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Is Housing Making People Sick?

An overview of seven studies that raise questions to consider as we incorporate health into planning and build new housing to address shortages and energy efficiency.

by Merilee D. Karr



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As our region incorporates health into its planning practices, the science... should increasingly inform our policies.

The current housing shortage, with calls to build new housing that often results in replacing older structures with new, more energy-efficient housing, presents a booby trap and an opportunity. The choice: demolish houses made of older, less-toxic raw materials, and build anew with up-to-date components that may predispose their residents to asthma and cancer; or build new homes like the Breathe-Easy homes described in our first study, that don't make people sick. As our region incorporates health into its planning practices, the science, like the studies featured here, should increasingly inform our policies.



For years, before the Gebrezgi family moved to Seattle's High Point housing development, their 12-year-old son's severe asthma attacks found them often in the hospital or emergency room. The fear that he could stop breathing at any time kept his parents on edge.

Asthma is common in the developed world, especially in kids. In the U.S., one

in twelve children, and one in fourteen adults, have this suffocating disease. And the patient is hardly the only one affected. Around every person who has asthma, there is a circle of people who miss work, miss school days, have trouble concentrating, and worry about medical bills.

The Center for Disease Control (CDC) estimates the cost of asthma at \$56 billion a year in the U.S. But no one can measure the drag of this illness on so many people's chances in life, or on their quality of life.

Asthma is steadily growing. Rates have doubled in the U.S. since about the 1980s. It's not clear why. All that's certain in epidemiology is that many factors contribute.

The Gebrezgi family's new home was not a typical rental. It was a Breathe-Easy Home — one of 60 in the 120-acre High Point development — designed to provide high-quality indoor air, without the indoor pollutants almost universally present in modern buildings. [Editor's note: the High Point HOPE VI development in

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Seattle explicitly incorporated health into its planning; New Columbia, Portland's HOPE VI project in Portland, which was developed around the same time, does not include "Breathe-easy" homes.] Before moving day in the summer of 2006, health researchers from the University of Washington met with the Gebrezgis to establish their son's baseline asthma level, frequency of symptoms, and use of medications.

The Breathe-Easy Homes did not visibly differ from other High Point homes. The interiors used paint, glue, flooring, and cabinetry that released low volumes of toxic volatile organic compounds

(VOCs), such as formaldehyde. To reduce mold growth, the exterior envelope was moisture-proof, and quiet exhaust fans were installed in kitchens and bathrooms.

The most important difference was an energy-efficient mechanical heat-exchanger ventilation system that pulled in filtered fresh air from outside. These features cost an average of \$6,000 per house.

After six months in a Breathe-Easy home, Mr. Gebrezgi's son was doing much better. His medications were reduced, he had less trouble breathing — and he had not had a single asthma attack. The father said, "I don't have to worry anymore that my son could stop breathing at any minute."

This family's results were typical. The researchers studying the effects of Breathe-Easy homes on children with asthma found an average sixfold drop in asthma attacks, and a decrease in days with asthma symptoms from 3 days a week to one day a week.

The average cost of an ER visit for a

child with asthma in 2006 was \$1,500. The charge for a hospital stay was \$3,600. So \$6,000 in home improvement, to prevent years of such medical costs, would pay off before the child outgrew a pair of shoes.

Why is this? If improving indoor air quality makes some people so much healthier so quickly, what's in normal indoor air that makes them sick?



For most of human history, structures did not strictly divide indoor air from outdoor air. People could warm their indoor air, but drafts whistling through chinks diluted both smoke and heat.

Building materials changed in the 20th century. A builder in 1901 used about 50 materials. By one estimate, modern construction has about 55,000 materials at hand, half of them synthetic. Celluloid was created in 1856, from natural cellulose. Bakelite, the first synthetic plastic, was invented in 1907, followed by acrylic, polyethylene, polyester, styrene, polystyrene, etc.

These shiny, shimmering new substances were first widely embraced in consumer products: combs, tableware, packaging, clothing, and assorted trinkets. After Pearl Harbor, they were enlisted by the military and refined.

