Health Starts in the Home: An Assessment of Efforts to Improve Occupant Health through Healthy Building Materials in San Francisco's Affordable Housing

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Health Starts in the Home: An Assessment of Efforts to Improve Occupant Health through Healthy Building Materials in San Francisco’s Affordable Housing

Staci Hoell

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Abstract

Americans spend 90% of their lives indoors, and much of this time is spent at home, surrounded by building materials that typically have added chemicals like flame retardants, highly fluorinated compounds, and antimicrobials. Recent research has linked these chemicals to adverse health outcomes such as asthma, endocrine disruption, cancer, neurodevelopmental issues, and reproductive problems (Bayer et al., n.d.; Green Science Policy Institute). Furthermore, these chronic health conditions disproportionately affect low-income populations. Fortunately, substantial efforts in research, practice, and policy are working to reduce the use of these potentially harmful chemicals in building materials, particularly in San Francisco’s affordable housing sector. The Green Science Policy Institute researches the health and ecological effects of chemicals in building products and educates policymakers about safer alternatives. Green building programs like LEED and Enterprise Green Communities serve as practical tools for developers, architects, and builders to incorporate healthy materials. Lastly, government housing funds can be leveraged for affordable housing developments to require or promote the use of healthy materials. This capstone project explores these current efforts in detail and highlights the cross-sectional collaborations that are improving occupant health and reducing health disparities, starting in the home. The paper concludes with recommendations to strengthen these efforts including the need for more health impact assessments and the applicability of a medical-legal partnership to improve housing conditions.

Keywords: healthy building materials, green building, affordable housing, endocrine-disrupting chemicals, medical-legal partnership
Health Starts in the Home: An Assessment of Efforts to Improve Occupant Health through Healthy Building Materials in San Francisco’s Affordable Housing

This paper will review chemicals in building materials and associated health effects; assess current efforts to promote healthy materials through research, practice, and policy; and explore policy recommendations for affordable housing developments in San Francisco. The content of this paper is based on my fieldwork experience at the Green Science Policy Institute where I researched the health and environmental impacts of flame retardants, highly fluorinated chemicals, and antimicrobials in connection with building materials.

Introduction

Imagine a baby crawling on the floor, exploring her new environment, touching everything around her, and putting her hands in her mouth every other minute. This is a familiar scenario. In fact, we have all experienced this during the first few years of our lives. What if these foundational movements that are vital to the baby’s growth and understanding of the world are putting the child in dangerously close contact with toxic chemicals on the floor? What if the indoor spaces where we live, work, and play are making us sick? The materials used to build our homes and indoor spaces may be to blame.

The Environmental Protection Agency (EPA) (1989) estimates that Americans spend about 90% of their lives indoors, and much of this time is spent at home. Buildings and homes are enclosed spaces, often with poor ventilation, that capture dust, volatile organic compounds, and a cocktail of chemicals from the building materials that make up these spaces. Indoor air quality (IAQ) has been a public health concern for many years, and the link between poor IAQ and buildings has been recognized since the World Health Organization (WHO) coined the term “sick building syndrome” in the 1980s (EPA, 1991). In a 1984 report, the WHO alleged that
new and remodeled buildings accounted for up to 30% of occupant health complaints (EPA, 1991). The built environment can cause negative health outcomes through multiple pathways including biological contaminants like mold and structural flaws such as poor ventilation. However, chemical contamination is a significant contributor to unhealthy conditions, and building materials may be a significant source of household chemical exposure.

**Health Disparities**

Chemicals added to building materials can cause acute health effects such as respiratory irritation, dizziness, and fatigue (EPA, 1991). They have also been linked to chronic conditions including asthma, cancer, diabetes, neurodevelopmental effects, hormone disruption, and reproductive effects (Bayer et al., n.d.; Green Science Policy Institute). Long-term exposure to these chemicals may contribute to poor health outcomes, especially for vulnerable populations like children, individuals with pre-existing chronic conditions, and low-income populations.

Public health research shows that populations of low-socioeconomic status are disproportionately affected by environmental health issues, including many of the conditions described above that have been linked to chemicals in building materials. Low-income individuals often lack health insurance, have inadequate access to health care, and experience lower quality of care. Furthermore, low-income populations typically bear a larger burden of environmental exposures such as air pollution and poor housing conditions.

