# Environmental Health Disparities in Housing

The physical infrastructure and housing make human interaction possible and provide shelter. How well that infrastructure performs and which groups it serves have important implications for social equity and health. Populations in inadequate housing are more likely to have environmental diseases and injuries.

Substantial disparities in housing have remained largely unchanged. Approximately 2.6 million (7.5%) non-Hispanic Blacks and 5.9 million Whites (2.8%) live in substandard housing.

Segregation, lack of housing mobility, and homelessness are all associated with adverse health outcomes. Yet the experience with childhood lead poisoning in the United States has shown that housing-related disparities can be reduced. Effective interventions should be implemented to reduce environmental health disparities related to housing. (*Am J Public Health.* 2011;101: S115–S122. doi:10.2105/AJPH.2010.300058)

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**THE PHYSICAL INFRASTRUC-** ture, and housing in particular, is one of the most basic and at the same time most varied foundations that makes living and modern social structures possible.[1,2] Without a functioning, protective, and equitable housing stock, people's very survival as individuals and as a community would not be possible, because housing provides shelter from the elements, access to food, clean water, clothing, and other basic necessities. The physical infrastructure also makes possible human communication, interaction, movement, psychosocial well-being—indeed, people's very individual and collective identities. Physical infrastructure is a major part of what people need to build social norms. How well that infrastructure performs and which groups it serves best (and worst) have important implications for social equity and environmental health. Populations that are ill served by physical infrastructure and inadequate housing have a host of unmet needs and environmental diseases and injuries, making their full participation in a productive society problematic. This results in profound losses for society at large, as well for at-risk communities and individuals.

I review the scientific data on disparities in housing and associated health outcomes to identify the existing state of knowledge, inform policy, assess effective interventions, and identify research needs.

## HOUSING AND THE SHARED COMMONS

Housing has no consistent perceived shared commons for which the public feels a communal benefit and responsibility, unlike other, more widely shared elements of physical infrastructure, such as water or transportation systems. Even the language is myopic; people refer to a "housing unit," with the connotation that it is small and insignificant. Why is developing an integrated approach that eliminates health disparities in housing so difficult? One answer is that the scientific evidence of harm to specific groups has not been adequately assembled. Another is that no dramatic moment of recognition of the problem has galvanized public action. A third is that responsibility for housing is diffuse, including architects, maintenance personnel, designers, code and building inspectors, occupants, engineers, urban planners, public environmental health professionals, and others. A final answer has to do with inadequate economic investment.

Despite these obstacles, signs of a more integrated approach are emerging. Two examples of such an integrated approach in community development activities include the Green Community Standards[3] and health impact assessment.[4]

## DEFINITION OF HOUSING

The United Nations Habitat Agenda used the term *housing* to encompass several attributes of the habitat that include physical infrastructure at the community and individual levels. The Habitat Agenda defined *adequate housing and shelter* broadly. It is more than merely a roof over one's head. Rather, *housing* is defined as meaning adequate privacy; adequate space; physical accessibility; structural stability and durability; adequate lighting, heating, and ventilation; adequate basic infrastructure, such as water supply, sanitation, and waste management facilities; suitable environmental quality and health-related factors; and adequate and accessible location with regard to work and basic facilities. The definitions of substandard housing or housing with severe or moderate physical problems are drawn largely from the sanitation movement of more than 100 years ago, which focused on addressing water and airborne communicable diseases. *Adequate housing* also means that it is affordable. *Healthy housing* is defined as housing that is sited, designed, built, renovated, and maintained in ways that support the health of residents.[5]

Conditions in the physical dwelling contribute to adverse health effects in at least 5 broad categories:[6]

1. Physical conditions such as heat, cold, energy efficiency, radon exposure, noise, inadequate light, ventilation, and fine particulates in the home;
2. Chemical conditions such as carbon monoxide, volatile organic chemicals, secondhand smoke, and lead;
3. Biological conditions, such as rodents, house dust mites, cockroaches and their associated allergens, and humidity and mold;
4. Building and equipment conditions, for example, accidents and unintentional injuries and access to sewer services (hygiene and sanitation issues); and
5. Social conditions, for example, architectural features related to mental health.

