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Housing and Healthy Child Development: Known and Potential Impacts of Interventions

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Keywords

housing, child health, healthy child development, toxic stress, intervention studies

Abstract

Housing is often described as an important determinant of health, but less commonly of child health. Despite acknowledgment of the importance of housing to health, however, there are relatively few studies of the effects of housing interventions on health, and again even fewer on child health. This article argues that a broad focus on healthy child development—as opposed to just physical health—coupled with a conceptual framework outlining specific attributes of housing with the potential to influence child health, should be adopted to guide a comprehensive approach to public health policy for healthy child development. Most housing interventions address direct pathways linking in-home hazard exposures to child health outcomes, with promising but mixed results. But few housing interventions address the broader aspects of healthy child development. This review addresses potential housing interventions that could impact the broader determinants of healthy child development and accompanying methodological challenges.

INTRODUCTION

Housing is often described as an important determinant of health, but less commonly as an important determinant of child health. Despite widespread acknowledgment of the importance of housing to health, however, there are, for a number of reasons, relatively few studies of the effects of housing interventions on health, and again even fewer on child health. This article argues that interventions on a narrow set of housing attributes have already demonstrated some mixed potential for reducing harm to children and improving their health. It further argues that a broad focus on healthy child development—as opposed to just physical health—coupled with a conceptual framework outlining specific attributes of housing with the potential to influence child health, should be adopted in order to guide a more comprehensive approach to public health policy and accompanying interventions for healthy child development.

This article begins by making the point that both housing and healthy child development are phenomena with multiple dimensions and that, in order to realize the potential for housing interventions to impact child health, it is necessary to identify the specific multiple attributes of housing and healthy child development that are potentially important to the relationship. This article begins by describing a framework that captures the key domains of healthy child development. This framework is similar to many other frameworks that attempt to capture the salient influences on healthy child development. It identifies five significant domains of healthy child development: physical health and well-being, social knowledge and competence, emotional development and maturity, language and cognitive development, healthy physical development, and communication skills and general knowledge (18). The interdependency of many of these domains is emphasized, and one important underlying determinant of these domains common to families in lower socioeconomic strata is the toxic stress of poverty (69). At the same time, poverty is an important determinant of poor-quality and unhealthy housing; indeed, housing may be one of the important ways that poverty shapes experiences that lead to toxic stress for children, both directly and indirectly (through parental and family interactions).

Given that housing is commonly understood to be a multiattribute phenomenon—a bundle, in other words, of numerous elements—this review then describes a conceptual framework that identifies key attributes of housing that are important to health. This framework was developed elsewhere (21), and not specifically for children, but it can be feasibly adapted to understand the housing experiences of children and the potential impacts of such experiences on child health and healthy child development. The main body of the article uses this housing and health framework as a template for describing the intervention evidence for housing interventions and child health.

Most housing interventions aimed at child health address direct pathways linking in-home hazard exposures to health outcomes, with promising but mixed results. At the same time, relatively few housing interventions address the broader aspects of healthy child development; this article addresses potential housing interventions that could have an impact on the broader determinants of healthy child development.

After describing the evidence on housing interventions and child health, the article then describes ways that different aspects of housing and child development may interact with such factors as household composition and structure. In addition, the article addresses some of the methodological challenges and opportunities for research on housing interventions for child health and healthy child development.

HEALTHY CHILD DEVELOPMENT: KEY DOMAINS

To conceptualize the impact of housing on healthy child development, it is necessary to establish the key domains of healthy child development because the causal processes linking attributes of

housing to healthy child development will differ across domains. Following the work of Kagan (47), Doherty (18), and Janus & Offord (45), this article argues that the key domains of healthy child development are (a) social knowledge and competence, (b) emotional development and maturity, (c) language and cognitive development, (d) healthy physical development, and (e) communication skills and general knowledge. A similar approach is used in a review of housing and child health by Vandivere (76).

The domain of social knowledge and competence refers to an “awareness of the general standards of acceptable behavior in a public place, the ability to control one’s own behavior, the ability to cooperate with others in working together on assignments, appropriate respect for adult authority, and the skills to communicate feelings and wants in socially acceptable ways” (18, p. 22). The domain of emotional development and maturity refers to such traits as the self-confidence to try new tasks and not to fear failure. It also includes the abilities to defer immediate gratification, to persist in repetitive exercises that are required for learning complex tasks, and to cope with momentary failures without emotional outbursts (18).