Asthma is one example of a public health issue that affects low-income populations at higher rates. A study published by Wolstein, Meng, and Babey (2010) showed that among California residents with incomes below 200% of the Federal Poverty Level (FPL) (considered low-income), the prevalence of asthma was 8.7%, while residents with incomes above 400% of the FPL (considered mid- to high-income) had a prevalence of 7.8%. This same trend was also
evident in health care utilization and number of days of school and work missed. Among low-income children with asthma, 23.9% went to the emergency department or urgent care facility for asthma-related symptoms at least once in the prior year, while only 12.5% of children with asthma in the mid- to high-income group used these services (Wolstein, Meng, & Babey, 2010). The researchers also found that “low-income children with current asthma miss more than twice as many days of school due to asthma as higher-income children (2.8 vs. 1.3 days)”, and “low-income adults with current asthma miss three times as many work days as higher-income adults (2.2 vs. 0.6 days)” (Wolstein, Meng, & Babey, 2010). In addition to the public health significance, this study also highlights the social and economic burden of asthma.

Low socioeconomic status has also been associated with increased risk of certain cancers. Low-income populations have increased cancer incidence rates and mortality rates and tend to be diagnosed at later stages for lung, colorectal, and cervical cancer. Using data from the National Longitudinal Mortality Study (NLMS) and the Surveillance, Epidemiology, and End Results (SEER) cancer registry database from 1950-2014, researchers Sing and Jemel (2017) found that the all-cancer mortality rate was 22% higher in the most deprived communities (estimated by percent of population living below the federal poverty level) compared to the least-deprived communities. Additionally, Singh & Jemel (2017) found that men in the most deprived communities had a 54% higher mortality rate for lung cancer than men in the least-deprived communities. Similarly, the mortality rate for cervical cancer was 4.0 times higher for women in the most deprived communities compared to women in the least deprived communities (Singh & Jemel, 2017).

The socioeconomic disparities for asthma and cancer illustrate the need to improve health outcomes for low-income populations. Chemical exposure is only one factor that may contribute
to poor health outcomes for low-income populations along with other factors like smoking, diet, and physical activity. There are many efforts to reduce these health disparities including medical-legal partnerships that advocate for better socioeconomic conditions, such as housing conditions, for patients. Given the connection between household chemical exposure and poor health outcomes, public health efforts should aim to improve housing conditions through use of healthier, non-toxic building materials.

**Target Population: Affordable Housing Residents in San Francisco**

These health disparities are also evident in San Francisco, where one in three residents lives below 200% of the federal poverty level (San Francisco Health Improvement Partnership, 2016). Low-income children in San Francisco experience higher rates of asthma than children of higher incomes, and low-income mothers have the highest rate of low-weight babies (San Francisco Health Improvement Partnership, 2016). While poor housing conditions may be contributing to these health disparities, new affordable housing developments and renovations present an opportunity to drastically improve the health of San Francisco’s low-income residents and reduce these disparities.

In light of the housing crisis in San Francisco, the Mayor’s Office of Housing and Community Development is pouring millions of dollars into new affordable housing projects and creating policies that incentivize private developers and non-profit community development corporations to build affordable units.
Figure 1. San Francisco affordable housing pipeline. From the San Francisco Mayor’s Office of Housing and Community Development website: https://data.sfgov.org/Housing-and-Buildings/Affordable-Housing-Pipeline

Figure 1 shows that there are currently 250 affordable housing projects in the development process, which will produce 14,077 affordable units by the year 2024 (San Francisco Mayor’s Office of Housing and Community Development, 2017). If policies to support healthy housing, including the use of healthy building materials, can be standardized, then these developments have the potential to improve the health of 14,077 families and individuals.