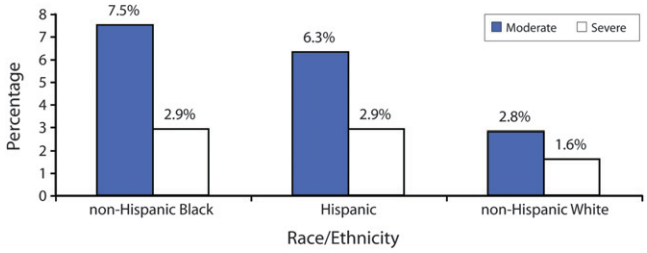


**FIGURE 1—Prevalence of severe and moderate substandard housing by race and ethnicity: American Housing Survey, 2005.**

## DATA SOURCES AND METHODS

To locate relevant literature, I used these key words to search PubMed: housing disparities, health disparities, housing environmental justice, and American Housing Survey disparities. I also reviewed other literature and data sources and key data tables, including the American Housing Survey (AHS), the National Health and Nutrition Examination Survey (NHANES), the American Healthy Housing Survey, the Residential Energy Consumption Survey, the National Health Interview Survey, and 1 data set from Europe, the Large Analysis and Review of European Housing and Health Status project (available at: http://www.euro.who.int/_data/assets/pdf_file/0007/107476/lares_result.pdf).

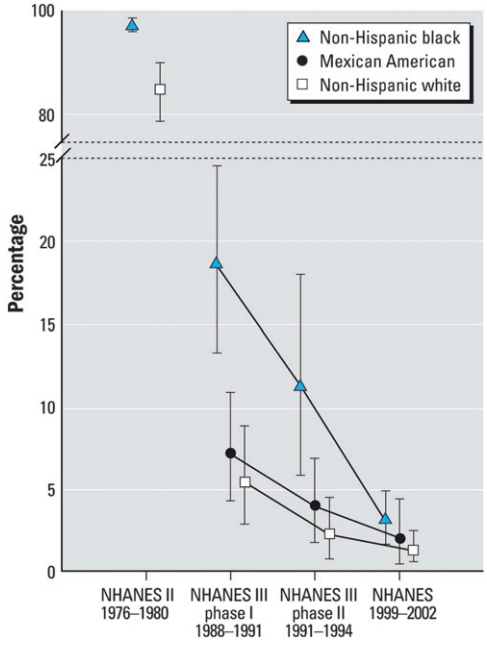


**FIGURE 2—Percentage of children aged 6 years or younger with blood lead levels ≥ 10 μg/dL: National Health and Nutrition Examination Survey (NHANES),[7] United States, 1976–2002.**

## HOUSING DISPARITIES AND EFFECTIVE INTERVENTIONS

Racial and ethnic disparities in housing with both severe and moderate physical problems are large (Figure 1). However, 1 case (childhood lead poisoning) provided evidence that such disparities can be reduced (Figure 2).[7] Most other health- and housing-related disparities have trended together for decades (Figures 3 and 4).[8,9] These 2 contrasting outcomes (improved and persistent disparities) are examples of the evidence that health-related housing disparities are pronounced but that effective interventions that can reduce them exist.[10,11] Of course, some housing-related health hazards are not necessarily related to socioeconomic and racial disparities. For example, the prevalence of radon hazards in housing appears to be associated with geological factors more than with socioeconomic factors (Environmental Protection Agency radon maps, available at http://www.epa.gov/radon/zonemap.html), although remediation resources are unlikely to be equitably distributed.