After the war, plastics returned with force to the marketplace.

In 1967, it was funny, because true, to give Dustin Hoffman's Benjamin Braddock one word of career advice: "Plastics." In real life in the same decade, seven students at the Harvard Business School did set out on careers in plastics.

The 150-page monograph of their class project for a course in manufacturing, "Plastics as Building Construction Materials," conveys a sober enthusiasm and barely restrained impatience. "What is the

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"The Breathe-Easy Home: The Impact of Asthma-Friendly Home Construction on Clinical Outcomes and Trigger Exposure," Tim K. Takaro, James Krieger, Lin Song, Denise Shapiro, Nancy Beaudet; *American Journal of Public Health* Vol. 101, No. 1. January 2011.

The researchers studying the effects of Breathe-Easy homes on children with asthma found an average sixfold drop in asthma attacks...

They wanted to reform plastic...to "overcome the war-born image of being a cheap and less desirable substitute."

delay? What are the restraining obstacles and attitudes? How do we go about overcoming them?" they cry in the introduction.

The authors encountered plastic goods in their daily lives – lightweight, inexpensive gadgets and utensils. They wanted to reform plastic, so to speak, to “overcome the war-born image of being a cheap and less desirable substitute.”

The monograph emphasizes that plastic is mechanically strong. It summarizes the types of plastic and their structural properties, and catalogs manufactured plastic products, including reinforced, laminated and “sandwiched” structural components.

The authors go beyond data, though, to introduce organizations that advocate for plastic building materials: the Manufacturing Chemists’ Association, the Society of the Plastics Industry, the Society of Plastics Engineers, and the Building Research Institute.

Plastics as Building Construction Materials, Joseph W. Burris, Theodore H. Elliott, Jr., Arthur L. Goldstein, John H. Hager, Daniel S. LaFar, Jr., Theodore E. Nelson, John A. Shane; This report was originally prepared by a group of second year students at the Harvard Graduate School of Business Administration in partial fulfillment of the requirements of General Georges F. Doriot’s course in Manufacturing during the academic year 1959-1960. 1960.

Looking back on it from the present, this monograph is an unusual hybrid of engineering and advocacy. Its aim shows most clearly in the section discussing strategies for moving more plastics into buildings. The prefabricated home industry, they note, is “especially attractive for penetration by plastics.” For the modern reader, that comment foreshadows the “FEMA trailer” episode of 2006, in which refugees from Hurricane Katrina were housed in trailers that released high concentrations of formaldehyde.

The authors also suggest that manufacturers of plastic building components bypass “restraining obstacles and attitudes” by “integrating forward into the building industry itself.”

And so they did. Thousands of plastic materials now hold our homes together, some structural, like decking, piping, furniture, and windows, and many not, such as paint, caulk, glue, insulation, and light fixtures. Plastics in homes and workplaces have lost the stigma of “cheap substitute.” They have advantages: they are light in weight and low in resource intensity.

These advocates for new, and in many ways better, materials tested the stuff, and their assumptions about them, rigorously. Their best arguments were proven data on the strength and flexibility of plastics. One cannot fault them for their lack of foresight in not testing for health safety. No one imagined that humans would ever live in such close, airless proximity to plastics.



The oil embargo of 1974 and the ensuing energy crisis transformed construction. Suddenly energy was precious.

Letting warm air slip away through fissures in walls became the equivalent of throwing money away, and reducing energy consumption the equivalent of virtue. Buildings had to be insulated and air leaks plugged. The energy efficiency industry was born. President Jimmy Carter created the Department of Energy (DOE) in 1977 to conserve U.S. energy.

Homes made of synthetic materials became unfortunate natural experiments when sealed up. The 1978 urea-formaldehyde foam insulation disaster, motivated by tax credits for insulation, was the best-known backfire.

Airtight, insulated buildings behaved differently. They did strange things to people and materials.

