Findings from the Initial Use of the Healthy Homes Rating System (HHRS) in Three American Cities

Katelyn Burkart · Jonatan Martinez ·
Alicia Streater · Lyke Thompson

Published online: 7 April 2017
© The New York Academy of Medicine 2017

Abstract HUD’s Healthy Homes Rating System (HHRS) is a modification of the English version, using scoring values developed in England. The goal of the HUD Three-City Healthy Homes Rating System (HHRS) study was to create a baseline of the prevalence and severity of 29 home health hazards in three cities—Detroit, MI; Greensboro, NC; and Alameda County, CA—and to compare the results to the prevalence and severity found in England. We analyzed 978 housing assessments over 3 years. Hygrothermal hazards (e.g., excess cold) were the most prevalent across the sites. However, significant differences in the type and severity of hazards across communities were found and were more severe in US sample homes than in their English counterparts. The results suggest that the tool shows promise in its ability to identify home health hazards.

Keywords Healthy Homes Rating System · Home health hazards · HHRS scoring

Introduction

A number of studies have linked the presence of home hazards to negative human health outcomes [1–5]. With Americans spending up to 90% of their time indoors and up to 50% of their time within their homes, the impact of health and safety hazards in the home is substantial [4, 6].

Home health hazards have been linked to a variety of negative health outcomes. Mold and volatile organic compounds have been linked to respiratory tract infections [7], asthma, and asthma morbidity [1, 3]. Radon has been linked to cancer [8, 9] and death [10]. Extreme weather has also led to the exacerbation of existing respiratory and heart ailments as well as to death [11]. Additionally, studies have linked the presence of lead paint in the home to lead poisoning and lower IQs [12–14], learning disorders [15], criminal activity [16], and hormonal deficiencies [17]. Hazards such as carbon monoxide have been highly correlated to lack of detectors in the home, and the effects can include neurotoxicity, coma, and death [18, 19]. Slips and falls are the leading cause of death and non-fatal injury in the home according to the Home Safety Council, exceeding harm done by objects and other people [20]. More than 90% of fire fatalities in the United States occurred in the home, with most of the fatalities occurring to residents younger than 10 [21]. The Centers for Disease Control (CDC), the Environmental Protection Agency (EPA), and the Department of Housing and Urban Development (HUD) have been jointly and independently increasingly focused on these health hazards associated with aging American housing stock. The goal is to reduce death, injury, and illness related to home hazards.

Given the increasing evidence that human health is tightly linked to the quality of housing, early identification and comprehensive measurement of the full range of housing hazards becomes the key. One approach that has been gaining popularity in the United States is a modification of the Housing Health and Safety Rating

K. Burkart (✉) · J. Martinez · A. Streater · L. Thompson
Wayne State University, Detroit, MI, USA
e-mail: dv2491@wayne.edu

System (HHSRS) used by the English Housing Condition Survey to assess and monitor housing conditions and inform national housing policies in England [22]. Despite this widespread adoption, we could not find detailed data on the original study that lead to the development of the HHSRS, including detail about the sample. However, the American version, known as the Healthy Homes Rating System (HHRS), was adapted from the English version with minor alterations and ratified as the standard in 2011 for identifying health and safety hazards in communities throughout the US [23, 24].

The HHRS is an evidence-based qualitative inspection process that allows a trained assessor to consider a broad range of housing hazards and compare their relative severity to identify risks to the health and safety of occupants. The tool includes the assessment of 29 home hazards and 3 sub-hazards. (A complete list of hazards and sub-hazards is included in Table 5.)

HUD has used the HHRS to assess housing for health and safety risks as the basis for decisions that shape the policy path related to housing health and safety standards in the United States. The results of the tool also can be used to guide decisions about investment of resources to improve the quality of housing and ensure that all Americans have the opportunity to live in a safe and healthy home.

However, the HHRS is relatively new in the US and relies on housing and risk data collected in England to estimate hazard levels [25]. To the extent that the US and England differ in climate, housing materials, and building codes, there is uncertainty that the data underlying the calculations used in the HHRS will produce comparable results. Because this method of assessment has policy implications for the measurement of housing quality nationally, there is a need to analyze the implementation of the HHRS in the United States.