## PERSISTENT HOUSING DISPARITIES

The disparities in US housing quality are best characterized by data from the AHS, a large representative longitudinal sample of housing conditions at both the national and the city levels. AHS data indicated that 7.5% of non-Hispanic Blacks reside in moderately substandard housing, compared with 2.8% of non-Hispanic Whites, with Hispanics falling between the two (Figure 1). The 2000 Census reported that 34.6 million non-Hispanic Black, 35.3 million Hispanic, and 211.5 million White people lived in the United States. Therefore, approximately 2.6 million non-Hispanic Black, 2.2 million Hispanic, and 5.9 million White people lived in moderately substandard housing. Clearly, the prevalence rates are higher among racial and ethnic minorities, and the absolute numbers suggest that the total number of White households at risk is also substantial. Little progress has been made in reducing these disparities since the late 1980s (Figure 4).

## EARLY HOUSING STANDARDS

The idea that housing and health are linked is not a new one. Florence Nightingale said, "The connection between health and the dwelling of the population is one of the most important that exists."[12] Many modern housing and building laws and codes originated in response to public health epidemics that occurred with the rapid industrialization and urbanization in Western countries more than 100 years ago. Early housing standards required improved

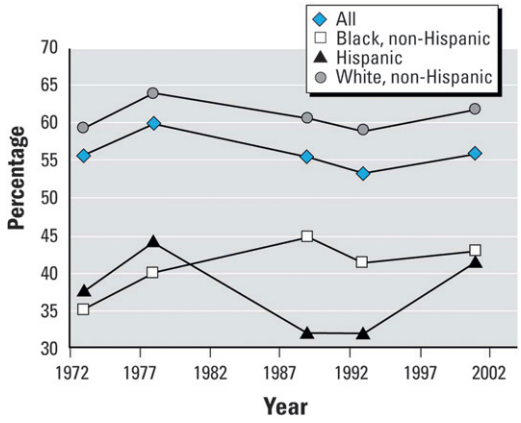


**FIGURE 3—Self-reported general health of the US population by race and ethnicity: National Health and Nutrition Examination Survey, 1972–2002.**

ventilation, sanitation, reduced crowding, structural soundness, adequate lighting, and other habitability criteria, in part as a response to the appearance of concentrated slum housing around factories and big cities during the Industrial Revolution. These laws were passed in part because of the evidence that cholera, typhoid, and tuberculosis were concentrated in disadvantaged low-income neighborhoods.[13]

The provision of indoor plumbing, a housing-based intervention (together with improved medical care), helped improve sanitation and the control of cholera and other similar diseases in the developed world. The typhoid and tuberculosis experiences showed that basic sanitation, ventilation, reduced overcrowding, and other improvements in housing made a powerful contribution to conquering these epidemics. More important, they still color people's understanding of substandard housing.[14]

## RECENT EVIDENCE OF THE RELATIONSHIP BETWEEN HOUSING AND HEALTH

In more recent years, the World Health Organization (WHO) has reviewed the evidence on how well certain housing deficiencies have been linked to specific disease and injury outcomes in the scientific literature.[15] The WHO created 3 categories: those links with "sufficient," "some," or "insufficient" evidence of an association with housing-related disease, injury, or both (see the box on the next page).

Another recently completed review of studies conducted primarily in the United States showed 11 housing interventions for which the scientific evidence was found to be adequate to support widespread implementation; 15 required further field investigation, 19 needed formative research, and 7 either had no evidence or were ineffective. Those interventions found to be effective include multifaceted, in-home tailored interventions for asthma, integrated pest management, elimination of moisture intrusion, removal of moldy items, active radon mitigation, smoke-free policies, residential lead hazard control, installed working smoke alarms, isolation pool fencing, preset safe-temperature water heaters, and rental vouchers.[11,16–19]

Although these recent reviews have greatly advanced the understanding of how housing quality is associated with specific health outcomes, this understanding has not improved people's grasp of how housing disparities are associated with environmental health disparities. This lack of improvement is partly because the United States does not have an integrated longitudinal representative national survey of health and housing status.[20] Instead, existing surveys measure either housing condition, such as the AHS, or they measure health, such as the NHANES. Short of the creation of such an integrated dataset, several recent attempts to overcome this deficiency in the data in the United States and in Europe are noteworthy.