Max Sherman started grad school in physics in the early 1970s, at Berkeley, intending to go into cosmology, or high-energy physics. But when he started looking for a dissertation topic, Professor Art



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Airtight, insulated buildings behaved differently.



Rosenfeld intrigued him with an emerging new field: Building science.

“He said energy efficiency was a whole new area of physics, nobody knew the science,” recalled Sherman in an interview. “Nobody knew the right numbers.” The young scientist got in, so to speak, on the ground floor.

This 1982 conference paper by Sherman and his colleague David Grimsrud was an effort to work out the basic principles of this strange new creature, the airtight house. The work was urgent because something about these new buildings made people sick. Not all people all the time — that would have been too easy — just some people. Sometimes.

Obviously, stopping air leaks reduced ventilation — the swapping of indoor air for outdoor air. And reducing ventilation plausibly allowed chemicals to accumulate indoors that were tolerable at low levels, but intolerable at high concentrations.

So they studied different ways to restore the missing fresh air. “The exact amount of fresh air, however, is not generally agreed upon.” Passive air movement, like open windows and air leaks, were relics of the energy-profligate past.

Active ventilation, with fans and ducts, would be needed. But how?

There are three fundamental forms of active ventilation system: push bad air out; pull good air in; or both at once, in balance. Many houses that have exhaust fans in the kitchen and/or bathroom are practicing the first example. As fans push cooking fumes and shower steam out, the air pressure in the house drops, and air rushes in wherever it can.

Sherman and Grimsrud found that the best type of ventilation depended on the

tightness of the house. For well-sealed houses, the balanced system gave the best mix of fresh air. For leaky houses, either exhaust fans or fans blowing in improved air quality.

They did not know where in the house pollutants emerged from. That was for chemists.



The 1980 General Accounting Office (GAO) report on indoor air pollution is a melancholy document. It confronts the recent discoveries of the health dangers of indoor air pollution.

Touting the success of reducing outdoor air pollution under the Environmental Protection Agency (EPA), empowered by the Clean Air Act of 1963, the report asked which agency could fix indoor air.

The answer? Too many, and none. The EPA recommended more air circulation to dilute pollutants. The Department of Energy (DOE) wanted less, to save energy. The Department of Housing and Urban Development (HUD), the Consumer Product Safety Commission (CPSC), and the Occupational Safety and Health Administration (OSHA) all oversaw part of the problem, but did not want all of it.

The report’s authors studied how European countries — Great Britain, Sweden, Denmark, and The Netherlands — were dealing with the problem. These nations all had active research programs on indoor air and health. They also had set air quality standards and/or product standards, for formaldehyde, and were moving ahead on regulations for other pollutants.

The report does not directly recommend any of these actions to Congress, but quotes the Europeans indirectly:

The best type of ventilation depended on the tightness of the house.

“A Comparison of Alternative Ventilation Strategies,” M.H. Sherman, D.T. Grimsrud, of Lawrence Berkeley Laboratory, July 1982. To be presented at the Third Air Infiltration Centre (AIC) Conference, “Energy Efficient Domestic Ventilation Systems for Achieving Acceptable Indoor Air Quality,” London, UK, September 20-23, 1982.

“Indoor Air Pollution: An Emerging Health Problem,” Report to the Congress of the United States by the Comptroller General, General Accounting Office, 1980.

Active ventilation, with fans and ducts, would be needed. But how?

“Most foreign researchers and government officials agreed that product quality control is the most effective and easiest corrective measure to enforce.” In contrast to indoor air quality benchmarks, which would be unwieldy.

The GAO advised Congress to amend the Clean Air Act to give the EPA jurisdiction over indoor air but noted that the DOE disagreed with that very recommendation.

The only recommendation of this report that was ever adopted was the one for public education.



Asthma increased much more in the United Kingdom than in the U.S. in the post-energy crisis era. As asthma doubled among Americans, it quadrupled in the UK.

British housing stock is overall much older than in North America, and harder to tightly seal. High VOC levels are found

in modern buildings, which are easier to seal, and made of VOC-releasing materials. Formaldehyde in late 20th-century buildings was three times as high as in pre-1919 dwellings.

