree air laws already prohibit vaping in public places and places of employment, some jurisdictions are interested in strengthening their code to clarify that their smokefree air laws apply unequivocally to the use of electronic smoking devices.

To support those legislative changes, **ChangeLab Solutions has made the following definitions available for tobacco control advocates to use when updating their smokefree air laws:**

- "Smoke" means the gases, particles, or vapors released into the air as a result of combustion, electrical ignition or vaporization, when the apparent or usual purpose of the combustion, electrical ignition or vaporization is human inhalation of the byproducts, except when the combusting or vaporizing material contains no tobacco or nicotine and the purpose of inhalation is solely olfactory, such as, for example, smoke from incense. The term "Smoke" includes, but is not limited to, tobacco smoke, Electronic Smoking Device vapors, marijuana smoke, and crack cocaine smoke.
- "Smoking" means engaging in an act that generates Smoke, such as, for example: possessing a lighted pipe, a lighted hookah pipe, a lighted cigar, an operating Electronic Smoking Device, or a lighted cigarette of any kind; or lighting or igniting a pipe, a hookah pipe, a cigar, or a cigarette of any kind.

Additional Resources from ChangeLab Solutions:

- *Model California Ordinance: Regulating Electronic Smoking Devices*
- *Regulating Toxic Vapor: A Policy Guide to Electronic Smoking Devices*
- *Comprehensive Smokefree Places Ordinance: A Model California Ordinance Regulating Smoking in Indoor and Outdoor Areas*

changelabsolutions.org/tobacco-control

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Photos courtesy of trinketsandtrash.org.

Smoke-Free Multi-Unit Housing

Approaches to Protect Tenants from Secondhand Smoke

Disclosure

State law requires landlords to indicate in new leases where smoking is prohibited on the property. Local governments can require landlords to provide all tenants with this information directly (landlords can also provide this voluntarily).

Smoke-Free Common Areas

Many indoor common areas, like hallways and laundry rooms, are already required by state law to be smoke-free. Local governments and landlords can also make outdoor common areas, like gardens and pool areas, smoke-free.

Smoke-Free Units

Local governments and landlords can make some or all individual units smoke-free, including patios and balconies.

Smoke-Free Buffer Zones

Local governments and landlords can prohibit smoking within a specific distance from all entrances, doorways, or operable windows of a building. Landlords who want to create designated smoking areas for their tenants who smoke should take care to locate them outside of the buffer zone.

Above: Essential elements of smoke-free housing (can be adopted by landlords or local government)

Below: Additional approaches that could be adopted by local government

Nuisance and Trespass

Local governments can declare involuntary exposure to secondhand smoke a nuisance, and designate unwanted tobacco smoke on residential property a trespass. This may give tenants greater legal recourse against drifting smoke.

Last Resort Move Out Options

Local governments can also pass a law allowing tenants to break their lease early and without penalty in cases where they're exposed to secondhand smoke from another tenant, and where the landlord fails to take adequate steps to remedy the problem. Local governments can make a landlord's failure to remedy a drifting secondhand smoke problem grounds for a claim of constructive eviction, which might allow tenants to escape their lease without penalty.

Implied Warranty of Habitability / Implied Convenant of Quiet Enjoyment

Local governments can make drifting secondhand smoke a potential violation of a landlord's responsibility to maintain property in habitable condition and to protect tenants' right to enjoy their unit.

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Tobacco-Smoke Exposure in Children Who Live in Multiunit Housing

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Tobacco-Smoke Exposure in Children Who Live in Multiunit Housing

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KEY WORDS

secondhand smoke, passive smoking, environmental tobacco smoke, multiunit housing, apartment

ABBREVIATION

NHANES—National Health and Nutrition Examination Survey

Dr Wilson participated in all aspects of the study, including study conception and design, interpretation of data, drafting and revising of the manuscript, and supervising the statistical analysis; Dr Klein made substantial contributions in the design of the study, interpretation of the data, critical revision of the manuscript, and supervision; Mr Blumkin provided the statistical analyses for the study, acquired the data, and assisted with the drafting and revision of the manuscript; Dr Gottlieb provided important information on the medicolegal and policy implications of the study, assisted in the interpretation of the data from the policy perspective, contributed to the revision of the manuscript, and supervision; and Dr Winickoff provided overall supervision for the direction of the manuscript and was involved in the conception and design, analysis and interpretation of data, and critical review of the manuscript.

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WHAT'S KNOWN ON THIS SUBJECT: Exposure to secondhand tobacco smoke is an important cause of morbidity and mortality among children, even at low levels of exposure. In a recent national sample, 54% of children who did not live with a smoker showed measureable amounts of cotinine.

WHAT THIS STUDY ADDS: Children who live in homes in which no one smokes inside have a 45% increase in cotinine levels if they live in apartments compared with detached homes. Multiunit housing may be a significant source of secondhand tobacco-smoke exposure for children, at levels associated with morbidity.

abstract

OBJECTIVE: There is no safe level of secondhand tobacco-smoke exposure, and no previous studies have explored multiunit housing as a potential contributor to secondhand tobacco-smoke exposure in children. We hypothesized that children who live in apartments have higher cotinine levels than those who live in detached homes, when controlling for demographics.

METHODS: We analyzed data from the 2001–2006 National Health and Nutrition Examination Survey. The housing types we included in our study were detached houses (including mobile homes), attached houses, and apartments. Our study subjects were children between the ages of 6 and 18 years. Cotinine levels were used to assess secondhand tobacco-smoke exposure, and those living with someone who smoked inside the home were excluded. χ^2 tests, *t* tests, and Tobit regression models were used in Stata. Sample weights accounted for the complex survey design.

RESULTS: Of 5002 children in our study, 73% were exposed to secondhand tobacco smoke. Children living in apartments had an increase in cotinine of 45% over those living in detached houses. This increase was 212% ($P < .01$) for white residents and 46% ($P < .03$) for black residents, but there was no significant increase for those of other races/ethnicities. At every cutoff level of cotinine, children in apartments had higher rates of exposure. The exposure effect of housing type was most pronounced at lower levels of cotinine.

CONCLUSIONS: Most children without known secondhand tobacco-smoke exposure inside the home still showed evidence of tobacco-smoke exposure. Children in apartments had higher mean cotinine levels than children in detached houses. Potential causes for this result could be seepage through walls or shared ventilation systems. Smoking bans in multiunit housing may reduce children's exposure to tobacco smoke. *Pediatrics* 2011;127:85–92

Tobacco-smoke exposure causes illness in children, including asthma[1,2] and respiratory infections,[3] and has been associated with sudden infant death syndrome,[4] metabolic syndrome,[5] and otitis media.[6] There is no safe level of exposure to tobacco smoke.[6] Very low levels of tobacco-smoke exposure have been associated with attenuated endothelial function in children,[7] as well as decreased scores on reading, math, and block-design tests of cognitive function.[8] Morbidity has been documented in those with the lowest levels of cotinine (0.015–0.5 ng/mL), and these children have greater rates of conduct disorder.[9] Even brief exposure to ambient tobacco smoke can decrease lung function and cause persistent elevations in inflammatory cytokines.[10]

Parental smoking is the most common source of secondhand tobacco-smoke exposure for children. In 1 study,[6] 25% of children aged 3 to 11 years reportedly lived with at least 1 smoker. However, 60% of the children in the study had detectable levels of cotinine,[6] a metabolite specific to tobacco smoke. Other known exposures do not explain all of the 54% of children with elevated cotinine levels who had no identified smoker in the home.[11,12] These children, therefore, must have been exposed to other sources of tobacco smoke that are not being captured by parent report.

Tobacco smoke can migrate through walls, ductwork, windows, and ventilation systems of multiunit dwellings and potentially affect residents in other units far removed from the smoking area.[11,13] In addition to the dissemination of this secondhand smoke into other apartments, tobacco toxins may persist on and be absorbed from surfaces in the indoor environment well beyond the period of active smoking.[14–16] This "thirdhand smoke"[17] may re-emit deposited volatile compounds and particulate matter on indoor surfaces, and particulate matter in dust may be resuspended into the air as respirable suspended particulate matter.[14,18,19] In addition to inhalation, there are other potential exposure routes, such as ingestion, that are particularly likely in children.[15]

Recent public health efforts to reduce tobacco smoke exposure have concentrated on banning smoking in public places outside of the home, including workplaces, restaurants, and bars, leading to improved air quality in those locations.[20] However, in New York City, where the prevalence of cigarette smoking is lower than the national average and there are strict smoking bans in bars and restaurants, a recent study[21] found that the prevalence of elevated cotinine levels among nonsmoking adults was higher than the national average. The authors speculated that contamination of multiunit buildings with tobacco smoke from other units may contribute to these surprisingly high cotinine levels, although no direct measurement of nicotine in the air was performed. Some municipalities have proposed legislation to reduce or ban smoking in apartment buildings,[22,23] and some public-housing authorities have implemented smoke-free policies.[24] In 2009, the Department of Housing and Urban Development encouraged public-housing authorities to ban smoking in low-income multiunit housing.[25] There also have been reports of privately owned housing units that have banned smoking because of the potential health risks, increased costs associated with removing tobacco residue from apartments after smoking tenants leave, and the need to relocate tenants disturbed by neighbors who smoke.[26] A recent study[27] of low-income apartments in Boston found that 94% had detectable air nicotine levels, including 89% of apartments inhabited by nonsmokers.

There still is a lack of scientific evidence about whether smoking in multiunit housing accounts for the presence of tobacco-smoke biomarkers in children who live in a home with no adult smokers. In the current study, we used data from the 2001–2006 National Health and Nutrition Examination Survey (NHANES) to examine the association between types of housing and cotinine levels in children. We hypothesized that children who live in apartments have a higher cotinine level than children who live in detached homes and that this relationship persists when controlling for poverty and race/ethnicity.

METHODS

The NHANES

The NHANES used a multistage sampling design that included a questionnaire (parent and teen reports), physical examination, and blood and urine samples. Survey components were administered to a proxy respondent for children up through 15 years of age, whereas children aged 16 to 18 years completed the survey responses themselves unless they were cognitively unable. Demographic variables included age, gender, and self-report of race and ethnicity. In addition, the federal poverty-level ratio was calculated. A federal poverty-level ratio below 1 means the family lives below the poverty level, whereas a ratio above 1 means they live above the poverty level.

Housing Type

Interviewers assessed housing type and asked respondents to verify their impressions. The response categories included detached house ("a one-family house detached from any other house"), apartment, attached house ("a one-family house attached to one or more houses"), mobile home, dormitory, or other. For these analyses, mobile homes were combined with detached houses. The other 2 categories analyzed were attached houses and apartments. Subjects reported to be living in dormitory or other settings were excluded.

Tobacco-Smoke Exposure: Survey

The NHANES assessed household smoking with the question, "Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?" For those households in which no one was reported to smoke inside the home, no other information was available about smoking status, home or car smoking bans, other sources of exposure, or outside smoking behaviors. Preliminary analyses on the full sample showed that children who lived in a house where anyone smoked inside had exposure levels that overwhelmed any relationship between cotinine level and housing type; we therefore limited the sample in this study to children who lived in a household in which no member was reported to smoke inside the home. Likewise, we excluded any child who admitted to smoking.

Tobacco-Smoke Exposure: Biochemical Verification

Serum cotinine was measured using isotope dilution-high-performance liquid chromatography/atmospheric-pressure chemical ionization tandem mass spectrometry; the detectable limit in the NHANES is 0.015 ng/mL, and the coefficient of variability is 2.5%.[28] Tobacco-smoke exposure was defined as a cotinine level of ≥0.015 ng/mL, although comparisons also were made at cotinine cutoff levels of 0.05, 1.0, and 2.0. A sensitivity analysis was done to determine whether the results were affected by the testing variability. In addition, because plants from the nightshade family contain low levels of natural nicotine,[29] we tested the model controlling for intake of tomatoes, eggplant, and potatoes for 96.3% of the sample for whom these data were available. For this subsample, there were no significant differences in cotinine levels when vegetable intake was included; therefore, we continued our analysis with the full sample.

Analysis

χ^2 and *t* tests were conducted to analyze bivariate data. Analyses that included cotinine level as a continuous dependent variable used Tobit regression models to account for the censoring of the data at the lower cutoff of 0.015 ng/mL.[30] Race/ethnicity by housing-type interactions were tested using Tobit regression for cotinine levels as the outcome and logistic regression when using tobacco exposure as the outcome. Cotinine levels were analyzed using log transformations and geometric means to normalize the skewed distribution. The assumption of linearity among all continuous covariates was checked. Stata was used to control for the complex sample weighting and design.[31] This secondary analysis of NHANES data was approved as exempt by the University of Rochester Research Subjects Review Board.

RESULTS

There were 5002 children surveyed in the NHANES who were living in a home in which no one smoked inside (81%). Compared with the children who were living in a home in which someone smoked, those who were living in a home in which no one smoked were more likely to live in a detached house (81.4% vs 73.4%) and less likely to live in an apartment (11.6% vs 16.7%; $P < .02$). They also were more likely to be over 12 years of age (46.9% vs 38.8%; $P < .01$), male (52.2% vs 46.7%; $P < .01$), and Hispanic (20.5% vs 8.8%) rather than black (14.0% vs 22.1%) or white (59.1% vs 63.7%; $P < .001$ for all comparisons). In addition, children who were living in a home in which no one smoked inside were more likely to be more than 400% of the federal poverty-level ratio (28.5% vs 11.3%) and less likely to be 100% or lower (17.8% vs 34.1%; $P < .001$).

