Windows of opportunity: lead poisoning prevention, housing affordability, and energy conservation

Rick Nevin and David / E. Jacobs

2006

Windows of Opportunity: Lead Poisoning Prevention, Housing Affordability, and Energy Conservation

Rick Nevin and David E. Jacobs
National Center for Healthy Housing

Abstract

We used housing demolition and window replacement rates to forecast prevalence trends for childhood lead poisoning and lead paint hazards from 1990 to 2010 for the President's Task Force on Environmental Health Risks and Safety Risks to Children. The mid-point of that forecast has now been validated by national blood lead data and the 1998–2000 National Survey of Lead and Allergens in Housing.

The validation of the task force model and new analysis of these survey data indicate that window replacement explains a large part of the substantial reduction in lead poisoning that occurred from 1990 to 2000. A public-private effort to increase window replacement rates could help eliminate childhood lead poisoning by 2010. This effort would also improve home energy efficiency and affordability, in addition to reducing air pollution from power plants, and a broader initiative could reduce other housing-related health risks as well.

Keywords: Community development and revitalization; Energy conservation; Lead poisoning

Introduction

The U.S. Centers for Disease Control and Prevention (CDC) states that blood lead levels above 10 micrograms per deciliter (µg/dL) are associated with "harmful effects on children's learning and behavior" (CDC 1997b, 9). This article shows that a substantial reduction in the number of children with elevated blood lead (EBL) at or above 10 µg/dL from 1990 to 2000 can be largely explained by window replacement. An initiative to increase window replacement rates could help eliminate childhood lead poisoning by 2010 *and* improve home energy efficiency and affordability because old windows with lead paint on interior surfaces also have single panes. Replacing single-pane windows with ENERGY STAR windows can substantially reduce home energy use, associated air pollution from power plants, and fuel bills that adversely affect the affordability of low-income housing.

In February 2000, the President's Task Force on Environmental Health Risks and Safety Risks to Children published the first federal interagency strategy to eliminate childhood lead poisoning from exposure to lead paint hazards by 2010. The report forecast the prevalence of lead paint hazards and EBL prevalence from 1990 to 2010 based on a model constructed in 1999, when the most recent data came from the National Health and Nutrition Examination Survey (NHANES) III, phase 2 (1992 to 1994), and the 1989–90 National Lead Paint Survey (NLPS) (U.S. Department of Housing and Urban Development [HUD], Office of Policy Development and Research 1990). The task force model combined these data with housing demolition and window replacement rates derived from the 1989–97 (five biannual) American Housing Surveys (AHS) (U.S. Bureau of the Census and HUD 2001) and the 1993 Residential Energy Consumption Survey (RECS) (U.S. Department of Energy [DOE] 1995). For 1989 to 2000, the model forecast a 25 percent decline in the number of housing units with lead paint hazards, with window replacement accounting for 70 percent of that decline and demolition accounting for the remainder. On the basis of the estimated decline in lead paint hazards, the model also forecast a substantial decline in prevalence of EBL in children under six.

The task force anticipated that the demolition of older homes would reduce both lead paint hazards and the prevalence of EBL because lead paint was widely used on interior and exterior surfaces before 1940. In addition, NLPS and RECS data for pre-1940 units showed that window replacement is a good indicator of the kind of housing rehabilitation that is likely to remove lead paint and the most severe dust lead hazards. NLPS data showed that 17 percent of pre-1940 units had no interior lead paint in 1989, and RECS data showed that 13 percent of pre-1940 units had had all of their windows replaced before 1990. This suggests that most pre-1940 units with no interior lead paint in 1989 had probably had it removed through substantial rehabilitation, including window replacement.

In addition to serving as an indicator of extensive rehabilitation and ongoing property maintenance, window replacement was directly linked to reducing lead paint hazards. The NLPS showed that windows were where lead paint and the highest levels of dust lead were most likely to be found. Dust lead on horizontal window surfaces is also significantly correlated with the levels of lead in children's blood (Lanphear et al. 1995). Further, the national evaluation of the HUD lead hazard reduction grant program showed that window replacement is a common hazard control strategy adopted by many local governments receiving HUD grants (National Center for Healthy Housing 2004).

An analysis of these national evaluation data demonstrated the short- and long-term effectiveness of window replacement with respect to controlling dust lead hazards (HUD, Office of Lead Hazard Control 1999a). This analysis found that pre-intervention median dust lead loadings in rooms treated with paint stabilization *and* window replacement were 60 percent higher than in rooms treated with paint stabilization and window repairs, and over three times higher than in rooms treated only with paint stabilization. These data indicate that window replacement was an especially common intervention strategy in rooms with severe dust lead hazards. But after six months, rooms that underwent window replacement, cleanup, and clearance had postintervention dust lead loadings that were significantly lower than they were in rooms with just window repair. Also, one year after the intervention, loadings were significantly lower in rooms that underwent window replacement than in rooms with just paint stabilization (HUD, Office of Lead Hazard Control 1999a). Moreover, evaluation data show that dust lead loadings were lower in units with window replacement three years after the intervention (National Center for Healthy Housing 2004).

In effect, the task force model assumed that units with interior lead paint in 1989 would follow one of three paths that would determine the risk of having lead paint hazards through 2010. Some would undergo window replacement and ongoing property maintenance, resulting in a low risk of lead paint hazards. Others would be demolished, and still others would remain occupied without window replacement, resulting in a high risk of lead paint hazards over the 20-year forecast horizon.

The term “high risk” as used here should not be confused with the regulatory definition of lead paint hazards. These are identified at a given housing unit at the time of risk assessment, whereas the task force model forecast the risk of such hazards over a 20-year horizon. From a regulatory standpoint, intact interior lead paint, by itself, does not constitute a lead paint hazard, but the model defined high-risk units in 1989 to include all units with interior lead paint, whether intact or deteriorated, because such homes had a higher risk of developing lead paint hazards (including dust lead hazards) over the 20-year horizon. Units that had dust lead hazards in 1989 but no interior lead paint were counted as low risk in the model because without a source of potential recontamination, these hazards would likely dissipate with routine housecleaning over the 20-year horizon. The NLPS showed that homes with interior lead paint were more likely to have lead paint hazards, so there was substantial overlap between 1989 units with lead paint hazards and units defined as high risk in the model.

The forecast was then combined with 1992–94 NHANES EBL data and AHS data on children under six per occupied unit to estimate the number of children with EBL through 2010 by family income, age of housing, and housing risk (high or low). The EBL forecast also reflected the 2000–10 impact of the HUD assisted-housing rule on lead paint (24 CFR Part 35), which took effect in 2000, protecting children in public housing and in project-based and tenant-based rental units. Assisted rehabilitation programs subject to the rule were expected to replace windows at about the same overall rate reflected in the housing risk forecast (which was based on AHS and RECS data that include these programs), so the model did not assume any further reduction in high-risk housing directly related to assisted rehabilitation.