Language development refers to such things as understanding how language can be used symbolically to represent remote or even imaginary events (18), as well as the ability to “understand adults’ and other children’s verbal communication. . . and verbally communicate experiences, ideas, wishes, and feelings in a way that can be understood by others” (18, p. 23). Cognitive development, on the other hand, “refers to the ways in which children perceive, organize, and analyze the masses of information provided by their social and physical environments. Adequate cognitive skills are essential for both the retention and retrieval of information, and for the effective exploration of new experiences” (18, p. 24).

Healthy physical development includes freedom from disorders that may result from direct exposure to hazards and toxins but “goes significantly beyond the concept of freedom from major disease or gross neurological impairment” (18, p. 21). It includes such factors as physical readiness for activities of daily life, physical independence, gross and fine motor skills, and general vitality and resistance to illness (19). Finally, the domain of communication skills and general knowledge includes the ability to clearly communicate one’s own needs and to understand others’, active participation in story-telling, and interest in general knowledge about the world (18).

While housing likely has a direct impact on only the healthy physical development domain above, the concept of toxic stress in childhood (67–69) helps to provide a broader framework through which poverty, which often includes poor-quality, insecure, and unaffordable housing, can influence physical, emotional, social, cognitive, language, and communicative aspects of healthy child development. This experience of stress may occur directly or through parenting and relationships with other household members; however, according to such a view, housing is influential as a context that shapes behavior and outcomes by exacerbating or ameliorating toxic stress and its effects on the broad spectrum of development.

The toxic stress framework (68) emphasizes how the social and physical environment can induce physiologic responses to toxic stress through a number of pathways. These include the hypothalamic-pituitary-adrenocortical (HPA) axis and the sympathetic-adrenomedullary system. These systems can lead to increased levels of stress hormones, such as corticotropin-releasing hormone (CRH), cortisol, norepinephrine, and adrenaline. Induced changes in these stress hormones “co-occur with a network of other mediators that include elevated inflammatory cytokines and the response of the parasympathetic nervous system, which counterbalances both sympathetic activation and inflammatory responses” (68). Although transient increases in stress hormones are protective, “excessively high levels or prolonged exposures can be quite harmful or frankly toxic, and the dysregulation of this network of physiologic mediators (e.g., too much or too little cortisol; too much or too little inflammatory response) can lead to a chronic “wear and

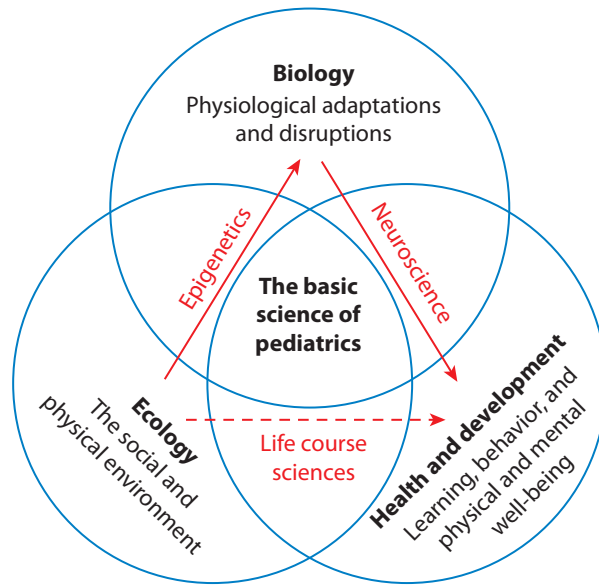


Figure 1

Model of toxic stress pathways between social and physical environments and child health and development. Figure reproduced with permission from the journal *Pediatrics*, Vol. 129, page(s) e232–e246, Copyright © 2012 by the AAP.