The remaining results pertain to those children who were living in a home in which no one smoked inside. The demographic characteristics of this sample are presented in Table 1. The overall geometric mean cotinine level among these children was 0.036 ng/mL (95% confidence interval: 0.030–0.043); cotinine levels were higher among children under 12 years of age, black children, and those living below the federal poverty levels. Mean cotinine levels among those who were living in apartments (0.075 ng/mL) were higher than in those who were living in detached houses (0.053 ng/mL; $P < .01$) and detached houses (0.031 ng/mL; $P < .001$). Overall, using the detectable limit of 0.015 ng/mL as the tobacco-exposure cutoff, 84.5% of children who were living in apartments had a cotinine level that indicated recent tobacco-smoke exposure, compared with 79.6% of children who were living in attached houses and 70.3% who were living in detached houses ($P < .001$) (Fig 1). Sensitivity analysis, using the higher cutoff of 0.05 ng/mL, showed exposure rates of 56.4% for children who were living in apartments, 47.0% for children who were living in attached homes, and 36.1% for children who were living in detached homes ($P < .0001$). Figure 2 shows the proportion of children by housing type who were unexposed at different cotinine levels, demonstrating the persistent and consistent decrease in the percentage exposed for those who live in detached homes.

The percentage of children who were exposed to tobacco smoke in different housing types varied significantly by

TABLE 1 Demographic Characteristics of the Sample

Variable	Weighted % ($n = 5002$)	Geometric Mean of Cotinine (95% Confidence Interval)	P
Housing type			<.001
Detached house	81	0.031 (0.026–0.038)	
Attached house	7	0.053 (0.035–0.079)	
Apartment	12	0.075 (0.062–0.091)	
Gender			.037
Male	52	0.039 (0.031–0.048)	
Female	48	0.033 (0.028–0.040)	
Age			.014
<12 y	53	0.040 (0.033–0.048)	
≥12 y	45	0.032 (0.026–0.039)	
Race/ethnicity			<.001
Black	14	0.105 (0.090–0.122)	
Hispanic	21	0.026 (0.022–0.031)	
White	59	0.031 (0.025–0.040)	
Other	6	0.033 (0.020–0.0501)	
Federal poverty-level ratio			<.001
≤100	18	0.085 (0.068–0.105)	
101–200	21	0.054 (0.041–0.072)	
>200–300	18	0.031 (0.023–0.043)	
>300–400	15	0.028 (0.021–0.036)	
>400	28	0.020 (0.016–0.025)	

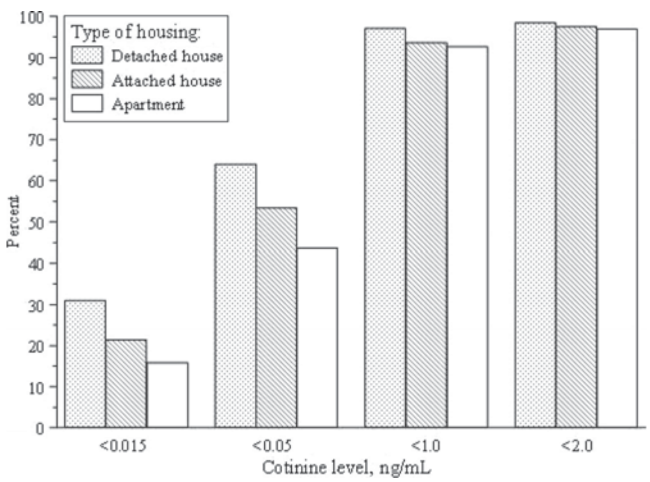

FIGURE 1
Percentage of children who are unexposed by housing type and cotinine cutoff. The y-axis shows the proportion of children who are unexposed at 3 different cotinine cutoff levels. These levels, displayed on the x-axis, are <0.015, <0.05, <1, and <2 ng/mL cotinine. The types of bars for each of the different housing types: detached house, attached house, and apartment.

race/ethnicity (Table 2). The highest level of exposure was found in white children who were living in apartments (99%), followed by black children who were living in apartments (96%); Hispanic and other race/ethnic groups had much lower levels of exposure (73% and 64%, respectively; $P < .001$). Black children who were living in attached houses had exposure rates similar to those who were living in apartments (92%), whereas the rates were much lower for white (76%), Hispanic (70%), and other (80%) children ($P < .05$). Black children who were living in detached houses also had higher rates of exposure (89%) than white (68%), Hispanic (66%), and other (74%) children ($P < .001$). When we performed a stratified analysis of children in the wealthiest category (those more than or equal to 4 times the federal poverty level), we found that the relationship between exposure and multiunit housing persisted (data not shown).

In the unadjusted Tobit regression model, with the natural log of cotinine as the dependent variable, the percentage increase in cotinine levels for children who were living in apartments compared with children who were living in detached homes was 140% (95% confidence interval: 87–301); for children living in attached homes compared with those living in detached homes, the percentage increase was 69% (95% confidence interval: 21–135). In the Tobit model adjusted for age, gender, and federal poverty-level ratio, including race/ethnicity and housing-type interactions (Table 3), white children who were living in apartments had a 212% increase in cotinine levels over those who were living in detached houses ($P = .003$); black children who were living in apartments had a 46% increase ($P < .05$) in cotinine levels. Differences for other race/ethnic categories were not significant.

DISCUSSION

The majority of US children who live in homes where no one smokes inside have biochemical evidence of tobacco-smoke exposure, and cotinine levels are significantly higher in children who live in apartments, compared with those who live in detached houses. Although it is likely that some of this excess exposure is from family members who smoke only outside of the home but carry in tobacco residue on their clothes, this is unlikely to explain all of the discrepancy. In addition, our data are consistent with the findings from Kraev et al,[27] which showed that 89% of low-income apartments with no smokers had detectable air nicotine concentrations.

The finding that children are at risk for tobacco-smoke exposure in apart-

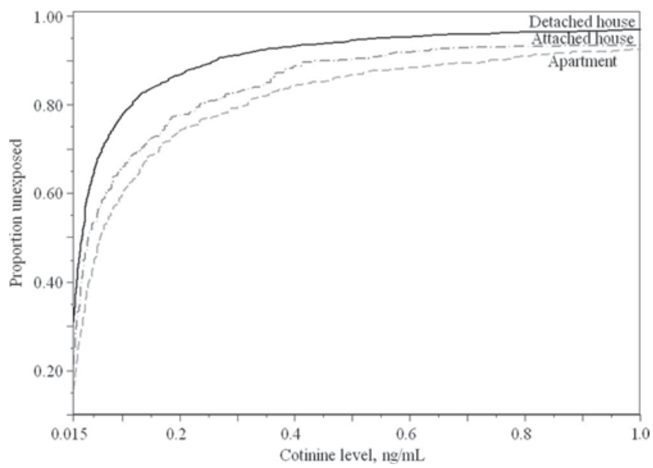

FIGURE 2
Percentage of children unexposed by housing type and cotinine level. The y-axis shows the proportion of children who are unexposed at different cotinine levels, which are displayed on the x-axis. The 3 lines represent each of the different housing types: detached house, attached house, and apartment (dashed line).

TABLE 2 Percentage of Children Exposed to Tobacco Smoke According to Race/Ethnicity and Housing Type

Variable	Race/Ethnicity (*n*)	Percentage Exposed (95% Confidence Interval)	*P*
Detached house	Black (885)	89 (85–92)	<.001
	Hispanic (1356)	66 (60–71)	
	Other (149)	74 (60–86)	
	White (1170)	68 (61–74)	
Attached house	Black (226)[a]	92 (83–96)	<.05
	Hispanic (133)	70 (52–83)	
	Other (22)[a,b]	80 (54–94)	
	White (64)	76 (61–86)	
Apartment	Black (385)[a]	96 (92–98)	<.001
	Hispanic (473)	73 (64–81)	
	Other (34)[a]	64 (40–82)	
	White (49)[a,b]	99 (91–99)	

[a] Relative SE is >30%.
[b] Inadequate sample size.

TABLE 3 Tobit Regression Model Predicting the Percentage Change in the Geometric Mean of Cotinine

Variable	Housing Type	Percentage Change (95% Confidence Interval)	*P*
Federal poverty-level ratio		−28.3 (−34.6 to −21.5)	<.001
White	Detached house	0.0	
	Attached house	−5.5 (−45.4 to 63.6)	.838
	Apartment	212.2 (50.3–548.7)	.003
Black	Detached house	0.0	
	Attached house	40.0 (−0.03 to 96.8)	.052
	Apartment	45.6 (5.4–101.1)	.024
Hispanic	Detached house	0.0	
	Attached house	4.7 (−38.1 to 76.9)	.863
	Apartment	7.8 (−23.0 to 50.9)	.656
Other	Detached house	0.0	
	Attached house	12.7 (−75.9 to 427.1)	.877
	Apartment	−18.5 (−71.1 to 130.2)	.694

Other variables included gender and age; includes the housing-by-race interaction.

ments may accelerate the current trend of limiting smoking in multiunit housing. One of the public health benefits seen from the restriction of smoking in the workplace has been a reduction in smoking rates and number of cigarettes smoked. Restrictions in multiunit housing may have a similar effect on residents; however, implementing these restrictions without providing smoking-cessation assistance for residents also might create a significant burden for low-income smokers. Adult residents of Department of Housing and Urban Development–funded housing who are uninsured will need access to free cessation programs, such as those offered by the national network of quitlines.[32]

Banning smoking in multiunit dwellings by property owners or by regulation would be the obvious way to mitigate contamination and children's exposure to tobacco toxins. Concern has been raised that dictating what can be done in a private dwelling is an infringement on personal privacy and liberty; however, this argument holds only if smoking in an adjacent apartment has no impact on one's neighbors. Legal doctrine supports restrictions on private behavior if there are consequences for others, such as noise levels, noxious odors, or release of toxic chemicals.[33,34] Tobacco smoke can be categorized both as a noxious odor and a toxic chemical. In addition, there is a strong probability that exposure may result in physical harm, particularly for children with underlying illnesses such as asthma. A recent analysis[34] addressing smoke-free public housing argued that phasing in such a policy as new leases were signed and existing ones renewed would be justified on legal and social justice grounds. The association between living in an apartment and child cotinine levels provides additional support to this exposure-reduction strategy. Smoke-free policies should recognize that tobacco smoke drifts and can be measured in high quantities more than 20 feet from an outdoor source.[36] Because restriction inside apartments may encourage increased smoking in common areas where exposure to nonsmokers still may occur, these policies should include smoking restrictions for balconies, common porch areas, and entrances.

Our overall prevalence of children exposed to tobacco smoke is significantly higher than that reported in the 2006 Surgeon General's report.[6] This difference is most likely because the NHANES now uses high-sensitivity cotinine testing that allows the detection of low levels of smoke exposure. Identifying those at risk for these low levels of exposure is important because there is increasing evidence that even small or brief exposure to tobacco smoke can cause physiologically significant cardiovascular effects.[37] Low-level exposure to tobacco smoke also has been associated with lower scores on cognitive testing.[8]

Although there was a significant association between living in an apartment and cotinine levels for white and black children, this was not the case for those of Hispanic ethnicity or other races. Overall, Hispanic and Asian adults have much lower smoking rates (13.3% and 9.6%, respectively) than black (19.8%) or white (21.4%) adults. This difference particularly is striking for women (8.3% of Hispanic and 4.0% of Asian women smoke compared with 15.8% of black women and 19.8% of white women).[37] Because Hispanic and Asian immigrants are more likely to be found in high-density ethnic enclaves where multiunit housing is common,[38] it is possible that the lower smoking prevalence among some ethnic groups reduces the overall tobacco-smoke burden in some multiunit housing.

There are other potential sources of exposure that need to be considered. Potential sources may include daycare centers or child-care arrangements[39] as well as smoke residue from a parent or caregiver who smokes outside. Other studies have found significantly increased house dust and air nicotine levels in households with a mother who smokes outside, with corresponding increases in children's urine cotinine level.[15] There also is an increase in air and surface nicotine found in used cars previously owned by smokers.[40] This is an important issue for families who may believe that they are protecting their children by smoking outside. However, because smoking prevalence is much lower than exposure prevalence,[37] this does not explain all of the excess exposure.

There are limitations to these data. First, we only were able to examine the association between apartment living and tobacco-smoke exposure; there are other unmeasured potential confounders. Population density and current smoke-free housing legislation are 2 factors that likely play a role; these will need to be examined in future research. In addition, the NHANES data set has no information about home smoking bans or outside smoking behavior, so we cannot know how many of these children have parents who smoke outside or if they are exposed at daycare centers or relatives' homes. We hope that future research will be able to separate out the individual contributions of apartment smoke drift, outside-smoker "off-gassing" and thirdhand smoke, occasional inside smoking by visitors, or exposures outside of the home.

Finally, people who smoke may inaccurately report whether they smoke anywhere inside the home. If underreporting rates varied between those in apartments versus single-family homes, our results may be biased. Assuming no differential in inaccurate reporting, children in apartments also might be expected to have higher cotinine levels because of the smaller square footage in apartments versus single-family homes. In general, however, people who smoke have demonstrated low rates of underreporting smoking behaviors in nonintervention trials.[41] Finally, a growing number of buildings are smoke-free already,[37] leading to an underestimation of the exposure rate in multiunit dwellings where smoking still is allowed.

CONCLUSIONS

Most children in the US continue to be exposed to tobacco smoke, even with the growing knowledge of its damaging effects at low levels of exposure. It is vital to understand the contribution of all potential sources of exposure for children: parents smoking outside, daycare, visiting homes where smoking is allowed, and from connected dwellings. However, significant tobacco-smoke contamination in the air of nonsmoking units of multiunit housing already has been shown. This study is the first to document through human biological sampling that disseminated tobacco smoke from multiunit apartments may contribute to the actual exposure of children. In addition, there are likely to be many adult nonsmokers who also are exposed to tobacco smoke by this mechanism. Biochemical data demonstrating the increased risk of involuntary tobacco-smoke exposure posed by living in apartments may change public opinion and policies about smoke-free multiunit housing for those who live in low-income housing, and for those who live in apartments owned by private companies. These results provide direct evidence for a background level of tobacco-smoke contamination in multiunit housing at levels associated with childhood morbidity. Ultimately, smoke-free multiunit housing could improve health status by reducing nonsmokers' exposure to tobacco smoke in their own units.