Background

Building Materials as a Source of Chemical Exposure

Building materials include everything from physical structures such as doors, cabinets, countertops, and drywall to additions like paint, adhesives, insulation, and flooring materials such as vinyl and carpet. Chemicals are often added to the materials to improve durability, functionality, and aesthetics. There are many hazardous chemicals that can be found in the home
such as lead, asbestos, and formaldehyde, but this paper will focus on three classes of potentially harmful chemicals that are commonly added to building materials:

- Flame retardants
- Highly fluorinated chemicals
- Antimicrobials

Flame retardants are added to insulation, carpet padding, furniture foam, and electronics to reduce flammability. However, the addition of flame retardants to these products is a controversial topic among environmental health professionals and fire code officials. Many fire safety advocates believe that flame retardants are necessary to prevent the spread of fire, yet scientists contest that widely used flame retardants cause human and ecological harm and do not add any additional fire protection when the product is protected by a thermal barrier such as drywall (Babrauskas et al., 2012). Highly fluorinated chemicals, also referred to as poly- and perfluoroalkyl substances (PFAS), are added to materials like carpet, textiles, and sealants to repel liquids. They are also added to many non-building products such as non-stick pans and outdoor apparel. These products are usually marketed as “water-resistant”, “stain-resistant”, or “non-stick”. Antimicrobials are added to products to kill or inhibit the growth of bacteria. They are found in many cleaning products, personal care products, clothing, and kitchenware. In building products they are added to paint, flooring materials like carpet, wood, tiles, and surfaces like countertops, toilet seats, and door knobs. In most cases they are added to these products to prevent mold.

**Chemical migration.** These chemicals can react with the environment and migrate from the material to air, dust, and water via leaching, oxidation, and degradation. Leaching occurs when water- and oil-soluble compounds dissolve into water or oil and wash away from the
material (Bayer et al., n.d.). Oxidation is a chemical reaction between oxygen and the chemical that can alter the molecular makeup and can occur in normal household conditions. Degradation can include photodegradation in which sunlight can break up molecules; hydrolysis when compounds break away from the material and bind to water; and abrasion, which occurs when chemicals are scratched or rubbed off of the material (Bayer et al., n.d.). There are also chemicals that evaporate easily, often under normal or slightly humid conditions, that are referred to as volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs) (Centers for Disease Control and Prevention, n.d.). Some examples of VOCs found in building materials are formaldehyde, benzene, and styrene, and SVOCs can include phthalates and halogenated flame retardants (CDC, n.d.; Bayer et al.).

**Human exposure.** There are three main routes of human exposure to these chemicals in the home: inhalation of air with volatized chemicals; ingestion of contaminated dust or food; and transdermal absorption via direct skin contact with materials (Bayer et al. n.d.; Valette, Schettler, & Wolfe, 2014; Winkens, Vestergren, Berger, & Cousins, 2017). Furthermore, throughout the material’s life cycle including processing, production, use, and disposal, the chemicals from building materials can wind up in streams, lakes, and eventually, sources of drinking water (Blum et al., 2015; DiGangi et al., 2010; Halden et al., 2017). Many of these chemicals are persistent and bioaccumulate in the environment. Certain flame retardants, fluorinated chemicals, and antimicrobials accumulate in sediment, soil, crops, and aquatic organisms, exposing all organisms along the food chain, including humans (Blum et al., 2015; DiGangi et al., 2010; Halden et al., 2017). These additional routes of exposure fortify the need to evaluate the health and environmental effects of these chemicals and safely reduce their use.
**Children.** Children are particularly vulnerable to high exposures, because the concentration of chemicals relative to their body weight is much higher than in adults. Additionally, the duration of time spent on the floor, in close contact with household dust, and the frequency of hand-to-mouth contact increases their exposure to chemicals from building materials. Infants (3-6 months) have approximately 28 hand-to-mouth contacts per hour (Winkens et al., 2017). Additionally, halogenated flame retardants, PFAS, and antimicrobials can bioaccumulate in human breast milk, so infants can be exposed directly through breastfeeding (DiGangi et al., 2010; Halden et al., 2017; Mogensen, Grandjean, Nielsen, Weihe, & Budtz-Jørgensen, 2015).

**Others exposed.** It is important to note that although this paper focuses on the occupant exposure to chemicals in building materials, other groups are exposed along the life cycle of the material. Manufacturers may be exposed during processing; construction crews may be exposed while installing the materials; maintenance and operations staff may be exposed while cleaning or working in the building; and emergency responders such as firefighters may be exposed during a fire or other natural disaster like flooding.

