REGULATORY IMPACT ANALYSIS

Instituting Smoke-Free Public Housing

Proposed Rule

Docket No. FR-5597-P-02

OEA-October 2015

1. Summary of Rule and Impacts

Since 2009, HUD's Office of Public and Indian Housing (PIH) has issued several notices encouraging PHAs to adopt smoke-free policies and guiding them on how to do so.[1] As a result of these combined actions, over 571 (out of 3090) public housing agencies (PHAs) have implemented smoke-free policies.[2] This voluntary effort has also resulted in an unsystematic implementation of smoke-free policies. To truly eliminate the risk of second-hand smoke (SHS) exposure to public housing residents, and implement uniform requirements to ensure all public housing residents are equally protected, HUD is proposing to implement a smoke-free policy which would require PHAs to implement, no later than 18 months from the effective date of the final rule, a policy requiring that all PHA-owned public housing units and indoor common areas be free from lit tobacco products.

The benefits of the rule are both to PHAs and to tenants of PHAs. PHAs will benefit from a reduction of damage in the form of maintenance costs caused by smoking, and both tenants and PHAs will gain from reducing costs associated with the risk of catastrophic fires. Many non-smoking tenants will experience health benefits through a reduction of exposure to SHS. In

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[1] See Notice PIH-2009-21 at http://www.hud.gov/offices/pih/publications/notices/09/pih2009-21.pdf; Notice PIH-2010-21 at http://portal.hud.gov/hudportal/documents/huddoc?id=10-21hsgn.pdf; Notice PIH 2012- 22 at http://portal.hud.gov/hudportal/documents/huddoc?id=12-22hsgn.pdf; and Notice PIH-2012-25 at http://portal.hud.gov/hudportal/documents/huddoc?id=12-25pihn.pdf.

[2] HUD-PIH program data.

addition, smokers in public housing will experience health benefits if they choose to stop or reduce their smoking. The aggregate benefit to non-smokers in the form of direct health benefits varies substantially depending on the discount rate, with upper bound benefits estimates ranging from $148 to $447 million with a 3 percent discount rate or from $70 to $137 million with a 7 percent discount rate. Reduction in costs for PHAs is expected to range from $16 million to $38 million per year. The reduction in fire damage is estimated at $32 million.

The costs of compliance with the smoke-free policy fall on PHAs and tenants and are not insignificant. The costs of implementing the rule will include learning, administrative, legal, and enforcement costs. Given the existence of HUD guidance on these subjects, it is not expected that the initial learning costs will be significant. However, implementing the requirements successfully may require additional enforcement legal costs for cases where repeated violations lead to evictions.

The most significant burdens on PHAs therefore depend on the method of enforcement chosen by the PHA. If a PHA hires someone whose sole job is to administer the smoke-free policy, then the rule will present significant opportunity costs, as money is shifted from other PHA priorities in order to pay for the new staff member. For this reason, PHAs are more likely to rely on self-monitoring by tenants. An unavoidable cost, however, is dealing with repeat offenders. Eviction costs in the aggregate could range as high as $2.2 million if those repeat offenders were to face eviction. Recurring notification costs could be $1 million.

Another non-negligible impact of the proposed rule is the welfare impact on smokers. Every cigarette will become costlier because smokers who choose not to quit (with or without the help of cessation medication), or to switch to non-combustible tobacco products, tobacco or nicotine FDA-approved cessation devices, snus, or electronic delivery devices (ENDS) or non-

combustible tobacco products, have to leave their units to smoke. The cost of the inconvenience can be measured by the opportunity cost of leisure time devoted to travel to a smoking designated area, and the time spent at the smoker-designated areas is a potential opportunity cost. HUD estimates the burden on smokers of compliance with smoke-free policies to be $209 million. The health benefits to smokers who are able to quit or reduce consumption may be extensive.

Many of the most important inputs into the cost and benefit calculations are subject to considerable uncertainty, and we therefore welcome comments, including submissions of data, that would allow for refinement of our estimates.

2. Need for the Proposed Rule

There are over 2.32 million residents of public housing across the United States, and approximately two-thirds of adult residents in federally subsidized housing are non-smokers.[3] Many PHAs have chosen to implement smoke-free housing policies, protecting the health of non-smokers. This leaves approximately 1.2 million non-smoking residents exposed to the dangers of SHS in their homes. In addition, PHAs that permit indoor smoking face higher costs in maintenance and insurance, as well as a risk of fires due to such smoking. In 2011, HUD included in the American Housing Survey (AHS) a number of questions about whether or not a person smoked in their unit. The AHS oversamples public and assisted housing units to allow us to provide information about those tenants and their units. The AHS data show that in public housing the rates of smoking are higher than in the general public although not substantially higher than other poor renters. Rates are lowest for elderly—16 percent—and highest for non-

[3] King, B., et al. (2014). National and state cost savings associated with prohibiting smoking in subsidized and public housing in the United States. *Preventing Chronic Disease*. http://www.cdc.gov/pcd/issues/2014/pdf/14_0222.pdf.

family non-elderly households (primarily non-elderly disabled)—38 percent. Families with children have a rate of households reporting some member who smokes in the unit at 24 percent. Of these roughly 119,000 households, 47,000 have a child under the age of 5 years old. There are roughly 60,000 children under the age of 5 living in a public housing unit where someone smokes.[4]

Currently, HUD encourages PHAs to develop and implement their own smoke-free policies. However, voluntary implementation is not necessarily efficient when there are external costs and benefits to a policy. PHAs have little incentive to implement smoke-free policies when the primary benefits of the rule—improved health and fewer lives lost due to catastrophic fires—do not directly redound to the PHA. The same would be true for the loss of life from catastrophic fires. Federal intervention is therefore an important and necessary tool to ensure that these benefits will be realized by society.

Other arguments made in favor of smoke-free policies, such as reduced maintenance costs and reduced fire risk, do appear to directly benefit PHAs. Ideally, a voluntary smoke-free policy would be the better approach to address PHA-internal gains from prohibiting smoking in public housing; that is where the benefits outweigh the costs of implementation. However, in reality, there are reasons to suspect why a smoke-free policy is not voluntarily adopted even when it is fiscally prudent. First, many PHAs and their representative industry groups generally report that their industry is administratively strained due to the reductions in operating costs, and they do not want to take on new challenges. Secondly, enforcement and ultimately eviction of persistent violators is required. Without a stronger signal of HUD support of smoke-free policy,

[4] See Homa, D., et al. (Feb. 6, 2015). Vital Signs: Disparities in nonsmokers' exposure to secondhand smoke — United States, 1999–2012. *Morbidity and Mortality Weekly Report, 64*,103-108. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6404a7.htm?s_cid=mm6404a7_w (discussing the distributional impacts among subpopulations and disparities in non-smokers exposure to secondhand smoke).

it is possible that PHAs are uncertain of whether evictions to enforce the smoke-free policy would be supported by HUD. Thirdly, the management of PHAs is of varying quality: there are large and small and high- and low-performing PHAs, so some PHAs would not implement a smoke-free policy even if it benefited their own, and HUD's, balance sheet. Lastly, PHAs are typically managed by a volunteer board of commissioners that vote to approve all policies. Commissioners can vary widely in their skills, experience, knowledge, and personal attitudes toward smoking and smoking-related issues. Thus, in the pursuit of operational efficiency and the desire to consistently support and apply policies that benefit tenants and reduce costs, HUD has a good cause to mandate the smoke-free policy.

2.1. The Health Effects of Second-Hand Smoke: A Consensus

Second-hand smoke creates a negative externality in society by causing and exacerbating serious health problems through passive smoking.[5, 6] Smoking has been determined to be a cause of diseases of nearly all organs in the body, and the effects of smoking are not limited to the smoker; the costs of smoking also extends to non-smokers.[7] However, measuring the social costs, including medical costs and loss of productivity due to disability or early mortality, of SHS is difficult. There is large variability in the estimates of such social costs, depending on assumptions about the extent of health effects. According to Gruber and Koszegi (2008), an estimate of the external cost of smoking from second-hand smoke is difficult to determine with

[5] U.S. Department of Health and Human Services, Centers for Disease Control and Prevention (2006). The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General. http://www.surgeongeneral.gov/library/reports/secondhandsmoke/fullreport.pdf.
[6] World Health Organization (2010). Second-hand smoke: Assessing the burden of disease at national and local levels.
[7] Office of the Surgeon General. (2014). The health consequences of smoking—50 years of progress. http://www.surgeongeneral.gov/library/reports/50-years-of-progress/full-report.pdf.

certainty.[8] This uncertainty is probably due to difference in approaches, varying medical evidence, and potential implicit interests of researchers or journals. The methodological difficulties appear to be disentangling costs from transfers and selectively counting secondary effects, leading to either an over- or under-estimation of the net cost. According to Chaloupka and Warner (2000): "calculation of the 'true' net negative externalities associated with smoking is an exceedingly difficult challenge, one that involves conceptual questions, epidemiologic and other data considerations, and 'moving targets' in terms of both knowledge and institutional structures."[9]

The most commonly used approach is to measure the external cost of SHS by the change in medical costs between individuals exposed to SHS and those without SHS exposure. Increased incidence of lung cancers and heart disease attributable to SHS combined could impose a social cost of 99 cents per pack of cigarettes consumed.[10] Perinatal effects resulting from SHS, including low birth weight and fatality, burden society with additional medical costs. Suggestive evidence exists that numerous other medical conditions may be caused by SHS exposure.[11] The total annual medical care cost of exposure to SHS could be as high as $4.982 billion, while the annual lost value of wages, fringe benefits, and services through SHS-related morbidity potentially creates another $4.683 billion of indirect costs to society.[12]

Gravelle & Zimmerman's (1994) calculation of the health effects yielded estimates ranging from $0.01 to $0.21 per pack of cigarettes consumed.[13] Under similar assumptions,

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[8] Gruber, J. & Koszegi, B. (2008). A modern economic view of tobacco taxation. Paris: International Union Against Tuberculosis and Lung Disease.
[9] Chaloupka, F.J. & Warner, K. (2000). The economics of smoking. *Handbook of Health Economics 1*, 1539-1627.
[10] Ibid.
[11] For a complete analysis of all health effects, see Office of the Surgeon General. (2014), *supra* note 7.
[12] Chaloupka, F.J. & Warner, K. (2000), *supra* note 9.
[13] Gravelle, J.G. and Zimmerman, D. (1994). Cigarette taxes to fund health care reform: An economic analysis. *Congressional Research Service, No. 94-214*.

Viscusi (1994) found the social cost of SHS to be $0.27 per pack.[14] Chaloupka & Warner (2000) assume a broader range of health consequences and placed the cost at about $1.20 per pack or greater.[15] On a per-pack basis, Behan, Eriksen, and Lin's (2005) approximate $10 billion cost estimate[16] translates to roughly $0.76 per pack.[17]

2.2. Second-hand Smoke is a Negative Externality

Non-smokers bear the cost of an SHS externality. Some disagree with this statement on social welfare grounds. For example, Manning et al. (1991) argue that since a family constitutes a basic economic unit and that SHS health consequences would befall smoker's family members in the home, SHS should be treated as a cost internal to the family.[18] This logic, however, ignores the health consequences of other concentrated smoke-filled environments, such as a workplace or a dense multiunit housing complex. Studies have shown SHS can travel from hallways into apartments and between neighboring units.[19] Controlling for socioeconomic variables, a child's exposure to tobacco smoke is greater in multi-unit housing than in attached or single-family homes. According to Wilson et al. (2011) "Children who live in homes in which no one smokes inside have a 45 percent increase in cotinine levels if they live in apartments compared with detached homes."[20] Such evidence of a negative externality in multi-unit housing is a strong motivation for smoke-free housing policy, especially since smoking rates are higher among low-income individuals. Moreover, children in smoking families are captive to their

[14] Viscusi, W. K. (1994). Cigarette taxation and the social consequences of smoking. *National Bureau of Economic Research No. w4891*.
[15] Chaloupka, F. J. & Warner, K. (2000), *supra* note 9.
[16] Behan, D.F., et al. (2005). Economic effects of environmental tobacco smoke. *Society of Actuaries*.
[17] This assumes all 264 billion cigarettes sold in 2014 in the U.S. (http://www.cdc.gov/tobacco/data_statistics/fact_sheets/economics/econ_facts/) are smoked, and 20 cigarettes are in one pack.
[18] Manning, W.G., et al. (1991). *The costs of poor health habits*. Cambridge, MA: Harvard University Press.
[19] King, B., et al. (2010). Secondhand smoke transfer in multiunit housing. *Nicotine and Tobacco Research 12*, 1133. http://ntr.oxfordjournals.org/content/12/11/1133.
[20] Wilson, K.M., et al. (2011) Tobacco-smoke exposure in children who live in multiunit housing. *Pediatrics 127*, 1.

guardians' secondhand smoke; thus even if costs were internal to smoking adults in a family, the health effects on any children in the family are external.

One set of researchers recognizes the difference between the cost to the individual, household, and society at large.[21] They estimate that the total social cost of smoking a pack of cigarettes was $40 per pack ($54.4 in $2015). The costs were broken down by: private costs borne by the individual primarily as a mortality cost ($45 in $2015), quasi-external costs borne by the smokers' family through increased health costs and reduced income ($7.50 in $2015), and external fiscal costs to society, representing the net effect of taxes paid and transfer payments received ($2.00 in $2015).

An emerging area of research is focusing on the potential hazards posed by residues of tobacco smoke that deposit on the surfaces of a home (referred to as third-hand smoke). Researchers have identified tobacco-specific carcinogens in these residues, and other toxicants such as lead are also known to be present (see section 4.1).[22] Quantitative risk assessment modeling young children's exposure to carcinogens in these residues resulted in estimates of significant lifetime cancer risks due to the exposures.[23] There are no data on the rate at which levels of toxicants in third-hand smoke residues would decline following cessation of indoor smoking activities; however, normal cleaning and maintenance activities would be expected to remove these residues over time.

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[21] Sloan, F.A., et al. (2004). *The price of smoking*. MIT Press.
[22] Thomas, J.L., et al. (2014). Thirdhand tobacco smoke: A tobacco-specific lung carcinogen on surfaces in smokers' homes. *Nicotine and Tobacco Research 16*, 26-32, doi:10.1093/ntr/ntt110.
[23] Ramirez, N., et al. (2014). Exposure to nitrosamines in thirdhand smoke increases cancer risk in non-smokers. *Environment International 71*. http://dx.doi.org/10.1016/j.envint.2014.06.012.

2.3. The Financial Costs of Smoking in Public Housing

Beyond the increased costs associated with higher healthcare expenses, smoking can have profound financial impacts on PHAs. Among these are greater maintenance and rehabilitation expenses necessitated by damage caused by smokers. In some cases, sufficient incentives may not exist for PHAs to adopt smoke-free policies, even where they would reduce costs of operation.

In 2014, the Centers for Disease Control and Prevention issued a report estimating the annual cost savings associated with banning smoking in all subsidized housing and in public housing alone.[24] Their method involved calculating three smoking-related costs that would have been averted in 2012 if smoking were prohibited in housing: health care costs associated with secondhand smoke, renovation costs of smoker-occupied units, and the damage from fires attributable to smoking. Using health care data from a study of Minnesota residents, renovation estimates from the Smoke-Free Housing Coalition of Maine, and fire statistics from the National Fire Protection Association, the study calculated national- and state-level estimates for costs averted.

They estimated the annual cost savings associated with banning smoking in public housing to be $152.91 million. Health care costs accounted for $94.01 million of the total, while renovation and fire costs were $42.99 million and $15.92 million, respectively. The State of New York stood to gain the most, saving an estimated $57.77 million. The authors believed, accordingly, that prohibiting smoking in public housing would yield substantial health benefits and cost saving to residents.

[24] King, B., et al. (2014), *supra* note 3.

It should be noted that this study subjected its estimates to sensitivity analysis on a number of dimensions, including the following: per capita secondhand smoke expenditures; percentage of time spent in public housing; per-unit cost of renovations; turnover rates; per capita fire losses; proportion of smoking related fires; and state cost of living. This variability in the estimating parameters implies variability in the overall cost saving estimates, which ranged from $79.81 million to $259.28 million when subjected to sensitivity analysis.