Validation of the model

Overall, the model forecast a decline in high-risk housing from 44.2 million units in 1989 to 33.3 million in 2000. This forecast has been validated by lead paint hazard data from HUD's 1998–2000 National Survey of Lead and Allergens in Housing (NSLAH) and the 1999–2000 NHANES data.

The model's emphasis on window replacement is also validated by analysis of NSLAH, RECS, and AHS data on windows (Jacobs and Nevin 2006). The NSLAH data show that dust lead hazards (as defined in the next section) are especially common and severe in units with lead paint on interior window surfaces. Comparing the NSLAH data with RECS and AHS window data indicates that replacing single-pane windows in pre-1960 homes also effectively targets windows with lead paint on interior window surfaces. These data, and the validation of the model, indicate that single-pane window replacement can help eliminate childhood lead poisoning by 2010, while at the same time increasing home energy efficiency, reducing air pollution from power plants, and improving affordability through lower fuel bills.

The risk to children from exposure to lead

Children under six are especially vulnerable to lead exposure because their nervous systems are still developing (National Academy of Sciences 1993). Although childhood blood lead levels at or above 10 μg/dL are characterized as EBL, CDC warns that "there may be no lower threshold for some of the adverse effects of lead in children" (1997a). In addition to many other adverse health effects, recent research has shown that even blood lead levels below 10 μg/dL in early childhood may be associated with intellectual impairment

(Canfield et al. 2003). Other research has shown that exposure to lead in early childhood has a strong association with delinquent and criminal behavior among juveniles and young adults (Denno 1990; Dietrich et al. 2001; Needleman et al. 1996; Nevin 2000).

During the 20th century, the two main sources of childhood lead exposure were leaded gasoline emissions and lead paint (Agency for Toxic Substances and Disease Registry 1988; Clark et al. 1991; Jacobs 1995). Lead poisoning can be caused by inhalation of lead in the air, ingestion of lead paint chips, and occasionally other sources, but the main exposure pathway today is from lead-contaminated dust that settles on horizontal surfaces such as floors and window sills and is then ingested via normal hand-to-mouth contact in children (Bornschein et al. 1987; Duggan and Inskip 1985; Lanphear et al. 1995). Very young children are especially at risk because the brain undergoes critical development in the first few years of life, when children have regular hand-to-mouth activity as they crawl. Lead ingested via contaminated dust on children's hands is absorbed into the bloodstream and carried to the developing brain.

The amount of dust lead ingested by young children due to lead paint or exposure to the lead in gasoline emissions is several times greater than average lead ingestion via other pathways (U.S. Environmental Protection Agency [EPA] 1986). Before leaded gasoline was banned, urban children were exposed to dust lead from settling gasoline emissions. Homes with interior lead paint are especially likely to have dust lead hazards if the paint has deteriorated (Jacobs et al. 2002), but these hazards may also be created by lead paint on friction and impact surfaces, such as windows, and by home renovation that disturbs the paint without appropriate dust containment and cleanup (President's Task Force on Environmental Health Risks and Safety Risks to Children 2000).

Pursuant to the Residential Lead Hazard Reduction Act of 1992, otherwise known as Title X of the 1992 Housing and Community Development Act (Public Law 101–550; 42 USC 4851 *et seq*.), EPA and HUD now define housing units with lead paint hazards to include housing that exceeds any one of the following (EPA 2001b):

1. Deteriorated lead paint above *de minimus* levels[1]

2. Dust lead loadings above 250 micrograms of lead per square foot of surface area (μg/ft^2) on interior window sills (measured by wipe sampling)

[1] References in this article to lead paint refer to paint equal to or exceeding the regulated minimum of one milligram of lead per square centimeter of painted surface (1 mg/cm^2), and deteriorated lead paint refers to deterioration exceeding *de minimus* levels of 2 square feet on large interior surfaces, 10 percent of window sashes or other small interior surfaces, and/or 20 square feet of exterior surfaces.

3. Dust lead loadings above 40 μg/ft^2 on floors (measured by wipe sampling)
4. Bare soil lead concentrations exceeding 1,200 parts per million (ppm) or 400 ppm in play areas

To put the dust standards into perspective, if a one-square-foot area of lead paint at the minimum regulated concentration (1 mg/cm^2) is sanded and turned into dust that is distributed evenly over a 10- by 10-foot room and none of that dust is cleaned up, then the level of dust lead would be 9,300 μg/ft^2 (HUD 1995), more than 230 times the level regulated by EPA and HUD. Dust lead loadings above the standards can raise blood lead to levels that can impair cognitive development in a child (EPA 2001b; HUD, Office of Lead Hazard Control 1999a; Lanphear et al. 1998). Higher loadings are associated with higher levels of lead in the blood and more severe cognitive damage.

Trends in childhood lead poisoning

The percentage of children under six with blood lead levels at or above 10 μg/dL fell from 88 percent during NHANES II (1976 to 1980) to 9 percent during NHANES III, phase 1 (1988 to 1991) (Pirkle et al. 1994). This decline revealed the public health benefit of regulatory actions to remove lead from gasoline, new paint, and the solder used in food and beverage cans. But those same data showed that 1.7 million U.S. children under six still had EBL. The sale of lead paint for residential use was banned in 1978 (U.S. Consumer Product Safety Commission 1977), but a large body of research shows that lead paint hazards in older homes are the most important remaining source of childhood lead exposure today (CDC 1991, 1997b; National Academy of Sciences 1993; President's Task Force on Environmental Health Risks and Safety Risks to Children 2000). The NHANES report concluded with the following warning about residential lead paint hazards: "Without efforts to reduce these exposures, population blood lead levels are unlikely to continue to decline" (as cited in Pirkle et al. 1994, 291).

EBL prevalence in U.S. children under six then declined to 4.4 percent during NHANES III, phase 2 (1992 to 1994), but those data showed a prevalence of 16.4 percent among low-income children and 22 percent among black children living in homes built before 1946 (CDC 1997c). EBL prevalence for all children under six fell further to 2.2 percent during the 1999–2000 NHANES (Meyer et al. 2003).[2] The decline through 2001 is confirmed by

[2] The 95 percent confidence interval for the 1999–2000 NHANES is large due to sample size limitations, but the decline in the NHANES EBL prevalence point estimate is also consistent with the CDC surveillance data trend.

CDC surveillance data (CDC 2000; Meyer et al. 2003) that reflect blood lead tests for about 7 to 8 percent of children under six for each year from 1997 to 2001 and account for a larger share of children with EBL because surveillance programs target low-income areas with older housing and a higher prevalence of EBL. Even within this at-risk population, the prevalence of EBL (as a percentage of children tested) declined from 7.66 percent in 1997 to 3.01 percent in 2001, although the disparity between low-income minority children and other children was still large (Meyer et al. 2003).

