HOUSING AND HEALTH—CURRENT ISSUES AND IMPLICATIONS FOR RESEARCH AND PROGRAMS

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ABSTRACT This article provides an overview of the ways in which the home environment can affect human health, describes how specific health hazards in housing are related, and considers implications of these concerns for research and programs to address the health-housing connection. The widespread availability of decent housing has contributed greatly to improvements in health status in developed countries through, for example, provision of safe drinking water, proper sewage disposal, and protection from the elements. However, a lack of decent housing and homelessness among a significant number of Americans remains a significant public health concern. In addition, a number of specific health hazards can be found even in housing that is in good condition and provides all basic amenities. Specific health hazards related to housing include unintentional injuries, exposure to lead, exposure to allergens that may cause or worsen asthma, moisture and fungi (mold), rodent and insect pests, pesticide residues, and indoor air pollution. A number of these specific hazards share underlying causes, such as excess moisture, and all may be influenced by factors in the community environment or by occupant behaviors. We make recommendations for developing programs and research efforts that address multiple housing problems in an integrated way, rather than categorically, and for closer collaboration between housing and public health programs.

KEY WORDS Housing, Environmental Exposures, Public Health, Social Factors.

INTRODUCTION

As in other areas of public health, progress in understanding the connection of housing conditions to health has involved both scientific advances and the

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rediscovery of historic observations and beliefs. In 1946, when Commissioner Israel Weinstein spoke on the 80th anniversary of the establishment of the Department of Health in New York City, he noted: "Thus the recognition that proper housing and adequate recreational facilities are related intimately to public health is not as recent as many people think" (see I. Weinstein, "Eighty Years of Public Health in New York City," this issue, p. 222). Indeed, public health concerns related to inadequate sanitation and overcrowding in tenement housing helped to motivate the establishment of the Department of Health and to shape much of its early work.

During the latter half of this century, improvements in general housing conditions in developed countries and advances in biomedical and environmental science have resulted in the identification of new, and often more subtle, health concerns related to housing, such as exposure to lead-containing paint and indoor air pollution. Neither grossly substandard housing nor subtler environmental hazards are unique to urban homes, but the concentration of such problems in densely populated, low-income neighborhoods poses a particular challenge to public health agencies.

Despite scientific progress in understanding the connection of health to housing, two aspects of current public and private efforts to ensure healthy housing may be hampering progress. First, such efforts have tended to be categorical, with each program addressing a narrow range of concerns, such as lead-poisoning prevention and injury prevention. Second, the connections between public health programs and programs to preserve and enhance the housing stock have become weaker than they once were.

This article provides an overview of health concerns related to the home environment, considers ways in which these diverse concerns are related to one another, and discusses some implications for research and for improvement of programs related to prevention of housing-related health problems. If relevant, the article draws on lessons learned from efforts to control exposure to lead-containing paint, perhaps the most studied environmental hazard in housing. Reference is also made to other articles in this issue of the *Journal* that address some of the specific concerns discussed below. The connections between health and housing are complex, and we have not addressed all aspects of the problem or any one aspect in great depth. Readers seeking additional information on this topic may refer to other reviews on health and housing in the biomedical and lay literature[1–3] and to detailed reviews of specific housing-related health concerns, many of which are cited here.

HOUSING CONDITION AND BASIC AMENITIES

Provision of safe water for drinking and personal hygiene, proper disposal of sewage, and facilities for safe food preparation and the absence of overcrowding are examples of how adequate housing can promote public health. Protection of occupants against temperature extremes and other natural hazards is also a basic requirement of safe housing.[4,5] While lack of basic facilities in housing is less frequent than it once was, the American Housing Survey documents such deficiencies in a sizable minority of the US housing stock. For example, in 1995, 1.5% of occupied homes lacked some or all plumbing facilities, 2.6% had more than one person for each room, and 5% had inadequate heating. Homes occupied by families below the poverty level are more than twice as likely to have a severe physical problem than other homes.[6]