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INKED-UP: *When my daughter, who is 15 years old, announced that she intended to get a tattoo, I, like many parents, was emphatic in replying, "Not until you are 18." As reported in* The Wall Street Journal *(September 29, 2010:Work and Family), teens and parents often don't see eye to eye about tattoos. Teens may view tattoos as an accessory while parents view tattoos as a permanent mark likely to be regretted. Tattooing certainly has become commonplace. One of the best selling Barbie Dolls, Tattoo Barbie, comes complete with multiple stickers to attach to her body suggesting interest in tattoos begins early. Almost 40% of youth between the ages of 18 and 29 are tattooed compared to 1/3 of adults born in the 1960s and 1970s, and 15% of baby boomers. In most states, teens need to be 18 years old to be able to obtain a tattoo without parental consent. That, of course, is not an insurmountable barrier. As many as one in six teens gets a tattoo from a friend or an unlicensed parlor. Regulation of tattoo parlors is often minimal. Only nine states require tattoo parlors to comply with infectious disease guidelines such as using sterilized needles and individual pigment cups. Interestingly, while teens like the idea of a permanent mark, the most common reason for regretting getting a tattoo is that the person made the decision at too young an age followed by the permanence of the tattoo. Removing a tattoo is considerably more difficult and expensive than getting one, and rarely completely effective. A tattoo is like a photo on Facebook; easy to post, hard to permanently remove. I am hoping she waits.*

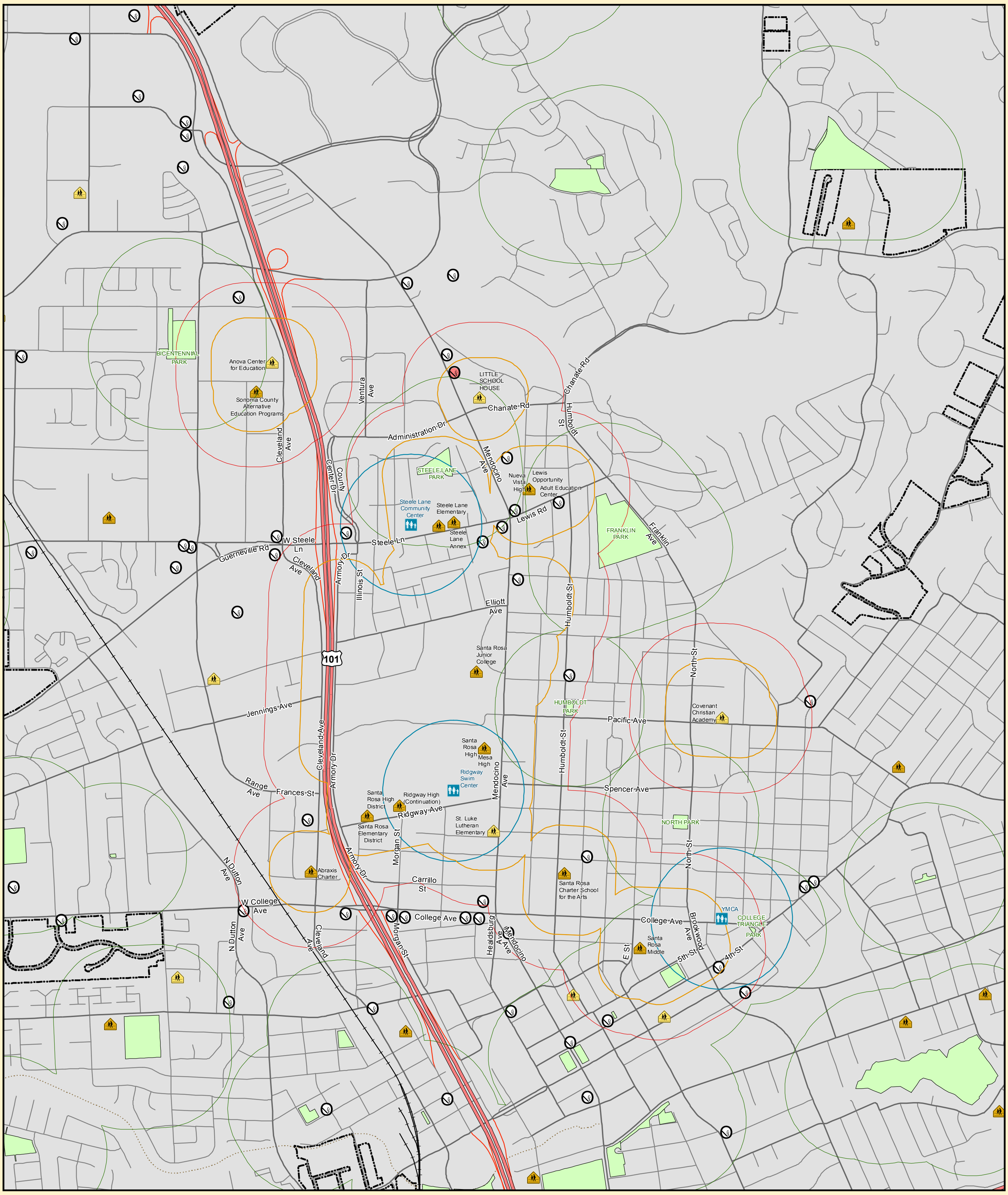
Noted by JFL, MD and WVR, MD

Tobacco-Smoke Exposure in Children Who Live in Multiunit Housing

Karen M. Wilson, Jonathan D. Klein, Aaron K. Blumkin, Mark Gottlieb and Jonathan P. Winickoff

Pediatrics published online Dec 13, 2010;
DOI: 10.1542/peds.2010-2046

TOBACCO RETAILERS
SRJC AND NORTH TO BICENTENNIAL



0 0.1 0.2 0.4 0.6 0.8 Miles

- Schools
- Schools 500' Buffer
- Schools 1000' Buffer
- Community Addresses
- Community Addresses 1000' Buffer
- Proposed Tobacco Retailers 2013
- Tobacco Licensed Locations 2012
- Public Parks
- Public Parks 1000' Buffer

sonomacounty
DEPARTMENT OF HEALTH SERVICES

Original Map & Source Data Revamped & Updated by:
Kit Tiura; HPPE, DHS, County of Sonoma; 3.8.2013
New Doc: Tobacco_Report_Mar2013.mxd

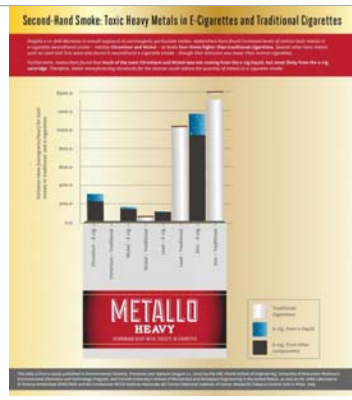
Author: Department of Health Services, Prevention & Planning
Projection and Coordinate System Tics:
California State Plane Coordinate System, Zone II, NAD 83, US survey feet,
Lambert Conformal Conic. Some data have been re-projected from other coordinate systems and may not reflect actual ground positions.
Original Document Source and Date: \\Sc-gissql\data\GIS Projects\HealthServices\PublicHealth\Prevention\Tobacco\Tobacco_Report.mxd; March 23, 2010
Source: Sonoma County GIS Central, Health Services Map

Second-hand e-cig smoke compared to regular cigarette smoke

Date: August 28, 2014

Source: University of Southern California

Summary: Second-hand e-cig smoke has 10 times less particulate matter than regular cigarette smoke; but higher levels of certain toxic metals, a new study finds.



Despite a 10-fold decrease in overall exposure to carcinogenic particulate matter, researchers find increased levels of certain toxic metals in second-hand smoke from e-cigs.

Credit: USC Viterbi [Click to enlarge image]

Despite a 10-fold decrease in overall exposure to carcinogenic particulate matter, researchers find increased levels of certain toxic metals in second-hand smoke from e-cigs.

E-cigarettes are healthier for your neighbors than traditional cigarettes, but still release toxins into the air, according to a new study from USC.

Scientists studying secondhand smoke from e-cigarettes discovered an overall 10-fold decrease in exposure to harmful particles, with close-to-zero exposure to organic carcinogens. However, levels of exposure to some harmful metals in second-hand e-cigarette smoke were found to be significantly higher.

While tobacco smoke contains high levels of polycyclic aromatic hydrocarbons -- cancer-causing organic compounds -- the level of exposure to these substances was reduced to almost zero in second-hand e-cigarette smoke, due to the fact that they do not burn organic material the way old-fashioned cigarettes do.

However, despite the lack of harmful organic material and a decrease in the majority of toxic metals emissions, e-cigarette smoke contains the toxic element chromium, absent from traditional cigarettes, as well as nickel at levels four times higher than normal cigarettes. In addition, several other toxic metals such as lead and zinc were also found in second-hand e-cigarette smoke -- though in concentrations lower than for normal cigarettes.

"Our results demonstrate that overall electronic cigarettes seem to be less harmful than regular cigarettes, but their elevated content of toxic metals such as nickel and chromium do raise concerns," said Constantinos Sioutas, professor at the USC Viterbi School of Engineering, and corresponding author of the study, which was published online on August 22 by the *Journal of Environmental Science, Processes and Impacts*.

Sioutas and his colleagues at Fondazione IRCCS Instituto Nazionale dei Tumori (National Institute of Cancer Research) in Milan, Italy, began this study with the goal of quantifying the level of exposure to harmful organics and metals in second-hand e-cigarette smoke, in hopes of providing insight for the regulatory authorities.

"The metal particles likely come from the cartridge of the e-cigarette devices themselves -- which opens up the possibility that better manufacturing standards for the devices could reduce the quantity of metals in the smoke," said Arian Saffari, a PhD student at USC Viterbi and lead author of the paper. "Studies of this kind are necessary for implementing effective regulatory measures. E-cigarettes are so new, there just isn't much research available on them yet."

For this study, the researchers conducted all of the experiments in offices and rooms. While volunteer subjects were smoking regular cigarettes and e-cigarettes, the researchers collected particles in the indoor air and studied the chemical content and sources of the samples.

"Offices and rooms- not laboratories -- are the environments where you're likely to be exposed to second-hand e-cigarette smoke, so we did our testing there to better simulate real-life exposure conditions," Saffari said.

Sioutas and Saffari compared the smoke from a common traditional cigarette brand with smoke from an Elips Serie C e-cigarette, one of the most popular European brands. The results could vary based on which type of cigarettes and e-cigarettes are tested, the researchers noted.

Sioutas and Saffari collaborated with researchers from LARS Laboratorio and the Fondazione IRCCS Instituto Nazionale dei Tumori in Milan, Italy, as well as University of Wisconsin-Madison and Cornell University in the United States.

Financial support for the study was provided by the Fondazione IRCCS Instituto Nazionale dei Tumori.

Story Source:

The above story is based on materials provided by **University of Southern California**. *Note: Materials may be edited for content and length.*

Journal Reference:

1. Arian Saffari, Nancy Daher, Ario Alberto Ruprecht, Cinzia De Marco, Paolo Pozzi, Roberto Boffi, samera H. Hamad, Martin Shafer, James Jay Schauer, Dane Westerdahl, Constantinos Sioutas. **Particulate Metals and Organic Compounds from Electronic and Tobacco-containing Cigarettes: Comparison of Emission Rates and Secondhand Exposure**. *Environmental Science: Processes & Impacts*, 2014; DOI: 10.1039/C4EM00415A

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White Paper: Electronic Cigarettes in the Indoor Environment

American Industrial Hygiene Association®

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October 19, 2014

Sponsored by the AIHA®
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Executive Summary

Electronic-cigarettes (e-cigarettes) are battery-powered devices of many different configurations that deliver vaporized nicotine and other chemicals or flavorings to users, but that do not contain tobacco or require combustion. E-cigarettes have an internal, rechargeable, battery-operated heat source that converts liquid nicotine and/or flavorings into a mist or vapor that the user inhales. These devices are frequently promoted as a healthier or safer alternative to traditional cigarettes for users and bystanders. Consequently, there has been growing interest among manufacturers and others to allow e-cigarettes to be used indoors and in other settings where traditional cigarettes have previously been banned. There has, however, been conflicting and at times confusing information presented to the public regarding the public health risks and benefits associated with e-cigarettes. This white paper attempts to present the best available science on the subject today.

The use of e-cigarettes (or "vaping") has seen an unprecedented increase worldwide. Vaping has been promoted as a beneficial smoking cessation tool and/or an alternative nicotine delivery device that contains no combustion byproducts. However, nicotine is highly addictive. Furthermore, available research indicates that vaping solutions and their emissions may contain much more than just nicotine, including aerosolized flavorings, propylene glycol, and other intentional and unintentional contaminants. These ingredients could present an as-yet undefined health hazard to both users and bystanders.

Whereas e-cigarette use and exposure may lower some or most risks associated with conventional cigarette use, the health effects of nicotine and aerosol exposures from e-cigarettes are not well-understood at this time. Current research indicates that vaping aerosols are not without risk, especially for nearby persons in areas with limited ventilation and persons with compromised health conditions. Limited published studies that evaluated the potential hazardous effects of the natural and/or synthetic chemicals used in e-cigarettes indicate that there are potential health effects reported for both users and those exposed secondhand.

