Moving the needle on home health: Reconceptualizing social problems in a multi-stakeholder system

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ABSTRACT

Despite significant evidence that housing quality plays a key role in the overall health of the population, health risks that originate at home have failed to garner direct policy attention or intervention commensurate with their impact. Drawing on the sociology of social problems, we identify how causal and political responsibility for risks in the United States context is complicated when these environmental health risks are embedded in private homes. We argue that changing how home health is addressed by health and building practitioners requires a reconceptualization of home health whereby the multiple responsible parties and sources of exposure become leverage points for future research and interventions. This reframing includes identifying housing as an arena of health, representing a class of risks tied to place. We also contend that health is an essential element of homes as systems and must be embedded in how those in building science, construction, property management, and code design approach housing. Finally, we suggest the need for specialists to navigate home health issues, drawing on the hospitalist model of health provision. These proposals illustrate multiple points at which residents, researchers, and health and building professionals may intervene and home health risks can be addressed.

1. Introduction

Housing is a well-researched and acknowledged social determinant of health [1–7]. Housing access, stability, quality, and safety impact the health of residents [7]. For instance, housing instability in the form of eviction and foreclosure can have significant physical and mental health impacts [8,9]. However, homes themselves represent a particular risk when quality, maintenance, and safety are lacking. The World Health Organization, for example, emphasizes that housing is becoming increasingly important to health due to continued urban growth, population aging, and climate change [10]. Even so, international standards for health in housing are unevenly developed and applied [3]. Indeed, in the United States (U.S.), health is rarely addressed at the level of the individual home and is typically dealt with by specialists in *either* housing or health. Questions about one's home are not an element of typical health screenings by medical professionals, who usually do not make home visits to understand the nature of health problems. Similarly, those working in the housing field are unlikely to see health as central to their work. Contractors or builders tend to focus on physical safety and do not typically seek health outcomes from their work.

Likewise, government building codes and government-funded home intervention programs such as energy efficiency do not include health as primary goals. Despite the importance of homes for health outcomes [4, 6,11] and for equity [12], data, policy, and funding, gaps remain in the connection between home quality and health [13,14].

This paper draws on the sociology of social problems to contend that home health has not arisen as a national social problem due to a lack of clarity about the responsibility for causing and responding to home health problems. While this situation likely extends beyond the U.S., we focus on the U.S. context in order to speak specifically to the barriers inherent in a single country's national agency structure, as well as health care, building construction, and maintenance institutions. We identify barriers that prevent home health from being perceived as a problem needing attention and intervention by the federal government. We then argue that changing how home health is understood and addressed requires a reconceptualization of home health whereby the multiple responsible parties and sources of exposure become leverage points for future research and intervention. Namely, we posit that practitioners dealing with health and housing tend to be specialists who approach the issue from the perspective of public health or building safety and quality

alone, rather than integrating these concerns. Thus, we argue the issue must be reframed by identifying housing as an important arena of health, representing a class of risks tied to place, in this case, homes. We also contend that health is an essential element of homes as systems and must therefore be embedded in how those in building science, construction, property management, and code design approach housing. This dual reconceptualization of homes creates opportunities for research and interventions that integrate the often-disparate fields of public health and building science. Finally, we suggest that to deal with the complex nature of home health risk we need generalists who can bridge public health and housing interventions. We call these proposed generalists home health navigators and draw on the hospitalist model of health provision and existing home health programs to elaborate their role. The proposed language provides a way for researchers and practitioners who recognize the importance of housing as a health determinant to enter discussion of public interest and policy priorities in an accessible manner.

1.1. Home health risks in the United States

For the purposes of this article, we focus on home health risks–where the effects may be delayed–rather than safety risks that pose an immediate risk to life. Homes represent an important class of exposures to environmental stressors. People spend much of their time at home—up to 70 % by some estimates [15] —and a variety of health risks occur primarily in the home, such as asthma triggers, lead-based paint, and radon, leading to complex exposures in indoor environments [16,17]. For instance, water leaks and high humidity in housing can lead to mold growth, which is associated with a host of respiratory issues including triggering asthma [18]. More than half of all the air inhaled across one's lifetime comes from inside the home [19]. Lead from peeling paint or lead pipes can lead to elevated blood lead levels in children, which are associated with lasting health and developmental impacts [20–22]. Smoking indoors can expose other inhabitants, and even neighbors, to harmful chemicals associated with respiratory and cardiovascular disease, reproductive problems in women, as well as sudden infant death syndrome [23–26]. Moreover, what occurs in homes has impacts beyond current occupants. Some risks, like smoking, can spread to nearby homes, particularly in the case of multifamily housing. Homes also outlast current occupants and affect others, as occupants move, host visitors, or run home businesses. The COVID-19 pandemic resulted in people spending even more time than usual at home, and increased levels of remote work and learning persist, so the influence of the home environment on health may have increased. Looking at homes comprehensively, as environments where risks are present and people are exposed to health and safety risks, underscores their importance in addressing overall health.