tear” effect on multiple organ systems, including the brain” (68, p. e235). This level of prolonged stress “can create a cumulative, stress-induced burden on overall systemic functioning. The aggregated costs, both physiologic and psychological, of coping with this persistent stress exposure and response, and returning the body to homeostatic balance, have been referred to as ‘allostatic load’” (68, p. e235). The wear and tear of allostatic load on the developing child is expressed through epigenetic mechanisms and a variety of neurological impacts on the development of immunological, endocrinological, and other systems over the life course. **Figure 1** illustrates how social and physical environments (i.e., ecology) can influence healthy child development in two different ways. The first pathway is through epigenetic mechanisms, which can influence biology (physiological adaptations and disruptions), which in turn can influence health and development (learning, behavior, and physical and mental well-being). The second pathway reflects a more direct pathway between social and physical environments and health and development over the life course (68). Overall, this model provides a compelling rationale for, and illustration of the mechanisms underlying, connections between housing as both a social and physical environment and a broad conception of healthy child development (despite the more narrow focus implied by reference to pediatrics in the figure, these phenomena are important for healthy child development generally).

HOUSING AND HEALTHY CHILD DEVELOPMENT: A FRAMEWORK

There is now a significant body of evidence showing that housing is an important determinant of health, but the relationship can be complex and even more so when considering healthy child development. Also, because of the nature of housing, it can be challenging to identify actionable attributes and have reasonable expectations of the potential impact on health, especially in the

HOUSING AND HEALTHY CHILD DEVELOPMENT: A FRAMEWORK

Attributes of housing include the following:

- Biological, chemical, and physical hazards
- Physical design
- Psychological attributes
- Social attributes
- Financial attributes
- Locational attributes

absence of a large evidence base of intervention studies. It is common to hear housing referred to as a multiattribute phenomenon, and if that is a credible claim, then it follows that it is important to identify which attributes of housing we can reasonably expect to affect healthy child development and by which mechanisms. Such an exercise is also valuable for identifying the most promising future housing interventions that should be evaluated for their impact on healthy child development. Consequently, the article is guided by a framework developed by Dunn et al. (21), which has been adapted for the purposes of this review. The framework is displayed in simple terms in the sidebar titled *Housing and Healthy Child Development: A Framework*, which lists the six attributes important to healthy child development. The sidebar titled *Factors Moderating the Relationship between Housing and Healthy Child Development* provides important contextual information for interpreting the framework. It displays a list of household and demographic characteristics that may moderate the relationship between housing and healthy child development. It is important to account for the fact that different attributes of housing will be more or less important to different household types.

Biological/Physical/Chemical Attributes of Housing

Housing can have a potentially direct effect on child health in several ways, through biological, physical, and chemical mechanisms (11, 16, 44, 58, 73, 76, 78). A large body of research draws quite direct relationships between exposure to biological (e.g., mold, infestations, vermin), physical (e.g., disrepair, hazards, temperature extremes), and chemical (e.g., radon, chemical exposures) hazards on the one hand and elevated risk of physical illness on the other hand. The most common

FACTORS MODERATING THE RELATIONSHIP BETWEEN HOUSING AND HEALTHY CHILD DEVELOPMENT

Household and demographic characteristics include the following:

- Housing tenure (own/rent)
- Income level
- (Dis)ability
- Age
- Gender
- Race/ethnicity
- Household type/composition

housing interventions aimed at improving child health that can be classified in this category focus on housing-related asthma incidence, lead exposure and its effects, and structural deficiencies that can lead to injury (64, 65). There is a strong justification for focusing on these specific exposures and outcomes: They are responsible for a large burden of morbidity in children, and the population exposed is very large and differentially distributed to the disadvantage of low-income, racialized, and marginalized households (11, 17, 78).

The most convincing evidence of the overall impact of housing interventions on biological, chemical, and physical pathways to child health comes from a review by Sandel et al. (65). The review covers three primary housing intervention targets for children: asthma triggers and incidence, lead exposure and impacts, and injuries.

Most interventions intended to improve or prevent asthma have focused on reducing dust mite exposure, primarily using secondary prevention interventions to reduce dust-mite allergy and asthma in subjects already identified as sensitive or at risk, with few primary prevention studies. The two most promising interventions identified in the review were both quite drastic and involved complete removal of exposures. The first was an intervention moving to a lower-poverty neighborhood [the Boston site of the Moving To Opportunity (MTO) experiment], which resulted in a nearly 50% reduction in children's asthma attacks, while controlling for other risk factors (49); another residential relocation study showed similar results for children and adolescents (71). Other successful interventions involved carpet removal and complete bedding replacement, which reduced dust-mite levels and improved either self-reported or objective outcomes (38, 66).