In October 2014, HUD's Office of Lead Hazard Control and Healthy Homes issued a report entitled "Change is in the Air," which provided an action guide for establishing smoke-free public housing and multifamily housing.[25] This report captured cost savings reported by PHAs. As discussed in report, one private agent of 4,500 units in the Southeast U.S. estimated an annual reduction in operating costs of $5000-$6000, or $100 per unit per year in turnover costs. This manager also noted that in previous years, two fires related to smoking cost the company over $1 million. A PHA interviewed priced the turnover cost savings at $700 for a three bedroom unit.

2.4. Support for Smoke-Free Housing

Surveys of renters' valuation demonstrate that tenants of multiunit housing are willing to pay more for smoke-free units.[26, 27, 28, 29] Residents say that they are willing to give up other amenities and/or pay a rent premium to live in smoke-free units. Other surveys of renters show

[25] See http://portal.hud.gov/hudportal/documents/huddoc?id=smokefreeactionguide.pdf.
[26] King, B., et al. (2010b). Multiunit housing residents' experiences and attitudes toward smoke-free policies. *Nicotine & Tobacco Research 12*, 598-605.
[27] Campbell DeLong Resources, Inc. (2006). Smoke-free rental housing in the portland metropolitan area. *Report Conducted for American Lung Association of Oregon, Multnomah County, Oregon, Clark County, Washington and Partner Agencies*.
[28] Cook County Department of Public Health. (2014). Smoke-free is legal, profitable & easy. *Healthy Hot Spot*.
[29] The Massachusetts Smoke-Free Housing Project. (2009). Market demand for smoke-free rules in multi-unit residential properties & landlords' experiences with smoke-free rules.

that residents tend to "support" smoke-free policies. [30, 31] A study of the vacation rental market in the Outer Banks of North Carolina reveals that vacationers are willing to pay additional rent for properties that prohibit smoking.[32]

3. Descriptive Data

In addition to using CDC data and reports, this analysis relies on HUD's own data on the number of PHAs that have adopted a smoke-free policy, as well as estimates derived from those data. There are approximately 2.3 million residents living in 1.2 million units. We assume that that 60 percent of the population is adult (based on administrative data) and that 29.7 percent of the adults are smokers.[33] Therefore, of the 2.3 million residents in public housing, we estimate that 414,000 are adult smokers.

The impact of the rule will be on the residents, smokers, and units of PHAs that do not yet have a smoke-free policy. The number of PHAs without smoke-free policies is estimated at 2,526. There are 1.4 million residents in 732,000 units living in the affected PHAs. The number of adult smokers in PHAs without smoke-free policies is approximately 257,000.[34]

[30] Hennrikus, D., et al. (2003). Preferences and practices among renters regarding smoking restrictions in apartment buildings. *Tobacco Control 12*, 189-194.
[31] Hood, N.E., et al. (2003). Individual, social, and environmental factors associated with support for smoke-free housing policies among subsidized multiunit housing tenants. *Nicotine & Tobacco Research 15*, 1075-1083.
[32] Benjamin, J.D., et al. (2001). The value of smoking prohibitions in vacation rental properties. *Journal of Real Estate Finance and Economics 22*, 117-128.
[33] Based on data from the 2013 National Health Interview Survey, calculated by HUD.
[34] For the sake of this analysis, HUD treated all PHAs as either smoke-free or not, implicitly assuming that all smoke-free policies are identical to the proposed rule. The result is underestimation of both costs and benefits. We request data that would allow for refinement of the analysis regarding the rule's impact on PHAs with partial smoke-free policies.

No Smoke Free Policy					
Number of PHAs	Number of Units	Number of People	Number of Adults	Number of Smokers	Number of Children
2,526	**732,086**	**1,443,796**	**866,278**	**257,285**	**577,518**

Smoke Free Policy					
Number of PHAs	Number of Units	Number of People	Number of Adults	Number of Smokers	Children
565	**427,827**	**878,551**	**527,131**	**156,558**	**351,420**

Totals					
PHAs	Number of Units	Tenants	Adults	Smokers	Children
3,091	**1,159,913**	**2,322,348**	**1,393,409**	**413,842**	**928,939**

3.1. Cigarettes Smoked

We find that the daily average number of cigarettes smoked by smokers who receive housing assistance varies from 10 to 14 depending on year of survey and demographic category. There is some fluctuation from year to year probably because of the small sample size. For this reason, an average of the most recent years, 13 cigarettes per day, is used as a basis for any calculations. It is not assumed, however, that all of these cigarettes are smoked at home.

Estimated Daily Smoking in Subsidized Housing* among Various Subpopulations

Group	Cigarettes per Day 2013 Survey	Cigarettes per Day 2014 Survey	**Cigarettes per Day Average**
All	13	12	13
Aged 65+	12	10	11
Employed	14	10	12
Unemployed*	13	12	13
Disabled**	13	13	13

Source: 2013 and 2014 National Health Interview Survey
*: Using 2010 Census Population weights. Calculated for current daily smokers who indicated they pay lower rent due to a government program
**: Defined as not working and not looking for work as of week prior to interview.
***: Defined as functionally limited in any way.

Other Combustible Tobacco. The 2012 National Adult Tobacco Survey found 7.3 percent of U.S. adults smoke cigars either "daily", "some days", or "rarely." Of those who smoke cigars, 3.3 percent report "daily" use, 25.6 percent report "some days" use, and 71.2 percent report "rarely" use. Thus, only a small fraction of smokers report frequent use of cigars. Pipes and cigars carry the same risks as cigarettes. A single cigar can contain about the same amount of

tobacco as an entire pack of cigarettes. Cigars also contain 10 to 20 times the amount of nicotine, potentially making them just as addictive even if they are smoked less often than cigarettes (WebMD).

According to the National Cancer Institute, cigar smoke has higher levels of some cancer-causing substances than cigarette smoke. Cigar smoke also has more "tar" and higher concentrations of some toxicants than cigarette smoke. However, cigar smokers generally smoke fewer cigars than cigarette smokers smoke cigarettes. In this analysis, HUD will measure the impacts by cigarette recognizing that in some cases that this may not provide a perfectly accurate analysis of the impacts of the rule.[35]

3.2. Home Rules

Very often throughout the analysis an impact (both costs and benefits) is adjusted by the percentage of homes with smoke-free rules. The existence of a voluntary rule would minimize some of the benefits and costs of an externally imposed rule. A smoke-free home rule is indicated by a respondent's choice of "No one is allowed to smoke anywhere inside your home" to a question concerning home rules. The CDC finds that the overall prevalence of smoke-free home rules was 83.0 percent during 2010–2011.[36] Among households with at least one adult smoker, the prevalence of home rules was 46.1 percent during 2010-2011. Some of our estimated benefits and cost would decline if smoking has already been moved outside of the home. The

[35] For example, Shanks and Burns find that chronic obstructive pulmonary disease risk, relative to nonsmokers, is 11.70 for cigarette smokers but only 1.42 to 4.39 for cigar smokers. Shanks, T.G. & Burns D.M. (1998). Disease Consequences of Cigar Smoking." In: D. Burns, K. Cummings, & D. Hoffman (eds.), Cigars: Health effects and trends. *Smoking and Tobacco Control Monograph No. 9*, 105-160. http://cancercontrol.cancer.gov/tcrb/monographs/9/m9_complete.PDF.

[36] King, B., et al. (2014b) Prevalence of smokefree home rules—United States, 1992–1993 and 2010–2011. *Morbidity and Mortality Weekly Report 63*, 765-769. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6335a1.htm.

rule-induced health gains from reducing exposure to SHS would not fall all the way to zero, however, because in multi-unit homes the exposure may originate from other households.

4. Benefits of the Proposed Rule

In proposing the implementation of a smoke-free policy in public housing, HUD is expecting the following benefits: improved health of public housing residents, reduced risk of catastrophic fires, and lower maintenance costs.

4.1. Health Benefits from Reducing Second-Hand Smoke

The U.S. Surgeon General estimates that exposure to secondhand tobacco smoke (i.e., the smoke that emanates from burning tobacco products and that is exhaled by smokers) is responsible for the death of more than 40,000 non-smokers in the U.S. each year from lung cancer and heart disease as well as the death of hundreds of newborns from sudden infant death syndrome.[37] Exposure to secondhand smoke (SHS) can also cause other illnesses, including acute respiratory infections in children and more severe asthma in children and adults. SHS contains hundreds of toxic chemicals and is designated by the U.S. Environmental Protection Agency and the International Agency for Research on Cancer as a known human carcinogen. The Surgeon General concluded that there is no risk-free level of exposure to SHS.[38] HUD recognizes, however, that the health benefits are different: some are acute and will be observed in the short-run while avoidance of chronic effects will be realized in the longer term.

The lead content of SHS is also an important source of lead in house dust and children's blood, as demonstrated in HUD-sponsored research using data from the National Health and Nutrition Examination Survey (NHANES) covering 1999-2004.[39] The CDC recently published

[37] Office of the Surgeon General (2014), *supra* note 7.
[38] U.S. Dept. of Health and Human Services (2006), *supra* note 5.
[39] http://www.cdc.gov/nchs/nhanes.htm

the results of analysis of NHANES data from 1999-2008 that confirmed the association between SHS exposure and blood lead levels in both youth and adults.[40] The authors concluded that youths with SHS exposure had blood lead levels suggestive of the potential for adverse cognitive outcomes.

A significant portion of the U.S. population is protected from SHS exposure through statewide and municipal laws prohibiting smoking in indoor areas of public places and worksites. However, millions of non-smoking adults and children continue to be exposed to SHS in their homes. Because SHS moves throughout buildings, individuals living in multiunit housing can be exposed to SHS even if there is no smoker in their households. Results from multiple studies employing resident surveys indicate that 26 percent - 64 percent of residents reported SHS incursions into their units from external sources (e.g., hallways, adjacent apartments).[41] The researchers further reported that 65 percent - 90 percent of the residents experiencing SHS incursions were bothered by it. HUD expects the rule to be effective in limiting exposure. Pizacani et al (2012) focuses on changes in behavior due to smoke-free policies in public housing in Portland, Oregon and find that the change in frequent (i.e., multiple times per week) exposure to SHS as a result of the rule: there is a decline from 41 percent to 17 percent of nonsmokers.[42]

The movement of contaminants from SHS within buildings has also been documented through direct measurements of fine particles (an environmental marker of SHS) in indoor air. Research has demonstrated the movement of SHS both from external hallways into apartments

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[40] Richter, P., et al. (2013). Trends in tobacco smoke exposure and blood lead levels among youth and adults in the United States: The national health and nutrition examination survey, 1999-2008. *Preventing Chronic Disease*. http://www.cdc.gov/pcd/issues/2013/pdf/13_0056.pdf.

[41] King, B.A., et al. (2015). Smoke-free multiunit housing: a review of the scientific literature. *Tobacco Control Research*. http://tobaccocontrol.bmj.com/content/early/2015/01/07/tobaccocontrol-2014-051849.full.

[42] Pizacani, B.A. et al. (2012). Implementation of a smoke-free policy in subsidized multiunit housing: effects on smoking cessation and secondhand smoke exposure. *Nicotine and Tobacco Research 14*, 1027-34.

and between adjacent units.[43] A study that was conducted in public housing documented lower concentrations of SHS contaminants in buildings covered by smoke-free housing policies (i.e., rules banning the smoking of tobacco products in all indoor spaces) compared to buildings without these policies.[44] Research has also demonstrated evidence of greater SHS exposure among children (aged 18 and younger) living in multiunit housing through measurements of cotinine (a metabolite of nicotine found in SHS) in their blood.[45] The study demonstrated that children living in non-smoking households in apartments had 45 percent higher levels of cotinine in their blood compared to children living in non-smoking households in detached homes.

4.2. Quantitative Estimates of Health Benefits

(A) Quantitative Approach #1

According to a CDC study, prohibiting smoking in public housing either owned or operated by a government housing authority would yield cost savings of $153 million annually, including $94 million in second-hand smoke-related healthcare.[46] The authors of this study determined the cost savings by adjusting 2003 healthcare claims[47] due to smoking to 2012 dollars, yielding a per capita expenditure of $91. The authors then applied a price deflator to this figure to account for cross-state differences in the cost of living and aggregated the state cost savings calculation. These figures reflect the cumulative effect of SHS over a period of time with much higher rates of smoking and smoking indoors, and therefore are the upper bounds of cost savings that would be generated in the near future.

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[43] King, B.A., et al. (2010), *supra* note 19.
[44] Russo, E., et al. (2014) Comparison of indoor air quality in smoke-permitted and smoke-free multiunit housing: findings from the Boston Housing Authority. *Nicotine and Tobacco Research 17*, 316-22. doi:10.1093/nts/ntu146.
[45] Wilson, K., et al. (2011). Tobacco-smoke exposure in children who live in multiunit housing. *Pediatrics 127*, 85-92.
[46] King, B.A., et al. (2014), *supra* note 3.
[47] Waters, H.R., et al. (2009) The economic impact of exposure to second-hand smoke in Minnesota. *American Journal of Public Health 99*, 754–9.

HUD conducted its own analysis of the cost savings created by this rule for the 1.4 million residents of public housing that are not presently under PHA smoke-free policies, analyzing the impact of the rule on acute illnesses caused by SHS. HUD does not believe that longer term and chronic illnesses are unimportant; however, for the purpose of understanding the immediate incremental impact, the focus of the analysis is on acute illnesses.[48] All of the illnesses chosen are ones that have been shown through extensive medical research to have a strong and significant association with SHS. Causation has been well established.

HUD's quantitative estimates reflect an assumption that the health benefits to active smokers of reducing SHS are negligible. One reason not to include smokers is that non-smokers were the subjects of cited studies of the health effects of SHS. Second, there may be physiological reasons for non-smokers to be more sensitive to SHS than smokers.[49]

Most illnesses can be caused by more one than contributing factor. Data on relative risk indicates how significant exposure to a particular environment is. For example, for coronary heart disease (CHD) the relative risk from SHS is 1.17, meaning that that those exposed to SHS are 17 percent more likely to have CHD. From a measure of relative risk, one can understand the reduction in risk by eliminating exposure to SHS. The exposed population's risk of CHD would be reduced by a substantial 15 percent (0.17/1.17). This quantity is known as the attributable fraction, which represents the fraction of the risk of disease among the exposed population that is due to exposure. One can use the attributable fraction to estimate the change in health conditions

[48] Even though stroke and coronary heart disease are acute illnesses, the clogging and hardening of blood vessels that causes these conditions is a process that occurs gradually over time; in other words, even if individuals whose SHS exposure is eliminated experiences an immediate reduction in risk, this reduction will not at first be all the way down to the level of non-exposed individuals (which is what is implicitly reflected in the calculations that follow). We request data that would allow us to revise the analysis to account for latency between SHS exposure and risk reduction for CHD and stroke.

[49] See Sloan, F.A., et al. (2004), *supra* note 21, discussion of Glantz, S.A. & Parmley, W.W. Passive smoking and heart disease: mechanisms and risk. *Jama 273.13,* 1047-1053.

of a population from exposure to the condition under question.[50] Most public health studies publish a relative risk (RR) measure, which conveniently yields an attributable fraction (AF = 1 – 1/RR). These attributable fractions are generally based on SHS exposure to nonsmokers who live with an active smoker.

HUD adopts the lower estimates of relative risk to account for the fact that second-hand smoke from another unit will not be as intrusive as a having an active smoker present in the household. HUD requests comments on whether this is the appropriate adjustment. To predict the impact on incidence of eliminating SHS among the population currently exposed to SHS, data on the prevalence of the illness is required. Prevalence is based on national data and multiplied by the proportion of population in smoke-free housing. The reduced incidence is equal to the prevalence multiplied by the attributable fraction. To arrive at a reduction in health care costs, we multiply the reduced incidence by the estimated cost of treatment:

health care saving = Attributable fraction x prevalence x cost per treatment

For example, for CHD the fraction of events attributable to SHS is 15 percent. There is an estimated 47,012 CHD events in public housing that is not smoke-free. Eliminating exposure to SHS would lead to a reduction of 7,050, saving approximately $44.3 million in treatment costs (7050 x $6,488).[51]

[50] Lightwood, J.M. & Glantz, S.A. (1997). Short-term economic and health benefits of smoking cessation: myocardial infarction and stroke. *Circulation 96*, 1089-96 (providing a dynamic analysis of relative risk).