These exposures are especially notable given how common health and safety concerns are in housing in the U.S. About 45 % of houses in U. S. metropolitan areas reportedly have one or more health and safety risks [27] and the problem seems to be getting worse—the percentage of homes with one or more health risks has increased steadily since 2007 [28]. Even excluding the problem of safety risks for the purposes of this article, the problem remains pressing. Half of all U.S. homes have problems with dampness or mold [29]. Levels of air pollutants indoors, not just in homes, can be two to five times higher than levels outdoors [30]. This estimate does not include all potential issues with indoor contaminants (e.g. nitrogen dioxide, VOCs), so the actual number of occupants with health risks is likely much higher. Other prominent risks in the indoor residential environment include lead-based paint (34.6 million homes), mice or other rodents (14.8 million), cockroaches (14 million), and radon (1 in 15 homes) [31].

In turn, these home hazards have wide-ranging effects. For example, more than 24 million people in the U.S. have asthma [32], which can be exacerbated, or even initiated, by home conditions like secondhand smoke, mold, dust mites, and pests. Mudarri and Fisk estimate that in the

U.S., about 20 percent of those with asthma can attribute their condition to exposure to dampness or mold in the home [18]. Disability-adjusted life years lost to indoor air pollution in the U.S., even excluding the effects of smoking, are about double those for outdoor air pollution [33]. Similarly, homes can expose residents to radon, a naturally occurring radioactive gas. The presence of radon in homes poses a considerable risk with 21,000 people dying from radon-related lung cancer each year according to the EPA [34]. Lung cancer risk due to radon is second only to smoking [34,35]. Together, home health risks represent serious health concerns for the population.

The economic burden of home health hazards in the U.S. is in the billions [18,36,37] Net avoidable costs associated with indoor air pollution are estimated at over $100 billion annually [38]. The national cost of asthma that is attributable to exposure to mold and dampness in the home is estimated to be $3.5 billion annually [18]. Lead poisoning in children is estimated to cost $192–$270 billion per cohort in medical treatment, lost earnings, tax revenue, special education, lead-linked ADHD cases, and criminal activity [39]. Together, this research indicates that in-home exposure poses a burden with significant societal costs.

Given the extent of health impacts attributable to the housing environment, it is worth considering why these circumstances have not gained attention commensurate with their impact. In what follows, we argue that the complexity of home health risks and housing have stymied attempts to form a unified scholarly or policy response.

1.2. The home and health system

Fig. 1 shows one way that a group tasked with sharing the importance of this topic might portray the breadth of interest and connections among actors. The combined characteristics of occupants and homes lead to home-based health outcomes. Independent of occupant diversity, home condition is influenced by a wide range of forces from government regulations and building codes to individual resident preferences. Home occupants create and change conditions within the home through their own behavior, the products they purchase, and the building professionals they hire. Health researchers have established associations between exposures and health outcomes, as in the case of particulate matter found outdoors. Public health officials have identified home health risks, for example, lead-based paint, and have recommended programmatic solutions or promulgated regulations. Industry professionals have developed associations and conferences to share knowledge of complex building systems. Building practitioners, or those who construct, maintain, and improve the structure and its systems, must meet government-mandated standards for component safety, but only during new construction, building retrofit, or occupant requests. Therefore, integrating considerations of health into home management could occur at multiple junctures and levels of interaction.

The many stakeholders depicted in Fig. 1 might suggest broad support for attention to home health. However, the links indicate connections that have occurred for individual topics or stressors, not for home health on a societal or national level. In the following sections, we detail how this complexity has been a barrier to "moving the needle" on the broader issue of home health in the U.S. By "moving the needle," we mean that attention to the problem (pink hexagons, Fig. 1) is altered in a way that increases the contribution of one or more products, outcomes, or events to improving home conditions. We recommend ways of conceptualizing parts of the system as potential leverage points, and we suggest opportunities for change. This reconceptualization of the home health system will appear as a rearrangement in Fig. 2 (Section 4.0).