The first is an attempt to retrospectively analyze trends in housing over the past 30 years and compare those trends in health over roughly the same time period, using AHS and NHANES data.[8] This ecologic analysis suggested several possible links in health and housing over time, but, ultimately, it is speculative.

A recent WHO survey demonstrated the power of a more integrated representative approach in revealing disparities related to housing and how many hazards are colocated. This survey was conducted using a representative sample of the population in 8 European cities (N = 3373 dwellings and 8519 inhabitants).

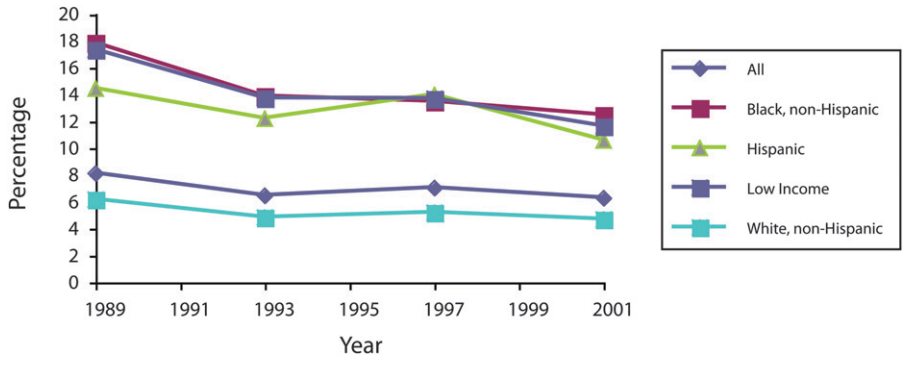


**FIGURE 4—Percentage of housing with severe or moderate physical problems by race, ethnicity, and income: American Housing Survey, 1989–2001.**

**Links Between Housing and Health: World Health Organization 2005**

**Linkages with sufficient evidence for estimating housing-related burden of disease**

Physical factors
- Heat and related cardiovascular effects and excess mortality
- Cold indoor temperatures and winter excess mortality
- Energy efficiency of housing and health
- Radon exposure in dwellings and cancer
- Neighborhood and building noise and related health effects

Chemical factors
- Secondhand smoke exposure in dwellings and respiratory and allergic effects
- Lead-related health effects

Biological factors
- Humidity and mold in dwellings and related health effects
- Hygrothermal conditions and house dust mite exposure

Building factors
- Building and equipment factors and injuries and domestic accidents

Social factors
- Multifamily housing, high-rise housing, and housing quality and mental health

**Linkages with some evidence for estimating housing-related burden of disease**

Physical factors
- Ventilation in the dwelling and respiratory and allergic effects

Chemical factors
- Volatile organic compounds and respiratory, cardiovascular, and allergic effects

Biological factors
- Cockroaches and rodents in dwellings and respiratory and allergic effects
- Cats, dogs, and mites in dwellings and respiratory and allergic effects
- Pets and mites and respiratory, allergic, or asthmatic effects

Building factors
- Sanitation and hygiene conditions and related physical health effects

Social factors
- Social conditions of housing and fear or fear of crime
- Poverty and social exclusion and related health effects
- Crowding and related health effects
- Social factors and social climate and mental health

**Linkages with insufficient evidence for estimating housing-related burden of disease**

Physical factors
- Lighting conditions in the dwelling and mental and other health effects
- Particulate matter in indoor air and respiratory and allergic effects

The cities were Angers (France), Vilnius (Lithuania), Forli (Italy), Ferreira (Portugal), Budapest (Hungary), Bratislava (Slovakia), Bonn (Germany), and Geneva (Switzerland). For example, low-income housing was found to be much more likely to have more than 1 type of hazard and the prevalence of hazards was much higher (Figure 5).[21]