Multiple scientific reports express the need for more research. There are several key data gaps and areas of uncertainty that hinder a more quantitative assessment of health risks related to e-cigarettes at this time. These include:

- Quality control of these products is lacking for both product constituents and labeling.
- Laboratory studies may not reflect actual exposures during use because of the variability in types of devices, user vaping habits and duration, and because many users mix their own vaping solutions.
- There is limited data on chemical emissions/thermal degradation products/exposures (especially among bystanders and in confined indoor settings).
- There is little information on the dynamics of pre and post respiration aerosols and their fate in the environment.
- There is limited information on dose-response relationships for many constituents, such as short- or long-term health effects associated with low-level exposures, including those for vulnerable populations.
- There is little or no information about the health effects of flavorings that are inhaled rather than ingested.
- There is little information about the synergistic effects from e-cigarette contents and other environmental contaminants.

Note that these issues are related only to an assessment of human health risks. They do not incorporate other potentially important factors, such as public risk perceptions, risk management options/control measures (e.g., ventilation), and nicotine dependence. In addition, serious safety issues have been reported and need to be addressed, including child safety and poisonings, battery explosions, and the potential for the vapor to set off smoke alarms.

Given this review of available information, the existing research does not appear to warrant the conclusion that e-cigarettes are "safe" in absolute terms. Although they may provide a "safer" alternative to tobacco cigarettes for the user, these products emit airborne contaminants that may be inhaled by both the user and those in the vicinity of vaping. Many of the data sources reviewed confirm that e-cigarettes are not emission-free and that their pollutants could be of health concern for users and those who are exposed secondhand. Clearly, e-cigarettes lack the combustion products produced by smoking tobacco, many of which are associated with cancer development. Although nicotine may not cause cancer, it is associated with other adverse physiological effects. In addition, the other components in e-cigarettes may not be without risk, particularly when they are inhaled rather than ingested. Therefore, e-cigarettes should be considered a source of volatile organic compounds (VOCs) and particulates in the indoor environment that have not been thoroughly characterized or evaluated for safety.

The Food & Drug Administration (FDA) currently regulates only e-cigarettes that are marketed for therapeutic purposes. However, the FDA has proposed a rule extending its tobacco product authorities to include other products like e-cigarettes and the World Health Organization (WHO) has recommended that consumers be strongly advised not to use electronic nicotine delivery systems, including e-cigarettes, until they are deemed safe and effective and of acceptable quality by a competent national regulatory body. Although several agencies and organizations have adopted restrictions on the use of e-cigarettes in public places, there is currently no U.S. federal law or regulation that explicitly bans the use of e-cigarettes on airplanes, railroads, buses, or other modes of transportation.

Because of concerns about primary and secondary exposure to e-cigarette vapors and liquids (also called "e-juices"), AIHA supports risk-based regulation of e-cigarettes using reliable safety, health, and emissions data. Four areas of risk based regulation relating to the safety of primary users and people exposed to secondhand vapors or e-juices should be considered:

1. Physical/Electrical Hazards - All e-cigarette devices, whether they are being used for therapeutic or recreational purposes, should be evaluated for potential physical and/or electrical hazards by applicable regulatory agencies.
2. Accidental Exposure - The health risks and economic consequences of accidental exposure to e-juice liquids by children, adults, and pets should be addressed, including proper labeling and child-resistant packaging requirements.
3. New Product/New Chemical Use - All future e-juice components that may be used by consumers should be fully evaluated for any potential hazards (e.g., toxicity, flammability, safety hazards, and secondary exposures) prior to introduction into the marketplace.
4. Relationship to Current Smoking Bans - Because e-cigarettes are a potential source of pollutants (such as airborne nicotine, flavorings, and thermal degradation products), their use in the indoor environment should be restricted, consistent with current smoking bans, until and unless research documents that they will not significantly increase the risk of adverse health effects to room occupants.

Introduction

E-cigarettes are battery-powered devices of many different configurations that deliver vaporized nicotine and other chemicals or flavorings to users but that do not contain tobacco or require combustion. E-cigarettes are the most common type of electronic nicotine delivery systems (ENDS). Originally patented in 1963 as a smokeless, nontobacco cigarette,[1] these devices may also be referred to as e-cig, electronic vaping device, personal vaporizer (PV), electronic hookah, and e-hookah. Because no smoke is generated, e-cigarettes are frequently promoted as a healthier or safer alternative to traditional cigarettes for users and bystanders.[2] Consequently, there has been growing interest among manufacturers and others to allow e-cigarettes to be used indoors and in other settings where traditional cigarettes have previously been banned.

There has, however, been conflicting and at times confusing information presented to the public regarding the public health risks and benefits associated with e-cigarettes. For example, the Consumer Advocates for Smoke-free Alternatives Association (CASAA), the leading consumer advocacy group promoting the availability and use of low-risk alternatives to smoking, has reported that e-cigarettes pose no health concerns and yield a significant risk reduction compared to regular cigarettes.[2,3] On the other hand, several studies suggest that e-cigarettes may cause a variety of short- or long-term health effects, such as increased airway resistance in the lungs.[4,5,6] The Food and Drug Administration (FDA), a federal agency responsible for protecting and promoting public health in the United States, has concluded that the safety and efficacy of e-cigarettes are largely unknown and have not been fully studied.[7] Similarly, the World Health Organization (WHO) has concluded that the safety and efficacy of these products has not been scientifically demonstrated and their potential health risks remain undetermined.[8] The American Lung Association has also issued a statement expressing its concern about the potential safety and health consequences of e-cigarettes.[9]

Poison control centers have recently warned of an increased rate of poisonings, especially in children, from the nicotine-containing multi-flavored e-liquids (also called “e-juices”) that are used to charge e-cigarettes.[10] The use of commercially available flavors of e-liquids that imitate common food, candy, and liquor flavorings parallels a trend reported in 2007 of the marketing and use of flavored tobacco products as a gateway for children and young adults to become regular cigarette smokers.[11] Due to the lack of regulations on vaping, there is currently no standard message or warning statement on e-cigarette supplies that indicates their potential danger to the public, especially children. Flavorings and other e-juice additives that may be acceptable for ingestion are now being inhaled without a clear toxicological understanding of the potential health effects from a different route of entry.

Although the literature reviewed for this report in most cases supports findings that e-cigarettes are likely to be much less harmful than tobacco smoking, many questions remain regarding the potential human health risks posed by the use of e-cigarettes indoors, especially among bystanders from secondhand and thirdhand exposures. The purpose of this white paper is to provide a critical and objective review of the available literature on what is currently known and not known with respect to public exposures and health risks from e-cigarettes. A key outcome of this review is the identification of key data gaps and areas of uncertainty that hinder a more quantitative assessment of health risk. Recommendations for additional research are also provided.

The aim of this white paper is to present a review of the available scientific evidence-based literature concerning potential exposures and risks from the use of e-cigarettes, particularly for persons (especially bystanders) in the indoor environment. As part of this effort, AIHA has undertaken a search of current and recent past literature using various publication sources (e.g., PubMed). Additionally, to capture the rapidly changing landscape of information on e-cigarettes, we have incorporated Internet sources in an attempt to find original research and newly published information regarding the health aspects and regulation of e-cigarettes and the chemical components used therein. Because of the rapidly changing nature of events and science with respect to e-cigarettes, this white paper presents what is known versus not known at the time of publication.

How E-cigarettes Work

Early e-cigarettes (first generation) were designed to look like conventional cigarettes. However, e-cigarettes do not contain tobacco or require a flame to extract the nicotine from the cigarette. Instead, e-cigarettes have an internal, rechargeable, battery-operated heat source that converts liquid nicotine and flavorings into a mist or vapor that the user inhales. The inhalation of vapors from e-cigarettes is commonly called “vaping” instead of “smoking.”

Figure 1: Disposable electronic cigarette resembling a traditional cigarette.

While some e-cigarettes are designed to be totally disposable (see Figure 1), most other e-cigarettes contain a rechargeable lithium battery, vaporization chamber, wicking system, and nicotine/flavoring cartridge. The cartridge containing nicotine liquid is first attached to the vaporization chamber, which contains an atomizer and/or heating coil. When the user inhales (from the mouthpiece at the tip of the cartridge), the atomizer is activated and the heating coil begins to vaporize the liquid. The liquid, in turn, wicks more liquid from the cartridge to the atomizer. The vaporized liquid cools and condenses into a fine aerosol (called vapor), which is inhaled, delivering nicotine, diluents, and flavoring(s) to the respiratory tract.

Some first-generation e-cigarettes have a light-up tip that glows when the user inhales to either simulate a flame and/or to indicate that there is still charge on the attached battery. Second- and third-generation devices have moved away from looking like tobacco cigarettes (see Figures 2 and 3). These devices have larger batteries and larger e-fluid reservoirs than first-generation e-cigarettes and often have variable voltage (vv) or variable wattage (vw) batteries that allow the user to increase or decrease power to the atomizer. Some devices have a variable airflow option as well: adjusting the battery voltage or the inhalation air flow can greatly affect the amount of vapor generated with each puff. After inhalation, the user exhales a portion of the vapor.

Figure 2: Second-generation e-cigarettes.

Figure 3: Examples of other kinds of e-cigarettes. By Izord (Own work) [CC-BY-SA-3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia.

Constituents of E-cigarettes: Emissions, Exposures, and Health Risks

Manufactured prepackaged cartridges can be purchased with varying concentrations of nicotine ranging between 0 and 24 milligrams (mg) of nicotine per cartridge.[12] Nicotine levels, however, have been found to be inconsistent due to poor quality control.[12] Flavorings are also frequently added to the liquid, with a variety of flavors available (e.g., tobacco, menthol, mint, chocolate, coffee, apple, cherry, and caramel). Occasionally, e-cigarettes have been advertised as containing other drugs, such as tadalifil (a drug used for erectile dysfunction) and rimonabant (a weight-loss aid).[13] Propylene glycol (PG) and vegetable glycerin are the main components used in e-liquids as the delivery vehicle and diluent for the nicotine and flavorings, and to synthesize the tactile sense of smoke (i.e., “vapor”) when the user exhales.[13,14,15]

Many of the toxic and carcinogenic agents in tobacco cigarette smoke are combustion byproducts, including nitrosamines, VOCs, polycyclic aromatic hydrocarbons (PAHs), and carbon monoxide. Because e-cigarettes do not have a combustion source, the health risks of vaping are believed to be greatly reduced compared with traditional cigarette smoking. However, many potentially toxic compounds are still present in the liquid or vapor components of e-cigarettes.[14,16] The primary components of electronic cigarette cartridges are propylene glycol, glycerin, and nicotine.[16] E-cigarettes also contain flavoring agents and other compounds, and the use of e-cigarettes has been shown to emit aerosols and VOCs, including nicotine, diethylene glycol, nitrosamines, 1,2-propanediol, acetic acid, acetone, isoprene, formaldehyde, acetaldehyde, propaldehyde, and flavoring compounds into indoor air.[7,15,17,18] Additionally, aerosols generated from e-cigarette consumption may contain various metals and silica particles from wick and heating coil constituents.[19] The following sections summarize what is currently known and unknown about public exposures and health risks from the constituents in e-cigarettes.

<u>Nicotine</u>

Nicotine is present in most e-cigarettes and e-liquids. However, advertising and labels for these products can often be inaccurate regarding their nicotine content.[3] In fact, the FDA reported that the analysis of many electronic cigarette cartridges that were labeled as containing no nicotine did, in fact, contain detectable levels of nicotine.[20] Three different cigarette cartridges that displayed the same label produced varying amounts of nicotine with each puff.[21] A French study evaluated the nicotine content and labeling of e-cigarettes and found incomplete or unusable information as well as unreliable labeling.[22] The amounts of nicotine measured in 20 prepackaged cartridge samples were generally higher than was stated on the package and, in some cases, the nicotine content was found to be two to five times greater.[22]

A review of a number of products purchased online revealed a lack of consistent labeling format and unclear information regarding nicotine content.[23] In one study, nicotine amounts in 9 out of 20 analyzed cartridges differed by more than 20 percent from the values declared by their manufacturers.[24] Several studies found that cartridges labeled as containing nicotine did not contain any nicotine, while other cartridges labeled as non-nicotine-containing did, in fact, contain nicotine.[10,15,24] Two studies discovered that, in many cases, nicotine degradation products and other impurities can be found in refill liquids, such as nicotine-cis-N-oxide, nicotine-trans-N-oxide, myosmine, anabasine, and anatabine, speculated to be from oxidative degradation of nicotine occurring either during the manufacturing of the ingredient or during the manufacturing of the final liquids, or from an unstable formulation[10,25], although the impurities were reported to be “below the level where they would be likely to cause harm.”[25] Goniewicz et al. found that in addition to the lack of quality control in content and concentration, some products are inconsistent in delivering nicotine.[24] In other words, some products may deliver different levels of nicotine to their users each time they are used even if they use cartridges that contain the same nicotine content.[24] In addition, because of this inconsistency in nicotine delivery, or because of the perception that e-cigarettes are “safer” than traditional cigarettes, users may consume e-cigarettes at a greater rate than traditional cigarettes and, therefore, generate greater amounts of secondhand contaminants. Therefore, user behavior and overall quality control of the e-liquids and of the e-cigarette devices may be in question when attempting to evaluate dosing and user responses.