2. The sociology of social problems

The literature on the sociology of social problems offers an explanation for why some issues garner attention and policy responses, while others do not. Broadly, this literature argues that social problems are
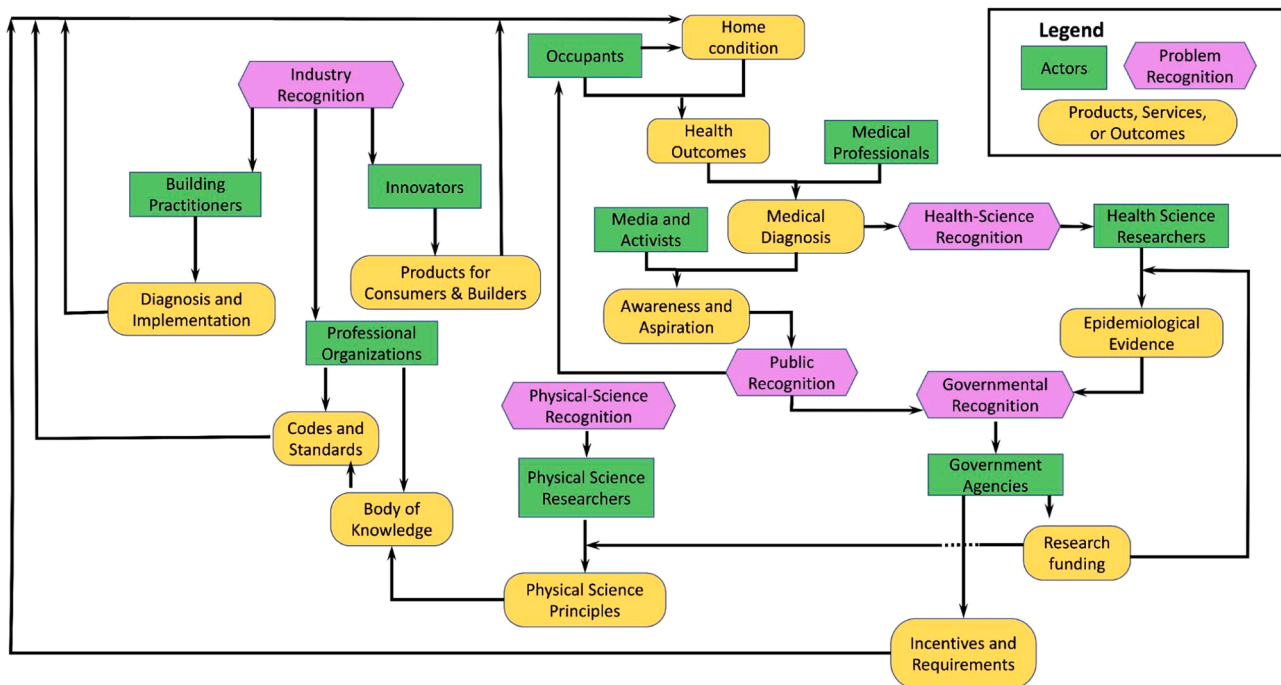
Fig. 1. Actors and outcomes that affect health outcomes whose source is the indoor residential environment. Pink hexagons show some awareness points where home health might be perceived as a social problem, leading to solutions. The figure is necessarily incomplete; for example, building and property managers play important decision-making roles but are not represented. Another exclusion is the role of individual investigators in initiating scientific recognition.
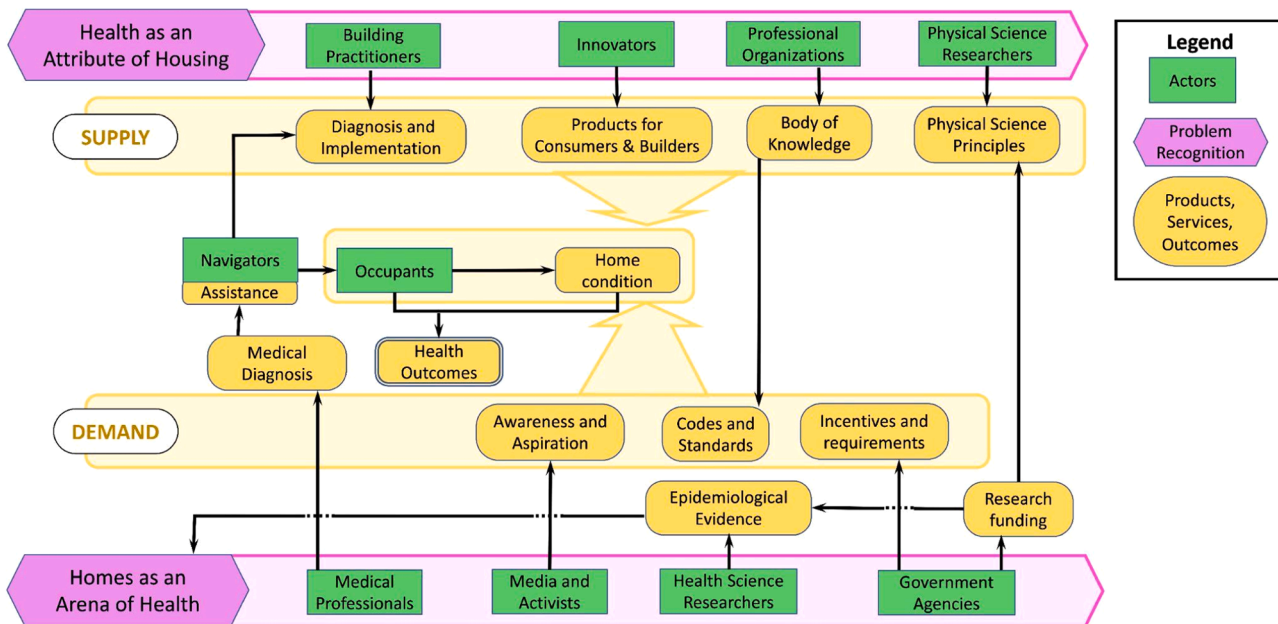