Despite substantial improvements in lead exposure in children, low-level lead toxicity is still a prevalent environmental hazard in children living in low-income, non-Hispanic black households in older rental housing (5, 46). Interventions are focused primarily on secondary prevention focused on lead-contaminated paint abatement and related measures, and the results are inconsistent, with one study even showing increased blood lead levels among children (54, 65). In countries that are characterized by damp climates and a housing stock where homes are not commonly insulated, interventions to reduce cold and dampness have also been shown to be effective (31, 41, 43, 53).

Injuries are a third target of housing interventions in this category, with a focus on physical attributes of housing and structural deficiencies (44, 65). Because homes may contain many hazards and the specific mix of hazards in any given home may be idiosyncratic, the most promising interventions involve home visiting, identification of multiple hazards, and provision of safety equipment (e.g., smoke alarms, cabinet locks, window guards, and radiator covers) (44, 65).

The causal pathways between exposures within this attribute of housing, on the one hand, and health, on the other, are relatively well understood and direct. That said, the social distribution of risk exposure is inequitable—in other words, low-income, racialized, and other marginalized groups, because of their precarious position in the housing market, are more likely to be exposed to biological, physical, and chemical hazards that come with inexpensive housing options. Moreover, the ability of such households to ameliorate or escape such exposures compounds the inequity of exposure to such risks. Such households, whether they are renters or owners, lack the financial resources to repair or remediate housing deficiencies that are causing exposures. In addition, because of their precarious position in the housing market, they have less leverage to use in complaints to a landlord because the landlord may retaliate against complaints about upkeep, disrepair, or infestation with an eviction notice, which exacerbates the tenant's precarious situation, whether the eviction is justified or not.

Physical Design of Housing

Poor physical design of housing may lead to elevated risk of trips, slips, falls, etc. and physical injury—a potential health hazard that features centrally in building codes, but such codes cannot protect occupants of older dwellings and dwellings that are in disrepair or have not been upgraded to current standards. Interventions that would address most of the hazards that fall into this category are addressed above in the discussion on injuries, but other aspects of physical design may be influential—the space and layout of the home—factors that are suspected to influence child health via psychological mechanisms, both directly and indirectly, through their impact on parents and caregivers (23, 25–27). At the level of site design in multiunit settings, factors such as legibility, wayfinding, and human scale may enhance psychological control, a known determinant of health (26). Evidence shows that, within dwellings, household crowding can be ameliorated by layout and use of space by household members, with specific impacts on children. Studies have shown that having a place where children can go to be alone, despite crowded housing, can be psychologically protective (24) because such a space allows household occupants to regulate social interaction and exposure to other stimuli in the housing environment (e.g., noise, light) (3). Interior design and layout of a dwelling, therefore, may affect health through the role it plays in providing an environment where occupants can practice self-regulation—a property of housing that is sometimes described as “restorative” (36, 37). Where this restorative quality is lacking, occupants experience additional stress and elevated risk of negative health impacts.

Relatively few examples of studies of interventions address physical design attributes of housing, in part because they are considered intractable for a given household. There is, however, a body of research that focuses on objects, interactions, and experiences that are available for a child in the home environment (6–8), which includes some longitudinal studies of the impact on educational outcomes of differences in the physical home environment subscale of the HOME score (Home Environment for Measurement of the Environment) (7, 8). Although these findings are compelling, little evidence from studies of interventions has addressed the health effects of the physical design attributes of housing. It would be difficult to finance and scale actual interventions in the built form of housing to address such issues, but it is possible to conceive of interventions that could show children and caregivers how to adapt to challenging physical designs that may inhibit regulation of stimuli. Such interventions would also have to account for the context of household characteristics that exacerbate the stimuli (e.g., overcrowded housing, lone-parent families, multigenerational families).