**Health Effects**

**Flame retardants.** Most flame retardants added to building materials, like insulation, are halogenated compounds containing either bromine, chlorine, fluorine, or iodine (American Public Health Association [APHA], 2015). Common halogenated flame retardants include Hexabromocyclododecane (HBCD), a chemical commonly added to polystyrene insulation; Tris(1-chloro-2-propyl) phosphate (TCPP), used in polyurethane and polyisocyanurate insulation; and a brominated styrene butadiene copolymer commonly referred to as “poly FR” (APHA, 2015). These chemicals accumulate in the human body and have been detected in
human serum and breast milk (DiGangi et al., 2010). HBCD is an endocrine disrupting chemical and causes reproductive and developmental issues in animals (Du, Zhang, Yan, & Zhang, 2012; Fernie, Marteinson, Bird, Ritchie, & Letcher, 2011; Park et al., 2012). In vitro and animal studies show that TCPP also causes endocrine disruption (Lie, Ji, & Choi, 2012). Although there is limited toxicological information on TCPP, a similar flame retardant, brominated tris, was found to be a human carcinogen and has since been banned from certain products in the U.S. (DiGangi et al., 2010). Due to the similar chemical makeup, TCPP may also be carcinogenic. The persistence and bioaccumulation of halogenated flame retardants in the environment is also a concerning characteristic.

**Highly fluorinated chemicals.** The human health effects of highly fluorinated chemicals, specifically per- and polyfluoroalkyl substances (PFAS), have been well-documented. Calafat, Wong, Kuklenyik, Reidy, and Needham (2007) detected PFAS in 98% of human serum samples taken from individuals in the U.S. during 2003-2004. PFAS are associated with liver toxicity, kidney and testicular cancer, elevated cholesterol, decreased fertility, thyroid disease, obesity, and interference with hormone function (Blum et al., 2015; Green Science Policy Institute). Like flame retardants, they are also extremely persistent in the environment and end up in food and drinking water (Blum et al., 2015).

**Antimicrobials.** Antimicrobials are often added to building materials to prevent mold. However, these chemicals have been under scrutiny recently due to research demonstrating potentially negative health and ecological impacts. Antimicrobials include triclosan, triclocarban, nanosilver, and quaternary ammonium compounds. Triclosan and triclocarban are endocrine disruptors and cause allergen sensitization (Halden et al., 2017). *In vitro* and animal studies demonstrate their potential to cause reproductive and developmental problems (Halden et al.,
2017). Exposure to quaternary ammonium compounds (quats) causes asthma, and in vitro studies have found that quats may also cause mitochondrial dysfunction (Costa, Domingues, Santos, & Vaz, 2013; Purohit, 2000). Furthermore, triclosan and nanosilver may contribute to antibiotic resistance (Gunawan et al., 2017; Halden et al., 2017).

**Scope of Project: The Assessment**

Although some building materials contain toxic chemicals, there are safer alternatives available, and there are effective strategies to reduce use of harmful chemicals in materials. My capstone research explores current efforts to promote the use of healthy building materials in new and renovated developments of affordable housing in San Francisco. The following assessment includes efforts in scientific research including the work I did at my fieldwork placement at the Green Science Policy Institute, practical tools used by developers to avoid harmful products, and policies and standards set by government housing agencies to promote and incentivize the use of healthier materials.

**Research: Green Science Policy Institute**

The Green Science Policy Institute (GSP) is a non-profit organization based in Berkeley, California that works to reduce the use of harmful chemicals in products. The Institute’s mission is “to facilitate responsible use of chemicals to protect human and ecological health”, and they achieve this through publication of peer-reviewed research, health policy promotion, education, and partnerships with key decision makers and purchasing institutions. Relevant projects include a partnership with the Healthy Building Network (HBN), the Six Classes approach to chemical regulation, scientific consensus papers, and the Safer Insulation Solution.