Fig. 2. Reconceptualization of home health in a multi-stakeholder system. Recognition of social problems is re-framed in two unifying principles that are loosely associated with supply and demand features of various products, services, and outcomes. The addition of navigators assists occupants in traversing complex systems.

socially constructed [40–45]. So, what becomes a social problem is not dependent on objective conditions but upon how this set of circumstances comes to be defined as something that requires a response. In particular, social problems are those issues "about which 'someone ought to do something'", p. 5 [42]. In the U.S. context, home health issues lack public attention or a push to respond because they share certain structural traits that form a barrier to public health and building science responses.

Gusfield [42], in particular, emphasizes that social problems tend to share a structure, which enables a set of conditions to rise to a level that requires notice and action. One element of this structure is the need for the problem to be "social;" that is, a cause of social harm. For example, regarding smoking Gusfield explains, "It is the public character of the risk rather than its application to specific persons that forms the basis for environmental control", p. 67 [46]. That is, smoking is only a social issue because it poses a risk to others beyond just the individual doing the smoking. The basis for action is typically that the impacts affect the public by targeting a common resource (e.g., outdoor air) or impact the

community as a whole.

Another element of this common structure is the need for clear responsibility for a set of circumstances in order for the public and social actors to perceive a problem. Gusfield [42] identifies two aspects of responsibility—political and causal—that affect whether circumstances become perceived as problematic. This theory proposes a model for social problems where the flow of action from the party responsible for solving problems toward the cause of problems is relatively simple. When these two forms of responsibility are clear a set of objective conditions becomes something that people mobilize to address, but when these forms of responsibility are unclear, even problematic issues may fail to garner attention, research, and intervention.

To Gusfield, causal responsibility is "an assertion about the sequence that factually accounts for the existence of the problem", p. 13 [42]. For example, in the case of ambient air pollution, a local factory might be said to have causal responsibility because their industrial activity has emitted certain pollutants, creating the problematic circumstances defined as ambient air pollution. Causal responsibility is about identifying the source of an issue as a target of attention, accountability, and sanctions. Knowing whom to blame enables targeted research, advocacy, or intervention.

Political responsibility, on the other hand, is about who or what agency is obligated to address the problem. For example, in the U.S., the Environmental Protection Agency (EPA) has political responsibility for addressing the problem of ambient air pollution. Therefore, when ambient pollution exists, the public expects the EPA to be the party that responds. While causal responsibility identifies targets, political responsibility identifies the means for addressing social problems. So, again in the case of ambient air pollution, the public expects the EPA to levy sanctions and policies towards those understood to be causally responsible (e.g., an emitting point source) to address the problem. Here, the means of addressing problems tend to be top-down federal responses, as in the case of the EPA and ambient air pollution.

This theoretical framework offers insight into why the relationship between homes and health has failed to garner attention commensurate with its impact. It is not enough that we know home health risks exist, that they are common, or that they are impactful. The nature of the issue—that it occurs in a private space, involves individual behavior, has complex causes, and is not the jurisdiction of a single political entity—hampers sustained attention, let alone a collective response, to home health. Home health may have three barriers to becoming actionable in public health and building professions: the problem may be perceived as private, not social; causal responsibility for public health in homes is complex and diffuse; and political responsibility for home health is currently unidentifiable. Generating increased attention, research, and intervention into home health issues requires rethinking how we understand health risks in the home and how we respond to them. In the following sections, we explain each of these barriers and how they might be overcome.

2.1. Homes as private

Perhaps the most straightforward barrier to the emergence of home health as a social problem and a "public" health issue is that home health risks are not perceived to pose a social or public harm, but rather a private, individual one. A perception can be that health risks within homes are the result of the inhabitants' actions, originate there, and affect only those in that space. Because these risks occur in a private space, they are perceived by many as a problem for individuals, not society as a whole. Therefore, they tend to be perceived as a private or personal harm and have not been taken seriously as a shared social problem that must be responded to systemically.

It is true that the actions of residents can exacerbate or create health and safety risks in the home. For example, residents who open windows during a wildfire may worsen their indoor air quality, while a resident who dislikes the noise of their bathroom fan while showering may

experience a moisture problem and ultimately mold. Yet while people assume that individuals *alone* exercise control in their homes and shoulder causal responsibility for the risks they encounter, this assumption ignores broader systemic sources of adverse health exposures.