The magnitude of the decline in the prevalence of childhood EBL reported by NHANES, from 9 percent in 1988 to 1991 to 2.2 percent in 1999 to 2000 clearly indicates a national trend, which is confirmed by 1997–2001 CDC surveillance data. But there were still 434,000 children with EBL in 1999 to 2000, and CDC noted that the 2000 national goal of eliminating blood lead levels above 25 µg/dL was not achieved. In short, despite significant progress, lead poisoning arising primarily from lead paint hazards in housing remains a major childhood environmental disease in the United States.

Policies and practices that reduce lead paint hazards and childhood lead poisoning

The dramatic decline in the prevalence of EBL over the 1990s is due in part to government efforts to reduce lead paint hazards, including efforts mandated by Congress with the passage of Title X, which authorized new programs that educated the public, required disclosure of known lead paint hazards in most pre-1978 housing, and provided HUD funding to eliminate lead paint hazards in privately owned low-income housing. HUD grant funding controlled lead paint hazards in many privately owned low-income units posing the greatest risks in the 1990s, but grant program units directly account for only a small percentage of the decline in units with lead paint hazards during that time. Regulatory efforts by some state and local governments also accounted directly for only a small portion of the decline. Title X prescribed activities to control lead paint hazards in federally assisted housing, but HUD did not issue new regulations for such housing until 1999, so the trend in childhood lead poisoning during the 1990s cannot be explained solely by regulatory changes.

The 1999 assisted-housing rule (24 CFR, Part 35) requires lead paint hazard evaluation and reduction in public housing, in project-based and tenant-based rental units, and in HUD-assisted rehabilitation and other programs (HUD, Office of Lead Hazard Control 1999b). For most assisted housing, the rule requires safe work practices, stabilization of deteriorated lead paint, cleanup, and clearance testing for dust lead hazards. For units receiving less than $25,000 of federal rehabilitation assistance (accounting for the vast majority of such units), the rule also requires friction and impact repair work on window surfaces with lead paint (as needed) to reduce friction as the sash is operated, thus reducing the generation of dust lead. The HUD rule does not generally require window replacement, but the economic analysis of the rule determined that replacement provides a longer-lasting reduction in dust lead hazards. Further, this analysis showed that the cost of window replacement could often be recovered by energy savings and increased home value resulting from energy-efficient windows (HUD, Office of Lead Hazard Control 1999a).

Recent trends in window replacement

The task force forecast through 2010 reflected window replacement rates based on RECS and AHS data through 1997 only. But AHS data (table 1) now show that the window replacement share of non-disaster-related assisted upgrades actually increased from 9.1 percent in 1997 to 13.3 percent in 2001, and the window replacement share of assisted-rehabilitation spending in pre-1960 homes rose from 7.2 percent to 15.3 percent. There was also a significant though somewhat smaller increase in the share of *unassisted* home upgrade spending in pre-1960 units devoted to window replacement, from 7.8 percent to 8.5 percent.

Higher window replacement rates are further evident in market research data showing that sales of residential replacement windows increased from 29.9 million window units in 1999 to 33.3 million in 2003, exceeding the 29.5 million sold for new construction in 2003 (Drucker Research Co. 2004). The increase in window replacement likely reflects a combination of increased awareness of how windows affect lead paint hazards and how replacement can reduce home energy costs. In 1997, window manufacturers formed the Effi-

Table 1. Percentage of Non-Disaster-Related Upgrade Expenditures Used for Window Replacement

	1997 (%)	2001 (%)
All assisted upgrades	9.1	13.3
Assisted upgrades in pre-1960 units	7.2	15.3
All unassisted upgrades	8.5	8.7
Unassisted upgrades in pre-1960 units	7.8	8.5

Source: U.S. Bureau of the Census and HUD 2001.

Note: The HUD rule on lead paint hazards in federally assisted housing, which took effect in 2000 and increased awareness of potential energy savings, appears to be shifting more upgrade expenditures to window replacement, especially in pre-1960 government-assisted projects.

cient Windows Collaborative (EWC) to promote energy savings and other benefits of high-efficiency windows. In 1998, the ENERGY STAR program, jointly sponsored by EPA and DOE, established the ENERGY STAR windows standard. Replacing single-pane windows with clear-glass double-pane windows can reduce fuel bills by about 10 percent to 15 percent, whereas savings with ENERGY STAR windows can exceed 20 percent, increasing the financial incentive for replacement (Nevin, Gazan, and Bender 1999). Concerns about generating capacity have also led to some utility-sponsored incentive programs for ENERGY STAR windows, because the low solar gain of high-efficiency windows produces the greatest savings in electricity during the afternoon hours when peak demand strains system capacity (EWC 2004).

Rising energy prices

Moreover, rising fuel oil and natural gas prices since 2001 have increased the energy saving incentives for window replacement. In the case of assisted housing, these incentives converge with a memorandum of understanding signed by HUD, DOE, and EPA in 2003, agreeing to use more ENERGY STAR products in HUD housing programs. According to the memorandum, HUD spends more than $4 billion annually on utility bills—in excess of 10 percent of its total budget (HUD 2004). CDC and HUD also sponsored a windows symposium in 2004, bringing together lead hazard reduction, weatherization, and other assisted rehabilitation grantees, plus mortgage underwriters and health and housing policy experts, to discuss the multiple benefits of window replacement (National Center for Healthy Housing 2005).

Windows of opportunity: Simultaneously eliminating childhood lead poisoning, increasing energy efficiency, improving housing affordability, and reducing air pollution

These findings indicate that window replacement can help eliminate childhood lead poisoning by 2010, while increasing housing affordability through greater home energy efficiency; however, window replacement that disturbs lead paint without proper cleanup and clearance testing can actually increase dust lead hazards in the short term. To eliminate short- and long-term risks, public education about lead paint hazards, regulatory requirements, and assisted rehabilitation funding should be designed to complement and enhance market incentives for window replacement and increase replacement rates in low-income housing with lead paint hazards.

The task force model accurately forecasted the decline in lead paint hazards and children with EBL through 2000 based on housing demolition and window replacement rates, but market forces alone are unlikely to achieve the national goal of eliminating childhood lead poisoning by 2010. The 2000 NSLAH showed that dust lead hazards are still common in units with deteriorated interior lead paint (Jacobs et al. 2002), thus indicating a continuing need for better enforcement of housing and health codes that prohibit deteriorated paint conditions, as well as public education about lead paint hazards. AHS data also show a much lower rate of window replacement in low-income housing, demonstrating the need for lead hazard reduction and other housing rehabilitation in such units.