[51] Studies on the impact of exposure to SHS on relative risk compare examine individuals to suffer direct exposure (in the same unit) to active smokers. The damage caused by a smoker in a different unit, while positive, is likely to be less than when very proximate. For this reason, our estimates could over-predict the health benefits to non-smokers. However, these studies do not examine exposure from other units. To accurately determine the effects, the HVAC system, building structure, and distribution of smokers and non-smokers would be necessary. Realizing that these will vary across the nation, we use the results from the Surgeon General's Report and recognize that not all non-smokers may achieve the same gains.

Immediate Reduction in Medical Costs from Eliminating Exposure to SHS

	Relative Risk[52] (95% CI)	Attributable Fraction[a]	Total Prevalence [b]	Population Affected by Rule[c]	Estimated Prevalence Among Public Housing[d]	Direct Costs of Treatment[e,f]	Reduction in Medical Costs[g]
Adult							
Stroke	1.34 (1.34 – 2.49)	25%	0.8 million	0.30%	2,400	$2,707[53]	$1.6 million
CHD	1.17 (1.17 – 1.33)	15%	15.5 million	0.30%	47,012	$6,488[54]	$44.3 million
Children							
Asthma	1.14 (1.14 – 1.33)	12%	6.1 million[55]	0.78%	47,929	$587[56]	$3.5 million
LRI	1.42 (1.42 – 1.69)	30%	545,000[57]	0.78%	4,251	$1716[58]	$2.2 million
Middle Ear Infection	1.33 (1.33 – 2.06)	25%	8.8 million[7]	0.78%	69,041	$399[59]	$6.8 million
Total							$58.4 million

[a] Attributable Fraction (AF) = 1 – 1/Relative Risk (RR)
[b] For stroke and CHD, the relative risk estimates involve comparisons within the population of nonsmokers (some exposed to SHS, some not); in other words, the attributable fraction estimates show the percentages of stroke and CHD cases occurring amongst nonsmokers that are attributable to SHS exposure. Meanwhile, the numbers of cases in this column are nationwide totals, including the presumably high numbers of stroke and CHD cases that occur amongst smokers. We request data that would allow us to revise the prevalence numbers to exclude cases involving smokers.
[c] Nonsmoking adults living in public housing without smoke free policy/total nonsmoking adult population, children living in public housing without smoke free policy/total population of children
[d] Total prevalence x population affected by rule
[e] all costs are calculated by annual cost per person
[f] all values are rounded and adjusted to 2012 dollars
[g] AF x estimated prevalence among public housing x direct costs of treatment

[52] Oberg, M., et al. (2010). Second-hand smoke: Assessing the environmental burden of disease at national and local levels. *Environmental Burden of Disease Series No. 18*. The estimates for stroke and asthma were generated using data from New Zealand. We request comment on the applicability of estimates for the New Zealand population to the U.S. residents who would be affected by this rule.
[53] Mozaffarian, D., et al. (2015). Heart disease and stroke statistics – 2015 update: a report from the American Heart Association. *Circulation*.
[54] Thom, T., et al. (2006). Heart disease and stroke statistics – 2006 update: a report from the American Heart Association. *Circulation*.
[55] CDC National Data on Current Asthma Prevalence (2013).
[56] Wang, L.Y., et al. (2005). Direct and indirect costs of asthma in school-age children. *Preventing Chronic Disease*.
[57] Henrickson, K.J., et al. (2004). National disease burden of respiratory viruses detected in children by polymerase chain reaction. *Pediatric Infectious Disease Journal*.
[58] Ehlken, B., et al. (2005). Economic impact of community-acquired and nosocomial lower respiratory tract infections in young children in Germany. *European Journal of Pediatrics 164*, 607-15.
[59] Soni, A. (2006). Ear infections (Otitis Media) in children: use and expenditures. *Statistical Brief #228*. http://meps.ahrq.gov/mepsweb/data_files/publications/st228/stat228.pdf.

The rule can only affect exposure to SHS in public housing and not in all of the other locations where one is susceptible to exposure: at work, in vehicles, and outdoors.[60] The close to $58.2 million in medical cost reduction is an estimate of the medical costs attributable to SHS and not exposure to SHS in multi-unit housing.[61] The direct health benefits will be greater than zero because the home is a major source of exposure, but less than the estimate because there are other sources of exposure. On the other hand, there are serious medical issues ignored in this suggestive analysis: long-term ones such as lung cancer and short-term ones such as S.I.D.S.

Exposure to SHS in any location should be a function of the duration of exposure and intensity of exposure.[62] This analysis does not address the difficult issues of whether a lengthy exposure at a low intensity is more or less harmful than a short exposure at a high intensity. Nor does the analysis address the issue as to whether relative risk of SHS is a linear function of the amount of exposure to SHS. For the purpose of this analysis, we assume that the relative risk is proportional.

There are a few ways of estimating the proportion of exposure occurring from a particular location over the course of day: a time study of activities with self-reported SHS exposure at those different locations; a time study including questions concerning intensity of exposure at different locations; and the most accurate, which would be a time study accompanied by the collection of biomarkers for second-hand smoke. Biomarkers are expensive to collect but are

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[60] U.S. Dept. of Health and Human Services (2006), *supra* note 5.

[61] For stroke, the relative risk estimate used in the preceding steps of the benefits calculation reflects both occupational and household exposure. For CHD, asthma, LRI and middle ear infection, the relative risk estimates are limited to home exposure. However, even for these health outcomes, it may be necessary to adjust benefits estimates downward in determining effects attributable to this rule because exposure to a spouse or parent's second-hand smoke occurs in locations, such as vehicles, other than the home.

[62] Klepeis, N.E. (1999). An introduction to the indirect exposure assessment approach: Modeling human exposure using microenvironmental measurements and the recent national human activity pattern survey. *Environmental Health Perspectives 107* (Supplement 2).

useful because they provide physical evidence of exposure, which may not be noticed and thus not reported.

The CDC used a time study[63] of direct exposure to allocate the gains from reducing SHS in multi-unit housing. From the same study, HUD finds the time exposed to smokers at home would be 42 percent[64] of all time exposed to smokers.[65] A later study by the same author uses 48 percent as the proportion of smoker exposure that occurs in residences.[66] The weakness of this measure is that it is one of direct exposure to a smoker rather than to second-hand smoke from other units in multi-unit housing. Some studies have shown that SHS can transfer between units; and others that tenants of multi-unit housing face a higher exposure, even when they are non-smokers.[67] Data from the NHANES show more people have a detectable level of serum cotinine than with live with smokers.[68]

It is a challenge to find good comparative data on exposure in different micro-environments. After a lengthy review of evidence the Surgeon General (2006) concludes that, "Homes and workplaces are the predominant locations for exposure to secondhand smoke" and that "Exposure to secondhand smoke tends to be greater for persons with lower incomes." Given that other literature finds that noticeable SHS exposure occurs among 26 – 64 percent of residents of multi-unit housing,[69] HUD believes that a reasonable estimate of the SHS from

[63] Ibid.
[64] Figure 2, ibid.
[65] HUD believes that the 58 percent used by CDC is the ratio of the "Doer %" from Table 7 (25.6/43.8). However, HUD does not use that figure because it is unsure of the interpretation and because the sum of the rows is greater than 43.8.
[66] This would be derived from Table 7 of the time study by dividing the minutes of exposure at residences by the total minutes of exposure to smokers (78/163).
[67] Snyder, K., et al. (2015). Smoke-free multiunit housing: A review of the scientific literature. *Tobacco Control*.
[68] Table 4.2 , Office of the Surgeon General (2006), *supra* note 7.
[69] Ibid.

residential exposure is one half of the total. HUD expects the immediate and direct health benefits to be at least $30 million.

In addition to direct costs of an illness, there are indirect costs. Case studies for these cost estimates use various forms of this definition. The data from the American Heart Association defines indirect costs to stroke and CHD as lost productivity resulting from morbidity and mortality. Wang et al. (2005) estimates indirect costs of asthma as lost productivity from parents' absence from work and the loss of potential lifetime earnings by the death of children with asthma.[70] Henrickson et al. (2004) only considers the indirect costs associated with loss of work days by parents.[71]

[70] Wang, L.Y., et al. (2005). Direct and indirect costs of asthma in school-age children. *Preventing Chronic Disease 2*(1), A11.
[71] Henrickson, K.J., et al., (2004), *supra* note 57.

Averted Indirect Costs to Individuals from SHS

	Relative Risk[72] (95% CI)	Attributable Fraction[a]	Estimated Prevalence Among Public Housing [b,c]	Indirect Costs of Illness[d,e]	Reduction in Indirect Costs[f]
Adult					
Stroke	1.34 (1.34 – 2.49)	25%	2,400	$2,489[73]	$1.5 million
CHD	1.17 (1.17 – 1.33)	15%	47,012	$5,806[74]	$39.7 million
Children					
Asthma	1.14 (1.14 – 1.33)	12%	47,929	$570	$3.4 million
LRI	1.42 (1.42 – 1.69)	30%	4,251	$147[75]	$184,829
Middle Ear Infection	1.33 (1.33 – 2.06)	25%	69,041	-	-
Total					$44.7 million

[a] Attributable Fraction (AF) = 1 – 1/Relative Risk (RR)
[b] Nonsmoking adults living in public housing without smoke free policy/total nonsmoking adult population, children living in public housing without smoke free policy/total population of children. For stroke and CHD, the relative risk estimates involve comparisons within the population of nonsmokers (some exposed to SHS, some not); in other words, the attributable fraction estimates show the percentages of stroke and CHD cases occurring amongst nonsmokers that are attributable to SHS exposure. Meanwhile, the numbers of cases in this column are calculated with nationwide totals, including the presumably high numbers of stroke and CHD cases that occur amongst smokers. We request data that would allow us to revise the prevalence numbers to exclude cases involving smokers.
[c] Total prevalence x population affected by rule
[d] all costs are calculated by annual cost per person
[e] all values are rounded and adjusted to 2012 dollars
[f] AF x estimated prevalence among public housing x indirect costs of treatment

Just as for the direct costs, only half of these benefits ($22 million) are estimated to be from reducing SHS exposure at home. The total benefit from reducing illness caused by SHS is $52 million. This is certainly an underestimate of total benefits to nonsmokers because it does not include the amenity of odor-free air.

(B) Quantitative Approach #2

[72] Oberg, M., et al. (2010), *supra* note 52.
[73] Mozaffarian, M., et al. (2015), *supra* note 53.
[74] Thom, T., et al. (2006), *supra* note 54.
[75] Ehlken, B., et al. (2005), *supra* note 58.

An in-depth analysis[76] provides similar but more subtle and accurate estimates of the costs of SHS in public housing. Compared to the more approximate analysis presented by HUD, these researchers analyze an extensive list of SHS-related illnesses, and for different levels of exposure. In addition, they analyze the impact of these SHS-related diseases in never-smoking residents as opposed to all non-smokers. They estimate the annual economic burden of SHS-attributable illness and death of never smokers in public housing to be between $183 million (LOD=0.05 ng/mL) and $267 million (LOD=0.015 ng/mL). Their estimates may be overestimates of the benefits for this rule: 38 percent of PHAs are already smoke-free. Predicted benefits would thus be either $114 million or $162 million (multiply estimates by 62 percent). Second, smoke-free housing may not eliminate exposure to SHS. Alternatively, the benefits from lowering levels from high to low ones could be $57 to $81 million (half of $114 to $162 million).

(C) Quantitative Approach #3

In the regulatory impact analysis for its 2011 rule requiring graphic warning labels on cigarette packages (76 Federal Register 36627), FDA estimated the health and longevity benefits and medical cost savings attributable to rule-induced smoking dissuasions. FDA's estimates are presented in the table below:

[76] Mason, J., et al. (2015). The economic burden of exposure to secondhand smoke for child and adult never smokers residing in U.S. public housing. *Public Health Reports 130*.

	Midpoint Aggregate Benefits Estimate (millions) [a]	Estimated Smoking Dissuasions	Per-Dissuasion Benefits Estimate ($2009) [a]	Per-Dissuasion Benefits Estimate ($2014) [a,e]
Longevity	$15,041.7 (3%) [b] $2,901.1 (7%) [b]	291,103	$51,671 (3%) $9,966 (7%)	$56,160 (3%) $10,832 (7%)
Health Improvements	$3,161.4 (3%) [c] $1,001.0 (7%) [c]	98,355 [d]	$32,143 (3%) $10,177 (7%)	$34,935 (3%) $11,061 (7%)
Medical Cost Savings	$859.9 (3%) $491.3 (7%)	291,103	$2,954 (3%) $1,688 (7%)	$3,211 (3%) $1,834 (7%)
TOTAL			$86,768 (3%) $21,831 (7%)	$94,305 (3%) $23,727 (7%)

[a] Discount rates in parentheses.
[b] Source: Table 5 (76 *FR* 36627 at 36723).
[c] Source: Table 6 (76 *FR* 36627 at 36724).
[d] Due to data limitations, FDA only quantified benefits of avoided nonfatal morbidity for a subset of estimated dissuaded smokers.
[e] Bureau of Economic Analysis, U.S. Department of Commerce. National Income and Product Accounts Table 1.1.9 Implicit Price Deflators for Gross Domestic Product.

FDA notes that its primary source, Sloan et al. (2004), suggests that spouse and child mortality effects from SHS are approximately 26.3 percent of mortality effects on smokers themselves. [77] If we assume this ratio applies to medical expenditures and morbidity, as well as to mortality, the resulting per-smoker SHS impacts are $24,802 (=0.263 x $94,305) at a 3 percent discount rate and $6,240 (=0.263 x $23,727) at a 7 percent discount rate. During the timeframe of Sloan et al.'s study, 9.6 percent of households with at least one adult smoker had self-imposed smoke-free policies, leaving 90.4 percent of smoking households where smoking was permitted inside.[78] If we make the simplifying assumption that SHS impacts are negligible in homes where smoking is not permitted, then the per-smoker impacts in households where smoking is permitted is approximately $27,436 (=$24,802/0.904) at a 3 percent discount rate and $6,903 (=$6,240/0.904) at a 7 percent discount rate. Multiplied by the 139,000 smokers in households whose PHAs would be affected by this proposed rule yields estimated benefits of $3.8 billion (at a 3 percent discount rate) and $960 million (at a 7 percent discount rate). These results are

[77] Sloan et al.'s per-pack mortality cost estimates are $20.28 for smokers themselves, $5.20 for spouses and $0.14 for infant children of smokers, thus yielding the 26.3 percent ratio (=[$5.20+$0.14]/$20.28).
[78] King, B., et al. (2014), *supra* note 24.

underestimated, in that they omit health and longevity benefits of avoided incursion of neighbors' smoke into the homes of nonsmoking PHA residents, and overestimated in that some spousal and parental SHS exposure—such as that occurring in vehicles—will not be avoided as a result of this rule.

It is important to note that these estimates are present values—that is, the sum of effects, with discount rates applied for each year between the present and the year of occurrence, that occur over the affected individuals' remaining lifetimes. Remaining lifetimes differ according to the age of the affected individuals; moreover, remaining years of SHS exposure do not necessarily equal remaining lifetime because smoking and nonsmoking household members may discontinue living together or smokers may quit. Both of these factors make it difficult to achieve consistency in the assessment of costs and benefits; in other words, it is difficult to determine what portion of remaining lifetime risk is mitigated by each year of the proposed smoke-free PHA policy (and thus each year of recurring costs).[79] Given the uncertainty regarding how to consistently match costs with benefits, we present 10-, 20-, 30- and 50-year annualizations in the table below and, elsewhere in this document, compare them against costs estimated to recur annually.

Benefits (millions) annualized over:	10 years	20 years	30 years	50 years
Discount Rate = 3%	$447	$256	$195	$148
Discount Rate = 7%	$137	$91	$77	$70

Implicit in this benefits estimation is the assumption that individuals currently exposed to SHS in PHAs would experience, as a result of the proposed rule, a reduction in risk down to the

[79] In presenting its estimates, FDA included twenty years of costs but many more than twenty years of benefits, based on the assumption that the addictive nature of tobacco smoking meant that someone dissuaded from smoking during the first twenty years of the FDA rule's implementation would remain dissuaded for the rest of his or her life.

level of individuals with no spousal or parental SHS exposure. However, as permitted under the rule as proposed, affected smokers may switch from combustible tobacco products to non-combustible tobacco, nicotine replacement therapy (NRT), or ENDS.[80] Unlike non-combustible tobacco or NRT, ENDS produce emissions that can be inhaled by those around the ENDS user. While ENDS emissions contain fewer toxicants than secondhand tobacco smoke, exposure to their emissions is not as safe as non-exposure. Therefore, rule-attributable benefits would be somewhat lower than the amounts shown above, with the decrease determined by the relative risks of ENDS emissions secondhand smoke from combustible tobacco products. Given the emerging nature of research on the health impacts of ENDS emissions, we have not attempted to adjust the estimates but, instead, refer to them elsewhere in this document as upper bounds.