Risks may stem from a house's construction, maintenance, or regulation and, indeed, may be the responsibility of people other than the current occupant. Still, other risks may enter homes from the outside (including common resources like air) despite residents' best efforts. Likewise, risks within one house can be contagious, spreading from one house to others, as in the case of secondhand smoke and fire hazards. This is particularly true in multifamily homes such as apartment complexes. Yet, the perception that these issues are private speaks to pervasive cultural ideas of homes and of who has control of the risks that originate and spread in residential spaces.

Where people live and what risks they are affected by may be the result of policies or social processes. Examples are redlining [47,48], zoning [49], and realtors steering buyers of different races toward different neighborhoods [50]. Thus, some populations are more likely to be in houses which are more prone to health hazards. It is possible that these systemic processes merely deepen the perception of home health risks as private issues that impact some "others," as those in well-maintained homes or affluent neighborhoods may perceive themselves to be immune to such health risks.

2.2. Causal responsibility and public health

The complex attribution of health impacts to home exposures makes identifying causal responsibility difficult. Public health responses tend to coalesce around problems where the causal connection between exposure and outcome is clear. Yet, with the health impacts of risks at home attribution is difficult. The role of individuals in managing their own health also impedes attempts to define these risks as a shared, social problem.

Disentangling the independent effect of housing from other social determinants of health can be difficult [11]. For example, low-income people more often live in substandard housing, so either the experience of poverty or housing characteristics can cause health impacts. Disparate risks may also be located together in homes, such that separating which specific risk has caused some outcome is difficult. Existing methods are often inadequate to tease out the complex relationship between building characteristics or housing conditions and individual health [38]. The desire to prove causal relationships between single exposures and outcomes can therefore prevent home health from being taken as a single, unified problem.

For many risks in the built environment, there is sufficient evidence to causally associate home conditions with health. For instance, the exposure pathways for lead water pipes, deteriorating lead-painted surfaces, or deposits of lead gasoline are well understood and there is substantial evidence for the causal relationship between these exposures and negative health and behavioral impacts like cardiovascular disease, developmental delays, cognitive impairment, and high-risk behavior [20,22,51–55]. Respiratory health has been found to be causally associated with dust mites, mold, pests, tobacco smoke, formaldehyde, nitrogen dioxide, and dampness in the home [56–58]. There is strong evidence that housing represents an important class of exposures for public health, even though the exact mechanism of some individual exposures is unknown.

Another element of this difficulty in attribution is that individuals are often identified as the cause of their own health problems. The U.S. culture of individual responsibility has long justified shifting attention from systemic issues to individual ones [59]. For example, anti-smoking efforts often focus on stigmatizing individuals' behavior, rather than on more systemic responses [60,61]. The impulse to blame individuals for being exposed to health hazards, especially at home, is well documented in historical public health debates. Early attention to lead poisoning

portrayed it as a problem of parental negligence rather than industrial malfeasance [62]. The ability of industry leaders to place blame for childhood lead poisoning on parental inattention and poor cleaning and hygiene habits enabled companies to avoid responsibility for the impact of lead-based paint and gasoline on children's health. This tendency is also noted in the academic literature. Auyero and Swistun [63] find that one element of what they term "toxic uncertainty," which stems from an unclear source of pollution, is shifting responsibility from industrial to individual sources. Despite living in areas of high industrial contamination and despite significant evidence of ambient pollution, parents were blamed for allowing their children to be exposed to toxic conditions [63].

The deeply ingrained tendency to blame individuals for their health makes a systemic approach to home health difficult. Current recommendations for home health, as found in "Healthy Homes" programs, are organized around actions that household residents can take on their own. These eight "Keep it" principles (e.g., keep it clean, keep it contaminant-free) emphasize personal action, rather than larger systemic factors that lead to exposures outside the control of occupants.

2.3. Causal responsibility and buildings

Identifying the cause of health risks in the home as a built environment is also difficult. In the public health context, causal inference is challenged by the complexities of attributing health effects to a precise cause. In the case of home health, this is an issue of who is responsible for the quality of the built environment.

In the case of environmental issues like ambient air pollution, the U.S. follows the "Polluter Pays" principle where the person who originates environmental harm, not those impacted, is responsible [38]. So, a polluting factory or power plant may be targeted for government sanctions if it is clear they are the source of emissions. But when it comes to indoor health, there is often no single, clear originator of risks. Jacobs et al. [38] note that "responsibility for buildings is diffuse, including architects, maintenance personnel, designers, employers, code and building inspectors, occupants, and others". Thus, it may not be possible to know where a risk originates and who ought to take responsibility.

Attribution is further impacted by how buildings develop and change over time. Buildings often have long lives with multiple individuals designing, building, and maintaining a building at different times. Most building practitioners do not tie their work to health, so the production of health risks may be an unintended byproduct of their work. Disentangling the outcomes of initial installation as opposed to maintenance, later alterations, or contextual changes can be difficult, as can identifying who, if anyone, "caused" the risk. Moreover, natural conditions, including disasters like flooding, and changes to the building's context, like the construction of a highway or factory nearby, can cause problems that are not attributable to individuals at all.