A number of studies have demonstrated a relationship between general housing quality and self-reported measures of well-being,[3] but demonstrating a causal relation to physical health in developed Western countries has been difficult for a number of reasons. One is the strong relationship between social disadvantage and living in poor quality housing, making it difficult to disentangle the contribution of social factors and housing conditions. In addition, poor health may have an impact on employment opportunities and income, thereby limiting access to decent housing. So, some of the health gradients associated with housing quality may be due to selection rather than causation.[7] Still another methodologic challenge is that minimally adequate housing is available to the majority of households in Western societies.[3] This limited variation in access to basic housing amenities is a limitation in individual-level epidemiologic studies. Ecologic relations of secular and geographic changes in sanitation and other housing amenities to broad measures of population health make a convincing case that provision of basic housing amenities has contributed greatly to improvements in health in developed countries.[8]

HOMELESSNESS

By one estimate, more than 7% of adult Americans have been homeless at some point.[9] One way of viewing homelessness would be as the low extreme of a continuum of access to decent housing. As with the impact of housing quality, it is difficult to disentangle completely the effects of low socioeconomic status, loss of housing due to disabling physical or mental illness, and the direct health impact of homelessness. However, homelessness involves a unique set of hardships beyond those presented by poor quality housing. A homeless diabetic

person, for example, may be faced with the impossible tasks of storing insulin and securing a diabetic diet.[10] Similarly, families of children with asthma, a common problem in some homeless populations,[11,12] are hard-pressed to maintain a regular medical regimen. Lacking the physical security provided by a home, homeless women may experience more severe physical and sexual assaults during their lifetimes.[13]

BEYOND BASIC AMENITIES— SPECIFIC HEALTH HAZARDS IN HOUSING

While many of the more recently identified housing-related health concerns are disproportionately common in housing that is substandard in other respects (e.g., has structural problems, lacks adequate heat, etc.), such housing-related environmental hazards may also exist in housing that is otherwise of good quality. Some selected examples are discussed below.

Unintentional Injuries

In 1997, unintentional injuries received at home resulted in 28,400 deaths, nearly 7 million persons being disabled for at least 1 full day, and $100 billion in economic costs. Common causes of fatal unintentional injuries at home include falls, fires, and burns, suffocation (mechanical or by ingestion), poisoning, and firearms. Poisoning deaths among young adults, mainly due to drug ingestion, have increased from the mid-1960s to the mid-1990s, while poisoning deaths have fallen dramatically among children aged 0–4 years during the same period.[14]

While behavioral factors play a role in household injuries, housing factors are important determinants amenable to intervention. For example, faulty heating equipment and electrical wiring contribute to the initiation of a substantial proportion of fires,[14,15] while working smoke alarms reduce the risk of death from residential fires by roughly half.[16,17] At least one smoke alarm is reported to be present in over 90% of households nationally, but smoke alarms may be less common in low-income households,[18] and roughly 50% may not be functioning 1 year after installation.[16] Distribution of free smoke alarms in communities in which the prevalence of smoke alarms is low is an effective strategy for preventing residential fire injuries.[19]

Other examples of injuries related to modifiable features of the urban home environment include tap water scald burns, which can be prevented by setting hot water heaters to produce water below 120°F,[18] and falls from windows, which can be prevented with the use of window guards (see K. E. Stone et al., "Childhood Injuries and Deaths Due to Falls from Windows," this issue).

Interventions to prevent home injuries need not focus on a single hazard. A

controlled community trial of home inspection, simple modifications, and injury prevention information by outreach workers produced significant increases in the use of smoke detectors, safe storage of medications, and reduced electrical and tripping hazards.[20] In a review of controlled trials of home visits to prevent childhood injuries, Roberts et al.[21] estimated a 26% reduction in the odds of injury based on pooled results from eight such trials.