However, the greatest contribution to asthma in the UK was likely from the dust mite because of the British predilection for carpet. Ninety-eight percent of British residences contained wall-to-wall (or “fitted”) carpet, vs. sixteen percent in France. Dust mites need humidity, which carpet and soft furnishings provide. The moisture retained indoors by tight construction and retrofits built a bonanza for dust mites.

Scottish researchers performed a randomized double-blind placebo-controlled trial — the gold standard of research ex-

periment design — to see if improving indoor air would help asthma.

They divided sixty-eight asthmatic subjects, who lived in apartments and ranged in age from 15 to 50, into three groups. One group received steam cleaning of carpet to kill dust mites, new bedding, and compact mechanical ventilation units in bedroom and living room windows to control humidity, so the dust mites could not return. The second group received steam cleaning of carpet, new bedding and placebo ventilation units. The third group, the control group, received placebo steam cleaning and placebo ventilation units.

These changes improved asthma for eighty percent of the first group, which had the most indoor air improvement. Forty percent of the second group improved, and the control group not at all. Results were significant at the 0.0001 level.

The researchers answered their question, “Are our homes causing the asthma pandemic?” with a strong “yes.”

They urged, “Building standards and professional codes must now be revised to prioritize moisture control,” keeping humidity below sixty percent, the dust mite survival threshold.

That has not happened.



At the turn of the 20th century, the state of indoor air was paradoxical.

Unhealthy indoor air had been unwittingly concocted in the 1970s by sealing buildings tight to save energy. Indoor air often accumulated much higher concentrations of pollutants than outdoor air contained. As the consequent health problems came to light, research concluded that most of the new indoor pollutants fell into three groups.

“Domestic ventilation rates, indoor humidity and dust mite allergens: are our homes causing the asthma pandemic?” S.G. Howieson, A. Lawson, C. McSharry, G. Morris, E. McKenzie, J. Jackson; *Building Services Engineering Research & Technology* Vol. 24, No. 3. 2003.

The greatest contribution to asthma in the UK was likely from the dust mite because of the British predilection for carpet.

Why the mismatch between harm and regulation?

1) Volatile Organic Compounds, or VOCs, released as gases from synthetic building and furnishing materials, including the very caulks used to make buildings energy-efficient. The best known was formaldehyde which is a carcinogen and causes respiratory distress.

2) Biologics, particularly dust mites and mold. Sealing air in also sealed in moisture. Mold and dust mites are important allergens. They are “asthmagens,” a new term coined in the tight-building era. Many, perhaps most, of the new indoor pollutants are asthmagens.

3) Combustion products, such as nitrogen dioxide, carbon monoxide, and soot, which are carcinogens and asthmagens.

But as the danger of indoor air became clearer, no good options for reducing harm came to light.

Keep the windows open? Not if it's cold out, or too hot for comfort, or if you care about your energy bill, or if the air quality outdoors is not good. Exhaust fans to suck moisture out of the bathroom, and combustion products out of the kitchen? Okay, but if there's radon in the ground the low air pressure inside will bring it in. Build a house with non-synthetic materials? Even if you can afford it, good luck finding any.

Allison Shore, a graduate student in Sociology at UC Santa Cruz, stood back and looked at this odd picture. The EPA's own research showed the greatest risks of cancer and other diseases arose from indoor air pollutants and chemicals in consumer products. But the EPA did very little to regulate these proven hazards.

Shore asked: Why the mismatch, be-

tween harm and regulation? And, where does the discrepancy leave people affected by it?

The why is an old story. Congress tried. Legislation attacking indoor air pollution was attempted several times between 1991 and 1995. Early bills were altered “to ease industry concerns and win Republican votes.” The 1993 version required the EPA to set action levels for particular indoor pollutants, and allowed citizen suits. All failed.

Industry mobilized against indoor air pollution control throughout this period. The president of the Building Owners and Managers Association (BOMA) testified, “This issue will not be solved by regulation... While we welcome practical guidance based on sound research, we oppose giving the EPA unilateral authority to regulate.”