2.4. Political responsibility

Like causal responsibility, the issue of political responsibility, or who ought to respond, is complex in the case of housing. Those who are most often engaged to work in housing, building professionals, are not defined as responsible for health, and federal agencies that normally respond to social issues also lack clear responsibility. No U.S. agency is wholly responsible for houses, and agencies tend to debate who has responsibility for the intersection of environment, health, and housing.

Only a small number of building professionals are taught to consider health as an element of the maintenance and construction of residential environments; their mandate covers only codes and standards that emphasize life safety, not health. The training building professionals receive is the result of legal mandates, so because home health has not yet become a priority, health-centered certifications remain largely optional and relatively uncommon. For instance, a training center in Urbana-Champaign, IL offers both Healthy Homes Evaluator (HHE) and energy efficiency certifications credentialed by the Building Performance Institute. Within 200 miles of the center, less than 45 individuals have the HHE certification compared to several hundred individuals who have energy efficiency certifications. Because these practitioners are empowered by codes and standards, the omission of health in these regulations lessens their authority to address the health risks they may identify in the course of their duties. In short, building professionals, particularly those in government enforcement positions, face barriers to taking political responsibility for home health.

In the case of most federal responses to environmental and public health problems, political responsibility stems from the issue's impact on a shared space or the community. Typically, communities expect their governments to take responsibility for issues that affect the public, both those that occur in public spaces and those that impact the population at large. This expectation stems from the legal concept of "the shared commons," which the government may act on behalf of, preventing actions that would deprive the public of a shared resource [38]. For example, outdoor air has been perceived as a shared resource, leading to federal protections like the Clean Air Act. On the other hand, lead premise plumbing within homes has been defined as an individual problem for households to solve, rather than a shared community problem to be dealt with by utility providers or the government at large. Thus, pressure for a collective response is lessened because issues of home health are seen as private responsibilities.

Most germane to the U.S. context, however, is that home health issues transcend the traditional functions of federal agencies. For example, lead abatement efforts suffered from the lack of jurisdictional clarity over who has political responsibility for homes [62]. In the 1980's more than 16 federal agencies were involved in addressing the lead crisis. Agencies attempted to limit their responsibility by defining the problem as the jurisdiction of other agencies. For instance, Health and Human Services argued that lead was primarily a housing issue, while Housing and Urban Development (HUD) found that lead contaminants were primarily an environmental risk that ought to be handled by the EPA [62]. Similarly, today the federal response to Healthy Homes is split across numerous agencies, including HUD, the Department of Health and Human Services, the Centers for Disease Control and Prevention, the EPA, the Department of Energy, the Department of Agriculture, the National Institute of Standards and Technology, and the Office of the Surgeon General. Without agencies taking responsibility, it is hard to elevate home health to a national priority deserving of policy, funding, and research.

Most similar efforts, for example combating ambient air pollution, have been handled in a top-down way with political responses living with a primary agency like the EPA. However, no such single response has arisen for the myriad health risks that even federal agencies confirm tend to be found in homes. As a result, actions toward home health have remained piecemeal. Instead of waiting for a top-down response to manifest, however, we advocate rethinking how home health is perceived by public health and building science fields and practitioners.

3. A Proposal for navigators

Homes entail systems within systems, as well as systems that interact with home occupants. This makes homes a complicated context in which health, safety, comfort, and behavior must all be carefully navigated if homes are to support health. An analogous field is that of complex medical care. In hospital settings, a special role, the hospitalist, has developed to help patients navigate the complexities of in-patient care. Drawing on this model, we argue that homes require navigators to organize different building and health specialists to change home environments.

Traditional models of health care delivery in the U.S. situated the primary care physician (e.g., general internist, pediatrician, or family medicine practitioner) as the physician of record for most non-surgical hospitalized patients, receiving assistance from subspecialists (e.g.,

neurologist, cardiologist, pulmonologist) as needed [64]. In the mid-1990s in the U.S. hospital leaders, health maintenance organizations, and medical groups sought solutions to lower the cost of inpatient care without compromising the quality of health care and patient satisfaction [65]. The model of the primary care physician caring for hospitalized patients was no longer considered to be feasible, given challenges such as fragmentation arising from professional specializations, the rise in disease complexity, and the escalation of health care costs [66]. Clinicians trained in inpatient medicine, termed "hospitalists," were identified as general practitioners responsible for managing the care of hospitalized patients, similar to primary care physicians' responsibility for managing the care of outpatients [67]. The expertise of the hospitalist is defined not by an organ system but by place of practice (e.g., hospital). The hospitalist then refers the patients back to their primary care physician at the time of discharge. Lee [66] provides an example:

> "a multiply injured patient can expect to be attended to by a swarm of highly trained doctors ranging from the emergency physician, the anaesthetists, the radiologist, the neurosurgeon, the cardiothoracic surgeon, the orthopaedic surgeon, the intensivist and eventually the rehabilitation physician. The development of each complication is likely to bring in even more specialized health care workers."