Lead

Exposure to lead, a potent neurotoxicant, remains one of the most important and best-studied household environmental risks to children. Measures to eliminate or reduce the use of lead in a range of products, including gasoline, food and beverage cans, new residential paint, and potable water conduits, have contributed to a dramatic decline in blood lead levels in all population groups from the mid-1970s through the mid-1990s.[22] Despite these declines, the most recent national survey, conducted from 1991 to 1994, showed that nearly 1 million US preschoolers still have blood lead levels in an established range at which subtle adverse effects on neurodevelopment occur.[23,24] A large reservoir of lead remains in housing built prior to the banning of lead-containing paint in 1978, especially in homes constructed prior to 1950, when white lead paint pigment was still used widely.[25] Lead contamination of residential soil is also common due to weathering of paint and fallout from past emissions from gasoline containing lead.[26] The most common pathway of residential lead exposure today is through ingestion of house dust contaminated with lead derived from deteriorated paint and tracked in soil.[27,28] The amount of lead in settled particulate on floors and window sills is the best available environmental measure for predicting the risk of elevated blood lead levels in children.[29,30] Its measurement can be performed with a widely available, inexpensive wipe test.[31]

The fraction of elevated blood lead levels in children attributable to deteriorating lead-based paint cannot be estimated precisely, but the relative prevalence of elevated blood lead levels by housing age indicates a major impact. Direct and indirect exposures of children to lead from paint are likely major factors in the prevalence of elevated blood lead levels among children living in pre-1946 dwellings (those built when the use of lead-containing paint was most common) being five times higher than among children living in homes built after 1973 (most of which do not have lead-containing paint).[32]

Strategies that include stabilization of deteriorated lead-containing paint, window treatments to reduce abrasion of lead-containing paint, and sealing and cleaning of floor surfaces result in large and sustained reductions in lead-contain-

ing dust in homes and little, if any, risk of substantial short-term increases in blood lead.[33–35] No controlled studies are available to measure the long-term impact of these interventions on blood lead levels, but descriptive longitudinal data and a controlled study of a less extensive intervention suggest a significant benefit.[36] Extensive paint removal without adequate precautions has caused increases in blood lead levels.[37–40]

Interventions that focus on reducing exposure to lead-containing dust and/or soil have produced modest benefits in two controlled studies.[41,42] Two other studies of abatement of soil with lower baseline contamination showed no benefit regarding reduction of blood lead levels.[43,44]

Allergens and Asthma

The public health impact of asthma is large and is increasing worldwide. In the US, the national prevalence of self-reported asthma among children aged 5–14 years was 7.4% in 1993–1994,[45] and asthma is a leading cause of school absence, lost workdays, emergency room visits, and hospitalizations. The especially high morbidity experienced by low-income, inner-city children is reflected in hospitalization data for New York City reported by Stevenson et al. elsewhere in this issue. While no single estimate of the amount of asthma attributable to the home environment is available, exposures to certain indoor allergens, including those from dust mites, domestic pets, and cockroaches, are risk factors both for development of allergies and asthma and for more severe symptoms among those already sensitized to these allergens.[46] Among inner-city children with asthma, ongoing exposure to high levels of allergen seems to be an especially common and important cause of more severe symptoms.[47] Household allergen particles generally are sampled in settled dust because, with the exception of cat allergens, they do not stay airborne for long periods.[48,49]

Housing factors can influence allergen exposure in a number of ways. Structural defects can facilitate entry of cockroaches and rodents. High relative humidity indoors favors dust mite proliferation. Carpets and drapes can harbor allergen-containing dust.[48] Interventions that include the use of mattress and pillow covers impervious to dust mites have been shown to reduce markers of disease severity in those with asthma.[46,50] The impact of measures to reduce other household allergens is less clear. Cockroach extermination plus family education about cleaning to remove allergens were associated with a transient decrease in cockroach allergen levels, which returned to baseline or above by 1 year after the intervention.[51] A number of ongoing studies are testing multifaceted home inter-

ventions to assess and reduce exposure to allergens and other asthma triggers (see Krieger et al., "Asthma and the Home Environment of Low-Income Urban Children," this issue).