4.3 Willingness to Pay for Smoke-Free Housing

Theoretically, the benefit to tenants of smoke-free housing could be measured by a rental premium on multi-unit housing. If tenants are made better off by a certain characteristic of their location, then they would be willing to pay more to live there. This logic has been used to estimate the effect of clean air on property values or the quality of urban life on rents.[81] The advantage of the hedonic approach is that we do not need to know why someone is willing to pay more but only that they have expressed a preference for the situation.

There is a dearth of research concerning the rent premiums, multi-unit housing, and smoke-free policy. One study of vacation rental properties[82] finds that the rental rates for smoke-free properties is 11 percent greater than for comparable ones (controlling for other indicators of

[80] Another possibility that would reduce benefits below the amounts quantified here is non-compliance, in which affected individuals use the relative privacy of their apartment units to continue smoking.

[81] Chay, K.Y., & Greenstone, K. (2005). Does air quality matter? Evidence from the housing market. *Journal of Political Economy 113.2*, 376-424; Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. *Journal of Political Economy 82*, 34-55; and Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy* 1257-1278.

[82] Benjamin, J.D., et al. (2001), *supra* note 32.

quality). The result is instructive and demonstrates the value of smoke-free policy. The added value could stem from the absence of third-hand smoke, the provision of a justification to ask smokers to smoke outside, and that "smoke-free" may serve as an indicator of quality not captured by other variables.[83] This empirical result is not easily applicable, however, because it is derived from the demand of higher income renters for single-family properties.

The Public Health Advocacy Institute reported[84] on a survey of 1,304 residents of multi-unit properties concerning smoke-free housing. Two-thirds consider SHS to be "very harmful" and one-quarter "somewhat harmful." Specific results (p. 6) include

- "81% of prospective residents are immediately less interested in an apartment or condominium unit if they smell tobacco smoke when looking at it.
- 43% of residents are willing to pay more to live in a smoke-free building. Of these residents who are willing to pay more, 26% are willing to pay 20% more, and 63% are willing to pay 10% more.
- 69% of residents of multi-unit properties are more interested in knowing upfront, in the property listing, that an apartment or condominium unit is located in smoke-free building. Fewer than 20% feel this listing information would make no difference in their decision."

The rent premium result holds across building types and demographic categories. The finding of a common willingness to pay of 10 percent aligns well with the research of vacation rentals. For apartment residents, which are most comparable, 39.7 percent of the tenants are willing to pay more for smoke-free housing. Of those apartment dwellers willing to pay more, 63.8 percent are

[83] The reader could be confused by the researchers' explanation for this result: that it is driven by the inconvenience costs of providing a smoke-free home by a smoking owner who occasionally resides in their property. First, this explanation runs counter to the theory of competitive economics. Non-smoking owners will be more efficient producers of smoke-free housing and be able to offer the amenity at a lower price than smoker-owners. Second, none of the other hedonic results in this study are justified by this approach.

[84] The Massachusetts Smoke-Free Housing Project, Public Health Advocacy Institute. (2009). *Market demand for smoke-free rules in multi-unit residential properties and landlords' experiences with smoke-free rules*. Boston, Massachusetts: Northeastern University School of Law.

willing to pay 10 percent more and 21.9 percent are willing to pay 20 percent more.[85] The weighted rent premium across all units would be 4.0 percent.[86]

The dollar value of the rent premium could be calculated from one of two bases: the rent that tenant pays or the cost of providing the unit. On average, public housing tenants pay $275 per month for their units. The federal government spends $512 on average per month per unit for operating expenses. The market rent for an equivalent apartment would be $787 ($275 + $512). The latter ($787) is a better indication of the market price but the former measure ($275) is one that is consistent with the household's budget. Our estimate of the average premium for a smoke-free unit ranges from $11 to $31 per month and $132 to$378 annually. We estimate 732,000 units in PHAs without a smoke-free policy. The intensity of desire for smoke-free policy will vary by tenant but, but on average, households would be willing to pay 4.0 percent more. The total surplus realized by tenants as a result of the smoke-free housing would be between $97 million and $278 million.

This range ($100 million - $300 million) serves to validate estimates of the benefits explicitly calculated. For example, a consumer's estimate of the expected incremental cost of illness attributable to SHS should not be greater than the willingness to pay for smoke-free housing, which encapsulates the many other benefits from avoiding illness and an unpleasant environment. More elaborate measures including expected value of health improvements are

[85] There may be some renters who would be willing to pay more to live in housing that is not smoke-free. It is assumed that this is accounted for by the burden on smokers.
[86] Table 3D (on page 25 at http://www.phaionline.org/wp-content/uploads/2009/04/phaihousingsurvey.pdf), 4.0 percent (= [69/678] x 20% + [(201-69)/678] x 10%).

expected to be similar to the hedonically based estimate.[87] The measures of benefits using alternative methods are corroborated by the hedonic approach presented in this section.

4.4. Reducing Costs of PHA Operations

Smoking indoors increases the cost of rehabilitating a housing unit because of the need for additional cleaning, painting, and repair of damaged items at unit turnover compared to non-smoking units. The cost of cleaning and renovating a smoking unit adds up quickly, and smaller properties generally pay more per unit than larger properties when repairing smoking damage. As reported in the CDC report, the implementation of a smoke free policy in public housing will yield about $43 million savings in renovation expenses— about $13,911 for each PHA per year.[88] The CDC findings are comparable to HUD's own findings. Other reports find that operators of multi-housing with smoke-free policies report a reduction in costs.[89]

HUD reports in the proposed rule that the additional cost of rehabilitating the units of smokers averaged $1,250 to $2,955. The CDC's estimate of maintenance benefits is $1,674, based on data from the Smoke-Free Housing Coalition of Maine.[90] The greatest savings benefit will be seen in units inhabited by smokers where there is currently no smoke-free policy, either self-restricted or PHA-restricted.

To calculate the savings in maintenance costs from a national smoke-free policy, HUD used the estimated turnover rate in public housing of 9 percent[91] and the 732,086 units of public housing not covered by a PHA smoke-free policy, resulting in 66,000 turnover units annually

[87] We do not suggest that every tenant has a better understanding of the scientific literature on the relative risk of second hand smoke. Instead, individuals are expected to value a healthy environment based on a rough approximation of its stream of benefits.
[88] King, B., et al. (2014), *supra* note 3.
[89] Snyder, K., et al. (2015), *supra* note 67.
[90] Smoke-Free Housing Coalition of Maine. Allowing smoking in your building is expensive and dangerous. http://www.breatheeasymaine.org/sites/default/files/content/Landlord%20Fact%20Sheet_0.pdf.
[91] HUD's Picture of Subsidized Housing data.

that would be affected by the proposed rule. Approximately one-third (32.7 percent) of these units (or 21,545) will be inhabited by smokers, perhaps less if smokers concentrate within a single unit.[92] To adjust for the fact that not all smokers of a household smoke indoors, we further multiply the number of turnover units inhabited by smokers by the percentage of smokers' homes with no smoke-free rule (59.3 percent) to arrive at a base of 12,700 units. Using our per-unit benefit estimates, we arrive at an aggregate estimate of $16 million to $38 million in annual renovation-related cost savings, compared to CDC's estimate of $21 million using the data from Maine.[93]

4.5. Reducing Risk of Fires

Smoking is the leading cause of fire deaths in multiunit properties.[94] From 2007 to 2011, smoking caused an annual average of 6,400 residential fires, resulting in 130 civilian deaths, 480 injuries, and $116 million in direct property damage.[95,96,97] The smoking-related fires comprise 6 percent of all fires in multiunit housing. Smoke-free policies would lead to a reduction of risk of fires or the number of fires attributable to smoking. Because of this risk reduction, insurance would be less expensive. Indeed, the Capital Insurance Group offers a 10 percent smoke-free

[92] The CDC has calculated the percentage of smokers in subsidized housing (not the percentage of units with at least one adult smoker) at 32.7 percent. King, B., et al. (2013), supra note 3.
[93] It should be noted that these savings are likely to vary somewhat by PHA given their interiors. Some PHAs have been encouraged to move to linoleum floors to promote indoor- health. Such floors are easier to clean, so the maintenance benefits will not be as great for these units.
[94] The causes of fire leading to fire death in multi-unit housing are (in descending order): smoking materials, cooking equipment, electrical distribution and lighting equipment, intentional, heating equipment, candles, and playing with heat source: http://www.usfa.fema.gov/downloads/pdf/publications/residential_structure_and_building_fires.pdf.
[95] Table 5B, p. 99, http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Occupancies/oshomes.pdf.
[96] This compares to a nationwide annual average across all residential units of 17,900 smoking-caused fires, 580 civilian deaths, 1280 civilian injuries, and $509 in property damage.
[97] By 2012, all states had adopted fire-safe cigarette laws, such that the estimates of damage based on 2007-2011 data could be an overestimate of fire damage from cigarettes. HUD does not expect the estimates to be extremely inaccurate, however. Many states had already adopted such laws during the 2007-2011. In 2003, states began requiring fire-safe cigarettes and by 2010, 47 states had already adopted fire-safe cigarette laws. http://www.nfpa.org/safety-information/for-consumers/causes/smoking/coalition-for-fire-safe-cigarettes/about-fire-safe-cigarette. Suggestions for more accurate estimates of multi-housing smoking-caused fire damage are welcome.

credit to owners of smoke-free multiunit housing.[98] Chaloupka and Warner (2000) report that fire and hazard insurance is higher for every smoker in a building.[99] The CDC analysis found that prohibiting smoking in housing either owned or operated by a government housing authority would yield cost savings of $16 million in smoking-attributable fire-losses,[100] based on figures obtained from the National Fire Protection Association's 2013 cost estimates.[101, 102]

To conduct our own calculation of gains from decreased fire losses in public housing due to smoke-free policies, it is necessary to use parameters that are specific to the type of structures found most commonly in public housing. A slightly higher proportion of fires in multiunit housing are caused by smoking (6 percent) than in structures with 1-2 units (4 percent). The damages caused by the fires that are caused by smoking in multiunit housing are disproportionate to the frequency of other fires: 15 percent of all property damage, 31 percent of all civilian deaths, and 11 percent of all civilian injuries in fires in multiunit housing are attributable to fires caused by smoking.[103, 104,105]

The most straightforward way of estimating the effect of the rule is to assume that the damage in smoking-caused fires in public housing is proportional to all multi-unit housing. The units in public housing without a PHA smoke-free rule comprise approximately 2.5 percent of

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[98] See http://www.ciginsurance.com/whats-new-sections/whats-new/smoke-free-policy-incentives/.
[99] Chaloupka, F.J. & Warner, K. (2000), *supra* note 9.
[100] King, B., et al. (2013), supra note 3.
[101] National Fire Protection Association. (2013a) *The total cost of fire in the United States—2013*. Quincy, MA. http://www.nfpa.org/~/media/files/research/nfpa-reports/economic-impact/ostotalcost.pdf?as=1&iar=1&la=en.
[102] National Fire Protection Association. (2013b). *Home structure fires—2013*. Quincy, MA. http://www.nfpa.org/~/media/Files/ Research/NFPA%20reports/Occupancies/oshomes.pdf.
[103] Table 5B., ibid.
[104] The annual average for all fires in multi-unit housing for which the cause was known was 102,000 fires, 380 civilian deaths, and $1 billion in damages (calculated by HUD from Table 5B, ibid.).
[105] The data from NFPA concerning fire damage to multi-family housing does not include the costs to firefighters. Suggestions for including the benefit of avoided costs to fire departments of smoking-caused fires in public housing are welcome.

the multi-unit housing stock.[106] We estimate that a rigorously enforced smoke-free rule would avert 160 fires, 3.25 civilian deaths, 12 injuries, and $4.7 million in property damages annually (multiply 6,400 fires, 130 civilian deaths, 480 injuries, and $116 million in damage by 2.5 percent).

For the value of a statistical life, we use $8 million, a standard estimate. The total gain from preventing an expected 3.25 deaths annually is $22.75 million ($8 million x 3.25). We predict an averted 12 injuries. The NFPA suggests an injury cost equal to 60 percent of a CPSC estimate equal to $166,000 (in $1993).[107] In $2014, the NFPA cost per injury would be $163,000. The value of the damages caused by injuries averted would be approximately $2.0 million (12 x $163,000). The aggregate benefit from reducing the incidence of fire in public housing would be $32 million annually.

[106] 732,086 with no official smoke-free policy/ 29,303,224 multifamily units = 0.025
[107] National Fire Protection Association. (2014). *The total cost of fire in the United States*. Quincy, MA. http://www.nfpa.org/research/reports-and-statistics/fires-in-the-us/overall-fire-problem/total-cost-of-fire.

Estimated Annual Fire Damage Averted in Public Housing under Proposed Rule

Civilian Deaths Averted	**VSL**	**Value of Deaths Averted**
3.25	$8 million	$26 million
Civilian Injuries Averted	**Cost of Injury**	**Value of Injuries Averted**
12	$163,000	$2.0 million
Direct Property Damage Averted	**Cost of $1**	**Value of Direct Property Damages Averted**
$4.7 million	$1	$4.7 million
Total Fire Costs Averted		
$32.7 million		

Source: NFPA, American Community Survey, HUD

4.6. Benefits to Smokers

The purpose of the rule is to protect non-smokers in public housing from environmental tobacco smoke, reduce the risk of fire, and lower maintenance costs. Nonetheless, the inconveniences imposed upon smokers and positive smoke-free messages may increase the likelihood of cessation by some smokers and reduce the number of cigarettes smoked by active smokers. Smoking bans, with successful compliance and/or enforcement, will no doubt alter established smoking patterns. In doing so, these policies have the potential to increase smokers' incentive to quit as well as prevent relapse due to fewer cues from others' smoking in the building. Given what we know about smoke free policies in other settings,[108] a smoking ban would lead to more cessation as well as less consumption of cigarettes.

[108] See Fowkes, F., et al. (2008). Scottish smoke-free legislation and trends in smoking cessation. *Addiction 103.11*, 1888-1895. This study reported greater rates of quitting in poorer areas.

The literature concerning smoking cessation[109] provides a variety of results concerning the impact on smoking behavior of a smoking ban specific to housing. The literature concerning housing is not as well developed as the research on work-place smoking bans, primarily due to the relative lack of residential smoking bans. Nonetheless, a discussion of the research provides insight into the type of effects we can expect and how certain we can be of those effects. In general, the evidence concerning the causation of smoking reduction by smoking bans is mixed. This is to be expected because researchers draw conclusions using different empirical methods, data sets, and study different policies. HUD believes that there is a possibility of an impact on smokers but that this indirect benefit should not be the focus of the analysis.

If the rule were to lead to a reduction of smoking, then the value of the health benefits conferred to smokers would be significant. One study found that a nonsmoking population spends fewer years with disability than a reference population of smokers and nonsmokers. The nonsmokers had lower mortality risks, but they also had a lower incidence of disability and a higher level of recovery from disability.[110] Such an outcome, if it occurs, will almost assuredly improve the health and finances of a smoker. In addition, a reduction or elimination of smoking will allow low-income smokers to realize substantial, immediate cost savings from no longer having to purchase cigarettes. Such an advantageous outcome is desired by HUD. However, HUD does not explicitly consider these potential benefits to smokers in its analysis. Doing so would distract from the more likely and more direct effects of the rule. Nonetheless, it is important for informational purposes to provide a full background on the benefits to smokers.

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[109] Smoking cessation is measured by one or more of the following predictors: self-reported quit attempts, use of smoking cessation aids (medication, nicotine patches, etc.), daily reduction in cigarette consumption, successful cessation among those who attempted to quit, and overall smoking cessation.

[110] Nusselder, W.J., et al. (2000). Smoking and the compression of morbidity. *Journal of Epidemiology and Community Health 54*, 566–74.