Window replacement and other rehabilitation work that disturbs lead paint without proper cleanup can increase exposure in the short run, and renovation without proper cleanup was a likely cause of dust lead hazards in some NSLAH homes with no interior lead paint. While the prevalence of dust lead hazards in such units was relatively low, homes without interior lead paint still accounted for a substantial number of all units with dust lead hazards. The median severity of those hazards (i.e., micrograms of lead per square foot) was relatively low, but any dust lead loading above regulatory standards can cause cognitive damage in young children. The HUD lead paint rule requires federally assisted housing programs to conduct cleanup and clearance testing to address the immediate risk of dust lead hazards, but further efforts are needed to encourage testing to verify proper cleanup after all rehabilitation and window replacement work that disturbs lead paint, including work done without federal assistance.

A simple home upgrade strategy for lead hazard reduction and energy efficiency

The task force strategy to eliminate childhood lead poisoning by 2010 focused on low-income children living in older housing and estimated the direct federal assistance needed to protect this most at-risk population. To protect middle- and upper-income children, the strategy also called for "education and training of painters, renovators, remodelers, maintenance workers, landlords, parents, and others, combined with tax or other financial incentives" (President's Task Force on Environmental Health Risks and Safety Risks to Children 2000, 13). About a third of children with EBL in the 2000–10 forecast actually come from families that have incomes above 130 percent of the poverty level and therefore are generally not eligible for government assistance.

The challenge of meeting the 2010 goal remains twofold: to provide the financial assistance needed to eliminate lead paint hazards in low-income households and to provide additional incentives for middle- and upper-income households to eliminate lead paint hazards in their homes. The validation of the model, the NSLAH data on windows and dust lead hazards, and the comparison of single-pane window data with NSLAH data on interior window surfaces with lead paint all suggest that this challenge can be met by a coordinated effort to promote the following "lead-safe window replacement" home upgrade:

1. Replace single-pane windows with ENERGY STAR windows
2. Use safe work practices to stabilize any deteriorated paint (HUD 1995)
3. Remove dust lead hazards with specialized cleaning
4. Conduct clearance testing for dust lead hazards to ensure that units are safe for children after the work has been completed

Under the HUD rule for federally assisted housing, lead paint hazard controls can be completed without testing the lead content in paint if all deteriorated paint is presumed to be lead paint and is stabilized and if work is followed by cleanup and clearance testing. Replacing single-pane windows in older homes would also effectively target windows with lead paint on interior surfaces, without testing for lead in paint. Therefore, an upgrade strategy that combines the replacement of single-pane windows, the stabilization of deteriorated paint, cleanup, and clearance testing would simultaneously address the immediate risk of lead paint hazards and the long-term risk of dust lead related to lead paint on window surfaces. This lead-safe window replacement upgrade could be combined with other work, and cleanup and clearance testing would also prevent the risk of dust lead hazards created by rehabilitation.

HUD and EPA have already taken some actions that should help encourage lead-safe window replacement. For example, the only independent inspection required for this upgrade would be a postproject visual evaluation for deteriorated paint and dust wipe clearance testing. To lower the cost of testing, HUD and EPA have developed clearance technician training that does not require more highly trained risk assessors and lead paint inspectors. An initiative that combined lead-safe window replacement with low-income homeownership assistance could also train home inspectors to be clearance technicians, and those inspectors could then provide dust lead clearance services to middle- and upper-income home buyers.

Further, HUD could encourage lead-safe window replacement by stating that this upgrade strategy satisfies regulatory requirements for any work done in coordination with lead hazard reduction grantees. Coordinating lead hazard reduction with homeownership initiatives, weatherization, and other assisted rehabilitation programs could be facilitated by establishing a single set of income eligibility criteria for programs funding lead-safe window replacement.

Federal aid

In fiscal year 2000, the federal government provided state and local governments with more than $8 billion for the rehabilitation of low-income housing, energy assistance, new home buyer assistance, construction of affordable housing, and economic development (HUD, Office of Policy Development and Research 2000). Just over 25 percent of this money was used for rehabilitation assistance, and only 2 percent was used for window replacement. The 2001 AHS data indicate that a larger share of assisted rehabilitation funds are now being spent on window replacement, but there is still more potential for a window replacement strategy that leverages federal and private sector funding to achieve long-term reduction in lead hazards and improvements in home energy efficiency that permanently reduce fuel bills.

Shared incentives and leveraged funding for a coordinated public/private window replacement initiative

A lead-safe window replacement initiative would provide enduring reduction in lead paint hazards, substantial home energy savings, improvements in affordability, and reductions in power plant emissions, plus higher home values and associated neighborhood revitalization. Stabilizing all deteriorated paint (including any lead paint) and conducting proper cleanup and clearance testing for lead-contaminated dust would eliminate any immediate risk of lead paint hazards, and replacing all single-pane windows would address the long-term risk of recurring dust hazards from lead paint on interior window surfaces. Replacing single-pane windows with ENERGY STAR windows would also reduce heating and cooling bills by 20 percent or more (EWC 2004; Nevin, Gazan, and Bender 1999), with associated reductions in power plant emissions. In addition to annual savings on fuel bills, there is evidence that energy efficiency, and particularly window replacement, increase residential home value (discussed later), with associated benefits for neighborhood revitalization. The multiple benefits of this upgrade strategy mean that window replacement in low-income housing could be financed in at least four ways:

1. By attracting additional funding through utility-sponsored and other charities that communicate multiple benefits related to children's health, energy efficiency, pollution prevention, low-income homeownership, and neighborhood revitalization

2. By leveraging public funding with energy-efficient mortgage (EEM) financing by combining window replacement with low-income homeownership efforts

3. By providing matching funds and regulatory incentives for state and local governments to shift more existing public funding to window replacement
4. By encouraging window manufacturers to incorporate health information into their marketing messages to create informed consumers

The first and third tactics are related in that utility-sponsored charities could provide a source of matching funds to encourage state and local governments to shift more existing public funding to lead-safe window replacement. Many utilities already sponsor fuel funds that make charitable appeals for low-income energy assistance. These generate over $100 million per year in donations, leveraged by Low-Income Home Energy Assistance Program (LIHEAP) incentive funds for which states can apply on the basis of nonfederal contributions.

LIHEAP primarily helps low-income households pay their energy bills, but states can use 15 percent (and, with a waiver, up to 25 percent) of LIHEAP funds for weatherization. Many local jurisdictions already coordinate their weatherization and lead hazard reduction programs. LIHEAP funds are generally administered together with Weatherization Assistance Program (WAP) funds. Most fuel funds use flyers mailed out with utility bills to appeal for short-term bill-paying assistance, but some have broadened their mission to include weatherization. A lead-safe window replacement initiative could build on this model, increasing the fund-raising potential by broadening the charitable appeal to encompass childhood health protection through lead hazard reduction, long-term reductions in fuel costs for low-income families through energy efficiency, and associated reductions in power plant emissions, plus housing rehabilitation and neighborhood revitalization.