Fungi (Mold) and Moisture

Allergens derived from fungi can cause allergic rhinitis, asthma, and hypersensitivity pneumonitis.[52] Certain molds found in the home environment produce mycotoxins and have been associated with a range of adverse health effects in animals, including inflammation and injury in gastrointestinal and pulmonary tissues.[53,54] Increased concern about the potential risk associated with exposure to *Stachybotrys* fungal species followed a reported association of a cluster of pulmonary hemosiderosis (PH) cases in infants with a history of residence in homes with recent water damage and with levels of *Stachybotrys atra* (SA) in air and in cultured surface samples.[55] Associations between exposure to SA and symptoms similar to those of "sick building" syndrome in adults have also been observed.[56] Other related toxigenic fungi have been found in association with SA-associated illness and could play a role.

Mold growth in a dwelling indicates the presence of a moisture problem. In addition, there is substantial evidence that the presence of moisture problems per se is a risk factor for respiratory illnesses and symptoms, especially in children.[57] A number of factors might mediate such an association, including the growth of allergenic molds and higher levels of dust mite infestation.[58,59] Excess moisture may also help support cockroach infestation, which contributes to asthma severity in sensitized children.[60]

Although some quantitative guidelines have been established for exposure to fungi in indoor air, the health basis for these guidelines is limited by a lack of substantial, objective human dose-response data and the reliance of many studies on grab samples to characterize chronic exposure.[61] Further research is needed to establish definitively environmental factors that cause PH, other potential health risks associated with household mold exposure, techniques for characterizing exposures and hazards from residential mold contamination, and the safety and effectiveness of remediation strategies. In this issue of the *Journal*, Vesper and colleagues report a detailed case study of remediation of a home with extensive moisture and mold problems associated with growth of *Stachybotrys chartarum* and a case of pulmonary hemorrhage in an infant. Their case study illustrates the potential complexity of the causes and remediation of moisture problems in housing.

Rodent and Insect Pests

Rodents can transmit a number of communicable diseases to humans through bites, arthropod vectors, or exposure to aerosolized excreta.[62–64] In addition, humans can become sensitized to proteins in rodent urine, dander, and saliva. Structural defects in housing can make it easier for rodents to enter the home environment. According to the American Housing Survey,[6] signs of rats in the last 3 months were reported in 2.7 million of the 97 million occupied units in the country. Surveillance of rat bite reports has been used in some jurisdictions to guide control efforts. Data from New York City in the mid-1970s showed rat bites generally occurred indoors, with young children at highest risk. The decline in rat bites over time was greatest in areas with active control programs.[65]

The observed association between exposure to cockroach antigen and asthma severity has been noted already. In addition, cockroaches may act as vehicles to contaminate food and environmental surfaces with certain pathogenic organisms.[66,67]

Pesticide Residues

Pesticide use, especially to control insects and rodents, is common in urban dwellings. Chlorpyriphos (CP), an organophosphate insecticide, was the most used pesticide in New York State in 1997, with the highest use occurring in two New York City boroughs.[68] While CP is a biodegradable pesticide, substantial persistence of CP on surfaces and toys has been demonstrated for at least several days following a broadcast application,[69] a use that will be phased out under a voluntary agreement between the Environmental Protection Agency and manufacturers.[70] CP residues are detectable widely in US homes.[68] Animal models have demonstrated that exposure to CP in the prenatal and early postnatal periods may impair neurodevelopment.[71]

Indoor Air Pollutants

Environmental tobacco smoke (ETS) is a carcinogen and respiratory irritant. ETS can aggravate asthma, especially in children, and exposure to ETS is common among inner-city children with asthma.[72] Children exposed to ETS also suffer more respiratory illnesses than other children and have decreased pulmonary function.