Psychological Attributes of Housing

Two key aspects of the psychological attributes of housing include meaning and control of housing (21). This follows from the argument that the home is not merely the backdrop for healthy child development, but rather a contributing factor to the interactions between children, caregivers, other household occupants, and the residential environment (3). Considering the importance of meaning first, the home is one of the most important sites for the investment of meaning in our lives, and a lack of meaning in life is a significant psychological risk for adults and children alike (3, 10, 79). Closely related to meaning is the concept of identity, which is a significant part of the relationship people have with their homes, as the home is an expression of self, an indicator of status, and a reflection of personal values (3).

In terms of control, the social epidemiological literature suggests that having control over one's life is a significant determinant of health. Indeed, many have hypothesized that control is the underlying factor that explains the socioeconomic gradient in health, at least with adults and in worksites (48, 74). The greater one's income, educational attainment, or other measure of

socioeconomic position, the greater control one is able to exercise over everyday life, and it is this underlying control that causes differentiation in health status by socioeconomic status. A similar relationship between control and health can be seen with children (59). If we translate the impact of control to housing, it can be illustrated by the observation that of all the spaces a person occupies in their daily life (and all human activity must occupy some space), the home is the only site where people are socially and legally sanctioned to have complete control. The home is also commonly regarded as a place where one can have a sense of security and refuge from the world (3). It follows, then, that where control in the home is lacking, occupants may incur a significant health risk. Uncontrollable stressors such as a lack of control in the home are likely to be key determinants of learned helplessness and a known health risk (24, 59). Similarly, the environmental psychology literature emphasizes the need for environments that provide opportunities for psychological restoration, which usually means the reduction or elimination of environmental stimuli (37).

For children, these psychological attributes are important for the development of self-regulation, self-esteem, psychological well-being, and mental health. Although no interventions were found that address these factors specifically, there is evidence from more generic housing interventions that improved housing is associated with mental health and to which the psychological mechanisms of meaning and control are likely partly attributable (1, 29, 70).

Social Attributes of Housing

Social support is a significant determinant of health, and social isolation is a significant risk factor for poor health. Social support performs an important range of functions for adults, including guidance (advice or information), reliable alliance (assurance that others can be counted on in times of stress), reassurance of worth (recognition of one's competence), attachment (emotional closeness), social integration (a sense of belonging to a group of friends), and opportunity for nurturance (providing assistance to others) (15). The existence of social support among adults is of course important for the children in their care in a domestic environment. The home is an important site for the establishment and maintenance of social ties. If one's home is not an appropriate site for participating in social relationships, then that shortcoming may confer health risks. For instance, a home that is poorly located or inadequate for making and maintaining social ties, therefore, may represent an important health risk.

The implications of the social attributes of housing are significant because the home is seen as "the framework for relationships with family and friends, a place to raise children, and a symbol for continuity in life" (3, p. 172). It is, of course, the routine environment in which most parenting takes place. Indeed, "the socialization of children. . .," according to Bartlett (3), "is a function not only of proximal interaction between parent and child, but is also expressed through the parents' response to the child's environment" (3, p. 174; 35).

At the neighborhood level, local social ties are the basis of security that comes from trust and the resources that can be acquired through reciprocal social relations and collective efficacy. These are a source of informal resources that promote social stability and durability, forces that can affect children directly and indirectly through their parents. Often described as "the strength of weak ties" (33), these kinds of local social ties that are associated with relative residential location are important elements of many people's social networks and have been positively related to health (4). It follows that if someone's home prevents them from developing at least locally based weak ties, a health risk may be conferred.

Financial Attributes of Housing

Urban land markets act as important engines of economic inequality in market-based societies, exacerbating underlying inequalities that stem from the operation of the labor market. Land

markets tend to transfer income in a regressive fashion, that is, from lower-income households to upper-income households (2). This transfer happens through a number of mechanisms, and most of these hinge on the distinction between homeowners and households who rent their housing. The tax advantages of home ownership are significant and largely invisible. The foregone government revenues from providing (largely tax) subsidies for homeownership are many times greater than spending on affordable housing in many countries. For this and other reasons, renter households, who tend to be lower income, tend to pay a greater proportion of their income toward shelter costs and have a limited number of affordable options available to them (72).