This study was developed to investigate the application of the HHRS in the United States using three geographically diverse cities to provide a baseline understanding of the prevalence and severity of the hazards and sub-hazards using the English data. A secondary objective was to compare the prevalence of hazards found in the US with the prevalence found in England to determine if adjustments in US policy decisions regarding housing standards are needed.

Methods

Sample

Three geographically diverse cities were selected for the study. All three communities were urban, had public housing authorities, and had different surrounding natural environments and demographic characteristics. In two of the three sites (Detroit and Greensboro), just the central cities were used for the sample, while in Alameda County, the entire county was used, including substantial suburban housing surrounding its central city of Oakland, California.

- Detroit, Michigan, is the largest city in the state. The city is 81.7% African-American and has 66.4% of adults participating in the labor force as of 2013 [26]. As of 2013, Detroit had a population of 706,663, a poverty rate of 39.3%, and a burglary rate of 1907.5 per 100,000. Approximately 93.1% of the housing in Detroit was built prior to 1980.
- Greensboro, North Carolina, is the third largest city in the state, located in the Piedmont region. Greensboro's population consists of 49.4% white and 40.4% African-American as of 2013 [26]. As of 2013, Greensboro had a population of 273,228, a poverty rate of 20.3%, and a burglary rate of 1211.4 per 100,000 people. Approximately 48.5% of the housing in Greensboro was built prior to 1980.
- Alameda County, California, is located in the San Francisco bay area of Northern California. The central city of Alameda County, Oakland, is the third largest city in California. Alameda County population is 43.0% white, 26.1% Asian, 12.6% African-American, with a sizable (22.5%) Hispanic population [26]. As of 2013, Alameda County had a population of 1,510,271, a poverty rate of 12.5%, and Oakland had a burglary rate of 1544.0 per 100,000 people. In the county as a whole, 72.6% of the available housing was built prior to 1980.

Across all study sites, the sample included both public and private housing, single- and multi-family units (although in the latter case, we often just assessed one flat of the building), and the age varied substantially (from recent homes built within the last 5 to 10 years to historic buildings over a century old). Table 1 presents an overview of the quality of housing in each of the sample sites.

Study Recruitment

A random sample of 500 homes in each city was drawn by Survey Sampling, Inc. A computer-aided telephone interviewing (CATI) system was used to call households and solicit their participation in the study. Each household reached was asked whether they would be willing to participate in an approximately 2 h visit by a team of assessors. They were offered a monetary incentive (originally \$10, later raised to \$15) for participation. Each household was scheduled for a visit, and two assessors were scheduled for an assessment (the second person was there for safety).

Prior to data collection, study protocols and instruments were approved by the Wayne State University Institutional Review Board (IRB). The IRB approval covered all three study locations. The three cities were chosen to get a wide range of differences in the status of housing quality, climates, and socioeconomic areas within the US.

Data Collection

All the assessors were trained by HUD-approved trainers. In addition, they participated in regular sessions which took two approaches to reinforcing the training and improving their abilities. First, they were asked to listen to a presentation of a case by one of the assessors and then jointly discuss the way it was rated. One or more experts (among the trainers) participated in this process. Second, staff discussed one kind of hazard (lead paint, moisture, etc.) in detail talking about the considerations that might be considered in making judgments about the level of the hazard or extent of injury. Non-identifiable photographs taken from the study homes were used in making hazard judgments by an independent rater to the group, in order to reinforce the training assessors had already received.

At the home, the assessor completed a visual assessment of the interior and exterior of the building guided by the electronic Healthy Homes Case Management System (HHCMS) accessed in the field using a tablet. Assessors took pictures of any visually identifiable hazards, which were stored in the HHCMS, to assure a complete database of the home's condition when the assessor returned from the field. Assessments were conducted between 2012 and 2015, across all seasons and weather. All hazards were assessed visually by

assessors, as the study attempted to minimize the use of self-reported answers by residents. For example, the *Falls on Stairs* category was determined by the tread, pitch, and size of steps; whether or not proper handrails were present, their sturdiness and their size; and the lighting above the stairs, among others.