In addition to serving as the physician of record for hospitalized non-surgical patients, hospitalist responsibilities include medical consultant, inpatient educator, ED triage physician, liaison between the hospital and primary care physician, and inpatient research, particularly on topics that cut across traditional subspecialty lines [64]. In short, hospitalists are generalists who are needed to integrate disparate types of knowledge and navigate systems in an acute care setting. This is especially true for aging or vulnerable people, who may experience simultaneous chronic diseases, such as diabetes, hypertension, stroke, ischemic heart disease, and dementia.

In a similar fashion, each home requires a number of specializations to effect change toward a healthy environment – an electrician, a plumber, an HVAC technician or engineer, a mason, a contractor, an appliance specialist, radon and lead mitigation professionals, drywall repair, etc. A general contractor might connect these different specialties during construction, but not during everyday maintenance, and even a general contractor would not seek outcomes related to health. Nor would it be expected that an individual addressing a health concern for the first time would be able to determine a solution that integrated a home's complexity, including its physical elements, with a human health response. We suggest that home health navigators could serve as generalists or "home hospitalists", integrating knowledge about buildings, personal choices, and human health responses. As with people, in old homes, multiple systems may fail due to aging infrastructure (e.g., lead service lines or lead premise plumbing) or outdated or outmoded technology (e.g., coal furnaces, single pane windows). The complexities of home health that have prevented it from arising as a social problem also impact individuals, therefore we suggest the need for individuals to navigate this system, connecting building and health professionals on behalf of home occupants.

There is precedent for this type of delivery model. For example, at Children's Mercy Hospital of Kansas City, a team of professionals with healthy home knowledge can be deployed when a child's symptoms indicate that persistent home environmental triggers may be present. There is also a nascent effort within the home retrofit sector to develop a delivery model along these lines. The Healthy Home Evaluator credential, mentioned previously, is intended for professionals who understand building science and the assessment of homes, and who want to apply this knowledge to health within buildings. In this way, those with the HHE credential are analogous to the hospitalist, being a home performance generalist who can then refer the home/residents to the appropriate specialists. While the use of HHEs remains uncommon, some new healthy homes programs require assessments by HHE-credentialed

individuals, who then make referrals to specific contractors to complete the work. This example illustrates how navigators can advance the implementation of healthy homes, beyond the research context.

4. A Proposal for reconceptualization

Improving the health of home occupants is ultimately the outcome of interest, yet this targeted outcome is a consequence of interactions among individuals, societal factors, and institutions, as shown in Fig. 2. In a successful ecosystem, goods, services, and knowledge would be available to support health at home, and they would be adopted by individuals who desire that outcome. This arena for exchange might be considered a "market" with supply, demand, and consumers. (This description of an exchange arena may include, but is not limited to, free-market behavior.)

To encourage the coalescence of this complex system, we advocate for two changes in the way policymakers, researchers, and practitioners approach this topic. First, we contend that homes should be treated as an arena of health: a place where health can be rooted or risked. This perspective creates a demand for health in all aspects of a home. Second, we argue that health should be promoted as an attribute of housing. With such a framing, building scientists, practitioners, and product manufacturers could become key players in home-based health interventions. Except for the addition of navigators, Fig. 2 contains the same elements as Fig. 1. Its contribution is the inclusion of unifying themes to coalesce fragmented events and narratives. Because these proposals may appear abstract, Box 1 provides some concrete examples of how implementation might appear.

In discussing homes as an arena of health, we use the term "arena" to designate a particular type of place in which health risks occur and can be addressed; that is, a determinant of health that has an association with place. The workplace has long had this denomination, with the outcome that occupational health is a recognized field of study, and regulation of workplace hazards is treated by an office or individual even when the mechanisms of hazards in that location are very different.

We argue that the concept of a place-classified determinant of health is needed to connect attention with the origin of risk. In epidemiological studies, risks may be correlated with the prevalence of individual stressors, or grouped by the medium of transport (air or water) [68]. However, the extensive literature on risk inequality due to environmental pollution recognizes the importance of place [69]. Comprehensive descriptions of individuals' overall health consider aspects of well-being in addition to physical wellness, such as social and spiritual; these aspects are sometimes termed "domains." In popular usage of these terms, environmental health may or may not be included in the list of domains, and housing is rarely mentioned. The World Health Organization recognizes housing as a social determinant of health; that is, a "non-medical factor that influences health outcomes." Its other determinants of health, such as education and non-discrimination, are purely social rather than physical. But in the case of housing, as in the workplace, it is the physical setting in which risks are recognized, and in which occupants see the ability to change.