(A) Smoking Cessation in Public Housing

The literature on smoking bans in multi-unit housing is developing as smoking bans themselves become more common. Currently the research is relatively limited compared to the study of smoking bans in other settings. Thus, conclusions as to whether smoke-free policies lead to a behavioral change among tenants cannot be precise.[111] Studies of smoking bans in other settings would suggest that a decline will occur.[112]

There exists only one published evaluation of smoke-free policies in subsidized multiunit housing. A longitudinal study on tenants in low-income housing in Portland, Oregon, before and after a smoking ban went into effect shows a decrease in indoor smoking and cigarette consumption and increased cessation within 17 months of policy implementation.[113] However, for those who quit, as many as 29 percent say they quit due to the policy. Another study was based on interviews of low-income tenants in subsidized multiunit housing with newly introduced smoke-free policies. While support for the policy from non-smokers is widely held, "most current smokers disliked the policy and did not follow it," leading to no change in smoking cessation.[114]

(B) Voluntary Household Smoking Bans

Another source of insight is the literature on voluntary smoking bans, for which a household chooses to restrict the smoking behavior of its members to outdoors. All of the aforementioned studies focus on private housing. The smoke-free homes from which these studies are were based on tend to contain smokers who are younger, of higher income or

[111] Hood, N. et al. (2012). Associations between self-reported in-home smoking behaviours and surface nicotine concentrations in multiunit subsidized housing. *Tobacco Control 23,* 27-32.
[112] Workplace smoking bans have been examined by many researchers. A brief review is provided in this section.
[113] Pizacani, B., et al. (2012), supra note 42.
[114] Drach, L., et al. (2010). The acceptability of comprehensive smoke-free policies to low-income tenants in subsidized housing. *Preventing Chronic Disease 7*.

educational attainment, smoke fewer cigarettes per day, or live with a nonsmoking adult or child.[115] These characteristics stand in stark contrast to the demographics of those living in public housing. Imposing a mandated policy in public housing could produce very different results than those found in voluntary restriction literature.

Research either utilizes longitudinal analysis,[116] or single cross sectional data sets. A large majority of results indicate strong and consistent evidence that a smoke-free policy in the home is associated with increased smoking cessation. Cross sectional studies have established a relationship between voluntary smoke-free homes and decreased daily cigarette consumption,[117, 118] a higher degree of interest in quitting, and reduced relapse for smokers who have quit.[119]

The longitudinal approach typically involves interviewing subjects before and after a smoking ban is instituted. Results from longitudinal studies find a significant association between self-imposed residential smoking bans and reduced cigarette consumption,[120] increased quit attempts,[121, 122] lengthier time to relapse,[123] lower rates of relapse,[124] and an increase in smoking cessation.[125, 126] One researcher interviewed approximately 5,000 subjects in 2001 and

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[115] Mills, A.L., et al. (2009). The effect of smoke-free homes on adult smoking behavior: A review. *Nicotine and Tobacco Research 11*, 1131-41.
[116] Hyland, A., et al. (2009). Smoke-free homes and smoking cessation and relapse in a longitudinal population of adults. *Nicotine and Tobacco Research 11*, 614–618.
[117] Gilpin, E.A., et al. (1999). Home smoking restrictions: Which smokers have them and how they are associated with smoking behavior. *Nicotine and Tobacco Research 1*, 153-62.
[118] Shields, M. (2005). The journey to quitting smoking. *Health Reports 16*, 19–36.
[119] Gilpin, E.A., et al. (1999), *supra* note 117.
[120] Farkas, A.J., et al. (1999). The effects of household and workplace smoking restrictions on quitting behaviors. *Tobacco Control 8*, 261–65.
[121] Ibid.
[122] Pizacani, B.A., et al. (2004). A prospective study of household smoking bans and subsequent cessation related behavior: The role of stage of change. *Tobacco Control 13*, 23–28.
[123] Ibid.
[124] Farkas, A.J., et al. (1999), *supra* note 120.
[125] Shields, M. (2007). Smoking bans: Influence on smoking prevalence. *Health Reports 18*, 9–24.

2005 and finds smoke free home policies to have a significant association with making a quit attempt and with quitting, increased use of smoking cessation aids, but no significant reduction in cigarette consumption.[127] This is supported by others who find that there is an increased likelihood of quitting smoking in the presence of home smoking restrictions, but that partial restrictions or restrictions with low levels of enforcement have no significant impact on smoking cessation.[128, 129]

For the regulatory impact analysis, the change in cigarettes smoked per day is of particular interest. It appears that from the studies that collect data on this particular measure, a reduction of 2 cigarettes per day is what is associated with home smoking bans.

Author	**Data**	**Smoke free home significantly associated with…**	**Outcome**
Shields 2007	Longitudinal	Quitting at follow up, decreased cigarette consumption	Odds ratio = 1.6, 2 fewer CPD
Messer et al. 2008	Longitudinal	Quitting at follow up, cessation for at least 90 days at follow up, decreased cigarette consumption	Odds ratio = 3.89, Odds ratio = 4.81, 2.18 fewer CPD
Gilpin and Pierce 2002	Cross sectional	Decreased cigarette consumption	3.1 fewer CPD
Shields 2005	Cross sectional	Decreased cigarette consumption	5 fewer CPD

Initially positive findings in cross-sectional studies suggest a relationship between smoke-free homes and decreased daily cigarette consumption. However, these findings may reflect the fact that smokers who smoke fewer cigarettes per day are more likely to allow for a smoke free policy to be implemented. The first obstacle to direct translation to public housing is that these studies may be unable to establish causality due to an endogeneity bias. It is unclear whether people are smoking less because of the ban, or they adopt the ban because they are

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[126] Shopland, D.R., et al. (2006). Association between home smoking restrictions and changes in smoking behavior among employed women. *Journal of Epidemiology and Community Health 60*, 44–50.
[127] Hyland, A., et al. (2009), *supra* note 116.
[128] Burns, E.K., et al. (2007). Differences in smoking duration between Latinos and Anglos. *Nicotine & Tobacco Research 9*, 731-37.
[129] Shopland, D.R., et al. (2006), supra note 126.

smoking less. Cross-sectional analyses unsurprisingly find evidence of increased smoking cessation among the households adopting smoking bans. Many longitudinal studies fail to find significant relationships between home smoking restrictions and smoking cessation. The second potential obstacle to direct translation to public housing is the data used. If smokers in these datasets differ from those living in public housing, the results may be questionable as to their use for HUD's smoke-free RIA.

A third and final difficulty is that smoking research often examines self-reported behavior. Hood et al. (2012) specifically examines the correlation between self-reported in-home smoking and surface nicotine concentrations in subsidized multiunit housing.[130] Their findings suggest tenants are more willing and able to accurately self-report their in-home smoking related behaviors when there is no smoking-ban than when there is one (even a self-imposed one). Smokers may prefer not to acknowledge violating an established policy.

4.7. Smoking Bans in Other Contexts

Fichtenberg and Glantz provide a review of the empirical literature of the effect of smoke-free environments on smoking behavior.[131] They find that the implementation of a totally smoke free workplace is associated with a reduction in the prevalence of smoking by an average of 3.8 percent and a reduction of consumption cigarettes by continuing smokers of 3 cigarettes. Although a causal relationship has not been fully established empirically, for illustrative purposes, we note that combining the estimated prevalence and intensity effects leads to an overall reduction of cigarettes smoked by 29 percent.

[130] Hood, N., et al. (2012), *supra* note 111.
[131] Fichtenberg, C.M. & Glantz, S.A. (2002). Effect of smoke-free workplaces on smoking behaviour: systematic review. *BMJ* 325, 188. See also Pizacani, B., et al. (2012), *supra* note 42.

There are a few difficulties to translating the research on restaurants and the workplace to residential sector. The first is that many more cigarettes are smoked at home than at work. This would make it easier for the smoker to comply with the workplace smoking ban. Second, the enforcement by others may be easier than for housing where smokers have more control and privacy.

The purpose of this rule is to stop smoking inside and in close proximity to public housing; it does not require smokers to stop or reduce their smoking. However, it is reasonable to expect that there may be a reduction in smoking by smokers in public housing. Such reduction or cessation would, in addition to other economic benefits discussed below, also reduce mortality costs to smokers and reduce health care costs.[132] These costs are usually calculated as the value of years of life lost due to smoking, assuming the value of a year of life to be at least $100,000. Cutler (2002) places the mortality cost to smokers at around $22 per pack,[133] while Gruber and Köszegi (2001) estimate a cost of $30 per pack.[134] Sloan et al. (2004) obtained a similar result, calculating the mortality cost to be about $20 per pack.[135] Viscusi & Hersch (2008) calculated the value of a life-year lost assumption and assessed the mortality cost to be as high as $222 per pack for men and $94 per pack for women.[136] Thus, although the value of longevity and quality of life is difficult to quantify, estimates are usually positive and significant. Fully recognizing the magnitude of this potential benefit, HUD is reluctant to include a detailed analysis given that the

[132] One study has shown that direct costs attributable to smoking comprise 6 to 9 percent of the total national health care budget. See Lightwood, J., et al. (2000). Estimating the costs of tobacco use. In P. Jha and F. Chaloupka, Eds., *Tobacco Control in Developing Countries* (63-103). New York: Oxford University Press.
[133] Cutler, D.M. (2002). Health care and the public sector. In AJ Auerbach and M Feldstein, Eds., *Handbook of Public Economics* (2145-2243). North Holland: Elsevier Science.
[134] Gruber, J. & Koszegi, B. (2001). Is addiction rational? Theory and evidence. *Quarterly Journal of Economics 116*, 1261–1303.
[135] Sloan, F. et al. (2004). *The price of smoking*. MIT Press.
[136] A reduction of 1.2 million cigarettes per day is equivalent to a reduction of 22 million packs annually. The benefits to smokers could be economically significant.

realization of this indirect benefit depends completely on how smokers elect to comply with the rule.

Suppose that the rule leads to a reduction of 2 cigarettes per day as shown in some the empirical studies described. As explained, this finding may not applicable to our analysis because lighter smokers and those with stronger desires to quit may be more likely to agree to a smoke-free home. Over one year, the rule would lead to a reduction of 730 cigarettes or 36.5 packs. Using the $20 per pack estimate of mortality cost, the annual health and longevity benefit to a smoker is $730. Over the approximately 139,000 smokers who do not live under smoke-free rules (either PAH or self-imposed), the aggregate health and longevity benefit would be very large: $100 million. The net benefit to smokers who reduce their tobacco consumption would be lower than this health and longevity benefit due to loss of utility associated with the activity of smoking. Applying Jin et al.'s 33-percent utility loss estimate yields a net benefit estimate of $67 million.[137,138] A more likely scenario would be a smaller reduction in cigarettes per day and thus smaller net benefits accruing to smokers. We request comment on the availability of evidence that distinguishes between causation and correlation in the context of indoor smoking bans' effect on consumption and could thus be used to reasonably estimate the smoking reduction attributable to this rulemaking. Furthermore, we request comments on costs that would potentially be incurred in conjunction with cessation attempts, such as increased provision of cessation aids.

[137] Jin, L., et al. (2015). Retrospective and prospective benefit-cost analyses of U.S. anti-smoking policies. *Journal of Benefit-Cost Analysis 6*(1): 154-186.

[138] The analytic question of whether utility loss is already counted sufficiently in the cost estimates in sections 5.4(E) 5.4(F), and thus would be appropriately omitted here, is made difficult to answer by the variety of behavioral responses that are implicitly reflected in the cost estimates and that would, under the rule as proposed, constitute compliance.

5. Costs of the Proposed Rule

The costs of the rule will be the costs of PHAs to administer and enforce smoke-free policy and the cost to smokers of complying with a smoke-free policy.

5.1. PHA Implementation Costs

The implementation of the smoke free policy in public housing would generate some compliance costs related to the drafting of the policy and the public hearing on the policy, the discussion meetings, the board resolution, the dissemination of the policy, training for the staff, and the revision of the leases. It is difficult to assess the costs associated with these activities. These are not new activities, but are activities that PHAs regularly engage in, resulting in no learning curve for the PHA. Additionally, the extended implementation time for PHAs allows them to incorporate new lease provisions at their annual lease renewals (or, if less costly, at a mass event) and any activities associated with their PHA plans into regularly scheduled meetings or changes. It is expected that any remaining costs will be small given that standard regulatory language and guidance is widely available to PHAs at no extra costs.

One study finding that approximately 15 percent of PHA residents who are smokers claimed to be ignorant of smoke-free policies in effect at their residential facilities underscores the importance of tenant outreach.[139] Under the proposed rule, PHAs must include the smoke free policy in the next annual plan ("PHA Plan") required under 24 CFR Part 903. Under 24 CFR 903.17, the PHA is already required to conduct a public hearing to discuss the PHA plan, invite public comment, and host a hearing at a location that is convenient to the residents served by the PHA. At least 45 days before the public hearing is to take place, the PHA must make the plan and related documents available and publish a notice on the hearing. The PHA must conduct

[139] Pizacani, B., et al. (2012), *supra* note 42.

reasonable outreach activities to encourage broad public participation in the PHA plans. HUD has published additional guidance on engaging residents, encouraging compliance, and preventing evictions in its "Toolkit for Owners/Management Agents of Federally Assisted Public and Multi-family Housing" and the "Change is in the Air" action guide.

The HUD guidelines emphasize the importance of notifying residents of the new policy. To promote success of the policy, the level of communication is likely to be greater than a formal written notice. Public housing tenants will receive counseling on all requirements of the smoke-free policy at admission and annual re-exam. One of the issues discussed would be the amendment of the lease. This could lead to a larger cost during the first year as all households are briefed in person and diminished costs as only the new admissions are briefed. In the first year all households would be affected. Afterwards, only movers (9 percent of total[140]) would be counseled on the requirement. We assume that all Public Housing Authorities would be subject to this cost, even those that already have a smoke-free rule. In the first year, 1.4 million would be briefed and in succeeding years 126,000 (9 percent of 1.4 million). Fifteen minutes would appear to be a likely maximum for discussing an addendum to a lease. The burden would be an extra 350,000 hours in the first year of implementation and 31,500 afterwards. The wage for clerical positions such as an examiner would be equivalent to a GS-9, or $20. The cost to an employer of an employee is greater than the wage. BLS data of total compensation for government office workers[141] yields a cost to employers of approximately $30 per hour. The year of notification would cost PHAs approximately $10 million in the first year and $1 million afterwards.

[140] Picture of Subsidized Housing, Percent moved in past year, national sample of Public Housing.
[141] http://www.bls.gov/news.release/ecec.t04.htm.

5.2. PHA Enforcement Costs: Monitoring

Enforcement is important and the key to an effective rule. Jackson and Bonnie (2011) collected data through telephone interviews with property managers of rental apartments, townhouses, senior housing, and public housing in Virginia.[142] Approximately half (53.4 percent) of property managers with smoke-free policies report their tenants and or/ guests violate the rule.

It is not clear how PHAs would enforce the smoke-free policy because there are many options. Experiences from the close to 600 PHAs[143] that have adopted and are implementing a smoke-free policy have been included in HUD's available guidance and technical assistance, and should help inform the debate. Pizacani et al. (2012) interviewed 11 property managers of smoke-free public housing in Portland, Oregon and found that 10 of them found enforcement to be extremely difficult. Nonetheless, 8 of the managers were in favor of the policy and noted few tenant complaints.

A wide range of alternatives of monitoring methods from smoke alarms to relying on neighbors reporting of violations have been discussed. Both the costs and the realized benefits are likely to depend upon the method chosen. It appears that monitoring by fellow tenants coupled with routine inspections is the most efficient and will be chosen by PHAs. PHA staff perform regular Uniform Physical Condition Standards (UPCS), housekeeping, and complaint-driven inspections of public housing as part of ongoing monitoring and maintenance. Maintenance and day-to-day property management staff are typically onsite, but the amount of time they are in a particular building will vary by PHA. Incorporating smoke-free monitoring

[142] Jackson, S. & Bonnie, R. (2011). A systematic examination of smoke-free policies in multiunit dwellings in Virginia as reported by property managers: Implications for prevention. *American Journal of Health Promotion 26*, 37-44.

[143] The latest count was 571 smoke-free PHAs. The analysis was completed using an earlier estimate of 565.

into regular inspection activities is a best practice discussed in the "Change is in the Air" guidance. Otherwise, compliance costs to PHAs will be very high.[144] Currently, there is no known PHA that utilizes anything other than staff monitoring and tenant complaints. However, verification by management of tenant complaints is required. Once evidence of a violation is found, HUD endorses a graduated approach in its available guidance, allowing opportunities to cure before moving to the ultimate step of eviction. Both detection and the process of assisting smokers will consume time and thus resources. It is difficult at this point, without clearer guidelines of the process or firm data of what choices PHAs make, to estimate the costs. Therefore, we request comments that would inform estimation of rule-induced enforcement and monitoring costs.