The federal government could also enhance incentives for matching funds by increasing the percentage of LIHEAP money that states can use to match fuel fund charity donations for lead-safe window replacement. Moreover, working through utility-sponsored fuel funds could leverage existing utility programs to promote Energy Star products, including windows. In addition, a funding appeal highlighting the multiple benefits of lead-safe window replacement in low-income housing would help communicate the benefits of this upgrade to middle- and upper-income households.

Moreover, the fuel bill savings from window replacement can provide a way to increase low-income homeownership by leveraging public funds with Federal Housing Administration (FHA), Department of Veterans Affairs (VA), Fannie Mae, and Freddie Mac EEMs. An EEM recognizes the economic value of energy efficiency as part of the mortgage underwriting process. HUD's (2004) Energy Action Plan calls for the promotion of the FHA EEM as a priority single-family insured loan product, and HUD has clarified and enhanced the EEM product to make it more widely available:

> The [FHA] EEM program allows a borrower to finance 100 percent of the expense of a cost-effective "energy package," i.e., the property improvements to make the house more energy efficient. A cost-effective energy package is one where the cost of the improvements, including maintenance, is less than the present value of the energy saved over the useful life of those improvements. The borrower does not need to qualify for the additional financing or provide additional downpayment. There is also no need for a second appraisal that reflects the expense of the energy package and the improvements may be applied to retrofit an existing house.…
>
> [T]he mortgage lender, using the energy rating report and an EEM worksheet will determine the dollar amount of the cost-effective energy package that may be added to the loan amount. This dollar amount cannot exceed 5 percent of the property's value (not to exceed $8,000) or $4,000, which ever is greater. Regardless of the property's value, every borrower who otherwise qualifies can finance at least $4,000 of the costs of the Energy Package if the cost exceeds $4,000.…The FHA maximum loan limit for the area may be exceeded by the cost of the energy efficient improvements. (HUD 2005)

With EEM financing, energy savings from lead-safe window replacement could effectively serve as down payment assistance, allowing state and local governments to support affordable housing, home ownership, energy efficiency, and lead hazard reduction with the same leveraged funds. FHA, VA, Fannie Mae, and Freddie Mac could also encourage a lead-safe window replacement homeownership initiative by providing a simplified EEM specifically for this upgrade strategy. EEMs generally require a home-specific energy rating to estimate the annual fuel savings from an energy-efficient upgrade, but the ENERGY STAR new home standard can be satisfied by a Home Energy Rating System (HERS) score *or* a set of prescriptive specifications called Builder Option Packages (BOPs) that EPA created for two reasons: "1) prescriptive specifications are an easy way to communicate ENERGY STAR qualified new home requirements to prospective partners, and 2) in states where HERS ratings are not available, BOPs represent an alternative verification method" (EPA 2005a).

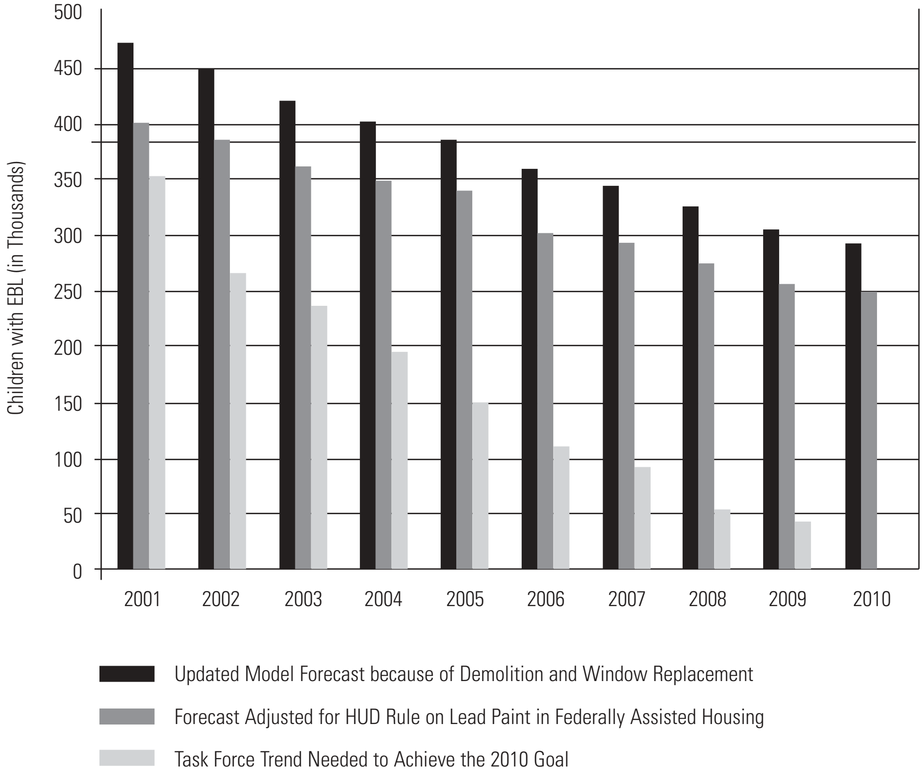
A simplified EEM could encourage assisted rehabilitation and weatherization grantees to pursue a leveraged home ownership, energy efficiency, and lead hazard reduction strategy by specifying that the lead-safe window replacement upgrade is a "rehab option package" that qualifies for EEM financing or at least that some percentage of upgrade costs would qualify. For example, if 80 percent of lead-safe window replacement upgrade costs qualified for the FHA EEM, then state and local grantees could finance a $10,000 upgrade with $2,000 of federal funding plus $8,000 added to the home buyer's mortgage, without the expense of obtaining a home-specific energy rating. Upgrade costs for lead-safe window replacements would be less than $10,000 in most assisted units, depending on the number of single-pane windows replaced, and would be closer to $3,000 per unit for a low-income homeownership effort targeting attached (row) houses for upgrades (HUD, Office of Lead Hazard Control 1999a), because row houses typically have fewer windows.

Of course, mortgage underwriters must be concerned with default risks related to loan-to-value ratios, but an analysis of AHS data indicates that home value increases by $20 for every $1 reduction in annual fuel bills, on average, consistent with a rational trade-off between fuel savings and after-tax mortgage interest (Nevin and Watson 1998). An analysis comparing this finding with the collective judgment of real estate agents participating in a *Remodeling Magazine* (*RM*) "Cost vs. Value" survey also found that the cost of window replacement can be fully recovered by the increased market value of energy-efficient windows (Nevin, Gazan, and Bender 1999). The 1993 *RM* survey actually reported that realtors in 60 metropolitan areas estimated that about 74 percent of the cost of window replacement would be recovered at resale, but an analysis of fuel savings associated with this upgrade indicated that the 1993 estimates were consistent with the energy efficiency value resulting from upgrades to clear-glass double-pane windows, plus an appearance value for new windows.