Burning of oil, natural gas, kerosene, and wood for heating or cooking purposes can release a variety of combustion products of health concern. Depending on the fuel, these may include carbon monoxide (a chemical asphyxiant); nitrogen dioxide (a respiratory irritant); polycyclic aromatic hydrocarbons (e.g., the carcino-

gen benzo[a]pyrene), and airborne particulate matter. Improper venting and poor maintenance of heating systems and cooking appliances can increase exposure to combustion products dramatically.[73] A survey of unintentional, nonfatal carbon monoxide poisonings in Connecticut residences found heating systems to be the most common source, with gas appliances and fireplaces accounting for the remainder.[74]

A variety of chemicals released from building materials, cleaning products, and other consumer products may contaminate indoor air. Most such pollutants are classified as volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) and are present at highest concentrations just after installation or use of the materials. A variety of mechanisms has been proposed to link VOCs to health complaints, but establishing causal relations has been difficult due to the complex mixtures of VOCs that may be present and the diverse health complaints that have been associated with them.[75]

Use or disturbance of certain building materials can generate exposures to specific contaminants that are the cause of special health concerns. Examples include asbestos fibers, which can be liberated when old insulation is disturbed, and formaldehyde released from particle board or medium-density fiberboard.[75]

Epidemiologic studies of miners exposed to high levels of radon in inhaled air show a dose-response relation for radon-induced lung cancer at high exposure levels. Though radon levels in living spaces of homes generally do not reach the levels found in these studies, extrapolation of these data has been used to estimate the excess risk of lung cancer attributable to exposure to radon gas at the lower levels found in homes. These estimates indicate that indoor exposure to radon accounts for approximately 10–14% of lung cancer deaths in the US.[76] Excessive exposures typically are related to home ventilation, structural integrity, and geographic location. Though there is regional variation in the proportion of homes with high indoor radon levels, radon concentrations can also vary among houses in a neighborhood, and high levels may be found in all regions. Measures to reduce indoor radon levels are triggered generally by radon testing, often at the time of property sales, but only 7% of households report having had a radon test.[77]

RELATIONSHIPS AMONG HOUSING-RELATED HEALTH HAZARDS

Many individual housing-associated health concerns are interrelated in ways that have important implications for research, policies, and programs. Excess moisture, whether caused by plumbing leaks, roof leaks, floods, groundwater

intrusion into basements, or ventilation problems, can contribute to a number of health hazards, including mold growth,[78] peeling paint containing lead, and structural deterioration that provides access for rodent and insect pests.

Dust traps such as carpets can harbor household allergens and can also be reservoirs for lead-containing dust and pesticides.[69] Treatment to control some housing-related hazards can create other health concerns. Cockroach infestation treated with organophosphate insecticides is an example. Another would be the installation of exhaust fans to control excess moisture; under some circumstances, these can create negative pressure and cause spillage of combustion products from furnaces and hot water heaters into the living space.

OTHER FACTORS CONTRIBUTING TO HEALTH HAZARDS IN HOMES

Factors related to the community environment around a dwelling may have an impact on the home environment. Infrequent trash removal and improper trash storage practices may contribute to rodent infestation. The risk of injury or death from fire can be increased if fire hydrants are not working or if adjacent, attached apartment buildings or row homes lack smoke alarms and sprinklers. Overtaxed public sewers may result in sewage backups in homes; these backups contribute to moisture and mold problems. Maintenance of homes may be influenced by owners' perceptions of economic prospects, by inspections and enforcement of housing codes, or by perceived norms of upkeep among neighborhood property owners. In this issue of the *Journal of Urban Health* ("Injury-Producing Events Among Children in Low-Income Communities"), O'Campo et al. report a relation of the frequency of housing code violations at the neighborhood level to the risk of injury-producing events among young children. It is not clear whether this association is due to hazards in the individual home environments, some aspect of the neighborhood context for which housing code violations is a proxy, or some combination of the two. Understanding the impact on health of community-level factors, of individual dwelling characteristics, and of interactions between the two will require multilevel studies that include measures of the neighborhood context, the home environment, and health.