Unaffordable housing is a significant threat to health because it reduces postshelter disposable income. This concept is important partly because housing is typically the single largest item in the budgets of low-income households, but it is also inelastic. If a household does not have much money in a certain month, it does not have the option of reducing the amount of housing it consumes (e.g., reduce the square footage they occupy). The only options available are to move (which involves significant transaction costs and may not be possible if they are at the bottom of the market) or to reduce household expenditures in other aspects of home life. As a result, households who have low postshelter disposable income tend to discount their health in important ways (12), by cutting back on other expenditures that affect health (e.g., food, prescriptions, out-of-pocket medical services) to maintain their housing when money is tight (52). For example, a study of households in 12 low-income neighborhoods in Toronto showed no relationship between income and food insecurity but showed a strong relationship between postshelter income and food insecurity (52). Two other studies (61, 62) find evidence of a relationship between housing affordability and child cognitive achievement (61) and evidence of discounting of child well-being in the face of high housing costs as a proportion of income (62). An additional study using a pseudo waitlist design finds that children (ages 2–17) in households who were placed in public housing were more likely to show significant improvements in parent-rated mental health than the comparison group from the student waitlist. Children in households that received housing vouchers did not see a significant improvement compared to the pseudo waitlist group (29).

In addition, households that pay a large proportion of their income toward shelter costs are highly vulnerable to exposure to substandard housing (e.g., biological, physical, and chemical hazards) (65). In addition, it is difficult for such households to escape these exposures. On the one hand, if they are homeowners, their lack of income may prevent them from taking action to ameliorate the exposures in their home. On the other hand, because vacancy rates are so low and housing affordability so challenging in most housing markets (72), there are few housing options available to low-income households within their budget; therefore, they are often forced to accept substandard and unhealthy housing conditions. Low-income households have little leverage (and high risk of eviction and homelessness) if they attempt to force their landlord to meet housing standards.

There is significant potential for further examination of financial housing assistance interventions, which have so far been investigated in very few studies (22). One systematic review of studies examining housing assistance and child health (70) identified 14 studies, including 4 quasi-experimental studies that investigated the impact of housing assistance interventions on child health (excluding housing mobility programs, addressed below). The housing interventions studies are primarily on public housing and housing vouchers. Most of the studies are of poor quality, and the four studies of moderate quality focus on mixed outcomes [self-reported violent behaviors, birth weight, caregiver's perception of child's health, measured body mass index (BMI), caregiver's report of internalizing and externalizing behaviors, caregiver's report of behavior problems, and perceived child health], with mixed results. Notable results from the quasi-experimental

studies include an association between public housing and higher violent behavior in a sample of youth (42); no association between public housing receipt and any of birthweight, BMI, or perceived child health (30); an association between smaller increasing internalizing behaviors over time for children receiving housing assistance (13); and evidence that housing assistance was beneficial for children with the fewest behavior problems (<10th percentile) and harmful for those with the worst behavior (>95th percentile) (60). Surprisingly few studies have been conducted on the impact of financial assistance with housing—this is effectively an income transfer—and can be seen as an improvement in postshelter disposable income. There are also very few examples of the impacts of household income supplementation interventions to guide us, but those that exist have shown positive effects on children, especially behavioral and attention outcomes (14). These results suggest strong potential for financial assistance with housing to have a significant impact on healthy child development, so long as the intervention is of sufficient magnitude.

Locational Dimensions of Housing

Land markets tend to operate as powerful socio-spatial sorting mechanisms, sorting people of similar socio-economic circumstances into similar parts of the city. This is significantly aided by zoning and other urban planning mechanisms, which govern proximity to amenities, size of residential lots, and size and types of dwelling units built in different parts of the city. At the same time, neighborhoods tend to operate as local “health opportunity structures” (56) and people of lower socioeconomic status are differentially exposed to health-promoting and health-diminishing opportunities, usually magnifying the health consequences of their socioeconomic disadvantage, in a process called “deprivation amplification” (57). According to Ellen & Glied (22), low-income children consistently live in poorer neighborhood conditions than do other children, and these neighborhoods are characterized by a number of attributes that make them less healthful for children. First, evidence shows that low-income children are more likely to be exposed to pollutants in their neighborhood of residence and to experience negative health effects as a result (22). High levels of automobile traffic are also more common in low-income housing neighborhoods, leading to elevated air pollution and risks to pedestrians (22). A number of amenities that serve everyday life are either absent, too widely dispersed, more expensive, or of poorer quality in low-income neighborhoods, including grocery stores with affordable nutritious foods (55), recreational facilities, schools, and health care services (22). Systematic neighborhood disadvantages in health opportunity structures such as these are driven in part by racial and income segregation. Somewhat surprisingly, however, neighborhood racial segregation has an equivocal relationship with overall children’s health, likely owing in part to self-selection into neighborhoods, but also to a lack of a full range of counterfactuals to fully populate multilevel models of neighborhood effects (e.g., there are few poor people living in rich neighborhoods and few rich people living in poor neighborhoods) (75).