In addition, this analysis found that additional energy savings from ENERGY STAR windows could increase resale value to close to 100 percent of the cost of the upgrade (Nevin, Gazan, and Bender 1999). According to the 2003 and 2004 *RM* surveys, some combination of higher fuel costs and greater awareness of higher fuel savings with ENERGY STAR windows has since increased the estimated resale value associated with window replacement to 85 percent of the cost of the upgrade (Alfano 2004).

The 2001 AHS data suggest that the overall window replacement rate in pre-1975 housing has increased by at least 20 percent, relative to the 1989–2000 replacement rates used in the original task force model. Figure 1 shows that the model, updated to reflect 2001 AHS data on children per unit and percentage below 130 percent of poverty, plus a 20 percent increase in window replacement rates for 2000 to 2010 (relative to 1989–2000 rates),

Figure 1. Forecast Decline in Children with EBL



Source: Task force model estimates (updated to reflect 2001 AHS data, and higher window replacement rates) (President's Task Force on Environmental Health Risks and Safety Risks to Children 2000).

Note: The updated model now forecasts that market trends for window replacement and demolition would reduce the number of children with EBL to 292,000 by 2010 without other efforts to reduce childhood lead exposure. The new HUD rule will also protect children living in federally assisted housing, and a lead-safe window replacement initiative could achieve the national goal to eliminate childhood lead poisoning by 2010.

now forecasts that window replacement and demolition market trends alone would reduce the number of children with EBL to 292,000 by 2010. The new HUD rule will also protect more children living in federally assisted housing, but figure 1 shows that without further action, 250,000 children would still be at risk in 2010. A public-private lead-safe window replacement initiative that leverages federal funds with EEM financing and charitable appeals, combined with the marketing strategies, enforcement, and other initiatives outlined here, holds great promise for protecting all children and eliminating childhood lead poisoning by 2010.

A broader strategy to achieve housing, health, and energy policy goals

The validation of the task force model also suggests that a more systematic effort to combine housing and health strategies could further protect children (and adults) from other diseases related in part to housing conditions. In addition, the lead-safe window replacement strategy could serve as a model for bundling home health hazard improvements with energy efficiency upgrades to leverage available resources. This intervention strategy could be accompanied by longitudinal health and housing research by using the national evaluation of the lead hazard reduction grant program as a model for tracking costs, health benefits, energy savings, and other benefits from bundled home improvements.

Although home weatherization is sometimes associated with increased indoor air pollution and mold and moisture problems, WAP has found that occupants of properly weatherized homes report a lower incidence of colds, flu, allergies, headaches, and nausea, while a control group showed no change over the same period (Berry, Brown, and Kinney 1997). Some of these health benefits may be directly related to energy efficiency improvements that reduce drafts and improve temperature consistency, but WAP also routinely repairs combustion equipment and exhaust ventilation systems to reduce the risk of carbon monoxide poisoning and other health hazards. Leaking air ducts reduce home energy efficiency and also cause moisture problems that are associated with mold-induced illness and the distribution of indoor air pollution throughout a home. An Energy Star specification promotes the indoor air quality benefits of proper duct sealing, in addition to the significant energy savings potential. In fact, EPA has proposed a system that combines Energy Star with other healthy housing investments (2005b).

Substandard housing conditions have been linked to a large number of adverse health outcomes (Breysse et al. 2004; Krieger and Higgins 2002; Matte and Jacobs 2000). For example, dust mites, mold, cockroaches, and other allergens in the home are triggers for asthma, especially in children. The specialized cleanup required to remove dust lead hazards, such as using a high-efficiency particulate air (HEPA) vacuum cleaner, is similar to cleanup techniques used to reduce allergens in dust. Such cleaning, together with other coordinated housing and medical interventions, has achieved statistically significant improvements in asthma in a large inner-city cohort of children in seven cities (Morgan et al. 2004). Integrating these hazard reduction protocols could simultaneously address both dust lead hazards and the most common triggers for asthma.

A cost-effective way to provide energy savings and previously unrecognized health benefits is to add wall insulation with high-density installation methods that provide significant energy savings related to air infiltration (Berry, Brown, and Kinney 1997). An Energy Star home sealing standard combines an upgrade to Energy Star windows with high-density insulation to achieve DOE-recommended levels, which vary by climate region, and better management of the fresh air supply, which can be verified by "blower door" tests (EPA 2001a). An integrated cleanup protocol, combined with Energy Star home sealing and improved moisture management, will reduce lead hazards and allergens linked to asthma while at the same time yielding substantial improvements in home energy efficiency. Independent evaluation costs could also be minimized and made available to more households by training home inspectors in dust lead clearance, allergen, and blower door testing.

Further research on the relationship between housing conditions and health outcomes is needed. While the energy efficiency benefits of window replacement, high-density insulation, and duct sealing are well established, related health benefits, especially those associated with chronic disease morbidity and mortality, are only beginning to be fully understood. The experience with lead poisoning, which clearly shows the benefits of housing-based health interventions, can serve as a model in addressing other housing-related health problems that are largely ignored in housing markets and are not reflected in value and price. This contributes to inefficient cost shifting between the housing and health care sectors of the economy, substandard housing, and inadequate health care (Jacobs 2005).

If a lead-safe window replacement initiative were expanded to address other healthy home energy efficiency improvements, an evaluation that tracks costs, health benefits, energy savings, and other benefits from bundled home upgrade strategies would be essential. This information could be linked to occupant health data to be collected in association with the planned National Children's Study, which will examine the effects of environmental influences on the health and development of a large number of children across the United States, following them from before birth until age 21 (U.S. Department of Health and Human Services 2005).

With a coordinated effort, a focused window replacement campaign will provide previously unrecognized but immediate and substantial cross-cutting benefits related to energy efficiency, affordability, rehabilitation and weatherization, low-income homeownership, air pollution reduction, and prevention of childhood lead poisoning and other housing-related diseases.

Authors

Rick Nevin is an Economic Consultant with the National Center for Healthy Housing. David E. Jacobs is the Research Director for the National Center for Healthy Housing and the former Director of the Office of Healthy Homes and Lead Hazard Control at the U.S. Department of Housing and Urban Development.

The authors wish to acknowledge the valuable contributions of Thomas Matte, MD, of the U.S. Centers for Disease Control and Prevention in helping to complete the report of the President's Task Force on Environmental Health Risks and Safety Risks to Children, as well as the valuable contributions of Artem Gonopolskiy and Heather Gazan for data analysis. The findings and opinions expressed in this paper are solely those of the authors.