Using more detailed analyses, the WHO data from more than 5700 inhabitants showed that annoyance with neighborhood noise resulted in a doubling of the odds of doctor-diagnosed asthma, chronic bronchitis, and other respiratory diseases. Those annoyed by traffic noise had a 68% higher odds ratio. Furthermore, the data showed that poor drainage, building structural problems, and leaky roofs produced increased odds ratios for asthma of 54%, 27%, and 35%, respectively.[20] These data could be analyzed by income strata, and such an analysis is an important area for future research.

## Housing Segregation and Health

Numerous studies documented adverse health consequences associated with living in highly segregated neighborhoods. Analysis using NHANES data showed significant variation in body mass index by neighborhood and ethnicity.[22] Inequalities in mortality between residents of poor and very poor (i.e., public housing) neighborhoods in New York City showed clear disparities in age-standardized all-cause mortality rates, with preventable diseases such as malignancies, diabetes, and chronic lung disease contributing to the disparity.[23] Repeated hospitalizations for childhood asthma are correlated with children residing in the census tracts with the highest proportion of crowded housing conditions, largest number of racial minorities, and highest neighborhood-level poverty.[24] Using 4 nationally representative surveys, Reid et al. [25] examined housing instability and found that worsening economic standing was associated with poorer health care access, being uninsured, postponing needed care, and higher hospitalization rates. In a large cohort of more than 12 000 households in New York City, asthma was most prevalent in Puerto Rican households, followed by other Hispanic and Black households, with exposure to deteriorated housing conditions and low social cohesion in the neighborhood significantly elevating the odds of asthma.[26] Indicators of housing deterioration in that study included maintenance problems such as toilet breakdowns; heating breakdowns; need for additional heat; the presence of rats or mice; leaks, cracks, or holes in floors, walls, or ceilings; and broken plaster. The study also used measures of crowding, and the neighborhood indicators included boarded-up buildings nearby, similar to the proposed healthy housing indicators I have listed. This study not only found increased odds of asthma but also demonstrated that multiple housing deficiencies are found together, thus magnifying the asthma risk. The analysis found, interestingly, that these housing and neighborhood factors were independent of the influence of socioeconomic status (but not of race and

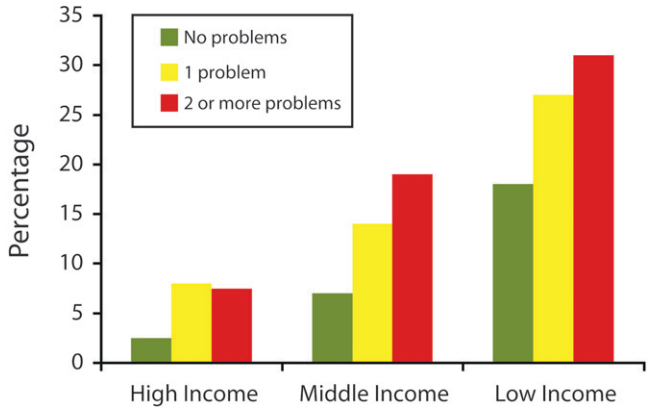


**FIGURE 5—Colocated mold, bad air quality, and cold in European housing by income: 1971–2010.**

ethnicity). These findings are consistent with those of another large study showing that housing is an important mediator of the pathway from social and physical conditions to pollutants to health outcomes.[27]

Disparities in asthma morbidity and mortality have been well characterized and have been associated with housing disparities and segregation. From 2001 through 2003, current asthma prevalence was higher in children (8.5%) than in adults (6.7%), in African Americans (9.2%) than in Whites (6.9%), in those of Puerto Rican descent (14.5%) than in those of Mexican descent (3.9%), in those below the federal poverty level (10.3%) than in those at or above the federal poverty level (6.4%–7.9%), and in those residing in the Northeast (8.1%) than in those residing in other regions (6.7%–7.5%).[28] Analysis of NHANES data also showed statistically significant increased odds of sensitivity of African American children than White children to cockroaches, house dust mites, and certain fungi (mold), all of which are important factors in housing-associated asthma.[29]