Mobility programs—notably the MTO intervention, which was designed to reduce poverty concentration by randomly assigning households to move to low-poverty neighborhoods—can also provide some limited insights. Although investigators randomized households to move residence to another neighborhood, housing is very much a black box in the design of the study; little is known about housing quality at baseline and follow-up. Additionally, the results of these mobility experiments are quite mixed. As Ellen & Glied (22) argue, the MTO intervention “did not appear to generate any detectable effect, long-term effects on children’s overall physical health” (32, p. 146), but the effects on mental health varied by gender and age. Girls who moved to low-poverty neighborhoods experienced significant reductions in depression and conduct disorder, but boys showed higher rates of depression, post-traumatic stress disorder, and conduct disorder

(51). Younger children from households participating in MTO were less likely to show increases in behavioral problems (28).

Applying the Framework for Different Households

The attributes of housing that make a difference for health described in this framework often operate differently for a number of different population groups and axes of social differentiation. Such differences include owners and renters, varying income levels, (dis)ability, varying age groups (children, seniors), gender, race and ethnicity, immigration status, and household structure/composition (see sidebar titled *Housing and Healthy Child Development: A Framework*). Thus, the housing needs and challenges associated with each of the attributes of housing described above may be more or less important or may operate differently, for these and other social groups. For children, the lone-parent families and overcrowded households, regardless of family structure, are typically the most vulnerable and often also have the poorest housing conditions and the most stressful household conditions for both caregivers and children.

POTENTIAL FOR FUTURE INTERVENTIONS IN HOUSING FOR HEALTHY CHILD DEVELOPMENT

While more work clearly needs to be done to develop and implement policies and interventions to reduce children's exposures to biological, chemical, and physical hazards in the home to address asthma, lead toxicity, and injuries (65), a broader view of the impacts of other attributes of housing (e.g., physical design, psychological attributes) on healthy child development also presents a number of opportunities. The effects of the other attributes of housing on healthy child development may be direct or indirect (e.g., through parents and other caregivers), and useful evidence indicates that effective in-home visiting programs can have a significant impact on the toxic stress experienced by children and its effects on epigenetic and biological stress responses (e.g., the HPA axis). In their review of interventions to address the biological impacts of child adversity, Purewal Boparai et al. (63) found 14 studies of interventions in community settings, half of which were part of the Strong African American Families program. The majority of interventions focused on epigenetics [e.g., properties of the risky short allele ("s") of the gene *5-HTTLPR*] and HPA axis (e.g., cortisol) outcomes. Although the studies in the Purewal Boparai et al. (63) review did not directly address housing as an intervention, the programs it reviewed showed a clear ability to alter the course of the biological impacts of child adversity. When coupled with the insights from Bartlett (3) concerning the home as not merely the backdrop for parenting but a significant context that enables and constrains specific caregiving behaviors and child reactions, this work on the biological impacts of child adversity leads to a variety of new intervention possibilities to enhance healthy child development through housing interventions.

METHODOLOGICAL CHALLENGES OF HOUSING AND CHILD HEALTH INTERVENTIONS

Every month of the year there are many thousands of households who are moving—changing their place of residence—and each residential move is potentially eligible for inclusion in a quasi-experimental study design to better understand the impact of housing on health. As a result, there should be much potential for more housing interventions to improve healthy child development; however, in reality, there are many complications. First, unless a household moves into some institutional housing situation (e.g., public housing), or receives some sort of government assistance, there is unlikely to be any way to collect data about the housing intervention that the household may have undergone, and data are rarely collected routinely on such movement.