5.3. PHA Enforcement Costs: Eviction

A primary challenge to enforcing the smoke-free policy effectively would be lease enforcement costs, culminating in the eviction of a repeat offender.[145] Pizacani et al (2012) report that 11 smokers were evicted for non-compliance with the smoke free policy over a period of 18 months.[146]

A HUD survey of 11 PHAs with smoke-free policies is more representative. The eviction rate is defined as the number of evictions occurring for smoking violations, only as a percentage of the smoke-free units in a PHA. The eviction rate from smoke-free units for persons smoking in restricted areas varies significantly, from 0 to 6 percent. Thus, the case study described above

[144] If we assume however, that each PHA hires compliance monitors to work around the clock, it would necessitate 24 hours x 365 days for a total of 8,760 man hours annually per monitor. At a federal minimum wage of $7.25, the initiative would cost a housing authority $63,510. This estimate is only meant as an upper bound and not a primary one, which would be closer to 0 given self-enforcing nature of effective smoking bans.

[145] Currently, a PHA may terminate the tenancy for criminal activity or repeated violations of PHA policy and administrative practice. Examples of lease vilations are: failure to make payments, being over the income limit for the program, criminal activity, alcohol abuse, or discovery of material false statements or fraud by the tenant in connection with an application for assistance or with reexamination of income.

[146] Pizacani, B., et al. (2012), *supra* note 42.

is within the range of HUD's findings. It is, however, on the high end. The median eviction rate is 0 percent because the majority of our sample evicted no households. A weighted average may be more appropriate as a parameter. The total eviction rate is 0.1 percent (sum of all known smoking evictions/sum of smoke-free units).

Examples of enforcement plans of smoking bans by from property managers are provided in HUD's Action Guide for Establishing Smoke-Free Public Housing and Multifamily Properties (October 2014). The Duluth Housing Authority, for example, allows for a three step process. The first violation initiates a verbal discussion with the manager and a letter of notification from the PHA. A second violation leads to another discussion with the manager concerning smoke-free policy and signing of an agreement that the tenants understands that another violation could lead to an eviction. The third violation elicits either an eviction letter or a probationary agreement. Across 536 units, Duluth PHA reports 2 evictions for smoking and 6 more for smoking and other reasons (over a period of slightly more than two years) leading to an average annual eviction rate of 0.2 to 0.7 percent. Also, at each stage the number of violations declines by 50 percent.

Public housing residents have a right to the grievance process outlined at 24 CFR Part 966, subpart B before the PHA seeks a court-ordered eviction. This process allows an informal settlement process and formal hearing if not the matter is not resolved through informal means. Typically, if a termination is avoided, the resident will be asked to agree to conditions to allowed continued residency.

There are a number of costs paid for an eviction. The most direct are court fees, server charge, and eviction services which may total from $400 to $700.[147] Legal fees and new repairs are among additional costs that would inflate the basic cost of eviction.

[147] http://personalfinance.costhelper.com/eviction.html.

The impact on evicted tenants will include substantial inconvenience. Adding the costs of different smoker strategies, such as smoking in permitted areas and moving out (either voluntarily or post-eviction), would amount to double-counting the burden on smokers. An eviction would be one of the most costly consequences of the smoke-free policy to a smoker. Tenants will find lower cost strategies of responding to the smoke-free requirement.

Estimating the aggregate cost of evicting tenants requires choosing the affected population. Given that the eviction rate is calculated with smoke-free units as a base, evictions incurred as a result of the rule is estimated from the number of units that are not currently smoke-free.[148] Approximately 732,000 units are not smoke-free. If we assume that .1 percent of those households will be evicted because of the smoke-free policy, there will be approximately 730 households evicted. The basic transaction costs to PHAs from evictions will range from $300,000 to $500,000. Other costs, such as the hastened cost of renovating a smoker-inhabited unit, legal costs, and costs to the household of being evicted, would increase the estimate dramatically. In the high cost scenario (assume $3,000 per eviction[149]), the aggregate cost of evictions would climb to $2.2 million.

The annual loss to an evicted household would be the loss of the subsidy from HUD, which is $6100 on average (12 months x $512 per month[150]). The expected loss would depend on the probability of detection and eventual eviction. Given the consequences, willful violation of the regulations is not likely to be a strategy pursued by tenants. The impact would represent a transfer from the evicted household to a new entrant to public housing.

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[148] The usual home rule adjustment of 54 percent is not included because no household would choose to evict itself for breaking its own rules.
[149] http://personalfinance.costhelper.com/eviction.html.
[150] See http://www.huduser.gov/portal/datasets/picture/yearlydata.html

There may be disproportionate costs to residents as a result of eviction, particularly for persons with disabilities, and especially those with mobility impairments. HUD recognizes that this rule could adversely impact those with mobility impairment or particular frailties that prevent them from smoking in designated areas. As mentioned above, HUD will develop guidance on reasonable accommodation, and HUD solicits public comment on how to mitigate these potential adverse impacts.

5.4. Compliance Costs for Smokers

A smoker can respond in numerous ways to the regulation. Reduction in smoking will bring about health benefits. The compliance will be costly however and will impose costs without active health benefits for the smoker who does not reduce smoking. Generally, a smoker will choose the reaction strategy that yields the highest post-rule smoker's utility in order to minimize the cost of the rule. An implicit distinction is made between the utility of a smoker and one of a non-smoker. [151] Smokers are assumed to derive some more satisfaction by consuming more tobacco as long as they are smokers.[152]

Most obviously, a smoker can comply by smoking in designated areas. Compared to the pre-rule state of affairs, the loss will be the time value of smoking outdoors. A smoker could choose not to comply and risk punishment by the PHA. Compared to the pre-rule utility, the loss would be the expected damage of punishment (probability of detection x loss). A smoker could switch to an alternative means of nicotine delivery (e.g., a non-lit tobacco product) in which case

[151] The Surgeon General concluded in 1988 that "cigarettes and other forms of tobacco are addicting. Patterns of tobacco use are regular and compulsive, and a withdrawal syndrome usually accompanies tobacco abstinence." Subsequent reports of the Surgeon General have documented the mechanisms by which smoking is addictive, including for youth. Apart from the biologic basis for the addictiveness of smoking, epidemiologic data reveal that more than two-thirds of smokers wish to quit. In addition, most smokers first try cigarettes as youth, before the areas of their brain responsible for rational decision-making and risk perception have been fully formed. For these reasons, smoking should not be viewed as a rational behavior.

[152] As supportive evidence, fewer cigarettes are consumed when cigarette prices are higher.

the loss would equal the lost smoking utility moderated by any difference in cost between combustible tobacco and the alternative product. To understand the compliance cost, we only need to know the least cost strategy because higher cost strategies will not be pursued. If, for example, we observe that individuals are not complying with the rule, then we can infer that the threat of punishment is less than the cost of compliance.

Compliance is more likely to involve continuous rather than discrete and extreme solutions. A smoker can choose to comply but smoke less combustible tobacco. Compared to the pre-rule smoker's utility, this smoker will experience reduced smoking utility and a loss of time. Compared to the inelastic compliance strategy (same amount of tobacco), the reduction will result in more time, more non-smoking consumption, but a lower smoking utility. [153] An even more sophisticated model would have the smoker choosing total combustible tobacco smoked, where it is smoked, and use of NRT, ENDS, or other non-lit tobacco products. Mixing strategies may permit smokers to find a hybrid strategy that is more advantageous to the smoker than any other. Even the lowest cost of the three unidimensional solutions could be improved upon.

It is assumed that the option of non-compliance is the most expensive. As smokers smoke more indoors, the probability of detection will increase. The eventual consequence for non-compliance is eviction: households may lose their housing subsidy. They certainly will face the costs of dislocation. Given these high costs, HUD believes that tenants will make an effort to comply with the rule.

One of the envisioned responses is that smokers smoke in designated areas. A smoke-free rule will impose a cost on smokers: every cigarette will become costlier because smokers have to leave their units to smoke. The cost of this inconvenience can be measured by the opportunity

[153] This discussion purposefully omits the health gains from reduced smoking or not smoking as they are analyzed in the section on benefits.

cost of leisure time devoted to the compliance. In addition to counting the inconvenience of traveling to a smoking area, one should consider the time spent at the smoker-designated areas as a potential opportunity cost. Smoking outside when it is intemperate is less pleasurable compared to a controlled climate. Smokers may have to stand instead of sit.[154] The smoker must also forgo certain private activities, which may be a complement to smoking, during the time the smoker occupies the designated smoking area. Some smokers will adjust by smoking faster. Others may begin to enjoy the ritual.

Given the uncertainty in quantifying the utility loss (conducted in later portions of this cost section), we attempt to check the robustness by examining the cost of another method of compliance—smoking at least 25 feet away from PHA buildings. Due to data limitations, we estimate only the portion consisting of travel costs:

Annual Burden to Smokers = (Smokers) x (Days) x (Hours lost per day) x (Value of Hour)

(A) Hours Lost per Day

Time studies of smoking breaks are most commonly available for places of employment because of the interest in productivity. The reported amount of time per day at work spent on smoking breaks varies substantially, from 8 to 30 minutes.[155] However, smoking breaks at work versus homes are different in that at home one may have more control over time at home. A second difference is that most cigarettes are consumed outside of work hours. Studies find that for average smokers approximately 2 cigarettes are smoked during work hours.[156]

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[154] The survey of the Portland PHA (Pizacani, B., et al. (2012), *supra* note 42) finds that those tenants with mobility impairments are less likely to comply with smoking restrictions.
[155] Javitz, H.S., et al. (2006). Financial burden of tobacco use: an employer's perspective. *Clinical Occupational and Environmental Medicine 5*, 9–29.
[156] Ibid.

To estimate time lost, start with the time lost per cigarette. Absent any direct evidence of the time required to exit a public housing unit, we must estimate that time based on several assumptions about the buildings and residents. There are basically four components to a smoker's round-trip under the rule: the trip from the unit to the stairs or elevator; the descent to the ground floor; the trip 25 feet away from the entrance; the time spent smoking the cigarette; and the return trip for all of these parts. While it is true smokers must also spend time gathering smoking materials in their home, they would spend this same time even if they smoked indoors, and hence it imposes no additional cost under the rule.

The aggregate trip to the elevator or stairs is difficult to estimate. 69.08 percent of public housing units are in projects with 250 or more units (source: HUD Picture of Subsidized Housing, 2009 updated to 2013). While units in larger projects are typically spread out among several buildings, it seems like at least some units would be located a considerable distance from stairs or elevators. The Minnesota Housing Authority stipulates that no dwelling unit in its multifamily housing shall lie more than 250 feet from an elevator.[157] Connecticut's housing authority mandates a 150 foot maximum length or corridor.[158] Others would likely be located in close proximity to points of egress, virtually negating this portion of the time cost. It is not clear that smokers are specifically put in units near or far from elevators/stairs, thus we must assume smokers face the same travel time to exits as any other resident on their floor. If we assume 200 feet is the length of the corridor (the average of the Minnesota and Connecticut maximums), we can use 100 feet, or halfway down the hall, as the length of the typical trip to the elevator. A

[157] Minnesota Housing Finance Agency. (2015). *Rental housing design/construction standards*. www.mnhousing.gov/get/MHFA_010795.
[158] Connecticut Housing Finance Authority. (2013). *Standards of design and construction*. http://www.chfa.org/content/Multifamily%20Document%20Library/2013StandardsFinal_122812.pdf.

typical walking pace for an adult is about 1.4 meters per second, which means the trip of 100 feet takes about 21.8 seconds to travel from a unit to the elevator or stairs.[159]

The time spent descending is the distance descended divided by the rate of descent. Many, though not all, public housing buildings have elevators for residents' use. According to Otis, the slowest elevator they produce travels at a rate of 125 feet per minute.[160] If builders installed a hydraulic elevator, that speed could be 100 feet per minute.[161] Assuming all elevator trips were on the slowest commercially-available elevators, the time spent descending would simply be the number of feet descended divided by 100 feet per minute. According to NYCHA data, the average public housing development in New York City is about 10.7 stories tall. Since some smokers are presumably on every floor, we assume the average trip is half the average building height, 5.4 stories or about 54 feet.[162] At 100 feet per minute, the trip would take about 32.0 seconds in an elevator.

Of course many residents will take the stairs if it is more convenient for them or if there is no elevator. Elevators may not be mandated in multifamily buildings below a certain height. Studies suggest that the vertical speed of adults ascending stairs is between .3 and .4 meters per second (59.1 to 78.7 feet per minute).[163, 164] Descents will likely be somewhat faster than ascents, but assuming smokers descend at 0.4 meters per second, the trip down the average 5.4 stories would take 40.7 seconds.

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[159] Nick, C. (2005). *Establishing Pedestrian Walking Speeds*. Portland State University. http://www.westernite.org/datacollectionfund/2005/psu_ped_summary.pdf.
[160] Otis Elevator Company. (2014). *About Elevators*. http://www.otisworldwide.com/pdf/aboutelevators.pdf.
[161] Popp, J. (2009). Elevator systems, *APPA*. http://credentialing.appa.org/documents/bokchapter21-elevatorsystems.pdf
[162] Assuming one story is 10 feet.
[163] Fujiyama, T. & Tyler, N. (2004). An explicit study on walking speeds of pedestrians on stairs. University College London: Centre for Transport Studies. http://discovery.ucl.ac.uk/1243/1/2004_21.pdf.
[164] Kretz, T., et al. (2008). Upstairs walking speed distributions on a long stairway. *Safety Science 46*(1), 72-78. http://tobias-kretz.eu/resources/preprint_safety_science_46.pdf

Once on the ground floor, the trip 25 feet away from the building to a spot suitable for smoking would take the average adult about 5.4 seconds.[165] This assumes the distance from the elevator or stairs to the outside is negligible, since data on that parameter are lacking. To correct for this uncertainty and account for various impediments encountered on a typical trip (e.g. waiting on elevators, acknowledging an acquaintance, walking behind somebody on the stairs, etc.), we assume 30 seconds will be added to the total one-way travel time. In total, a one-way trip for typically-abled adult in public housing should take either 1.49 or 1.63 minutes depending on whether the elevator or stairs, respectively, were used. Assuming the return trip occurs at the same rates of speed, the total round-trip travel time is between 2.99 and 3.28 minutes (i.e. two times the one-way time).

Residents of public housing who are elderly or physically disabled are likely to have somewhat longer travel times due to their mobility limitations. 31 percent of all public housing units have a head of household who is at least 62 years old.[166] 20 percent of all persons in public housing are disabled.[167] For the purpose of simplification, we assume mobility impairments among both groups are such that they travel at the same speeds. Walking speeds among the elderly range from about .92 to 1.09 meters per second.[168, 169] Ascent speeds among the elderly are similarly between 0.3 and 0.4 meters per second.[170] Using .92 meters per second walking and .3 meter per second on the stairs, the one-way travel time for the elderly and disabled is 1.72

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[165] In some cases, locations more than 25 feet from a smoker's own residence may be within 25 feet of other buildings, in which case smokers will need to travel more than 25 feet each way. We request comment and data that would allow us to quantify the frequency of this possibility.
[166] HUD Picture of Subsidized Housing, 2009 updated to 2013.
[167] Ibid.
[168] Studenski, S., et al. (2011). Gait speed and survival in older adults. J*ournal of the American Medical Association 305*, 50-58. http://jama.jamanetwork.com/article.aspx?articleid=644554.
[169] Novaes, R.D., et al. (2011). Usual gait speed assessment in middle-aged and elderly Brazilian subjects. *Brazilian Journal of Physical Therapy 15*, 117-22. http://www.scielo.br/pdf/rbfis/v15n2/a06v15n2.pdf.
[170] Fujiyama, T. & Tyler, N. (2004), *supra* note 163.

minutes by elevator and 2.09 minutes with the stairs. The round-trip travel time for the elderly and disabled is thus 3.45 and 4.19 minutes respectively.