Biologic agents related to housing structure that have received the most study include allergens from cockroaches, rodents, dust mites, fungi, and respiratory irritants, including fungal cell wall components. Excess moisture in a home supports the growth of mold and provides an environment favorable to dust mites, cockroaches, and rodents, and leaks and moisture are more common in low-income and minority housing. Two recent reviews of numerous studies found that multifactorial tailored home-based asthma interventions are effective, but that those with a single focus (e.g., mattress covers) were not.[16,30]

In 2000, more than 80% of US homes had detectable levels of house dust mite allergen in the bedroom, 46% had levels associated with sensitization, and 24% had levels associated with asthma morbidity; these allergens were most highly concentrated in low-income housing.[31] Inner-city children with asthma exposed to cockroach allergen have more frequent asthma symptoms and hospital admissions for asthma.[32] Cockroach allergen levels are highest in low-income minority housing.[33]

If housing segregation can be reduced, one would expect to see improved health outcomes. In the Moving to Opportunity study, 4608 low-income families residing in central-city public housing in high-poverty neighborhoods in 5 cities were randomly assigned to 1 of 3 groups:

1. The experimental group, which was offered Section 8 (a federal subsidized housing program) vouchers that could be used only in a low-poverty, mixed-income neighborhood;
2. The comparison group, which was offered geographically unrestricted Section 8 housing vouchers and tended to reside in more segregated housing; and
3. The control group, which did not receive vouchers but remained eligible for public housing.

Although health was not the primary focus of the Moving to Opportunity study, Orr et al.[34] did find better health among members of the experimental group, including a reduction in adult obesity by 11% in the experimental group and improved perceived safety and improved mental health in girls, including reductions in psychological distress, depression, and generalized anxiety disorder and lower rates of smoking and marijuana use.[34] Data from the Yonkers Scattered-Site Public Housing Program have corroborated the evidence linking improved mental health outcomes to housing mobility interventions and reduced housing segregation.[35,36] Because low-income populations tend to move from house to house frequently, studies that examine health outcomes associated with housing mobility are especially important in building the evidence base of effective interventions, especially for disadvantaged populations.

## Homelessness and Health

Many studies showed that homelessness is associated with both racial and ethnic disparities and disparate health outcomes. One study showed that homeless people with HIV/AIDS are at increased risk of negative health outcomes (both physical and mental) and are more likely to be uninsured and use emergency rooms more often and less likely to take prescribed medication.[37,38] Children who experience housing instability or homelessness have a 25% greater risk of poor health in adulthood and experience higher mortality rates in adulthood than individuals who reside in stable housing as children.[39]

## Homeownership, Neighborhood Safety, and Health

Among the elderly, housing equity is more important than income in determining health status, and housing assets account for more than 90% of disparities in socioeconomic status and 54% of disability inequalities.[40] The likelihood of home ownership declines significantly if the household has significant health problems,[41] and adults who consider their neighborhoods to be unsafe are less likely to be physically active than those who consider their neighborhood to be safe. Safety is ranked as the most important factor in whether children are allowed to play outdoors.[42]

## Housing Disparities and Injury

Community-level concentration of owner-occupied housing and age of housing are significantly associated with nonfatal hospitalized