Without routine administrative data, primary data collection poses the challenges of recruitment, retention, language, and ethics, among others, in doing research with low-income, marginalized populations (20, 77), which can be made even more complicated when the target population of the research is children. Even under optimal circumstances, when households do change housing, rarely can they be recruited without significant selection effects, and both baseline and follow-up data can be captured with a tolerable level of attrition. Moreover, with the exception of leaving homelessness for housing, drastic changes in housing quality or affordability are rare in the affluent countries of the world: Households generally tend to move to housing that is only a little bit better than the housing they had before. Such an assessment—of only modest improvements in housing quality—is merely an impressionistic one, however, because unfortunately there are few good options for measuring housing conditions except in the domain of biological/chemical and physical attributes of housing. The most straightforward method to assess housing conditions, i.e., by resident self-report, is problematic given its vulnerability to bias. Although standardized visual assessments of housing conditions made by trained assessors would be ideal, only the most egregious deficiencies in housing quality are visible to the naked eye, and in most affluent societies a small minority of households live in such conditions. Still other aspects of housing quality are context dependent, for instance may be problematic only for a single-parent or a crowded household. Only two standardized measures have yet been developed, neither of which have enjoyed widespread use (27, 50), severely limiting the potential for conducting rigorous studies that can investigate the effects of change in housing quality on change in health status. Furthermore, housing has a very wide variety of attributes with the potential to affect health (21), and not all of these attributes can or should be measured in any one study. In housing and healthy child development, the HOME scale (9) predominantly measures the presence of objects within the home that may stimulate child development, rather than attributes of housing itself and exposures that might be harmful to healthful child development.

Despite these challenges, many opportunities are worth pursuing, and some important new developments in study designs have emerged to assist with housing intervention studies. One example is the possibility of using the stepped-wedge cluster-randomized trial design (39), in which baseline data are collected from a group of people on a waitlist and then, at some later point in time, a subset of this group is randomized to receive the intervention. This design is particularly well suited to the study of housing because it is common in housing systems for households to sit on a waitlist for public or other forms of housing programming for a long time and then, at some point, to receive the intervention, i.e., new housing. Randomization to the intervention can be repeated for multiple subgroups of the original baseline group. Although this design is powerful, it can be challenging to convince housing service providers to allocate housing to waitlist applicants on a randomized basis. In such an instance, defining a comparison group to the intervention group using a pseudo waitlist approach (29), despite its vulnerability to potential selection effects, provides another promising design for investigating the effects of housing on health and healthy child development.

One final methodological challenge common to all interventions on the socioeconomic determinants of health, including housing, is that people carry their history with them. In other words, even a drastic intervention to improve a socioeconomic determinant of health may not have a significant impact on a person's health because the cumulative lifelong impact of their prior socioeconomic deprivation cannot be (completely) undone. The effects of prior socioeconomic deprivation may be less impactful for children, in part because any cumulative impact on health has had less time to develop, but also because evidence indicates that in children the effects of some exposures can be ameliorated and possibly even reversed with the right stimulation (40, 63), at least for certain outcomes, but is also influenced by processes of biological embedding across generations as well (34).

CONCLUSIONS

Housing is an important determinant of child health. Research on interventions on a narrow set of housing attributes has already demonstrated some mixed potential for reducing harm to children and improving their health. A broader focus on the impact of housing interventions on healthy child development—as opposed to just physical health—has significant potential for future housing and healthy child development policy in public health. Frameworks that break down the specific attributes of housing and the potential mechanisms linking them to healthy child development can inform interventions more effectively than can black box approaches. In terms of healthy child development, use of the concept of toxic stress of poverty and disadvantage is a helpful frame to understand the biological mechanisms that link housing—a critical social and physical environment in the everyday lives of children—to epigenetic and biophysiological responses to stress. Notwithstanding the potential, which is evident when one considers that every month some people change residential location—and therefore become potentially eligible for participation in research on housing interventions—there are numerous methodological opportunities and challenges to expand the evidence base for housing and healthy child development.

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