The assumption of building height relies on data from New York due to availability, though it is worth noting the buildings in many PHAs affected by the rule will be much different than New York's properties. This assumption may have merit, since urban PHAs have produced the most smoke-free units to date. One half of all smoke-free units reside in areas under the 51 largest PHAs, by resident population, that have any smoking ban. Those 51 PHAs represent just 9 percent of the 565 PHAs with smoking bans. Overall, one half of all smoke-free units reside in areas under the 125 largest PHAs by resident population. Those 125 PHAs represent just 4 percent of the 3,091 total PHAs. While smoke-free coverage is already fairly concentrated in larger PHAs, so too are the units not yet under a smoking ban. The largest 117 PHAs by resident population, just four percent of all PHAs, control 50 percent of the units not yet under a smoking ban. New York City alone houses about 12 percent of all units which the rule would affect. Given that many large PHAs will be affected rule, data on New York buildings seems appropriate for this analysis.

Round Trip Time by Category of Smoker

Category	Mode	Time (min)
Unimpaired	*Elevator*	3
	Stairs	3.7
Elderly/Disabled	*Elevator*	3.4

The burden of the rule on smokers depends on both the building and the smoker. Recipients of housing assistance consume, on average, between 12 and 14 cigarettes per day.[171] Not all cigarettes are smoked at home and this rule will have no incremental impact on those

[171] National Health Interview Survey, 2013.

cigarettes consumed by the smoker away from home. In keeping with standard measures, it is safe to assume that at least 2-3 cigarettes will be smoked away from home. A resulting measure would therefore result in approximately 10 cigarettes smoked per day at home.[172] If we assume cost-minimizing behavior, the rule would impose a compliance burden of thirty minutes per day for the unimpaired and thirty-four minutes per day on the elderly or physically impaired (183 and 207 hours annually, respectively).

(B) Value of Time

Time is a resource allocated by consumers among different activities: personal care, work-related, household, shopping, education, and leisure. Time spent traveling in order to participate in these activities reduces a household's available time resources. In effect, compliance with the rule imposes travel costs on smoking a cigarette in public housing. The estimated time spent travelling is expected to vary between 3 and 4 minutes per cigarette and up to 30 minutes a day. To monetize the regulatory burden, a value of time must be applied. Estimates of the value of time vary widely. Our primary estimate is ½ of the wage and an independent measure ($1.58) for those who are unemployed.

Wage as Measure of the Opportunity Cost of Time. A traditional means of valuing the opportunity cost of time as a resource ("the shadow wage") is to equate the shadow wage to the hourly wage. There is some theoretical appeal to this measure: original models of labor supply equate the marginal value of leisure with the hourly wage. There are two implicit assumptions in such a measure. First, time can be transferred continuously (in minutes and hours) between labor and leisure rather than in lumpy quantities (shifts or half days). Second, there is no disutility to being at work. The case of low-income public housing residents strays far enough from these

[172] The unemployed, with more leisure time, may have more opportunities to smoke away from the building.

assumptions that it is worthwhile to search for alternatives. Low-income individuals are not likely to have freedom in determining their work schedules. The work itself may be unpleasant. Finally, the major source of income for a majority of the households in public housing is not labor income, making the wage a potentially imperfect measure of the time constraint imposed by the rule.

Insights from Estimating the Value of Travel Time. The value of time has been examined carefully by transportation economists because the opportunity time cost of travel time is the best predictor of commuting behavior, better than any direct pecuniary costs. Theoretical work led to a standard equation estimated by economists: the value of travel time is the marginal tradeoff between travel time and unearned income that would leave the traveler indifferent. Expressed as an equation, the relation is:

value of travel time = wage + (utility from time at work – utility from time traveling).

The simplest model of the labor-leisure trade-off would be accurate only if there was no utility lost or gained from either work or travel. However, empirical estimates of the value of travel time are lower than an individual's market wage because the utility of travel time is often greater than the utility of time at work (or the disutility is smaller). It is industry practice to express the value of travel time as a proportion of the wage. For example, the Department of Transportation recommends a range of 35 to 60 percent for personal travel. Established findings from the literature on the value-of-commuting time are as follows[173]:

- The value of time for commute trips typically averages ½ of the hourly wage.
- Values vary by trip purposes: being highest for business and lowest for discretionary leisure
- Value of travel time increases with income.
- Shorter trips are characterized by lower average time costs than longer trips.
- Unpredictable trips have a greater VOT.

[173] Small, K.A. (2012). Valuation of travel time. *Economics of Transportation 1.1*, 2-14.

- The value of travel time varies with other time constraints (seniors and students have lower values of time than other adults).

We believe that it is appropriate to use the ½ of wage measure, as suggested by DOT. Higher estimates of the value of time are less likely given that the trip has many of the characteristics of those that have low average time costs: short, predictable, and for recreational purposes.

Insights from Estimating the Value of Leisure. While the literature on travel time is well-established, the measurement of the true opportunity cost of time, or the value of leisure, is less well-established, primarily because the modelling must be more creative to separate the marginal value of leisure from other household activities. The researchers build from the established commuting demand literature and posit an optimal condition for time allocation in every activity:

value of time saved in an activity = value of time as a resource – value of time assigned to an activity

In the case of work, the value of time saved in an activity would equal the wage, w; the value of time as a resource is considered the marginal utility value of leisure (VOL); and the marginal utility value of time assigned to work (VOW). If the value of time at work is negative (disutility from work), then the value of leisure will be less than the wage. An international study found the average VOL in Santiago, Chile to be 2/3 of the wage. We believe that this sample approximates the unstable work conditions of low-income workers in the United States.

A study of the U.S. population's marginal value of time devoted to work indicates that the wage is a good measure of the value of leisure.[174] The researchers conclude that their empirical result implies that "individuals in the sample work not just for monetary gain, but also

[174] Konduri, K., et al. (2011). Joint analysis of time use and consumer expenditure data: examination of two approaches to deriving values of time. *Transportation Research Record: Journal of the Transportation Research Board 2231*, 53-60.

because they derive some pleasure from the activity." However, the sample is not reflective of residents of the public housing. The sample for the study included only workers living alone. While the researchers' analytical methods are impeccable, the choice of study subjects (workers living alone) removes many of the constraints as well as the advantages that characterize the time allocation problem of most households. Single-adults may be prone to working more. Thus, we are hesitant to draw conclusions from this particular study.

Although it is intuitively appealing to use the wage as the basis of the opportunity cost of time, doing so may be inaccurate for at least the 72 percent of households whose major source of income is not wage income. We expect that, on average, the under- or unemployed would be less constrained for time than the full-time employed. The opportunity cost of time will be lower for households earning the majority of their income from another source than wages or salaries. The opportunity cost of time would not be equal to zero, however, but it will be lower than the wage.[175] For insight, we turn to the research on the value of travel time for recreational purposes. This empirical literature, while not as vast as the commuting time literature, has the advantage of studying an activity that may be more similar than commuting to work.

A summary of recreation demand models reviews two studies of recreation demand in which travel cost is not directly observed (a latent variable).[176] The first study reviewed uses a variety of variables (including wages, distance, and pecuniary costs of travel) to estimate a travel

[175] It is possible that a non-participant of the labor market may have a value of leisure (or working at home) that exceeds the market wage; however, this possibility is remote for public housing residents.
[176] Phaneuf, D.J. & Smith, V.K. (2005). Recreation demand models. In K.G. Maler and J. Vincent (Eds.), *Handbook of Environmental Economics*. Amsterdam: North-Holland.

cost.[177] The researchers' estimate of the opportunity cost of time is close to one-third of the wage.

The second study reviewed is of particular interest because the researchers estimate the shadow wage[178] of individuals depending on employment status.[179] They begin with the insight that those who choose not to enter labor force may place a higher value on their leisure time than those who work. Building on the labor supply models of Heckman,[180] the researchers propose a model that is modified to include constraints on the flexibility of time allocation. Doing so allowed them to estimate a shadow wage for all individuals, even those who have no labor income. The shadow wages are then used to predict recreational travel demand. The researchers find that shadow values are closer to the market wage (90 percent of market wage) for employed workers. For underemployed, the opportunity cost of time is 60 percent of the wage. The researchers propose a value of one hour of $1 for unemployed, using 1994 data. Inflating to 2014 values, the value of one hour of leisure for the unemployed is $1.58.

A last approach of interest is that of Bartik,[181] who claims that the reservation wage of the involuntarily unemployed reflects the value of time in leisure. To calculate this, the author measures the reservation wage of the newly employed. He assumes unemployed in excess of 3.0 percent is involuntary unemployment; the elasticity of labor force participation with respect to the unemployment rate is -0.5; and the elasticity of labor supply with respect to wages is

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[177] Englin, J. & Shonkwiler, J.S. (1995). Estimating social welfare using count data models: An application to long run recreation demand under conditions of endogenous stratification and truncation. *Review of Economics and Statistics 77*, 104–12.
[178] Shadow values, which measure the willingness to pay for an additional unit, are usually unobserved and thus more difficult to analyze.
[179] Feather, P. & Shaw, W.D. (1999). Estimating the cost of leisure time for recreation demand models. *Journal of Environmental Economics and Management 38*, 49-65.
[180] Heckman, J. (1974). Shadow prices, market wages, and labor supply. *Econometrica*, 679-694.
[181] Bartik, T. (2012). Including jobs in benefit-cost analysis. *Annual Review of Resource Economics 4*, 55-73.

0.15.[182, 183] With unemployment at the end of 2014 at 5.6 percent, by his calculations, the ratio of the reservation wage to the market wage will be the reservation wage of the newly employed is approximately 77 percent[184] below the market wages for that individual. While we do not use this measure, it does indicate again that the value of leisure is likely to be less than the wage for unemployed.

(C) Dollar Burden per Smoker

The dollar burden per smoker is calculated for two different types of smokers: employed and unemployed. We assume that the employed are unimpaired and that the unemployed are also elderly or unimpaired. The consequence of this assumption is that the groups are differentiated by the opportunity cost of time and travel time.

For the first group, we use a time value equal to half of the estimated wage. The average amount of earned income by public housing residents is $22,000,[185] which at the typical 42.5 hour work week, would be an average $10 wage. Almost all of the studies reviewed place leisure at a lower value than the wage, with 50 percent being a consensus. The opportunity cost per hour would be $5.00 and the opportunity cost per minute $0.08. The estimate of round-trip length by elevator is 3 minutes, bringing the opportunity cost of a trip to $0.25 per cigarettes. This estimate was calculated from the tall buildings in New York: the average for PHA residents in less dense areas is likely much lower.

Elderly and impaired are assumed to be earning most of their income from other sources such as social security payments. The opportunity cost of time based on the recreation travel

[182] Bowen, W.G. & Finegan, T.A. (1969). *The Economics of Labor Force Participation*. Princeton University Press.
[183] Gordon, R.J. (2010). The demise of Okun's Law and of procylical fluctuations in conventional and unconventional measures of productivity. *Northwestern University Working Paper*.
[184] $\exp[(0.056 - 0.03)(1 + 0.5)(-1)/0.15] \approx 0.77$
[185] HUD Quality Control Survey

demand study is $1.58 per hour. The time required for a round trip is predicted to be longer at 3.4 minutes per cigarette, resulting in a compliance cost of $0.09 per cigarette.

HUD administrative data show that the major source of income for 28 percent of the households in public housing is wage and salary earnings; 72 percent have non-labor sources of income such as pensions and public assistance. Weighting the per cigarette results, we calculate an average cost per minute of $0.04; an additional burden of 3.3 minutes and a travel cost per cigarette of $0.13 (0.28*0.25 + 0.72*0.09).

To calculate a daily cost for smokers, the number of cigarettes smoked per day must be estimated. There does not appear to be an obvious difference from year to year between different categories of smokers receiving assistance: 13 cigarettes per day is the average. Not all of these cigarettes will be smoked at home. One study finds that for average smokers approximately 3 cigarettes are smoked during work hours.[186] A time study of daily activities suggests that approximately half of all smoke exposure occur in residences.[187] At least 7 and as many as 10 cigarettes are smoked at home. HUD uses the higher estimate.

The average smoker affected by the rule incurs an opportunity cost of $0.13 per cigarette, $1.34 per day ($0.134*10) and $491 annually ($$1.34*365 days per year). The annual cost is differentiated by category of smokers' household: those whose wages are a primary source of income bear an annual opportunity cost of $913; and those whose primary source of income is not earnings incur an annual opportunity cost of $327.

(D) Aggregate Opportunity Cost of Time for Smokers

[186] Javitz, H.S., et al. (2006), *supra* note 155.
[187] Klepeis, N.E., et al. (2001). The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology 11*, 231–52.

Adult smokers living in homes without any smoking rules will incur incremental compliance costs. There are roughly 410,000 adult smokers (29.7% of population who are smokers*60% adults*2.3 million residents in public housing) who will be affected by this policy action. Of those 410,000 adult smokers, approximately 257,000 live in units managed by PHAs without a smoke-free policy. Many households have self-imposed rules against smoking within the units. If that were the case, then it could be argued that there would be no cost imposed upon a smoker who is already asked to smoke outside by his household. The proportion of households with their own home rule is 46 percent.[188] Thus, 54 percent (100 – 46) of the adult smokers in housing that is not yet smoke-free would be affected by the rule: approximately 139,000. The aggregate annual opportunity cost is roughly $68 million (139,000 affected adult smokers*$491).

Estimate of Total Burden of Trips to Designated Smoking Area

Category	Tenants	Base Opportunity Cost of time/Hour	Base Opportunity Cost Per minute	Minutes Per Cigarette	Cost Per Cigarette	Cigarettes Smoked at Home	Total Cost Per Day	Total Cost Per Year
Employed (Major Source	28%	$5.00	$0.08	3	$0.25	10	$2.50	$913
Other source of Income	72%	$1.58	$0.03	3.4	$0.09	10	$0.90	$327
All Households	100%	*$2.54*	*$0.04*	*3.3*	*$0.13*	*10*	*$1.34*	*$491*
Aggregate	138,934						*$186,816*	***$68,187,869***

(E) Comparing Behavior Change Due to Smoke-Free Policies and Due to Changes in Cigarette Price

As discussed in other portions of this analysis, there exists a body of scholarly literature that investigates the effects of smoke-free policies on smoker behavior. A related literature addresses other determinants of smoking behavior, such as cigarette price. In the proceeding analysis, we assume proportionality of observed behavior change and underlying costs—i.e., if a smoke-free policy causes double the behavior change as a one-dollar cigarette price increase,

[188] King, B., et al. (2014), *supra* note 3.

then the cost of the policy driving that change is likely to be approximately double the cost borne due to the price increase. By extrapolating from the cost of a price increase—which is naturally expressed in monetary terms—generate a monetized estimate of the cost of a smoke-free policy, such as the one proposed by this rule.

As the first step of this approach, we turn to the work of Markowitz (2006), who estimates the effects of changes in cigarette price and the implementation of smoke-free policies on sudden infant death syndrome (SIDS).[189] The coefficient on cigarette price is -0.626, and the coefficient on workplace smoke-free laws, which does not quite reach conventional levels of statistical significance, is -0.073. The workplace smoke-free variable is constructed so that the values 1 and 2 represent partial bans and 3 represents a complete ban.[190] These results indicate that, during the period studied by Markowitz (1973-2003), switches to statewide workplace smoking bans from the workplace smoking policies that would have existed in the absence of state legislation (either local ordinances or voluntary employer policies) could be expected to have 35 percent (=3*0.073/0.626) the effect on smoker behavior as a one-dollar increase in the price of a pack of cigarettes.

As noted previously, HUD estimates that, on an average day, smokers who reside in public housing consume 10 cigarettes at home and general smokers consume three cigarettes at work. Farrelly, Evans and Sfekas (1999) note that, in late 1992 and early 1993, 46.7 percent of Current Population Survey respondents who worked indoors and were not self-employed

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[189] Markowitz, S. (2006) The Effectiveness of Cigarette Regulations in Reducing Cases of Sudden Infant Death Syndrome. *NBER Working Paper No. 12527*. http://www.nber.org/papers/w12527.pdf.

[190] The version of this paper published in the *Journal of Health Economics* in 2008 includes three different indicator variables for the different completeness possibilities. The resulting coefficient estimates are of mixed signs and levels of statistical significance. Any endogeneity or multicollinearity problems that may be indicated by these inconsistent results would also characterize the specifications that appear in the working paper. We invite comment on whether more robust estimates available for use in monetizing the utility effects of behavior changes brought about by this rule.

reported that their workplaces had complete smoke-free policies. [191] Therefore, only the remaining 53.3 percent, or an estimated 1.6 cigarettes (=3*53.3%) per smoker per day, had the potential to be affected by state smoke-free workplace laws. Combining these results, a smoke-free policy imposed in public housing may, on a per-smoker basis, influence behavior 6.3 (=10/1.6) times more than the smoke-free state laws examined by Markowitz.[192] Hence, a smoke-free housing policy could influence per-smoker behavior 2.19 (=6.3*0.35) times as much as a one-dollar increase in the price of cigarettes.