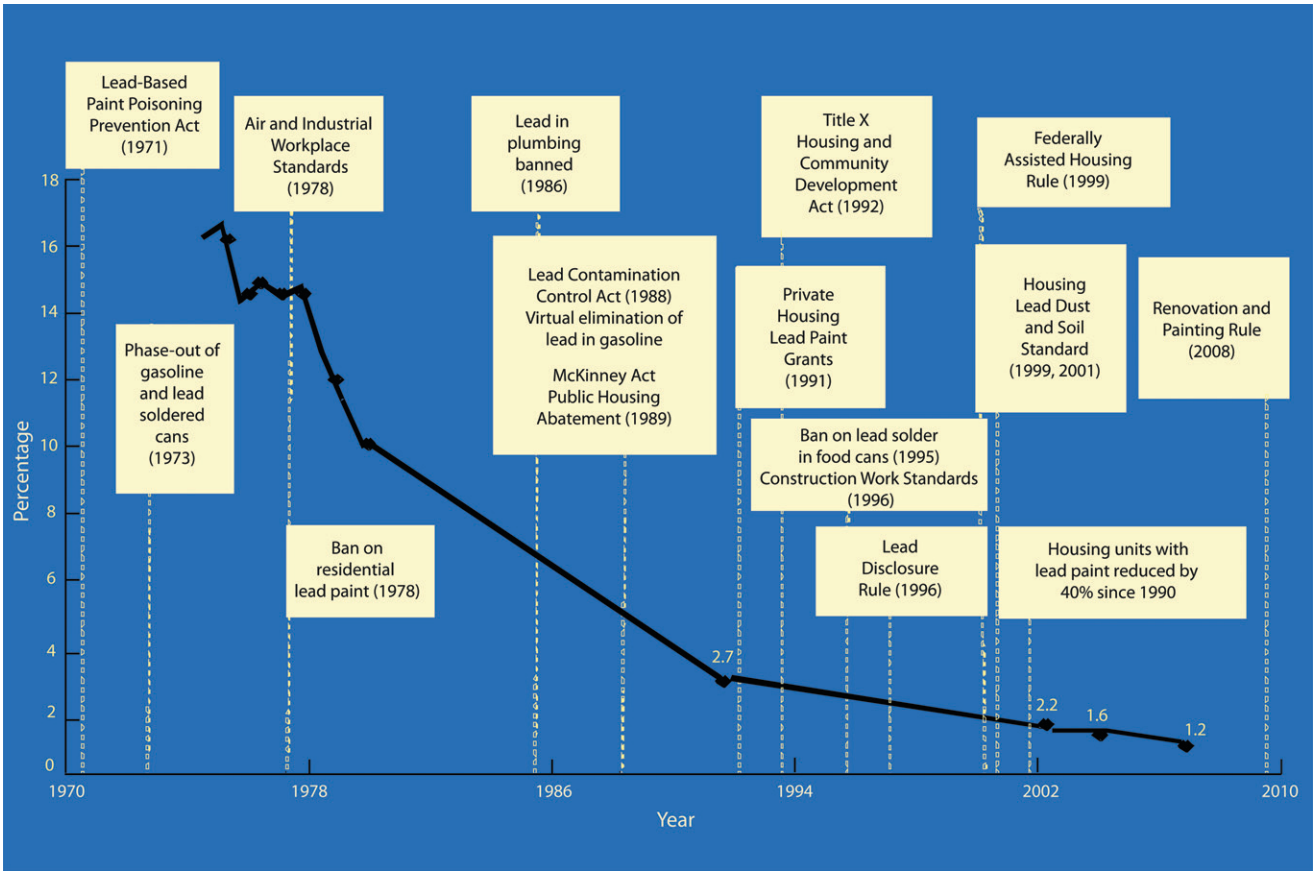


**FIGURE 6—Policy changes associated with reductions in children's blood lead levels (percentage > 10 μg/dL): United States, 1971–2010.**

pediatric injury; housing conditions mediate poverty and individual- and community-level determinants.[43] Residential injuries result in thousands of deaths and millions of emergency department visits each year. Groups at increased risk of fire-related injury and death include infants, young children, the elderly, African Americans, Native Americans, low-income residents, rural residents, and those living in manufactured (i.e., mobile) homes (particularly those built before 1976 when building codes changed) and substandard housing.[44–46] Although some evidence showed that injuries in housing are related to disparities, more research is needed to quantify the distribution of those disparities.