References

Agency for Toxic Substances and Disease Registry. 1988. *The Nature and Extent of Lead Poisoning in Children in the United States: A Report to Congress.* Atlanta: U.S. Department of Health and Human Services.

Alfano, Sal. 2004. *Remodeling Online: 2004 Cost vs. Value Report.* World Wide Web page <http://www.remodeling.hw.net/industry-news.asp?articleID=79166&sectionID=173> (accessed April 5, 2005).

Berry, Linda G., Marylyn A. Brown, and Laurence F. Kinney. 1997. *Progress Report of the National Weatherization Assistance Program.* Oak Ridge, TN: Oak Ridge National Laboratory.

Bornschein, Robert L., Paul Succop, K. M. Kraft, Scott Clark, B. Peace, and Paul Hammond. 1987. Exterior Surface Dust Lead, Interior House Dust, and Childhood Lead Exposure in an Urban Environment. In *Trace Substances in Environmental Health, 20* (Proceedings of the University of Missouri's 20th Annual Conference, June 1986), ed. D. D. Hemphill, 322–32. Columbia, MO: University of Missouri.

Breysse, Patrick, Nick Farr, Warren Galke, Bruce Lanphear, Rebecca Morley, and Linda Bergofsky. 2004. The Relationship between Housing and Health. *Environmental Health Perspectives* 112:1583–88.

Canfield, Richard L., Christopher R. Henderson, Deborah Cory-Slechta, Christopher Cox, Todd A. Jusko, and Bruce P. Lanphear. 2003. Intellectual Impairment in Children with Blood Lead Levels below 10 µg/dL. *New England Journal of Medicine* 348:1517–22.

Clark, Scott, Robert Bornschein, Paul Succop, Sandy Roda, and B. Peace. 1991. Urban Lead Exposures of Children in Cincinnati, Ohio. *Chemical Speciation and Bioavailability* 3(3/4): 163–71.

Denno, Deborah W. 1990. *Biology and Violence.* New York: Cambridge University Press.

Dietrich, Kim N., M. Douglas Ris, Paul A. Succop, Omer G. Berger, and Robert L. Bornschein. 2001. Early Exposure to Lead and Juvenile Delinquency. *Neurotoxicology and Teratology* 23:511–18.

Drucker Research Co. 2004. *Dip in Residential Sales Expected after Record-Breaking 2003: Drucker Study Sees Window and Door Demand Remaining at Historically High Levels.* World Wide Web page <http://www.windowanddoor.net/articles.php?id=136> (accessed April 5, 2005).

Duggan, Michael J., and Michael Inskip. 1985. Childhood Exposure to Lead in Surface Dust and Soil: A Community Health Problem. *Public Health Review* 13:1–54.

Efficient Window Collaborative. 2004. *University of Minnesota, Alliance to Save Energy, and Lawrence Berkeley National Laboratory.* World Wide Web page <http://www.efficientwindows.org/index.cfm> (accessed April 14, 2005).

Jacobs, David E. 1995. Lead Paint as a Major Source of Childhood Lead Poisoning: A Review of the Evidence. In *Lead in Paint, Soil, and Dust: Health Risks, Exposure Studies, Control Measures, and Quality Assurance*, ed. Michael E. Beard and S. D. Allen Iske, 175–87. American Society for Testing and Materials Special Technical Publication No. 1226. Philadelphia: American Society for Testing and Materials.

Jacobs, David E. 2005. Housing and Health: Challenges and Opportunities (Keynote speech given at a conference sponsored by the World Health Organization, Centre for Environment and Health, Noise and Housing Unit, and held on September 29–October 1, 2004, in Vilnius, Lithuania). In *Proceedings of the World Health Organization Symposium on Housing and Health*, 35–50. Bonn, Germany: World Health Organization.

Jacobs, David E., Robert Clickner, Joey Zhou, Susan Viet, David A. Marker, John W. Rogers, Pamela Broene, and Daryl C. Zeldin. 2002. The Prevalence of Lead-Based Paint Hazards in U.S. Housing. *Environmental Health Perspectives* 110:A599–A606.

Jacobs, David E., and Rick Nevin. 2006. Validation of a Twenty-Year Forecast of U.S. Childhood Lead Poisoning: Updated Prospects for 2010. *Environmental Research*. World Wide Web page <doi:10.1016/j.envres.2005.12.015>

Krieger, James, and Donna L. Higgins. 2002. Housing and Health: Time Again for Public Health Action. *American Journal of Public Health* 92(5):758–68.

Lanphear, Bruce, Mary Emond, David E. Jacobs, Michael Weitzman, Martin Tanner, Benjamin Yakir, and Shirley Eberly. 1995. A Side-By-Side Comparison of Dust Collection Methods for Sampling Lead-Contaminated House Dust. *Environmental Research* 68:114–23.

Lanphear, Bruce, Thomas Matte, John Rogers, Robert Clickner, Brian Dietz, Robert Bornschein, Paul Succop, Kathryn Mahaffey, Sherry Dixon, Warren Galke, Michael Rabinowitz, Mark Farfel, Charles Rhode, Joel Schwartz, Peter Ashley, and David Jacobs. 1998. The Contribution of Lead-Contaminated House Dust and Residential Soil to Children's Blood Lead Levels: A Pooled Analysis of 12 Epidemiological Studies. *Environmental Research* 79:51–68.

Matte, Thomas D., and David E. Jacobs. 2000. Housing and Health—Current Issues and Implications for Research and Programs. *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 77(1):7–25.

Meyer, Pamela, Timothy Pivetz, Timothy Dignam, David Homa, Jaime Schoonover, and Debra Brody. 2003. Surveillance for Elevated Blood Lead Levels among Children, 1997–2001. *Morbidity and Mortality Weekly Report* 52(SS10):1–21.

Morgan, Wayne J., Ellen F. Crain, Rebecca S. Gruchalla, George T. O’Connor, Meyer Kattan, Richard Evans III, James Stout, George Malindzak, Ernestine Smartt, Marshall Plaut, Michelle Walter, Benjamin Vaughn, and Herman Mitchell. 2004. Results of a Home-Based Environmental Intervention among Urban Children with Asthma. *New England Journal of Medicine* 351(11):1068–80.

National Academy of Sciences. 1993. *Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations*. Washington, DC: National Academy Press.

National Center for Healthy Housing. 2004. *Evaluation of the HUD Lead Hazard Control Grant Program. Final Report by the National Center for Healthy Housing and the University of Cincinnati, Department of Environmental Health*. World Wide Web page <http://www.hud.gov/utilities/intercept.cfm?/offices/lead/EvaluationFinalReport.pdf> (accessed April 22, 2005).