Burns, Major and Shanks (2003) find that average daily cigarette consumption amongst smokers decreased from the low twenties during the mid-1970s to the high teens during the late 1990s (roughly the time period of the Markowitz study).[193] Because smoke-free workplace laws became more widespread over time and because we are attempting to compare price increases with contemporaneous policy changes, the later results should be weighted more heavily than the earlier, so we assume average daily consumption of 18.5 cigarettes per day. Thus, a one-dollar-per-pack increase in price would cost an average smoker $686 per year, including adjustment for inflation between 1983 (the midpoint base year used by Markowitz) and the present. If a smoke-free housing policy causes 2.19 times the behavior change as a one-dollar cigarette price

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[191] Farrelly, M.C., et al. (1999) The Impact of Workplace Smoking Bans: Results from a National Survey. *Tobacco Control 8*, 272-277.

[192] This six-fold increase would be overestimated if smokers in the Markowitz data set consumed more cigarettes at work than the more recent population for which the three-cigarette result was estimated or if, as might reasonably be expected, voluntary workplace smoke-free policies are negatively correlated with cigarette consumption. On the other hand, the increase is underestimated in that, as indicated by Farrelly et al., many workplaces had partial smoke-free policies for which the per-cigarette impact of statewide bans would have been lower than what would be experienced in a change from no smoke-free policy to a complete smoke-free policy, such as is proposed in this rule. In the absence of further evidence, we assume that the overestimation and underestimation roughly offset each other and invite comment that would allow for refinement of the analysis.

[193] Burns, D.M., et al. (2003). Changes in Number of Cigarettes Smoked Per Day: Cross-Sectional and Birth Cohort Analysis Using NHIS. In *Those Who Continue to Smoke: Is Achieving Abstinence Harder and Do We Need to Change Our Interventions?* Smoking and Tobacco Control Monograph No. 15. U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. http://cancercontrol.cancer.gov/brp/tcrb/monographs/15/monograph15-chapter7.pdf.

increase, then the cost of the policy driving that change is likely to be approximately 2.19 times the cost borne due to the price increase, or $1,501 (=2.19*$686) per smoker, which aggregates to $209 million across the 139,000 smokers affected by this proposed rule.[194]

(F) Resident Behavior

The preceding cost estimate reflects the behavioral changes that have been available to smokers in response to workplace smoke-free policies. Some of the ways a smoker could minimize the cost of compliance are similar in the workplace and housing settings. For example, the timing of smoking breaks could be altered in such a way as to eliminate the travel cost aspect. A smoker could smoke more often when outside the building, about to enter the building, and immediately after leaving the building. All of these small changes are less costly alternatives to a smoking break that involves a two-way trip. If the smoker elects to travel to and fro, then it could be done during a time when the smoker would not suffer significantly from not being in their unit or work station (e.g., in the housing setting, during a commercial break).[195] A smoker could reduce average travel costs by smoking two cigarettes during one break. Another change in behavior that is possible both at work and at home is that a smoker could quit or smoke less. Behavioral possibilities that are analogous, but not identical, are moving to different housing and switching jobs.

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[194] This analysis reflects an assumption that a one-dollar change in price will produce behavior change of a consistent magnitude, regardless of the initial price of a pack of cigarettes. Another possible assumption is that a particular percentage change in price will produce behavior change of a consistent magnitude. The average price of a pack of cigarettes in Markowitz's sample is $1.15, so a one-dollar price increase represents a rise of 89 percent. The American Lung Association (http://www.lung.org/stop-smoking/tobacco-control-advocacy/reports-resources/cessation-economic-benefits/states/united-states.html) reports that the current nationwide average cigarette price is $5.51 per pack, so an 89 percent increase equals $4.79. Using the same consumption estimates as above, a $4.79 price increase would cost a smoker $1,620 per year. If a smoke-free housing policy causes 2.19 times the behavior change as a one-dollar cigarette price increase, then the cost of the policy driving that change is likely to be approximately $3,544 (=2.19*$1,620) per smoker, which aggregates to $493 million across the 139,000 smokers affected by this proposed rule. We request comment on whether the absolute level or the percentage price change is more reasonable for use in this cost analysis.

[195] Adda, J. & Cornaglia, F. (2006). Taxes, cigarette consumption, and smoking intensity. *American Economic Review 96*, 1013-28.

A smoker affected by this proposed rule could risk non-compliance, potentially leading to strategies to hide smoking within the home (increasing fire risk) or smoking each cigarette more intensely (increasing health problems). Given the relative lack of privacy in workplace settings, non-compliance is probably not meaningfully reflected in the cost estimates extrapolated from the workplace setting. Also not reflected is the widening range of alternative means of nicotine delivery, including FDA-approved nicotine replacement therapies (i.e., gum or the patch), as well as non-therapeutic products such as dissolvables, smokeless tobacco, snus, and ENDS.[196]

Because there are multiple methods of compliance available to PHA smokers, they will choose the option (or combination of options) that has the lowest net cost, given their preferences and circumstances.[197] Based on this logic, smokers with a high opportunity cost of time, who have mobility limitations, live furthest from areas where smoking is permitted, or who face harsh weather or dangers (such as traffic or crime) in outdoor areas may be more likely to comply with the rule by quitting smoking or switching to an alternative means of nicotine delivery. Smokers with a low opportunity cost of time and movement, in safe areas with mild climates, may be more likely to comply by smoking tobacco outside.

Because two notable behavioral responses (switching to newly-developed substitute products and non-compliance) are more likely in the housing setting than in the workplace setting, and a greater variety of compliance options decreases regulatory costs, the estimate extrapolated from the workplace setting may represent an overstatement of the costs to affected smokers of this proposed rule.

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[196] Under the Affordable Care Act and subsequent guidance, cessation medications, including nicotine replacement therapy (NRT) products, are to be made available to the insured—including Medicaid enrollees—at no cost to the beneficiaries. Thus, cessation aids may be less expensive than other tobacco products, and affected public housing residents may elect to try to quit with the NRT products rather than substitute a non-combusted tobacco product.

[197] For simplicity, we express the decision as cost-minimization, but benefits—such as health and longevity benefits that are understood and internalized—would factor into affected individuals' decisions as well.

A summary of some of the most notable compliance options, and their implications for the rule's impacts, appears in the table below.

Method of Compliance	***Cost and benefits, as compared with estimates appearing elsewhere in this document***
Smoking at least 25 feet from PHA buildings	Costs as partially estimated in sections 5.4(A) through 5.4(D) and benefits as estimated in section 4.
Switch to ENDS	Costs decrease; health and longevity benefits may decrease but amount of decrease is uncertain due to emerging nature of ENDS research. (If ENDS availability increases compliance with the rule, then benefits may decrease relative to estimates that appear in section 4 but not relative to what would actually be realized with smoking at least 25 feet from PHA buildings as the primary compliance option.)
Smoking cessation	Costs as estimated in section 5.4(E); health and longevity benefits as shown in section 4, including as discussed in sub-section 4.6.
Smokers move out of PHAs, non-smokers move in	Costs decrease but the amount of decrease is unknown due to moving itself being costly; benefits decrease as SHS exposure and fire risks are transferred to new non-PHA neighbors.

6. Transfers

Most studies of the economic impact of smoking address directly observable health costs. Other studies have added other economic impacts such as the reduction of tobacco tax revenue and more controversial "death benefits" such as reduced pension and social security payments.[198] Even when considering additional transfers, there is a net fiscal gain to reducing smoking.[199] The net gain is even larger when SHS is considered.[200]

There are some indirect transfer effects that may be caused by the rule. For example, if smokers move to housing where smoking is allowed because they cannot or do not want to quit, then the costs of the second-hand smoke and the potential for cigarette-caused fires will be transferred to tenants of the new housing, if they choose a multiunit property.

[198] Viscusi, W.K. (1994). Cigarette taxation and the social consequences of smoking. No. w4891. National Bureau of Economic Research; Gravelle, J.G. and Zimmerman, D. (1994). Cigarette taxes to fund health care reform: An economic analysis. *Congressional Research Service No. 94-214*.
[199] Sloan, F.A., et al. (2004), *supra* note 21
[200] Viscusi, W.K. (1994), *supra* note 198.

7. Alternatives

7.1. Status Quo

One alternative to mandating smoke-free policy is to continue to allow PHAs to choose whether and how to implement a smoke-free policy. Such a strategy, which provides flexibility, would be appropriate when all of the costs of smoking are internalized by the individual tenant or PHA. It has also resulted in an inconsistent or scattered adoption across the country, and partial policies that are not as protective. However, sufficient evidence concerning the negative externalities on non-smokers is a strong motivation to favor a mandatory smoke-free policy. Allowing status quo also means that PHAs will continue to absorb the additional costs associated with turning over units after smokers leave, and suffer the substantial costs of renovations and demolitions associated with catastrophic fires.

7.2. Broader Implementation

Currently, the rule exempts dwellings in mixed-finance developments and includes only HUD's government-owned public housing. However, the implementation of smoke-free policy to a wider stock of housing may generate greater benefits given the arguments in favor of smoke-free policy. Mixed-finance projects are an increasing proportion of the affordable housing stock.[201] However, it is reasonable to learn more about the benefits and costs of a rule from the experience of one sub-sector before implementing the rule more broadly.

Another scope of the rule issue concerns the treatment of electronic nicotine delivery systems (ENDS), including electronic cigarettes, which are not currently included in the proposed rule (see see § 965.653(c) of proposed regulatory text). HUD is therefore requesting additional comments on the issue of including ENDS in its policy, including evidence of

[201] In addition, there is the possibility that smokers will move to mixed-finance housing where SHS pollution is permitted.

secondhand smoke health impacts from ENDS. Given the current lack of good estimates on the costs and benefits of including ENDS in the smoke-free policy, this version of the RIA does not speculate on the effects of smokers substituting to ENDS. However, this allowance in the rule will substantially lower the cost of compliance to smokers.[202] The impact on the benefits of the rule depends on substitution behavior by smokers, the secondhand smoke health impacts of active ENDS use, and the external (second-hand) effects of ENDS. All of these variables are subject to substantial uncertainty, especially the secondhand smoke health impacts of the effects of exposure to emissions from ENDS use, the evidence of which is still developing.

Regarding the possibility of substitution, a study of U.S. tobacco markets found that sales of disposable e-cigarettes were higher in areas covered by comprehensive smoking bans than in areas without bans, but this association was not found to be statistically significant. However, that same study found no consistent and statistically significant relationship between sales of ENDS and increases in tobacco cigarette prices or taxes.[203] Moreover, it is important to note the

[202] As discussed in more detail in sections 5.4(E) and 5.4(F), the primary cost estimate is extrapolated from data collected before ENDS were available in the market; therefore, those estimates are likely to be more applicable to this regulatory alternative in which ENDS use is not permitted in public housing than to the rule as proposed. In order to provide a meaningful comparison between the two policy options, we would need a method for estimating costs when electronic but not combustible tobacco products are permitted to be used in homes. Toward this end, we note that individuals who currently smoke combustible tobacco products, rather than switch to electronic nicotine delivery systems, in spite of the lower cost of ENDS, provide an observable willingness-to-pay that could be used to monetize the utility (or "surplus") loss that affected individuals experience as result of the rule. The difference in surplus of each system is bounded by the difference in cost (or willingness to pay for a nicotine experience) between combustible tobacco products and ENDS. (Although some may disagree with framing the problem as one of consumer surplus when analyzing an addictive good, we need not address that issue here because in this case we are comparing two nicotine-based substances.) Back-of-the-envelope calculations indicate that the expenditure differences ranges between $620 and $740 annually ($1,100 for combustible tobacco products, minus $360 to $480 for ENDS). Therefore, across the 139,000 smoking PHA residents who do not already live in units with self- or PHA-imposed smoke-free policies, lost utility estimates range from $86 to $103 million per year. The existence of multiple compliance methods leads to the $86 to $103 million range being interpreted as a ceiling for compliance costs. On the other hand, lack of voluntary switching from combustible to electronic tobacco products indicates that the price difference is a floor on utility loss and thus compliance costs. In light of these analytic challenges, we request comment on methods for estimating regulatory costs under various policy alternatives.

[203] From the study: "Reusable e-cigarette sales were higher in markets with more of the population covered by 100% smoking bans; however, the association was not statistically significant." Huang, J., et al. (2014) The impact of price

limitations of using sales data for this purpose, which may introduce bias. First, the sales figures underestimate the total size and growth of the e-cigarette market because the data do not include sales from other sources where many ENDS users report buying these products, including the Internet and "vape shops." Second, sales data do not capture the full range of ENDS products currently available. In particular, premium tank systems and e-hookahs are likely not captured by these data. A study of New Zealand smokers estimated the cross-price elasticity of demand for electronic and combustible cigarettes to be 0.16.[204] ENDS and tobacco cigarettes might or might not, therefore, be perceived as strong traditional substitute goods.

8. Conclusion

There is little debate on the benefits of living in a smoke free environment. The implementation of a smoke-free policy in public housing would certainly improve the health of public housing residents; reduce the risk of catastrophic fires, and lower overall maintenance costs. Notwithstanding, the implementation of the smoke free policy in public housing will generate some regulatory, compliance and enforcement costs. Further, if the smoking ban is successful, it will have both positive and negative impacts on the welfare of smokers.

The major costs and benefits are as follows:

Source	Compliance Costs	Benefits
PHA	Implementation, enforcement, and eviction	Reduced Fire risk, Lower maintenance costs
Non-smokers	None	Health benefits from reduced SHS
Smokers	Inconvenience	Health benefits from reduced smoking, net of lost Benthamite utility

and tobacco control policies on the demand for electronic nicotine delivery systems. *Tobacco Control 23*, iii41-iii47. http://tobaccocontrol.bmj.com/content/23/suppl_3/iii41.full.pdf+html.

[204] From the study: "Reusable e-cigarette sales were higher in markets with more of the population covered by 100% smoking bans; however, the association was not statistically significant." Grace, R.C., et al. (2014). Estimating Cross-Price Elasticity of e-cigarettes using a simulated demand procedure. *Nicotine and Tobacco Research*. ntu268.

We explore the dimensions of costs to PHAs and the impacts on smokers.

Impact	**Source**	**Amount** (Discount Rates in Parentheses)
Cost (potentially recurring but concentrated during first few years of the rule's implementation)	PHA Compliance	$3.2 million[205]
Cost (recurring)	Inconvenience	$209 million
Cost (recurring)	Enforcement	not quantified
Benefit (recurring)	PHA Reduced Maintenance	$16 to $38 million
Benefit (recurring)	PHA Reduced Fire Risk	$32 million
Benefit (annualized over 10 to 50 years)	Non-Smoker Health	Less than: $148 to $447 million (3%) $70 to $137 million (7%)
Benefit (recurring)	Non-Smoker Well-Being (PHA residents who do not live in units with smokers)	$96 to $275 million
Benefit (recurring)	Smoker Health	not quantified
Partially Quantified Net Benefits (recurring)	See above	Less than: -$19 to $302 million (3%) -$97 to -$8 million (7%)

The burden on smokers is estimated to be approximately $209 million. Smokers who quit or substantially reduce smoking would experience decreases in smoking-attributable medical costs, health improvements, and productivity gains.

The burden on PHAs will depend on method of enforcement. If a PHA hires someone whose sole job is to administer the smoke-free policy, then the rule will present significant opportunity costs. For this reason, PHAs are more likely to rely on self-monitoring by tenants. An unavoidable cost, however, is dealing with repeat offenders. Eviction costs could range as high as $2.2 million in first few years.

[205] Maximum eviction costs of $2.2 million plus notification costs of $1 million. In the first year, the costs of notification are expected to be substantially higher ($10 million).

The aggregate benefit to non-smokers in the form of direct health improvement varies substantially depending on the discount rate, with upper bound benefits estimates ranging from $148 to $447 million with a 3 percent discount rate or from $70 to $137 million with a 7 percent discount rate. Reduction in costs for PHAs is expected to range from $16 million to $38 million. The reduction in fire damage is estimated at $32 million.