The health effects of exposure to nicotine are well-documented. The effects of short-term (less than eight hour) exposures to nicotine at low concentrations are reported to include tremors and an increase in heart rate, respiratory rate, blood pressure, and level of alertness. Ocular exposure can cause irritation and redness of the eyes.[26] Ingestion or inhalation of nicotine can cause nausea, vomiting, abdominal pain, headache, dizziness, confusion, agitation, restlessness, and possible burning sensation in the mouth, throat, and stomach.[26] Nicotine is a teratogen,[26] can promote tumor growth[27,28], and has caused abnormalities in the offspring of laboratory animals.[29] In addition, the National Institute on Drug Abuse states that nicotine is highly addictive.[30] Addiction to nicotine can occur within days of inhaling one's first conventional cigarette.[31] Nicotine increases heart rate, myocardial contractility, and blood pressure.[32]

Nicotine exposure during pregnancy can potentially cause effects to the unborn child. According to the Centers for Disease Control and Prevention, nicotine is a teratogen.[26] Prenatal exposure to nicotine in animal studies with doses as low as 0.5 mg/kg/day have shown learning and attention deficits in performance in both young and adult rats.[33] Nicotine has also been demonstrated to produce fetal brain cell damage.[33] An Environmental Protection Agency study shows that maternal nicotine exposure during fetal development, in doses similar to the dose of nicotine acquired with moderate smoking (0.5 to 1 pack/day), can result in central nervous system and neurologic deficits such as impairments in learning and memory performance.[34] Nicotine acts on specific neurotransmitter receptors in the brain and is a neuroteratogen, which suggests that some of the adverse perinatal outcomes resulting from cigarette smoking may in fact be due to nicotine.[35] According to research by Slotkin, the effects of nicotine on brain development are very similar to those of cocaine.[35]

Study results have confirmed that some e-juices contain amounts of nicotine that are potentially lethal to both children and adults.[36] Because nicotine can readily pass into the bloodstream following dermal contact, one study reports that spilling of five milliliters (ml) of e-cigarette liquid (equivalent to 110 mg of nicotine) onto the skin can cause severe intoxications or even death.[36] In addition, the tested e-cigarette solutions were found to contain several sensitizing chemicals, including benzylalcohol and l-limonene, which can cause allergic contact dermatitis and immediate contact reactions.[36]

Because nicotine can be absorbed into the body via inhalation, ingestion, skin contact and through the mucous membranes [29], it is possible that the vapor from electronic cigarettes can potentially cause secondary and tertiary environmental exposure to nicotine for those in the area around e-cigarette users. Airborne concentrations of nicotine have been studied for both regular and electronic cigarettes. Using a smoking machine connected directly to sampling devices and a sample bag, McAuley et al. compared airborne concentrations of several components of both nicotine cigarette smoke and e-cigarettes.[18] The authors reported airborne nicotine concentrations ranged from 725 to 8770 nanograms (ng) per liter (equivalent to 0.725 to 8.77 micrograms per cubic meter [$\mu g/m^3$]), which were lower than those from regular cigarettes, which ranged from 5.04 $\mu g/m^3$ to 48.05 $\mu g/m^3$.[18] Czogala et al. examined e-cigarette vapors from three different brands and compared the components to those from secondhand tobacco smoke through the use of an exposure chamber.[21] Though the level of nicotine exposure varied by brand of e-cigarette, the authors reported that e-cigarettes were observed to emit nicotine in concentrations ranging from 0.82 $\mu g/m^3$ to 6.23 $\mu g/m^3$ while the average concentration of nicotine from tobacco cigarettes was 10 times higher.[21] Schober et al. reported airborne concentrations of nicotine during a two-hour vaping session ranging from 0.6 to 4.6 $\mu g/m^3$.[36]

OSHA regulates exposure to nicotine in the workplace to less than 0.5 mg/m^3 (500 $\mu g/m^3$) for the industrial workplace, and the American Conference of Governmental Industrial Hygienists publishes a Threshold Limit Value for nicotine at the same level for an eight-hour time-weighted average (TWA).[37] However, ANSI/ASHRAE Standard 62.1-2013 – *Ventilation for Acceptable Indoor Air Quality (IAQ)*, applicable to office buildings, schools, larger multifamily housing, and many other spaces, cautions that the OSHA standards and ACGIH guidelines are intended to limit worker exposure to injurious substances at levels that do not interfere with the industrial work process and do not risk the workers' health and safety. These standards and guidelines do not attempt to eliminate all effects, such as unpleasant smells or mild irritation.[38] Therefore, the target population and use of these standards and guidelines are different from those for the populations of many public and commercial buildings.[38] Consequently, while the reported airborne levels measured for nicotine from e-cigarettes in the chamber study by Czogala et al.[21] and vaping session by Schober et al.[36] were at a fraction of the OSHA regulatory level, there are other factors that need to be considered. OSHA standards are based on working with nicotine occupationally, so they are not entirely applicable or appropriate for IAQ irritation, nuisance, and exposure purposes.

A literature review for information on potential surface deposition of nicotine from e-cigarette use (tertiary, or thirdhand, exposure) revealed that very little information is available. In February 2014, the Roswell Park Cancer Institute in Buffalo, N.Y., presented data from an unpublished research project to the Society for Research on Nicotine and Tobacco in Washington state. Researchers analyzed three brands of e-cigarettes filled with varying nicotine concentrations.[39] The e-cigarettes were smoked, or vaped, in an exposure chamber, and the resultant nicotine levels on five different surfaces of the smoking chamber were measured.[39]

The surfaces included glass, floors, walls, windows, wood, and metal. The researchers found that three out of four experiments showed significant, yet varying, increases in nicotine found on the five surfaces. The researchers concluded by stating that future research should "explore the risks of exposure to carcinogens posed by thirdhand exposure from e-cigarettes."[39] According to Bloomberg School of Public Health Professor Dr. Patrick Breysse, in a pilot study conducted by Johns Hopkins University, two of three surface samples collected in a vaping lounge had detectable levels of nicotine (P. Breysse, personal communication, May 14, 2014).

Glycols and Glycerin

Propylene glycol, a chemical found in theatrical smoke, and vegetable glycerin are both used in e-cigarettes as vehicles for the nicotine and the flavorings, and to create the "vapor" that is emitted.[13,14,15] Analysis of various vaping solutions has revealed concentrations of propylene glycol ranging from 60 percent to 90 percent, and up to 15 percent glycerin,[13,14,15] although some vendors have reported mixtures of equal parts [40] and others substitute glycerin and water for PG completely.[41] Many websites now supply custom e-liquids formulated the way the user requests it, including such variables as flavors, nicotine concentrations, and whether glycols or glycerin are used and in what concentrations. Users may purchase raw materials and compound e-liquids themselves[42] with the help of numerous online concentration calculators[43] or calculation applications available for mobile phones. While propylene glycol has been used in other legitimate drug delivery methods, such as inhalers and nebulizers, the frequency of use and exposure is expected to be much higher for electronic cigarette users than for recognized medical uses.[16]

Concentrations of 1,2-propanediol (propylene glycol) in the range of 110 $\mu g/m^3$ to 215 $\mu g/m^3$ and glycerine in the range of 59 $\mu g/m^3$ to 81 $\mu g/m^3$ were found in the gas phase of emissions during an e-cigarette vaping study.[36] Another study reported airborne concentrations of PG ranging from 2254 ng/l to 120,000 ng/l (2.25 mg/m^3 to 120 mg/m^3).[18]

A generally recognized occupational guideline for airborne exposures to propylene glycol mists and vapors is the AIHA® Workplace Environmental Exposure Level (WEEL), which recommends a maximum eight-hour TWA for total vapor and aerosol of 50 parts per million (ppm) (156 mg/m^3);for aerosol alone the TWA is 10 mg/m^3.[44] Exposures during theatrical fog use are not expected to be near those levels.[44] However, in a study of the health effects of theatrical fogs, it was determined that exposure to these fogs may contribute to both acute and chronic health issues, such as asthma, wheezing, chest tightness, decreased lung function, respiratory irritation, and airway obstruction.[45] Information shared among many vaping websites includes the following information:

> Some of the side effects experienced by people that use propylene glycol are muscle pain, sore throat, and stronger smelling urine. These symptoms can all result from using e-cigs that use propylene glycol-based e-liquid. Since PG is considered a humectant (it collects moisture), your throat can become dry after use and potentially sore. It can also result in an increase of lactic acid production by your body causing muscle aches that occur more often than normal.[40]

In one case, the suspected cause of a patient's development of exogenous lipoid pneumonia, which is a rare form of pneumonia caused by inhalation or aspiration of a fatty substance, was from recurrent exposure to glycerin-based oils in e-cigarette nicotine vapor.[46]

An unfortunate outcome of the presence of glycerin may be the presence of acrolein, formaldehyde, and acetaldehyde in the vapor, which has been shown to form as a result of heating or pyrolysis of glycerin.[47] This is a particular concern with second-generation (tank type) and third-generation (rebuildable atomizer type) e-cigarettes with adjustable voltages, and perhaps low-resistance coils as well. As-yet unpublished laboratory studies by Johnson and Floyd have shown that the mass of aerosol produced during vaping increases dramatically with the power of the device, which goes up as the square of voltage (power in watts = potential in volts^2/resistance in ohms). In experiments with a tank type (second generation) variable voltage e-cigarette with a 3-ohm resistance coil, these researchers measured a 33-fold increase in fluid mass vaporized with only a doubling of voltage from 3V to 6 V. (D. Johnson and E. Floyd, personal communication, May 29, 2014). This suggests a geometrically increasing risk of toxic effects as the devices gain power via stronger batteries, lower resistances, and adjustable voltages.

Diethylene glycol, an impurity of PG, is also an organic compound of concern because it was observed to be present in one of 18 refill cartridges evaluated by the FDA and has thus been cited as a contaminant of concern by the FDA.[7,15,16,36,41] Toxicity studies with diethylene glycol indicate that chronic inhalation of vapor, fog, or mist should be avoided, especially where it is heated or used at elevated temperatures.[48] Because of its adverse effects on humans, diethylene glycol is not allowed in food and drugs.[15] However, a review of 15 additional studies of compounds associated with electronic cigarettes did not identify diethylene glycol to be present.[16,41]

<u>Flavorings</u>

A review of several online suppliers and manufacturers of e-cigarette liquids revealed that an extensive assortment of flavors is available. Flavor additives are often referred to as natural, though further information is not provided about the composition or source of these additives.

The most widely and readily available source of flavorings is for food products, so it can likely be assumed that many manufacturers of flavored e-cigarette liquids are using flavoring products intended for food ingestion.

The Flavor and Extract Manufacturers Association (FEMA) maintains an independent program that evaluates the safety of substances for their intended use as flavor ingredients.[46] The primary route to regulatory authority to use flavor ingredients in the United States is the FEMA GRAS program. Some manufacturers of e-liquids use a wide variety of natural and artificial flavoring agents, with the most readily available sources being those whose origins were intended for inclusion as flavoring in food products. Research on some flavorings used in tobacco products has revealed that benzaldehyde has been detected in cherry flavoring, methyl anthranilate was detected in grape flavoring, and 1-hexanol was detected in apple flavoring.[50]

Some websites that sell premade e-liquid mixes are using manufacturing sources from outside of the United States. FEMA has stated: "None of the primary safety assessment programs for flavors, including the GRAS program sponsored by FEMA, evaluated flavor ingredients for use in products other than human food. FEMA GRAS status for a flavor ingredient does not provide regulatory authority to use the flavor ingredient in e-cigarettes in the U.S."[49] Therefore, the safety of the use of these flavorings in e-cigarettes has not been tested or approved. In addition, the heating process and vaporization of these products in electronic cigarettes result in an inhalation of aerosol, rather than ingestion. Further, no research is known to have been conducted on the pyrolyzation products of any of the flavorings, which may be occurring at higher vaping powers. Therefore, a compound that may be GRAS when ingested is no longer automatically safe for inhalation.

A clear example of this problem is the use of diacetyl (butanedione or butane-2,3-dione) as a buttery flavoring for popcorn, baked goods, and liquor. Numerous research papers have been published and lawsuits have been filed in the past decade regarding employees in several factories that manufacture or use artificial butter flavoring who have been diagnosed with bronchiolitis obliterans, a rare and very serious disease of the lungs.[51]

Diacetyl is an example of a flavoring that is approved for ingestion but has potential health effects when volatilized and inhaled. In November 2010, the state of California passed legislation relating to employee exposure, physical examinations, and personal protective equipment when working with diacetyl in the workplace because of the potential health concerns associated with inhaling the aerosolized flavoring.[52] Due to a lack of strong quality control or labeling requirements, and the lack of research on domestic and imported e-liquids, it is unknown at this time how many other GRAS (or non-GRAS) flavoring agents may fall into this same ingestion vs. inhalation quandary.

<u>Volatile Organic Compounds</u>

A number of published studies have been conducted worldwide examining, among other things, the presence of various VOCs in e-cigarette vapors. One German study compared secondhand emissions, including VOCs, of e-cigarettes and conventional cigarettes.[17] Researchers tested three different brands of e-cigarettes loaded with three different liquids, two containing nicotine and one that is nicotine free. The authors stated that continuous monitoring of the e-cigarette vapor showed only a slight increase in formaldehyde concentrations, which the researchers theorized may have actually been caused by the test subject instead of the e-cigarettes.[17] Other indoor pollutants of special interest, such as benzene, were detected only during the tobacco smoking experiment. It should be noted, however, that the test subject took only six puffs from each cigarette, with a 60-second delay between puffs, which may not be representative of normal vaping behavior.[17]

Another German study, using commercially available e-cigarettes and three different liquids (both with and without nicotine), reported that formaldehyde, benzene, and the pyrolysis products acrolein and acetone did not exceed background concentrations.[36] Indoor concentrations of vanillin and benzylalcohol were only slightly increased compared with control values. However, PAH concentrations increased on average by 20 percent over background levels.[36]

A Polish study of three popular e-cigarette brands with nicotine containing liquid reported that only toluene was detected in the exposure chamber after e-cigarette usage, and that the levels were not statistically above background concentrations.[21] The authors also studied emissions from regular cigarettes and compared them to those from the e-cigarettes. They noted that smoking as few as two tobacco cigarettes significantly increased the airborne concentration of toluene, ethylbenzene, m,p-xylene, and o-xylene, and that for toluene, the average concentration after smoking tobacco cigarettes was 3.5-fold higher than after using e-cigarettes.[21]

Another Polish study examined the vapor generated by 12 brands of e-cigarettes filled with nicotine-containing liquid analyzed for 11 common VOCs and 15 carbonyl-containing VOCs. Of the 11 common VOCs, only toluene and m,p-xylene were identified in the vapor generated from the e-cigarettes, but they were found in almost all of the e-cigarettes tested.[47] However, the researchers also noted that the levels of m,p-xylene detected in the vapor were similar to those found in the blank samples. Of the 15 carbonyl-containing VOCs, formaldehyde, acetaldehyde, o-methylbenzaldehyde, and acrolein were observed in nearly all e-cigarettes tested. [47]

A U.S. study examining emissions from four different high-nicotine-content e-liquids vaporized by generic two-piece e-cigarettes, as well as from conventional cigarettes, found detectable levels of ethylbenzene, benzene, toluene, and m,p-xylenes in the vapor.[18] However, the levels in the tobacco smoke were orders of magnitude higher than those found in the e-cigarette vapor.