## LESSONS FROM CHILDHOOD LEAD POISONING PREVENTION

The data presented thus far suggest that housing disparities and associated health disparities have not changed over time. Childhood lead poisoning is 1 notable exception to this finding. The prevalence of children's blood lead levels of 10 micrograms per deciliter or more decreased from 8.6% in 1988 to 1991 to 1.4% in 1999 to 2004, which is an 84% decline. From 1988 to 1991 to 1999 to 2004, children's geometric mean blood lead levels declined in non-Hispanic Black (5.2–2.8 μg/dL), Mexican American (3.9–1.9 μg/dL), and non-Hispanic White children (3.1–1.7 μg/dL).[47] The percentage of children's blood lead levels more than 10 micrograms per deciliter fell from an astonishing 97% in 1976 among African American children to 3.1% in 2002.[7] Despite this improvement, disparities continue to exist, although they are far smaller than in previous decades. Blood lead levels continue to be highest among non-Hispanic Black children relative to Mexican American and non-Hispanic White children. Residence in older housing, poverty, age, and being non-Hispanic Black are still major risk factors for higher blood lead levels. The interventions responsible for this improvement included some at the population level (e.g., gasoline lead phase-out, lead-based paint ban, lead-soldered food can phase-out) and others that were targeted to high-risk subpopulations in housing contaminated with lead paint hazards (Figure 6). In short, the United States' experience with childhood lead poisoning showed that it is possible to reduce housing-related exposures to an environmental toxicant in a way that reduces population-wide risks, while at the same time dramatically reducing disparities in exposures by focusing resources on

the subpopulations at greatest risk.

## STRATEGIES FOR PROGRESS

A key reason for the progress in the lead poisoning prevention field is that a significant investment in research produced a clear understanding about disparities in risk. With new information on emerging contaminants in the home, identifying these contaminants and understanding how exposures are distributed in the population is essential.

For example, application of pesticides is an emerging issue in the indoor housing environment and has been shown to contaminate untreated surfaces, including kitchen counters and toys,[48–50] indoor air,[51,52] or dust.[53] Pesticide residues in the indoor environment may persist because they are removed from factors that enable degradation, such as sunlight. Outdoor pesticide applications on agricultural fields, lawns, or house perimeters in an adjacent outdoor area can affect the indoor environment in adjacent buildings through contamination of indoor air[54] and dust.[55] Pathways through which pesticides contaminate housing and the disparity of those exposures are examples of areas that require further investigation.

Numerous housing-related disparities affect environmental health, including biological, physical, and chemical agents; segregation; moderate and severe substandard housing; housing mobility; homelessness; and injury. No unified research agenda for housing and health disparity research exists in the United States, although advances have recently occurred in this area. The absence of a place for housing disparity health research within the National Institutes of Health, Environmental Protection Agency, Centers for Disease Control and Prevention, and other research agencies is noteworthy. Measuring such disparities is a prerequisite to focused remediation and prevention. This lack of data compounds the historic underinvestment in the nation's housing and ongoing housing disparities that contribute to high health care costs among high-risk populations. Housing-based interventions are effective and should be implemented to reduce environmental health disparities related to housing conditions.

Finally, investment in representative, longitudinal housing-and-health integrated surveys and in more robust research to systematically study the relationship between housing and health is required, as is the need to identify emerging concerns, such as patterns of use of products and building materials in the home environment.

Reducing housing-related health disparities requires increased investment in research that examines sources and pathways of exposure in the home and community environment; practical and proven interventions that prevent and reduce the probability of illness and injury; a unified healthy housing research agenda; longitudinal integrated representative housing and health population-based surveys; and perhaps most important, broad implementation of healthy housing concepts into housing design, construction, maintenance, finance, and rehabilitation systems. ■

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