Upon leaving the home, the assessors first rated the probability of a hazard causing an injury or harm using a scale that ranged from 0 to 5000+. These estimated probabilities were then classified into hazard summary bands ranging from A through J as shown in Table 1. Next, they estimated the extent of the harm ranging from minor illness or injury to death that would occur if the risks of harm were realized. A range of factors were taken into consideration, such as age and situation of the structure (a single-family vs. multi-family unit, for example) to calculate risk. Harm was classified into four categories that ranged from minor injuries such as stress, scrapes, and bruises (class IV) to death and dismemberment (class I). These were considered by the assessor when scoring the HHRS. Having completed this, an overall score for the hazard could be calculated. This process was completed for each of 29 hazards and three sub-categories for a total of 32 individual hazard ratings for each home.

The HHRS score was determined by calculating the sum of products for harm multiplied by a harm weight and the likelihood. Likelihood tables have averages imbedded in them to help guide the assessor's justification for their decision. The scores are displayed by lettered hazard bands or grades. An A rating is considered most severe, J is considered the least likely to cause harm to inhabitants (see Table 2). The hazard scores, along with estimates of injury outcomes, produce a clear understanding of the risks from the home health hazard [5]. This calculation is done for each of the 29 hazards and 3 sub hazards to produce an overall set of identified hazards for a residence.

Table 1 Housing overview [26]

	Detroit	Greensboro	Alameda County
Number of houses	363,194	125,852	584,652
Pre-1980 housing	93.1%	48.5%	72.6%
Percent owner-occupied	51.9%	53.1%	53.2%
Vacancy rate	29.3%	11.3%	6.8%
Median rooms	5.6	5.2	4.9

Table 2 HHRS hazard band and ratings score ranges

Hazard band (rating)	Score range
A	5000+
B	2000 to 4999
C	1000 to 1999
D	500 to 999
E	200 to 499
F	100 to 199
G	50 to 99
H	20 to 49
I	10 to 19
J	9 or less

Finally, a subset of homes (100 was the goal for each site, although it was only reached in Detroit) were chosen to be assessed again using a different assessor to determine the inter-rater reliability. In addition to the 100 Detroit homes re-assessed, an additional 72 in Greensboro and 64 in Alameda County were conducted. Ratings were completed and entered into the HHCMS database, which was used for the analysis.

Results

A total of 978 houses were assessed in the project. Slightly more than half of the assessments ($n = 497$, 51%) were completed in Detroit, 264 (27%) of the assessments were completed in Greensboro, and 217 (22%) were completed in Alameda County. The prevalence and severity of hazards differed across the three communities, as well as, from house to house within a single site. Following the HHRS classification system, an A–C hazard rating would indicate an immediate need to act in order to reduce the likelihood and/or severity outcomes currently present within the home. Hazard

ratings D–J were considered less serious and the need for taking remedial action was less clear. Table 3 presents the three most common A–C hazards across the study sites.

The results showed some consistency in hazard prevalence across the three sites. Hygrothermal hazards were the most frequently occurring in the study, with Excess Cold being the most prevalent A–C hazard across all three sites. At 3.1% average, falls were the second most likely group of hazards, after hygrothermal (15.6% A–C on average). In Detroit, Mold and Dampness and Excess Heat (also a hygrothermal hazard) round out the top three A–C hazards. Falls on Stairs were the second most likely hazard to be rated A–C in both Greensboro and Alameda County. In Alameda County, Calif., fire was the most frequently occurring serious hazard, found in 11.8% of homes, but this rate was much lower in Detroit (0.6%) and Greensboro (2.7%).

With respect to the proportion of homes with any identified A–C hazards, Detroit and Greensboro were similar having the highest proportion of homes with at least one serious hazard. As shown in Table 4, in both cities over 62% of the housing units assessed had at least one serious hazard requiring remediation. In contrast, less than a third of the homes in Alameda County had a serious hazard. With respect to homes with multiple serious hazards, Detroit had the highest percentage (18.1%) followed by Greensboro (15.5%), and Alameda County (10.6%).