A Japanese study of 13 e-cigarette brands (363 e-cigarettes in total) found that nine of the brands generated detectable airborne levels of various carbonyl compounds, including formaldehyde (concentrations up to 61 mg/m^3), acetaldehyde (concentrations up to 48 mg/m^3), acrolein (concentrations up to 34 mg/m^3), and propanal (concentrations up to 27 mg/m^3).[53] The authors noted that there were very large variations in the carbonyl concentrations, not only among the different brands but also among individual e-cigarettes from the same brand. They theorized that the compounds were generated as a result of the e-liquids incidentally touching the heated wiring in the atomizers.[53]

<u>Metal and Silica Particles</u>

Electronic cigarettes are designed with metal components that have also been found in the aerosol. Resistive wire filaments (nickel-chromium or other metals) are used to heat the wick and evaporate the e-liquid.[19] Often these resistive wires are coupled to nonresistive extensions of copper wire (sometimes coated with silver), and often tin solder joints connect the wires to each other and to the air tube and mouthpiece.[19] Fibers found in some cartomizers (atomizers, heating coils) had copper deposits, and both tin particles and tin whiskers were found in some cartridge fluid.[19] Aerosols generated from electronic cigarettes have been found to contain tin, silver, iron, nickel, aluminum, sodium, copper, magnesium, lead, chromium, manganese, potassium, zinc, silicates, and nanoparticles of tin, chromium, and nickel.[19] The silicates appear to come from fiber glass wicks used in the product and are not expected to be crystalline silica.[19] Goniewicz et al. also found cadmium to be present in the aerosol generated from some, but not all, e-cigarette products.[47]

One study found lead and chromium concentrations in electronic cigarette aerosols within the same range as conventional cigarettes (0.017 µg/10 puffs for lead and 0.007 ug/10 puffs for chromium).[19] Airborne nickel was found to be in higher concentrations in e-cigarette vapor than in conventional cigarette smoke (0.005 µg/10 puffs vs. the highest concentration of 0.0014 µg/10 puffs for conventional cigarettes).[19] Overall, the researchers found concentrations of nine different metals to be higher than or equal to the range of concentrations found in conventional cigarette smoke.[19] Another study found airborne aluminum concentrations increased from the approximately 0.20 µg/m^3 background concentration to approximately 0.48µg/m^3 during e-cigarette vaping sessions.[36]

While the airborne exposure for all metals during vaping has not been well-defined in terms of dose or concentration (in mg/m^3 or ppm), all of the elements found in the aerosol have the potential to adversely affect the respiratory system; some can affect reproduction and development (e.g., lead); and some are considered carcinogens or “reasonably anticipated to be human carcinogens” (e.g., nickel and lead).[19,54,55] Lead, nickel, and chromium are also on FDA’s “harmful and potentially harmful chemicals” list.[19]

Williams et al. evaluated the cytotoxicity of electronic cigarette fluids, with and without tin particles, and found that the fluids with tin particles were observed to be cytotoxic in assays using human pulmonary fibroblasts, but the fluids without tin particles were not.[19] The presence of tin in the fluid appeared to be dependent on the quality of the wire soldering and the extent of presale use or testing performed on the units, as several of the “new” units evaluated showed signs of use prior to purchase.[19]

Ultrafine Particulates

Research over the last two decades has demonstrated that exposure to airborne fine and ultrafine particulate matter results in a variety of adverse health effects. Wichmann et al. found significant associations of elevated cardiovascular and respiratory disease mortality with various fine (and ultrafine) particle indices.[56] In his study, significant associations were found between mortality and ultrafine particle number concentration, ultrafine particle mass concentration, and fine-particle mass concentration.[56]

The particulate size distribution and composition of tobacco smoke is well-documented and will be reviewed here only as a comparison to e-cigarettes. Schripp conducted studies in an 8 m^3 chamber to evaluate the size distribution of submicron particulates from both tobacco smoke and e-cigarettes.[17] The traditional cigarette produced a log-normal distribution around a mean size of 100 nanometers (nm) in diameter, with a peak concentration of 4.0×10^4 particles/cm^3, while the e-cigarette were found to produce a size distribution around a mean of 35 nm in diameter with a concentration 2.0×10^3 particles/cm^3.[17] Although the concentration of particulates from the tobacco smoke was found to be an order of magnitude greater than the electronic cigarettes (when generated under the same conditions), these findings are significant because both the particulate size and concentration levels are a concern.

Schripp also examined the size distribution as the e-cigarette particles aged. The aging process at different temperatures suggests that exhaled e-cigarette vapor can result in passive exposure as well a shift in the particle size, where peak size shifted to smaller sizes, from about 180 nm at 23°C to 60 nm and 45 nm at elevated temperatures (37°C and 50°C respectively).[17] However, e-cigarettes release particles only during exhalation, whereas regular cigarettes emit particles continuously during combustion via side-stream smoke. The overall conclusions presented by Schripp et al. were that vaping will introduce particles into the indoor environment that are of concern from both a size and concentration standpoint but are substantially less than tobacco cigarettes.[17]

In another study of e-cigarette emissions, Ingebrethsen reported even higher particulate concentrations and larger average particle masses. Particle diameters of average mass in the 250 nm to 450 nm range, and a total particle count in the 10^6 particles/cm^3 range, were reported for aerosols from e-cigarettes measured with an electrical mobility analyzer.[57] These measurements were reported to be similar to those observed from tobacco cigarettes. Yet another study by Zhang et al. reported e-cigarette particle size between 10 and 1000 nm, with an average of 400 nm.[58] Based on particle size, the authors expect deposition in the human lung similar to that of tobacco cigarette smoke.[58]

Research shows that ultrafine particles form from supersaturated 1,2-propanediol vapor, which can be deposited in the lung.[36] Schober et al. found that airborne $PM_{2.5}$ concentration during vaping sessions with e-cigarette users were approximately 373 µg/m^3, with the highest levels (514 µg/m^3) found during vaping sessions with no nicotine in the vaping solution.[36] These results reflect airborne concentrations in a fairly large room due to exhaled vapor. Therefore, these results relate primarily to the potential for secondhand exposures.

Another study, using a device that simulated vaping during a three-minute session, reported $PM_{2.5}$ concentrations of 43 µg/m^3 after three minutes.[54] People who have frequently been exposed to theatrical fogs containing ultrafine particles of propylene glycol are more likely to suffer from respiratory, throat, and nose irritations than do unexposed people, suggesting that e-cigarettes may foster similar health effects.[59] Therefore, while these limited results vary, the generation of airborne ultrafine particles from e-cigarettes is a potential indoor air quality issue.

As a measure of impact from inhaling ultrafine particles from e-cigarettes, Marini et al. examined the acute effects of electronic and tobacco cigarettes on exhaled nitric oxide (eNO).[60] Exhaled nitric oxide has been used as a noninvasive method to measure inflammation of the lung after exposure to pollutants. Marini applied eNO tests to a group of 25 volunteers who use tobacco, e-cigarettes with nicotine, and nicotine-free e-cigarettes.[60] The eNO tests were applied before and after smoking/vaping to allow for the comparison in the changes in eNO for individuals.[60] The average total particle number concentration peak was found to range from $3.1 \times 10^9/cm^3$ for conventional cigarettes to $5.1 \times 10^9/cm^3$ for e-cigarettes with nicotine.[60]

Oddly, the e-cigarette particulate emissions were found to be 1.5 times higher than those from traditional cigarettes, a stark contrast to previous studies.[60] However, the main focus of this article was to understand changes in eNO levels from e-cigarettes with and without nicotine. The mean eNO changes measured after each vaping test were found to be 3.2 parts per billion (ppb), 2.7 ppb, and 2.8 ppb for electronic cigarettes without nicotine, with nicotine, and for conventional cigarettes, respectively.[60] The control sessions were found to have negligible change in eNO.[60] Hence, the short-term respiratory effect found in this study was that e-cigarettes, as well as traditional tobacco cigarettes, led to immediate reduction in eNO, suggesting inflammation of the airways.

Floyd et al. recently compared vaping aerosols from a second-generation adjustable voltage tank style e-cigarette to tobacco cigarette smoke aerosol (D. Johnson and E. Floyd, personal communication, June 12, 2014). They measured particle size distributions over a broad range, from 16 nm to 20 µm, and found that less than 40 percent of both the e-cigarette aerosol and tobacco-smoke aerosol particle mass was comprised of particles less than 1 µm in diameter. They also observed a 32-fold increase in vaporized e-fluid when voltage was increased from 3.15 V to 5.81 V, demonstrating the potential for newer generation, more powerful devices to produce much higher concentration aerosols. The higher heating coil temperatures associated with these high-power devices also pose the risk of chemical changes in the e-fluid, which is suspected to produce aldehydes and carbonyls.[61,62]

The work completed to date on aerosols generated from e-cigarettes suggests that they present a new source of aerosols in indoor environments. While the aerosol number concentration is smaller than that from traditional cigarettes, the smaller size distribution of e-cigarette aerosols may result in different deposition locations within the lung. Because of the relatively new widespread use of e-cigarettes, the relationship between exposure and any health effects is still evolving. However, the evidence of health effects from a number of authors linking ultrafine particles to respiratory and cardiovascular disease clearly indicates a potential health concern.

Tobacco-specific Nitrosamines

Tobacco-specific nitrosamines (TSNAs) have been reported to be found in trace levels in electronic cigarettes in at least two studies, but are found in concentrations well below TSNA levels in regular cigarettes.[16,47] However, residual nicotine from tobacco smoke has been shown to react with ambient nitrous acid to form TSNAs over time, therefore increasing the overall potential exposure.[63] Some TSNAs are known human carcinogens and are suspected to contribute to the cancer burden of smokers.[64]

Nut Allergens

An area about which knowledge is currently lacking is the presence of nut allergens that may be found in e-cigarette liquids. On the General Frequently Asked Questions (FAQ) page of e-liquid supplier Johnson Creek's website, a question was posted from a consumer worried about allergy to nuts and the use of e-liquids. The company's website response was:

> If you have an allergy to nuts, we recommend that you NOT use Johnson Creek Original Smoke Juice. It is possible that some of our flavors may have nut-based ingredients, or may be produced in a facility that processes nuts.[65]

The presence or potential presence of nut allergens within e-cigarette liquid obviously poses a concern for users with nut allergies. What is currently unknown is whether a nut allergen contained in a flavored e-liquid can become airborne during e-cigarette use and pose an airborne exposure risk for sensitive individuals nearby. This is an area where research is warranted, especially with the implication of risk for individuals with nut allergies exposed to secondhand e-cigarette vapor. This identifies another area needing research: If a nut allergen becomes airborne, could this allergen then deposit onto surfaces in the area of use and then pose a dermal risk for allergic individuals – a thirdhand exposure?

<u>Other Constituents</u>

As previously stated, there is evidence that the vaporization technology used in e-cigarettes has been employed to deliver other drugs such as tadalifil (a drug used for erectile dysfunction) and rimonabant (a weight-loss aid)[13] and that this technology may prove beneficial for specific prescription drug mobilization. However, as the e-cigarette technology has been described in detail in the public domain and numerous online special interest groups (SIGs), hobbyists and dedicated e-cigarette users and supporters are able to purchase individual components to manufacture their own e-cigarette hardware configurations.

As of May 2014, this subject review has identified numerous websites that sell components for the elution of plant material extracts into the cigarette delivery system.[66] In short, one may now deliver liquid extracts of medical marijuana, hashish, and crack cocaine[67,68] into the vaping system with allegedly no odor detection by other room occupants.

Overall Health Effects Associated with E-cigarettes

Currently, there are limited published studies that evaluate the potential hazardous effects of the natural and/or synthetic chemicals used in e-cigarettes. Overall, the literature to date indicates that there are potential health effects reported for both users and those exposed secondhand.