Occupants interact with the home environment in ways that can create new hazards or modify hazards related to the building itself. Examples include smoking, keeping pets, storing and maintaining household chemicals, and installment and maintenance of protective devices such as smoke alarms and carbon monoxide detectors. A distinct group of home hazards related to occupant behaviors involves so-called fouling the nest: contamination of the home environment with

substances used at work or in hobbies. When the clothing, hair, skin, or shoes of workers become contaminated with hazardous materials in the workplace, such contaminants may be carried inadvertently to the home environment. Such take-home exposures have been demonstrated, for example, in homes of lead-exposed workers.[79] In addition, certain hobbies or workplaces located in the home may provide an especially great risk of household contamination.

IMPLICATIONS FOR PUBLIC HEALTH AND HOUSING PROGRAMS

The relationships among individual housing-related health hazards and among the community environment, home environment, and occupant behaviors have important implications for developing future prevention programs and research. In addition, some important lessons can be drawn from the fairly long history of efforts to understand and control lead hazards associated with housing.

Integrated Approach

For households with the resources to obtain environmental assessment services privately, public education campaigns about healthy housing may prompt action to identify hazards in the home. In low-income urban communities, however, home visits by an environmentalist, housing inspector, outreach worker, or public health nurse may be required to identify problems. A substantial investment of time and effort is required just to schedule a visit, gain access to the home when the family is available, and complete a walkthrough inspection for a single hazard, such as lead. If the personnel carrying out home assessments are qualified and trained to identify multiple housing problems, the marginal cost of adding additional assessments, such as for fire or injury hazards, may be small relative to the overall inspection cost.

As with assessments, efficiencies may be gained in interventions by allocating certain relatively fixed costs of repairs, such as those for insurance, permits, and project management, to interventions that address several hazards at the same time. Interventions that correct underlying causes may produce larger and more lasting health benefits in the long run. For example, roof repair to fix a moisture problem may not only prevent lead-containing paint from peeling in the future, but also reduce exposure to allergenic molds. Interventions that are more permanent may be more costly, however, and may not be feasible without pooling resources targeted at multiple health concerns.

While it seems a reasonable hypothesis that a more integrated approach to healthy housing is more cost effective, research and demonstration projects are needed to test this strategy. Some programs that use an integrated approach have been established already, and projects supported under a recently announced

initiative of the Department of Housing and Urban Development should begin to provide some answers in the coming years.[80]

Tapping Larger Resource Pools

Efforts to address lead paint hazards in housing have been hampered by a lack of resources to fund needed repairs in the economically distressed housing in which lead poisoning often occurs. Much of the work needed to correct hazards from paint containing lead, and indeed from a wide range of health hazards, very often includes substantial repair, maintenance, or rehabilitation of a home. Indeed, the cost of lead hazard control can be reduced greatly if integrated into planned housing rehabilitation or routine maintenance. At the same time, financial resources for preserving and improving the housing stock are far greater than those potentially available for specific environmental and health concerns. For the Community Development Block Grant Program of the Department of Housing and Urban Development (HUD), for example, current funding is approximately $3 billion per year,[81] compared with roughly $60 million annually for HUD's lead paint hazard reduction grant program.[82] Achieving major improvements in economically distressed housing will require leveraging a variety of public and private sources of funds to address environmental concerns while improving access to affordable housing and promoting ownership of homes.[83]

Community-Level Interventions

In designing and testing programs, it must be recognized that some housing problems cannot be addressed only in individual dwellings. Lead-contaminated soil and dust, for example, tends to cluster in communities, and both children and dust are mobile. Thus, strategies for addressing lead contamination at the neighborhood level, as well as in individual dwellings, need to be developed and tested.

Need for Controlled Studies

Controlled studies of the effectiveness of lead hazard reduction measures have revealed some interventions to be less effective than anticipated; others actually were harmful. Similarly, controlled studies are needed to evaluate the effectiveness and potential risks of new interventions aimed at other hazards. Controlled studies in the home environment entail challenges beyond those of clinical investigations. For example, in rental property, the consent of both occupants and property owner may be required, depending on the nature of the intervention. The mobility of populations, especially low-income inner-city populations, may lead to contamination of study groups, as well as loss to follow-up. While it may

be possible to address these challenges in individual-level studies, they also may indicate that community-level intervention is in order.