To address the second objective of the study, the hazard band results found in the three cities were compared to the prevalence results in England. Table 5 shows the English average ratings along with the ratings for each hazard at each US site and for the study as a whole.

The average rating for the study agreed with the average rating for England on 7 hazards, with the American study posting the higher rating on 22 occasions. Detroit agreed with the English averages most

Table 3 Most common serious (A–C) home hazards across study sites

Detroit, MI		Greensboro, NC		Alameda Co., CA	
Hazard	% A–C hazard rating	Hazard	% A–C hazard rating	Hazard	% A–C hazard rating
Excess cold	47.7%	Excess cold	57.3%	Fire	11.8%
Mold and dampness	8.9%	Falls on stairs	8.9%	Falls on stairs	10.1%
Excess heat	8.9%	Mold and dampness	4.6%	Excess cold	7.5%

Table 4 Percentage of households in sample with serious (A–C) home hazards present

Household location	0 A–C hazards present	1 or more A–C hazards present	Multiple A–C hazards present
Detroit	37.4%	62.6%	18.1%
Greensboro	37.9%	62.1%	15.5%
Alameda County	69.4%	30.6%	10.6%

frequently, sharing ratings on 11 of 31 letter rating averages, followed by Alameda (10), and Greensboro (9). On every hazard in which the rating was not the

same, Detroit hazards were rated as more severe than Britain. Greensboro also had more severe scores in all instances of disagreement. Alameda and Britain rated 10

Table 5 Hazard bands by site, compared to English averages

Hazard	England	Detroit	Greensboro	Alameda	Study Avg.
1. Damp and mold growth	J	D	I	G	E
2. Excess cold	D	C	D	E	C
3. Excess heat	–	C	C	C	C
4. Asbestos and other MMF	J	C	H	G	D
5. Biocides	J	J	J	J	J
6a. Carbon monoxide	J	G	E	G	F
6b. Nitrogen dioxide	J	J	I	I	I
6c. Sulfur dioxide and smoke	J	J	J	J	J
7. Lead	J	E	H	H	F
8. Radiation	H	G	G	G	G
9. Uncombusted fuel products	J	I	I	J	I
10. Volatile organic compounds	J	J	J	J	J
11. Crowding and space	I	H	H	H	H
12. Entry by intruders	F	E	F	F	E
13. Lighting	J	J	J	J	J
14. Noise	J	J	J	I	J
15. Domestic hygiene, pests and refuse	J	H	I	H	H
16. Food safety	J	J	I	J	J
17. Personal hygiene, sanitation and drainage	J	G	H	J	H
18. Water supply	J	H	J	J	H
19. Falls associated with baths	J	H	I	G	J
20. Falls on level surfaces	F	F	E	E	E
21. Falls on stairs	H	E	E	D	E
22. Falls between levels	J	J	H	G	H
23. Electrical hazards	J	G	G	H	G
24. Fire	I	F	F	E	F
25. Flames and hot surfaces	H	H	G	G	G
26a. Collision and entrapment	I	G	F	G	G
26b. Low overhead	J	I	H	H	H
27. Explosions	J	H	I	I	H
28. Position and operability of amenities	J	J	J	J	J
29. Structural collapse	J	I	H	H	H

hazards the same way. Of those not agreeing, 19 were rated more severely in Alameda County than in Britain. Findings indicate that American housing hazards are rated more severely than those in England.

There were 5 hazards which shared ratings across all sites: biocides, sulfur dioxide, volatile organic compounds, lighting, and position and operability of amenities. Notably, all these hazards were rated as having the lowest probability of occurrence. Conversely, there were 15 hazards in which none of the averages matched the English average rating in the three cities in this study, or the overall project average rating. Those hazards consisted of damp and mold growth, asbestos and MMF, carbon monoxide, lead, radiation, crowding and space, domestic hygiene, falls associated with baths, falls on stairs, electrical hazards, fire, collision and entrapment, low overhead, explosions, and structural collapse. In general, the English and American scores are very different, whether because of actual objective differences or because of variation among the assessors.