E-cigarette users in online forums self-reported a variety of health symptoms that they associate with using e-cigarettes, including mouth and throat irritation, cough, nausea, changes in heart rhythm, and dizziness.[69] Although studies have shown that consumption of e-cigarettes did not show changes in blood pressure for participants, a review of these forums revealed that blood pressure changes were reported by 3.5 percent of e-cigarette users.[69] Some users also reported experiencing increased heart rates, although some scientific studies have shown that heart rate did not increase during the use of prepackaged e-cigarettes.[70]

Bahl et al. studied the cytotoxicity of 35 samples of e-cigarette refill fluids using human embryonic and adult cells.[71] Twenty-seven of the 35 refill samples were moderately to highly toxic to the embryonic cells, with less severe effects on the adult cells.[71] The observed cytotoxicity was not attributable to the nicotine present in the fluids but was correlated with the number and concentration of chemicals used to flavor the fluids.[71] Their research indicated that the observed cytotoxic effects could potentially translate into embryonic loss or developmental defects during pregnancy.[71] Additional preliminary information presented by Cressey indicates that human bronchial cells exposed to high levels of e-cigarette vapor in vitro expressed gene patterns similar to human bronchial cells exposed to tobacco smoke in vitro.[72] These researchers state that, while e-cigarettes may be safer than tobacco, "preliminary studies suggest that they may not be benign."[72]

Overall airway resistance and lung function associated with e-cigarette use has been studied with varying results. Flouris et al. reported that neither a brief session of active e-cigarette smoking, nor a one-hour duration of passive e-cigarette smoking, resulted in any significant interference with lung function measured using forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), FEV_1/FVC ratio, peak expiratory flow (PEF), or forced expiratory flow in the middle 50 percent of FVC (FEF_{25-75}).[14] However, a different study that evaluated the fraction of exhaled nitric oxide (FeNO), a marker of bronchial inflammation, along with FEV_1, FVC, FEV_1%, PEF, maximal expiratory flow (MEF) at 25 percent, 50 percent, and 75 percent of vital capacity, and total respiratory resistance discovered that five minutes of e-cigarette use was sufficient to lead to an increase in lung flow resistance and a decrease of FeNO concentrations, which is a marker for oxidative stress in the lung.[5]

However, another study found a rise of FeNO in users of nicotine containing e-cigarettes, but not in users of non-nicotine-containing e-cigarettes.[36] A limited Greek study found that e-cigarette users experienced an instant increase in airway resistance that lasted for approximately 10 minutes, using a spirometry test and other diagnostic procedures.[4] Smokers experienced an airway resistance from 176 percent (mean average) to 220 percent, while nonsmokers experienced an airway resistance from 182 percent to 206 percent.[4] Long-term exposures were not evaluated in any of these studies.

Early research showed that, per puff, nicotine absorption is lower for e-cigarettes than for tobacco cigarettes.[14] One study reported that e-cigarette users have, in general, approximately 10 percent of the nicotine concentration in their blood plasma as compared to tobacco cigarette users,[69] while others have shown no significant changes in plasma nicotine as a result of the use of some prepackaged products.[20] These values may change with the increased use of personal mixes of liquids where the user can control the nicotine concentration.

Flouris et al. found that while active and passive tobacco smokers experience an increased white blood cell count, lymphocyte count, and granulocyte count, active and passive e-cigarette smokers do not.[73] Farsalinos et al. reported that there were no acute adverse effects on cardiac function reported in smokers or nonsmokers using e-cigarettes.[74] This is consistent with reports that cardiovascular disease from tobacco use is likely related to the combustion byproducts of tobacco smoke.[71]

Other Health and Safety Issues

Because some styles of e-cigarettes resemble regular cigarettes, allowing the use of e-cigarettes in smoke-free places may lead people to believe that no ban on smoking in that location exists and, as a result, to light up conventional cigarettes.[75] Some research shows that for smokers, the observation of others smoking increases the craving and potential for ultimate consumption of cigarettes.[76] Therefore, careful consideration should be given to allowing the use of e-cigarettes without restriction in the workplace, as it may induce others who are attempting abstinence to desire to smoke as well.

Moreover, recent media attention has brought additional safety issues, including child safety and poisonings, battery explosions, and the potential for the vapor to set off smoke alarms. The American Association of Poison Control Centers reported that poison control centers have reported an increase in emergency calls regarding exposures to e-cigarette devices and liquid nicotine, with more than half of the exposures occurring in children under the age of six. [77] Although many e-cigarette vials have safety caps, the caps are currently not required by law.

Several incidents of fires and explosions have been reported from the lithium-ion batteries used to charge e-cigarettes. The most common causes of fires have been using incorrect chargers or over-tightening of the screwed connection to the charger, which can damage the battery cells and lead to overheating.[78] Unfortunately, many lithium–ion batteries used in e-cigarettes do not have overcurrent or overcharge protection, so if they are left charging, the coil can overheat and cause the battery to explode.[78]

One vaper demonstrated online that it is possible to set off a smoke alarm using an e-cigarette.[79] However, whether the vapor can or will set off smoke detectors appears to be dependent on the situation and the type of smoke alarm.

Current Regulatory and Health Agency Statements

E-cigarettes are enjoying some support from those who back their use as a way to reduce harm from smoking traditional tobacco cigarettes. Dr. Richard Carmona, the U.S. Surgeon General during the George W. Bush presidency and who was responsible for a 2006 report on secondhand smoke that helped to ban smoking in restaurants and bars, joined the board of directors of an e-cigarette manufacturer in March 2012.[80]

Carmona advocates that e-cigarettes reduce the risk for smokers and recipients of secondhand smoke by eliminating combustion byproducts, many of which are carcinogenic.[80] However, he notes that he joined the board on four conditions: (1) that the company seek FDA regulation; (2) that the company conduct research and openly publish results regardless of real or potential financial impact; (3) that the company may not use his name or previous position to promote its e-cigarettes; and (4) that the company not market e-cigarettes to children.[80] His idea is that the company will research effects of secondhand vapor and how well e-cigarettes help people totally wean themselves from both tobacco products and e-cigarettes.[80]

WHO has recommended that consumers be strongly advised not to use electronic nicotine delivery systems, including e-cigarettes, until they are deemed safe and effective and of acceptable quality by a competent national regulatory body.[8] WHO noted that the safety of the devices has not been scientifically demonstrated.[8] While WHO discourages the use of e-cigarettes, it has not yet taken a position on whether they should be banned. It has been reported that WHO is planning on regulating e-cigarettes in the same way as traditional tobacco products.[81] E-cigarettes would be classified as tobacco under the Framework Convention on Tobacco Control, which is a WHO treaty that obliges governments to curtail smoking rates around the globe.[81] However, as of the publication date of this white paper, WHO has made no official statement or position on this matter.

The regulatory status of e-cigarettes is constantly changing. Although these products may use some ingredients derived from tobacco, such as nicotine, other ingredients are clearly not related in any way to tobacco products. The FDA currently regulates only e-cigarettes that are marketed for therapeutic purposes.[82] However, the FDA has proposed a rule extending its tobacco product authorities to include other products like e-cigarettes.[83] The FDA has previously taken action against manufacturers of e-cigarettes, claiming that they violated good manufacturing practices and made unsubstantiated drug claims.[84] However, manufacturers sued the FDA, claiming that e-cigarettes should be regulated as tobacco products, and not as drugs.[84] Beginning in 2016, Great Britain will start to regulate e-cigarettes as a nonprescription medicine.[85] Other countries, such as Brazil, Norway, and Singapore, have banned the use of e-cigarettes.[85]

Several agencies and organizations have adopted the approach that e-cigarettes are equivalent to traditional cigarettes, or that the hazards are unknown and, therefore, are subject to the current bans on cigarette advertising; restrictions on sales; and bans on use in public places, transportation facilities, and restaurants and bars. For example, the states of Arkansas, New Jersey, North Dakota, and Utah[86]; and the cities of Los Angeles, New York, Washington, DC, Chicago,[87] and Duluth, Minn.,[88] have included e-cigarettes in indoor smoking regulations. Mississippi's DeSoto County has added e-cigarettes to the local smoking ban in government buildings,[86] and the governor of Oklahoma has banned the use of any electronic cigarette or vaping device on any properties owned, leased, or contracted for use by the state.[89] Many other states and municipalities are discussing similar legislation or bans.

Although traditional cigarettes are currently taxed heavily in the United States, e-cigarettes are not uniformly subject to tobacco taxes if no tobacco-derived products are involved, which makes them relatively less expensive than traditional cigarettes. The nontaxed cost of e-cigarettes can be viewed as encouragement of the use of e-cigarettes.

Several states have included e-cigarettes under tobacco tax requirements, though they are currently not subject to federal tobacco taxes. For example, Minnesota has modified the definition of "tobacco products" to include terminology that allows e-cigarettes to be taxed as tobacco products.[84] However, careful review of the wording of each state's tobacco laws would be required to extend purchasing limitations of e-cigarettes as a tobacco product to minors.[84] Restrictions on advertising to minors and bans on Internet sales or sales to minors have either been enacted, or are being planned, by several organizations including 38 states[90] and the FDA.[91]

Regarding whether the use of e-cigarettes is allowed or banned on commercial aircraft in the United States, the regulatory status is not clear. During a hearing in 2010 before the Senate Committee on Commerce, Science and Transportation, Susan Kurland, Assistant Secretary for Aviation and International Affairs, U.S. Department of Transportation (DOT), when asked whether the agency planned to explicitly ban the use of electronic cigarettes on commercial airplanes, stated that the smoking of e-cigarettes was already banned.[92] However, some question that statement, noting that only "tobacco products" are banned on certain scheduled air carrier flights in Part 252 of Title 14 of the Code of Federal Regulations, "Smoking Aboard Aircraft." [93]

In 2011, DOT proposed amending its existing airline smoking rule to explicitly ban the use of e-cigarettes on all aircraft in scheduled passenger interstate, intrastate, and foreign air transportation.[94] In their proposal DOT cited its specific statutory authority to prohibit smoking, under Section 41706 of the Title 49 of the United States Code, on "Prohibitions against smoking on scheduled flights" which does not specifically mention tobacco or explicitly limits its scope to smoking of tobacco products. [95] DOT also based its proposal on its general duty statutory authority that, regarding "interstate air transportation, [a]n air carrier shall provide safe and adequate interstate air transportation."[96] A group of organizations, including the American Lung Association, the American Heart Association, and the Cancer Action Network, sent a letter of support for DOT's proposal to prohibit e-cigarettes on all commercial aircraft. The reasons provided included that health consequences were unknown and that allowing the use would create significant confusion for passengers, along with enforcement challenges for airline personnel.[97] However, to date a ban has not been issued. In addition, the Federal Aviation Administration has not promulgated a ban and has left it to the airlines to set their own policies in regard to whether e-cigarettes are allowed on flights.

Major U.S. airlines have amended their no-smoking policies to specifically include e-cigarettes. For example, United Airlines' smoking policy states: "Smoking (including use of electronic simulated smoking materials and smokeless cigarettes) is not permitted on any flights operated by UA."[98] However, not all airline smoking policies are completely clear about e-cigarettes. For example, JetBlue's Contract of Carriage's smoking policy simply states: "Smoking aboard the aircraft is prohibited in accordance with Federal Law"[99], but the help section of JetBlue's website states, "JetBlue does not allow the use of [e-cigarettes] on any of its flights. It is considered a nuisance item as small amounts of vapor are expelled from the cigarette."[100]

Even with clear prohibition of e-cigarettes by certain airlines, some e-cigarette proponents have posted recommended strategies for being allowed to use the device, suggesting that it be called a "nicotine inhaler" and insisting that the use of the device is not covered by smoking bans on airplanes.[101]

Other transit systems, such as commuter rail lines, subway systems, and bus services, have also created issues with ambiguity over e-cigarette usage by only referencing federal law that smoking (of tobacco) is banned. Amtrak has had a no-smoking policy since 2008 that specifically includes e-cigarettes both on trains and in stations.[102] Many transit entities have updated their policies to specifically include e-cigarettes, such as the New York City-area Metropolitan Transit Authority, operator of the Long Island Rail Road and Metro-North Railroad, which updated its policy in the 2013.[103] The Los Angeles County Metropolitan Transportation Authority amended its policy in March 2014 to prohibit vaping.[104]

A trade magazine reported that, as of April 2014, at least six additional transit-rail agencies – Caltrain, Chicago Transit Authority, Dallas Area Rapid Transit, Metropolitan Atlanta Rapid Transit Authority, Tri-County Metropolitan Transportation District of Oregon, and Virginia Railway Express – had adopted e-cigarette restrictions.[105] Regarding private-sector bus companies, the Megabus policy states: "Smoking, including the use of electronic simulated smoking materials, e-cigarettes, and smokeless cigarettes, is prohibited in our buses"[106]; however, the BoltBus policy simply states that "Smoking is prohibited aboard the bus in accordance with Federal law"[107] and the policy for Greyhound states only that "Smoking is prohibited."[108]

To summarize, there is currently no federal law or regulation that explicitly bans the use of e-cigarettes on U.S. airplanes, railroads, buses, or other modes of transportation. For organizations and businesses that have smoking bans, especially those required by law, it would be advisable for them to update their bans to specifically include e-cigarettes in order to eliminate potential confusion among patrons as well as employees charged with enforcing those bans.

Key Data Gaps and Uncertainties

There are several key data gaps and areas of uncertainty that hinder a more quantitative assessment of health risks related to e-cigarettes at this time. These include:

- Quality control is lacking with regard to product constituents. (Manufacturers may not disclose all of the chemical ingredients used in their products, nor, other than nicotine, their amounts.)
- Because many users mix their own blends and there are so many different types of devices, what may be studied in the lab may not reflect actual exposures during use.
- There is limited data on chemical emissions/exposures (especially among bystanders and in confined indoor settings).
- There is limited information on dose-response relationships for many constituents (such as short- or long-term health effects associated with low-level exposures).
- Established safety levels (occupational vs. environmental) are lacking.
- At this time, there is no clear understanding of how much liquid is vaped by a user or a population of users in a given day in comparison to how many cigarettes are smoked in a day.[106] Variations in vaping habits, variable liquid strength, and uncertain overall daily vaping duration make any scientific conclusions about the vaping population tenuous at best.

Note that these issues are related only to an assessment of human health risks. They do not incorporate other potentially important factors, such as public risk perceptions, risk management options/control measures (e.g., ventilation), and nicotine dependence.

As the scientific community attempts to determine the inhalation health effects of the primary components of e-cigarettes, current literature reveals little about the potential synergistic effects of the main chemical components and of the numerous flavoring additives used. Additionally, there is a dearth of information about the synergistic effects from e-cigarette contents and other environmental contaminants.