The term "arena" acknowledges specific settings as social determinants of health, stipulates locations for investigation in the environmental domain, and aligns with the growing recognition of place as a source of health risk. Grouping and investigating exposures by arena allows for systems of solutions that address multiple health risks, and can enable a more holistic treatment of the health-home relationship among researchers and practitioners, overcoming the fragmentation that has prevented sustained and concerted attention to home health.

Normalizing the home as an arena of health can lead to heightened demand for information about and practice of healthy homes. As is the case for any problem in which outcomes are temporally separated from action, demand does not naturally arise from individuals, but is societally constructed. Attribution of causal responsibility for a problem and knowledge of who holds political responsibility to address it are central

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Box 1
Examples of "moving the needle" in the complex system of housing and health.

Housing as an arena of health

- Faculty lines within academic public health departments have a "housing health" label, similar to an "occupational health" label
- Questions about housing conditions form a section in a medical intake form

Health as an attribute of housing

- Home improvement stores have a "health at home" aisle and consumer education programs
- Home builders commonly advertise building health ratings in addition to Energy Star ratings

Navigators

- Advisors at health clinics have training in healthy home practices and conduct home visits
- Home assessors have health credentials and contacts to recommend further improvements

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for a social problem to emerge as something that must be addressed. In turn, government priorities, codes and standards, common practices, and public awareness can all contribute to the demand for interventions and solutions. For example, the emergence of COVID-19 created a new demand for policies, products, and practitioners who could address the disease. Government pandemic policies around personal protective equipment, hygiene, and air ventilation led to new markets for masks and hand sanitizer, as well as air filters and air purifiers. Similarly, the public attention to COVID as an airborne disease led to greater awareness of the role of air for disease exposure, such that there was public demand for increased airflow in buildings, outdoor dining options, and enforced social distancing. Establishing homes as an arena of health can create demand for further public, government, and market response to home health risks.

Our second argument is that health must be promoted as an attribute of buildings. By "attribute," we mean a feature associated with the building, even if it is not a characteristic of the physical structure [70]. In common English usage, housing is called healthy or safe when it provides protection from illness or hazard to its occupants.

Health risks occur in buildings, in part, due to how those buildings are constructed and maintained. Building scientists, building practitioners, and products are integral to any discussion of place-based health. Yet, building scientists and public health researchers have largely addressed the issue without reference to each other. For example, while building scientists consider ventilation and infiltration rates in buildings, their approach often does not consider how these airflow rates impact the health risks from contaminants inside and outside of the home. On the other hand, public health researchers start their analysis with the presence of a health risk in a home without considering what systems within or characteristics of that home enabled it to enter.

In addition, research that spans multiple disciplines is insufficient. A comprehensive response to home health requires a market that can overcome the complexity of the issue. Therefore, a successful market includes a diverse supply of relevant solutions, including products, principles, and practitioners. Further, a successful market requires a strong translational pipeline that enables the actualization of ideas and research into pragmatic recommendations and tools that may be used by the practice community. In health research, conventional wisdom suggests the "bench to bedside" pipeline, or the time it takes for laboratory discoveries to advance clinical benefit for patients, to be at least 17 years [71]. This pipeline is lengthy due to aspects germane to the development of clinical treatments, such as pharmaceuticals, but also due to factors that are germane to any academic discipline.

The creation of knowledge generally entails researchers speaking amongst themselves, rather than speaking to the practice community. This is exacerbated by the siloing of academic disciplines. In the miasma age of public health, the built environment and public health were inextricably tied through sanitation and health outcomes. We see a movement back to the interweaving of multiple disciplines in public health yet are locked in a struggle to bring that knowledge to practice. In the case of healthy homes, individuals and disciplines constructing or working in buildings are often separate from discussions of home health. Practitioners must see their work creating not only desirable environments for people to live in but healthy environments as well. Likewise, academicians in this space must work to develop practicable, meaningful recommendations based on their research.

Home health has been seen as a fragmented endeavor that lacks accountability to anyone. While this fragmentation has long proved a barrier to making home health a shared, social problem, we argue that it is merely a manifestation of the many entry points to the overall arena of health at home. What is lacking is not a unifying national agency that is given responsibility, but more deliberate nurturing of connections within a complex arena that is likely to defy ownership. Our dual recommendations to acknowledge homes as an arena of health, and to promote health as an attribute of homes, provide two endpoints among which exchange can occur in a market-like ecosystem, while our vision for navigators would cultivate pathways that transcend complexity through experience. In a complex system, the needle moves only through the alignment of purpose and facilitation of access. In turn, recognizing that homes are such a complex system requires engaging all actors involved to improve the lives of residents.

CRediT authorship contribution statement

Sheryl Magzamen: Writing – review & editing, Writing – original draft, Supervision, Project administration, Conceptualization. **Paul W Francisco:** Writing – review & editing, Supervision, Conceptualization. **Tami C Bond:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Investigation, Funding acquisition, Data curation, Conceptualization. **Paige Ambord:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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