Differing Primary and Secondary Prevention Effects

Housing interventions may be carried out to prevent exposure and adverse health outcomes (primary prevention) or may be carried out in the homes of persons who have already developed a health condition to control further exposure and improve outcomes (secondary prevention). The impact of these approaches may differ substantially, and studies should be designed and interpreted with attention to the approach that is being evaluated. Correction of lead hazards prior to exposure of a child early in life may prevent the accumulation of a lead burden. The same intervention carried out in the home of a lead-poisoned child may have less of an impact on blood lead due to release of lead from high bone stores.[84] Exposure to certain allergens early in life may lead to sensitization and perhaps the onset of asthma, while the same exposures later in life may trigger asthma attacks. The exposure-response relation for these two end points (asthma onset vs. asthma-exacerbating symptoms) may be different. A corollary would be that an intervention shown effective for primary prevention may not be effective for secondary prevention purposes and vice versa.

There may be cost implications as well. When lead paint hazards are addressed because of a child with an elevated blood lead level, arrangements for relocating the family and storing, moving, or covering furniture must be made with attendant costs and delays. Primary prevention interventions, on the other hand, may be carried out at opportune times, such as at the turnover of a rental unit or resale, when a vacant unit simplifies a safe intervention.

Understanding Exposure Pathways

It is becoming increasingly easy to identify and measure environmental contaminants and other potential hazards in the home environment. However, environmental measurements in homes cannot guide public health action without an understanding of exposure pathways and the distribution of levels in the housing stock more generally. Here again, the lead example is instructive. Past intervention approaches that focused on paint removal and did not attend sufficiently to controlling lead-containing dust actually caused increases in lead exposure.[37,38] Similarly, developing effective measures for preventing exposure to allergens and harmful constituents of mold will require a thorough understanding of the pathways by which exposure occurs.

Need for Surveillance Data

Data from the National Health and Nutrition Examination Survey[23] showed a strong relation of housing age to blood lead levels of children nationally[23] and have had important policy implications. In general, though, programs to address housing-related health concerns are hampered by a lack of data on the distribution of health hazards and their relation to one another in housing at the national, state, and community levels. Stone et al. ("Childhood Injuries and Deaths Due to Falls from Windows," this issue), for example, note that prior attempts to regulate the requirement for window guards in Cincinnati, Ohio, were thwarted, in part, by a lack of data describing the magnitude of the problem. While the dissemination of such data is no guarantee of policy change, it is an essential part of the decision-making process. Improvements in surveillance can be built into existing systems by adding, for example, information about housing conditions to existing health surveys and information about environmental hazards to existing housing surveys.

Collaboration Between Housing and Public Health Programs

Public efforts to ensure safe housing have and will continue to have a major impact on public health. Stronger ties between housing and public health, as have existed in the past, would be helpful in a number of ways, including application of epidemiology and other public health sciences to the evaluation of housing programs; addressing emerging public health concerns in building and housing codes and providing this process with adequate surveillance data; and training public health and housing professionals to recognize and communicate with each other about health and housing problems encountered in the context of existing programs, such as home visits, housing inspections, housing rehabilitation, and public health education.

CONCLUSION

Although basic living conditions have improved over the past century, the home environment can have an adverse impact on human health in a variety of interrelated ways, some of which remain to be discovered. To address housing-related health concerns, integrated approaches that can address multiple hazards at the levels of the community, the individual dwelling, and the occupants need to be developed and tested. To make the best use of available resources, home environmental concerns should be incorporated into larger programs to improve, preserve, and provide affordable housing and into existing public health and housing surveys. Closer collaboration between the public health and housing

sectors, such as those that existed in the last century, will be required to bring about real progress.

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