Health and Sustainability Considerations

Many groups are affected either directly or indirectly by e-cigarettes. The type and magnitude of the effects are dependent on which group is being evaluated. Groups of interest include current smokers, former smokers, adults who never smoked, middle and high school students, children, pregnant women, workers, the public, and individuals with compromised health (e.g., immunocompromised, heart disease, and lung disease). Discussions in the general literature, and even in the scientific literature, often evaluate these groups indiscriminately.

For smokers, vaping is less toxic than smoking because the particulates and harmful toxicants generated by the burning process are significantly reduced or eliminated. On its surface, this is the only group that clearly benefits from e-cigarettes. For adults who are not current smokers or who have never smoked, vaping clearly introduces toxicants including nicotine, flavorings, and vehicle compounds, and their thermal degradation products.

Although the health effects to vapers may not be as great as those associated with traditional smoking, they are greater than not vaping at all. Nicotine itself raises blood pressure, increases heart rate, and is highly addictive. The flavorings used are often considered GRAS as food additives, but these chemicals are inhaled during vaping, which obviously changes the route of exposure. There is little or no information about the health effects of various food additives that are inhaled rather than ingested. For example, diacetyl is safe when ingested on popcorn, but it potentially causes severe lung problems when inhaled during the manufacturing process.[51]

If the only individual affected by using e-cigarettes were the vaper, the discussion could end here. That is not, however, the case. Similar to secondhand smoke, the ingredients exhaled by the vaper include nicotine, metals, flavorings, and glycol that accumulate in the ambient air. Recipients of secondhand vapor have not chosen to – many, in fact, have explicitly chosen not to – use e-cigarettes. The exposure to secondhand vapor, just like secondhand smoke, raises issues of involuntary exposure and competing rights. This is even more critical for groups that may be, and probably are, more susceptible to adverse effects of secondhand vapor, including children, pregnant women, and people with already compromised health, some of whom may have limited ability to leave the spaces in which vaping occurs or has occurred.

The question of scale must also be considered. When secondhand vapor is evaluated, the scale of the vaping must be included. This would include the volume of the space (size of the room), number and type of e-cigarettes in use, the length of time in use, and the ventilation rate. For example, ASHRAE has developed standards for ventilation rates to maintain indoor air quality in general, and for smoking rooms in particular.[38]

Even with the ASHRAE standards, smoking rooms still have the potential for elevated levels of toxicants from traditional tobacco products. In addition, the implementation of these ASHRAE standards is not without cost. Measurements and evaluation cost time and money. The health effects to individuals exposed before adequate standards are developed and implemented are another cost.

Lastly, health effects that occur throughout the life cycle of an e-cigarette should be considered. The health effects incurred by workers during the extraction of metals; the manufacture of nicotine, flavorings, plastics, and batteries; and the health effects costs to package and distribute e-cigarettes should be evaluated.

Sustainability requires an evaluation of social and economic aspects as well as health and environmental effects. Advertising is a large component of the social acceptability of e-cigarettes. Advertising promoted a positive social image of traditional cigarettes during the mid-20th century. If e-cigarettes are perceived as being used by individuals whom society admires (e.g., movie stars and athletes), their social acceptance will likely be assured. Advertising aimed at high school students and young adults is particularly effective. Once e-cigarettes are socially acceptable, the addictiveness of nicotine will provide a continued user group.

No doubt some individuals and businesses will profit from the development of an e-cigarette industry, and a few might become quite wealthy. There are several economic costs, however, that must also be evaluated. If e-cigarettes are not regulated in public places, contaminants produced by them in the ambient air may keep customers away. At this point, most Americans would not want to be an airplane passenger or be eating in a restaurant where traditional cigarette smoking is freely permissible. If e-cigarettes are not regulated in workplaces, the real and/or perceived effects will likely result in lost productivity, comparable to the lost productivity associated with poor indoor environmental quality. Any increased health care costs associated with the use of e-cigarettes, especially when health care costs are already enormous, must be factored into overall national and global economies.

Quantitative health risk assessment and the setting of exposure limits are useful in some situations, such as occupational exposure control and environmental cleanup projects.[110] Other types of risk assessment may be more useful in evaluating e-cigarettes, such as a risk assessment methodology that looks at the costs and benefits of using a product and then compares them to the costs and benefits of not using the product. In the case of e-cigarettes, the only group that may benefit from their use consists of people who already smoke and who may want to reduce their exposure to combustion byproducts. For other groups, however, there are no benefits and there may be health risks. The health consequences of secondhand exposure to nicotine and other substances may be imposed involuntarily on vulnerable populations, such as children, pregnant women, and people with cardiovascular and/or lung conditions.

Health effects that occur throughout the life cycle of the e-cigarette should also be considered. Sustainability evaluations involve life cycle analyses that evaluate costs associated with extraction, manufacturing, delivery, use and disposal of e-cigarettes. The health effects incurred by workers during the extraction of metals, the manufacture of nicotine, flavorings, plastics, and batteries, as well as the health effects costs to package and distribute e-cigarettes, should be evaluated. Metals used in e-cigarettes and the batteries to run them are mined by workers exposed to dust and other hazards. Also, inhalation and musculoskeletal health effects are associated with the manufacture of plastics, nicotine, and flavorings used in e-cigarettes.

End-of-useful-life considerations for e-cigarettes should also be done before mass production begins. Considerations should include battery recycling and/or reuse, and how the plastic used in the cigarette itself will be recycled or reused, in order to reduce the environmental impact of disposing of these e-cigarette components.

Conclusions and Recommendations

Given this review of available information, the existing research does not appear to warrant the conclusion that e-cigarettes are “safe” in absolute terms. Although they may provide a “safer” alternative to tobacco cigarettes for the vaper, these products emit airborne contaminants that may be inhaled by both the user and those in the vicinity of vaping. Many of the data sources reviewed confirm that e-cigarettes are not emission-free and that their pollutants could be of health concern for users and those who are exposed secondhand. Therefore, e-cigarettes should be considered a source of VOCs and particulates in the indoor environment that have not been thoroughly characterized or evaluated for safety.

Multiple scientific reports express the need for more research. Much can be learned, however, from critically evaluating what we already know. Clearly, e-cigarettes lack the combustion products produced by smoking tobacco, many of which are associated with cancer development. Although nicotine may not cause cancer, it is associated with other adverse physiological effects. In addition, the other components in e-cigarettes may not be benign, particularly when they are inhaled rather than ingested.

Some areas that need further research include:

1. Health effects from inhaling e-cigarette flavorings and other ingredients that are reported to be generally recognized as safe via ingestion but which have not yet

been evaluated for inhalation toxicity, as well as their thermal degradation products;

2. Effects of secondhand emissions, thirdhand exposures, and nicotine addiction from e-cigarettes, especially on vulnerable populations;

3. The dynamics of pre- and post-respiration aerosols and their fate in the environment; and

4. Life cycle and end-of-use issues.

Because of concerns about primary and secondary exposure to e-cigarette vapors and e-juice fluids, AIHA supports risk-based regulation of e-cigarettes using reliable safety, health, and emissions data. Current regulations for devices that are advertised for "therapeutic purposes" do not address the multitude of e-cigarette devices and flavored e-juice formulas. However, until reliable data can be obtained on the vapor contents, using standardized test methods and procedures, regulatory efforts may either fall short or overreach.

E-cigarettes are likely to touch several regulatory frameworks but have, until recently, fallen through the lattice of existing laws and regulations. The April 24, 2014, decision by the FDA to pursue regulation of e-cigarettes as a tobacco product is the first of several possible regulatory reviews of this product family.[80] Others include the Consumer Product Safety Commission and OSHA. Four areas of regulation relating to the safety of primary users and people exposed to secondhand vapors or e-juices should be considered:

1. All e-cigarette devices, whether they are being used for therapeutic or recreational purposes, should be evaluated for potential physical and/or electrical hazards by applicable regulatory agencies.
2. The health risks and economic consequences of accidental exposure to e-juice liquids by children, adults, and pets should be addressed, including proper labeling and child-resistant packaging requirements.
3. All future e-juice components that may be used by consumers should be fully evaluated for any potential hazards (e.g., toxicity, flammability, safety hazards, and secondary exposures) prior to introduction into the marketplace.
4. Because e-cigarettes are a potential source of pollutants (such as airborne nicotine, flavorings, and thermal degradation products), their use in the indoor environment should be restricted, consistent with current smoking bans, until and unless research documents that they will not significantly increase the risk of adverse health effects to room occupants.

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Secondhand marijuana smoke may damage blood vessels as much as tobacco smoke

Submitted by sglantz on Sun, 2014-11-16 08:02

This research, led by UCSF professor Matt Springer, is being presented today (November 16, 2014) at the American Heart Association Annual Scientific Sessions.

Study Highlights:

- Secondhand marijuana smoke may have similar cardiovascular effects as tobacco smoke.
- Lab rats exposed to secondhand marijuana smoke had a 70 percent drop in blood vessel function.

CHICAGO, Nov. 16, 2014 — Breathing secondhand marijuana smoke could damage your heart and blood vessels as much as secondhand cigarette smoke, according to preliminary research presented at the American Heart Association's Scientific Sessions 2014.

In the study, blood vessel function in lab rats dropped 70 percent after 30 minutes of exposure to secondhand marijuana smoke. Even when the marijuana contained no tetrahydrocannabinol (THC) — a compound in marijuana that produces intoxication — blood vessel function was still impaired.

Reduced blood vessel function may raise the chances of developing atherosclerosis and could lead to a heart attack. Atherosclerosis is the disease process that causes plaque build-up in the arteries which narrows them and restricts blood flow.

"Most people know secondhand cigarette smoke is bad for you, but many don't realize that secondhand marijuana smoke may also be harmful," said Matthew Springer, Ph.D., senior author of the study and cardiovascular researcher and associate professor of Medicine at the University of California, San Francisco's Cardiology Division.

Marijuana and tobacco smoke are chemically and physically alike, aside from their active ingredients.

The drop in blood vessel function from THC-free marijuana suggests that the compound isn't responsible for the effect. Similarly, this study confirms that nicotine is not required for smoke to interfere with blood vessel function.

In the study, researchers used a modified cigarette smoking machine to expose rats to marijuana smoke. A high-resolution ultrasound machine measured how well the main leg artery functioned. Researchers recorded blood vessel dilation before smoke exposure and 10 minutes and 40 minutes after smoke exposure.

They also conducted separate tests with THC-free marijuana and plain air. There was no difference in blood vessel function when the rats were exposed to plain air.

In previous tobacco studies, blood vessel function tended to go back to normal within 30 minutes of exposure. However, in the marijuana study, blood vessel function didn't return to normal when measured 40 minutes after exposure.

Now that marijuana is becoming increasingly legalized in the United States, its effect on others is a growing public health concern, Springer said.

"If you're hanging out in a room where people are smoking a lot of marijuana, you may be harming your blood vessels," he said. "There's no reason to think marijuana smoke is better than tobacco smoke. Avoid them both."

Secondhand tobacco smoke causes about 34,000 premature deaths from heart disease each year in the United States among nonsmokers according to the U.S. Surgeon General's 2014 report on the consequences of smoking.

More research is needed to determine if secondhand marijuana smoke has other similar effects to secondhand cigarette smoke in humans.

The National Institute on Drug Abuse and the Elfenworks Foundation funded the study.

Here is the abstract:

Brief Exposure to Marijuana Secondhand Smoke Impairs Vascular Endothelial Function

Xiaoyin Wang, Ronak Derakhshandeh, Shilpa Narayan, Emmy Luu, Stephenie Le, Olivia M. Danforth, Hilda J. Rodriguez, Richard E. Sievers, Suzaynn F. Schick, Stanton A. Glantz, Matthew L. Springer, Univ of California, San Francisco, San Francisco, CA

Objectives: Despite general public awareness that tobacco secondhand smoke (SHS) is harmful, much of the public still regards marijuana SHS as benign. Because marijuana smoke and tobacco smoke are chemically and physically similar (other than nicotine and tetrahydrocannabinol (THC)), we tested this assumption by asking whether short exposure to marijuana SHS causes acute vascular endothelial dysfunction similar to that caused by tobacco SHS. Exposure to tobacco SHS impairs arterial flow-mediated dilation (FMD) in humans and rats.
Methods: We used a rat model to test the effects of secondhand marijuana smoke on FMD. We exposed anesthetized rats to marijuana SHS using a modified cigarette smoking machine, and measured FMD three times: before 30-min exposure ("pre"), 10 min after end of exposure ("post10"), and 40 min after end of exposure ("post40"). FMD was measured by micro-ultrasound measurements of femoral artery diameter before and after transient (5 min) surgical ligation of the common iliac artery. Concentrations of respirable suspended particles <2.5 μm (RSP) fell during exposure; exposure conditions are denoted by starting concentrations.
Results: Marijuana SHS starting at 667±62 μg/m3 RSP (n=8) caused FMD to fall from 7.5±0.94% (SEM) pre to 2.3±0.50% at post10 and 2.2±0.80 at post40 (P<0.01 for both post10 and post40 vs. pre, adjusted for multiple comparisons). SHS from placebo marijuana lacking THC starting at 671±49 μg/m3 RSP (n=7) similarly impaired FMD (9.9±1.4% pre, 4.3±0.64% post10 (p<0.01), 5.5±1.3% post40 (P<0.05)), confirming that impairment did not depend on the THC. In contrast, air in the exposure chamber (1.8±0.7 μg/m3RSP; n=8) did not alter FMD (11.0±0.64% pre, 11.4±0.72% post10, 11.7±0.86% post40, P>0.70).
Conclusions: Marijuana and tobacco SHS impair endothelial function similarly under comparable exposure conditions. Public exposure to SHS should be avoided whether the source is tobacco or marijuana.

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Comments

Submitted by sglantz on Sun, 2014-11-16 17:36.

Interviews with Matt Springer

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