The president of the Chemical Specialties Manufacturers Association (CSMA) testified, “The setting of pollutant-specific action levels...is completely inconsistent with a non-regulatory, public awareness approach and can only be regarded as a table-setter for a pollutant-specific command-and-control program.”

No indoor air pollution legislation survived this onslaught. Shore concluded, “... industry has largely shaped EPA's current approach.” The only modus operandi left standing was “public awareness,” which is what the EPA does now concerning indoor air.

But this is a contradictory public awareness. As indoor air contaminants and consequent health problems increase, the actions that can be recommended to breathers are mostly purchasing different products. Buy low-VOC paint. Don't install carpet, or if you do, steam-clean it often. Choose a HEPA-filter vacuum. Don't steam up your bathroom, install a

“Indoor Air Pollution: Environmental Inequality Inside,” Allison Shore, in *Synthetic Planet: Chemical Politics and the Hazards of Modern Life*, ed. Monica J. Casper, Routledge, New York and London, 2003.

bathroom exhaust fan. Most of these options are unavailable to renters.

In a special issue of *EPA Journal* in 1993, EPA officials rationalize the limits placed on them. One writes that there is “public antipathy towards this form of intervention inside the home.”

And, in another article, “By definition, indoor air is within a building that someone owns. As long as someone owns the air, he or she obtains both the benefits and the costs from deciding how clean it should be...”

Who among us can decide how clean our air should be? Very few have the knowledge, let alone the power. Despite “public awareness” programs about indoor air pollution, few know how polluted their indoor air is, much less that anything can be done about it.



The Healthy Building Network (HBN) was founded in 2000 to identify safe, non-toxic building materials for the green building

industry, with or without manufacturer cooperation. They do this by testing the chemical contents of actual products, and curating chemical content databases produced by other organizations, into a cross-referenced encyclopedia of structural ingredients called Pharos, meaning lighthouse.

Far from being just chemistry nerds, HBN also pursues strategic goals with cheerful ruthlessness — like pressuring manufacturers into making better goods — by exposing the asthmagens, carcinogens, and endocrine disrupters normally included in these products.

For example, in 2015, the world’s largest flooring companies, Mohawk and Tarkett, along with retailers Home Depot, Lowe’s,

and Menard’s, agreed to stop using phthalate plasticizers in vinyl flooring. This was the result of a long, collaborative effort of HBN, Consumers Union, and a couple of generations of public health researchers.

Such leverage over manufacturers to change their ways works best at the high price point of the green building industry. But once producers find it’s possible to make safer goods, the learning trickles down to the rest of the market. As with phthalates in flooring,

In this report, HBN researchers Sarah Lott and Jim Vallette mark new territory in the effect of asthmagens on people. They distinguish between the reactive model of reducing asthmagens in the homes and workplaces of asthma patients to improve their symptoms — like the Breathe-Easy Home that helped Tesfai Gebrezgi’s son in Seattle — and a preventive paradigm of eliminating asthmagens in the environment to avoid triggering the disease in the first place. Release fewer asthmagen chemicals, make fewer asthmatics.

HBN would like building material manufacturers to simply abandon secrecy and reveal ingredients on the label. Creating secondhand transparency for a reluctant industry is laborious and expensive. But until manufacturers see the light, essential.



Portland’s recently approved 2035 Comprehensive Plan includes human health as a guiding principle, specifically: “Avoid or minimize negative health impacts and improve opportunities for Portlanders to lead healthy, active lives.” As Portland and the region confront the housing crisis — particularly the need to build more affordable and energy efficient homes — and as we incorporate health into our urban planning efforts, studies that examine the costs and benefits of new materials are critical to informed decision-making. **M**

"As long as someone owns the air, he or she obtains both the benefits and the costs from deciding how clean it should be..."

“Full Disclosure Required: A Strategy to Prevent Asthma Through Building Product Selection,” Sarah Lott, Jim Vallette, Healthy Building Network, 2013.