Discussion

This three-city study using the HHRS clearly demonstrates both commonalities and differences among US cities. First, it found that excess cold is a common challenge across the three cities. Mold and dampness and falls on stairs were common to two of the three cities. At the same time, it was clear that two of the cities (Detroit and Greensboro) had doubled the number of severe hazards than did Alameda County.

There were clear indications that the American results differed substantially from the English. Specifically, the hazards identified in American cities tended to be more severe than their English counterparts. This was the case for 24 hazards out of the total 29. In no case were the English ratings more severe than the average of those identified in the US. Whether this is the result of objective conditions or differences in assessment practices is unknown, and may provide an area for further study.

The nearly 1000 assessments we conducted created a baseline of the prevalence and severity of the 29 home health hazards in the three cities, as well as a baseline for homes in the United States. In addition, we performed the first in depth look at the efficacy and reliability of the HHRS as an assessment tool. We found that this tool shows promise in its ability to display the condition and

the need of homes in the United States to help guide policy decisions and resource distribution.

A number of potential limitations were associated with this study, including the issue of potential bias at the assessor level. While we attempted to rectify this through the internal assessor meetings where cases and photographs from study homes were presented and then audited by the group (including at least one independent observer), and through follow-up visits that occurred in 100 Detroit homes, 72 Greensboro homes, and 64 Alameda County homes. Despite this, inter-rater reliability proved to be low. A possible method for establishing inter-rater reliability would be to have another rater review the pictures from the home visits. However, in careful review of this, we found that only about half of the hazards can be adequately observed visually. Nevertheless, this could be a possible future study. Another future study that could help assess the validity of the HHRS would be using physical measurements to capture the extent of many hazards. Here again, challenges exist in that adequate physical measures do not exist for a number of the hazards observed in the HHRS.

In the end, if these results are confirmed, the CDC, EPA, and HUD have good reason to be concerned with US home health hazards. In two of the three cities, more than 60% of the housing had at least one serious, potentially life threatening hazard. Overall US home health hazards appear to be substantially worse than those in England. This suggests the need for more aggressive policy action to reduce risks for vulnerable populations, particularly in older existing housing. Just as the US is underinvesting in other infrastructure, this study appears to indicate we are also underinvesting in housing infrastructure.

References

1. Gruchalla RS, Pongracic J, Plaut M, et al. Inner-city asthma study: relationships among sensitivity, allergen exposure, and asthma morbidity. *J Allergy Clin Immunol.* 2005; 115(3): 478–85.
2. Habib G, Hoen B, Tornos P, et al. Guidelines on the prevention, diagnosis and treatment of infective endocarditis. *Eur Heart J.* 2009; 30: 2369–413. doi:10.1093/eurheartj/ehp285.
3. Nriagu J, Martin J, Smith P, et al. Residential hazards, high asthma prevalence and multimorbidity among children in Saginaw, Michigan. *Sci Total Environ.* 2012; 409: 5423–31.
4. Klepeis N, Nelson W, Ott W, et al. The National Human Activity Pattern Survey (NHAPS): a resource for assessing