National Center for Healthy Housing. 2005. *CDC Windows Symposium*. World Wide Web page <http://www.centerforhealthyhousing.org/html/projects_policy.html#CDC%20 Windows> (accessed April 22).

Needleman, Herbert L., Julie A. Riess, Michael J. Tobin, Gretchen E. Biesecker, and Joel B. Greenhouse. 1996. Bone Lead Levels and Delinquent Behavior. *Journal of the American Medical Association* 257:363–69.

Nevin, Rick. 2000. How Lead Exposure Relates to Temporal Changes in IQ, Violent Crime, and Unwed Pregnancy. *Environmental Research* 83:1–22.

Nevin, Rick, Heather Gazan, and Christopher Bender. 1999. More Evidence of Rational Market Values for Home Energy Efficiency. *Appraisal Journal* 67(4):454–60.

Nevin, Rick, and Gregory Watson. 1998. Evidence of Rational Market Valuations for Home Energy Efficiency. *Appraisal Journal* 66(4):401–09.

Pirkle, James L., Debra J. Brody, Elaine W. Gunter, Rachel A. Kramer, Daniel C. Paschal, Katherine M. Flegal, and Thomas D. Matte. 1994. The Decline in Blood Lead Levels in the United States. *Journal of the American Medical Association* 272(4):284–91.

President’s Task Force on Environmental Health Risks and Safety Risks to Children. 2000. *Eliminating Childhood Lead Poisoning: A Federal Strategy Targeting Lead Paint Hazards*. Report and Appendix. Washington, DC: U.S. Department of Housing and Urban Development and U.S. Environmental Protection Agency.

U.S. Bureau of the Census and U.S. Department of Housing and Urban Development. 2001. *American Housing Survey (AHS). Analysis of Biannual AHS Data for 1989–2001*. Washington, DC: U.S. Department of Housing and Urban Development. World Wide Web page <http://www.huduser.org/intercept.asp?loc=http://www.census.gov/prod/99pubs/h150-97.pdf> (accessed September 1, 2004).

U.S. Centers for Disease Control and Prevention. 1991. *Preventing Lead Poisoning in Young Children: A Statement by the Centers for Disease Control and Prevention.* Report No. 99–2230. Atlanta: U.S. Department of Health and Human Services.

U.S. Centers for Disease Control and Prevention. 1997a. *Facts on…Lead.* World Wide Web page <http://www.cdc.gov/nceh/lead/guide/1997/docs/factlead.htm> (accessed April 22, 2005).

U.S. Centers for Disease Control and Prevention. 1997b. *Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials.* Atlanta: U.S. Department of Health and Human Services.

U.S. Centers for Disease Control and Prevention. 1997c. Update: Blood Lead Levels—United States, 1991–1994. *Morbidity and Mortality Weekly Report* 46(7):141–46.

U.S. Centers for Disease Control and Prevention. 2000. Blood Lead Levels in Young Children—United States and Selected States, 1996–1999. *Morbidity and Mortality Weekly Report* 49(50):1133–37.

U.S. Consumer Product Safety Commission. 1977. *Ban of Lead-Containing Paint and Certain Consumer Products Bearing Lead-Containing Paint.* 16 CFR 1303. *Federal Register* 42:44199.

U.S. Department of Energy, Energy Information Administration. 1995. *1993 Housing Characteristics from the 1993 Residential Energy Consumption Survey (RECS).* Washington, DC.

U.S. Department of Health and Human Services. 2005. *The National Children's Study: Overview of the Study Plan.* World Wide Web page <http://www.nationalchildrensstudy.gov/research/study_plan/explanation.cfm> (accessed April 18).

U.S. Department of Housing and Urban Development. 1995. *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing.* HUD 1539–LBP. Washington, DC. World Wide Web page <http://www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm> (accessed April 22, 2005).

U.S. Department of Housing and Urban Development. 2004. *HUD's Energy Action Plan.* World Wide Web page <http://www.hud.gov/utilities/intercept.cfm?/offices/cpd/energyenviron/energy/library/energyactionplan.pdf> (accessed September 1).

U.S. Department of Housing and Urban Development. 2005. *HUD's Energy Action Plan and Energy-Efficient Mortgages.* World Wide Web page <http://www.mortgagebankers.org/resident/2005/fha-05-21.pdf> (accessed November 15).

U.S. Department of Housing and Urban Development, Office of Lead Hazard Control. 1999a. *Economic Assessment of the Final Rule on Lead-Based Paint: Requirements for Notification, Evaluation, and Reduction of Lead-Based Paint Hazards in Federally Owned Residential Property and Housing Receiving Federal Assistance.* Washington, DC. World Wide Web page <http://www.hud.gov/utilities/intercept.cfm?/offices/lead/leadsaferule/completeRIA1012.pdf> (accessed September 1, 2004).

U.S. Department of Housing and Urban Development, Office of Lead Hazard Control. 1999b. *24 CFR, Part 35: Requirements for Notification, Evaluation, and Reduction of Lead-Based Paint Hazards in Federally Owned Residential Property and Housing Receiving Federal Assistance*. World Wide Web page <http://www.hud.gov/offices/lead/leadsafe rule/index.cfm> (accessed September 1, 2004).

U.S. Department of Housing and Urban Development, Office of Policy Development and Research. 1990. *Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing. Report to Congress*. HUD–PDR No. 1295. Washington, DC. World Wide Web page <http://www.hud.gov/utilities/intercept.cfm?/offices/lead/reports/plan1990.pdf> (accessed September 1, 2004).

U.S. Department of Housing and Urban Development, Office of Policy Development and Research. 2000. *Partnership for Advancing Technology in Housing (PATH): Strategy Implementation for PATH Existing Home Goal*. Washington, DC.

U.S. Environmental Protection Agency. 1986. *Air Quality Criteria for Lead*. Volume I. EPA 600/8–83–028 a–d. Research Triangle Park, NC: Environmental Criteria and Assessment Office, Office of Research and Development.

U.S. Environmental Protection Agency. 2001a. *Energy Star Home Sealing Specification*. World Wide Web page <http://www.energystarhomesamerica.com/homeseal.pdf> (accessed April 22, 2005).

U.S. Environmental Protection Agency. 2001b. *Lead: Identification of Dangerous Levels of Lead. Final Rule*. 40 CFR, Part 745. World Wide Web page <http://www.epa.gov/lead/leadhaz.htm> (accessed September 1, 2004).

U.S. Environmental Protection Agency. 2005a. *Energy Star Policy Page for Labeled Homes*. World Wide Web page <http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.pt_homes_policies> (accessed November 16).

U.S. Environmental Protection Agency. 2005b. *Energy Star with Indoor Air Package Pilot Specifications*. World Wide Web page. <http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.pt._bldr> (accessed July 22).