- exposure to environmental pollutants. *J Expo Anal Environ Epidemiol*. 2001; 11(3): 231–5.
5. Shaw M. Housing and public health. *Annu Rev Public Health*. 2004; 25: 397–418. doi:[10.1146/annurev.publhealth.25.101802.123036](https://doi.org/10.1146/annurev.publhealth.25.101802.123036).
 6. *Leading our nation to healthier homes: the healthy homes strategic plan*. U.S. Department of Housing and Urban Development, Office of Healthy Homes and Lead Hazard Control. Washington, DC: U.S. Department of Housing and Urban Development, Office of Healthy Homes and Lead Hazard Control, 2009.
 7. Araki A, Kawai T, Titaki Y, et al. Relationship between selected indoor volatile organic compounds, so-called microbial VOC, and the prevalence of mucous membrane symptoms in single family homes. *Sci Total Environ*. 2010; 408(10): 2208–15.
 8. Darby S, Hill D, Dool R. Radon: likely carcinogen at all exposures. *Ann Oncol*. 2001; 12(10): 1241–351.
 9. Angell W, Zeeb H, Shannoun F. *WHO handbook on indoor radon: a public health perspective*. Geneva, Switzerland: World Health Organization; 2009.
 10. Heart B, Mettler F, Harley N. Radon: is it a problem? *Radiology*. 1989; 173(3): 881. doi:[10.1148/radiology.172.3.2549562](https://doi.org/10.1148/radiology.172.3.2549562).
 11. Klinenberg E. *Heat wave: a social autopsy of disaster in Chicago*. Chicago, IL: University of Chicago Press; 2002.
 12. Dixon L, Jacobs D, Wilson J, Akoto J, Clark C. Window replacement and residential lead paint hazard control 12 years later. *Environ Res*. 2012; 113: 14–20. <http://www.ncbi.nlm.nih.gov/pubmed/22325333>.
 13. Bellinger DC, Bellinger AM. Childhood lead poisoning: the torturous path from science to policy. *J Clin Invest*. 2006; 116(4): 853–7.
 14. Weiss D, Boyle E, Chavagnac V, Herwegh M, Wu J. Determination of lead isotope ratios in seawater by quadrupole inductively coupled plasma mass spectrometry after $\text{Mg}(\text{OH})_2$ co-precipitation. *Spectrochim Acta B At Spectrosc*. 2000; 55(4): 363–74.
 15. Eubig P, Aguiar A, Schantz S. Lead and PCBs as risk factors for attention deficit/hyperactivity disorder. *Environ Health Perspect*. 2010; 118(12): 1654–67. doi:[10.1289/ehp.0901852](https://doi.org/10.1289/ehp.0901852).
 16. Needleman H, McFarland C, Ness R, Fienberg S, Tobin M. Bone lead levels in adjudicated delinquents a case study. *Neurotoxicol Teratol*. 2002; 24: 711–7.
 17. Gollenberg L, Singh J, Lallas C, Trabulsi E. Hormone therapy in the management of prostate cancer: evidence-based approaches. *Ther Adv Urol*. 2010; 2(4): 171–81. doi:[10.1177/1756287210375270](https://doi.org/10.1177/1756287210375270).
 18. McDonald E, Gielen A, Shields W, et al. Residential carbon monoxide (CO) poisoning risks: correlates of observed CO alarm use in urban households. *J Environ Health*. 2013; 76(3): 26–32.
 19. Weaver L. Carbon monoxide poisoning. *N Engl J Med*. 2009; 360(12): 1217–25.
 20. Lockhart T, Smith J, Woldstad J. Effects of aging on the biomechanics of slips and falls. *Hum Factors*. 2005; 47(4): 708–29.
 21. Runyan C, Casteel C, Perkins D, et al. Unintentional injuries in the home in the United States Part I: mortality. *Am J Prev Med*. 2005; 28(1): 73–9.
 22. University of Warwick's Institute of Health. *Health hazards in the home environment: a risk assessment methodology*. Paper presented at: healthy building conference, Lisbon, Portugal, 4–8 June 2006.
 23. *Advancing Healthy Housing: a strategy for action*. U.S. Department of Housing and Urban Development, Federal Healthy Homes Work Group. Washington, DC: U.S. Department of Housing and Urban Development, 2013.
 24. Vesper S, McKinstry C, Haugland R, et al. Development of an environmental relative moldiness index for US homes. *J Occup Environ Med*. 2007; 49(8): 829–33.
 25. *Operating Guidance: healthy homes rating system*. U.S. Department of Housing and Urban Development, Office of Healthy Homes and Lead Hazard Control. Washington, DC: U.S. Department of Housing and Urban Development, Office of Healthy Homes and Lead Hazard Control, 2012.
 26. *American Community Survey 2013 5-year estimates*. U.S. Census Bureau. Washington, D.C., 2013.