GSP and HBN collaborate on a project called the Healthy Affordable Materials Project to research potentially hazardous materials and related health effects in affordable housing. The
project features databases of products and chemicals that developers and architects can use when selecting materials as well as initiatives to encourage manufacturers to declare all product ingredients and additives. GSP has also developed the Six Classes approach to chemical regulation. This innovative policy and education tool provides a framework for policymakers, purchasers, and, in this case, builders of affordable housing to consider whole classes of chemicals rather than one single chemical at a time. Policies typically aim to restrict or ban a specific chemical, but manufacturers often replace these chemicals with a chemical “cousin” that has a similar molecular make up, function, and potential for harm. The Six Classes include:

- Flame retardants
- Highly fluorinated chemicals
- Antimicrobials
- Phthalates and bisphenols
- Some solvents
- Certain metals

GSP has also produced several scientific consensus papers highlighting health and ecological information for chemical classes and policy recommendations. The consensus papers, which are published in widely distributed academic journals, include the “San Antonio Statement on Brominated and Chlorinated Flame Retardants,” the “Madrid Statement on Poly- and Perfluoroalkyl Substances,” and the “Florence Statement on Triclosan and Triclocarban.” Lastly, GSP facilitates the Safer Insulation Solution project which aims to improve building codes and reduce hazardous flame retardants in plastic foam insulation by providing up-to-date health and ecological information to building code officials and architects. Specifically, GSP serves as a scientific liaison for the International Codes Council and provides unbiased information in the
process to update the International Building Code that is used as a model building code by most municipalities around the world.

**Practice: Green Building Programs**

Green building programs have become a useful tool for translating research on healthy building materials into practice. Common green building programs used in the affordable housing sector include Leadership in Energy and Environmental Design (LEED), WELL, Enterprise Green Communities, Living Building Challenge, and GreenPoint Rated. These programs provide guidelines and resources for architects and developers to incorporate best practices, and they offer certifications based on a set of standards and building criteria. Although most programs focus heavily on sustainability and resource conservation, all of the aforementioned programs address healthy building materials to some degree.

LEED, developed by the U.S. Green Building Council, is the most widely used green building standards in the U.S. The program mainly focuses on energy efficiency and environmental sustainability, and it has been criticized for not putting a large enough emphasis on occupant health and reduction of toxic materials (Wargo, 2010). However, the most recent version of LEED guidelines (LEED v4), launched in 2013, prioritizes selection of healthier materials by rewarding credits for material ingredient reporting and disclosure (U.S. Green Building Council [USGBC], 2012a). Additionally, LEED launched Pilot Credit 54 in 2012 to encourage builders to avoid certain chemicals of concern (USGBC, 2012b). Chemicals on this list include perfluorinated chemicals and halogenated flame retardants (USGBC, 2012b).

WELL, developed by the International WELL Building Institute, is also affiliated with the U.S. Green Building Council, but is focused wholly on occupant health, incorporating aspects of active design to promote fitness, proximity to healthy foods, and design strategies to support
mental health. LEED and WELL complement one another and are often achieved simultaneously. The seven concepts of WELL include air, water, nourishment, light, fitness, comfort, and mind. Healthy materials and indoor air quality are addressed at length in the air component.

The Living Building Challenge (LBC), developed by the International Living Future Institute, is a comprehensive program that address both sustainability and occupant health. The seven “petals” of the program include place, water, energy, health + happiness, materials, equity, and beauty. The materials petal includes resources such as the Red List, which is a detailed list of chemicals that should be avoided. Halogenated flame retardants and perfluorinated chemicals are included on the Red List (International Living Future Institute).

Enterprise Green Communities (EGC) is a program specific to affordable housing projects. EGC is an initiative of Enterprise Community Partners aimed at producing green and healthy homes for low-income populations. Building materials are addressed in Section 6 of the 2015 Green Communities Criteria. Though the criteria in this program are mostly concerned with reducing VOCs such as formaldehyde, mold prevention, and using recycled and local materials, the guidance does specify the avoidance of spray polyurethane foam insulation (which typically contains halogenated flame retardants) and the use of Green Label Plus certified carpet products, which do not contain flame retardants (Enterprise Green Communities, 2015).

GreenPoint Rated is a green building program specific to California. It provides a practical set of tools and checklists to achieve California building standards and go beyond the standards to improve energy efficiency. The five components include energy efficiency, water conservation, indoor air quality, resource conservation, and livable communities. Healthy
materials are marginally addressed in the indoor air quality component, but there is much room for improvement.

**Market shift.** Green building certifications provide incentives for developers to incorporate sustainable design, and by association, healthier building materials. Growing demand for green building design is causing a significant market shift towards these innovative green practices. A recent survey of the building industry showed that the top two reasons for building green are client demand (35%) and market demand (33%) (USGBC, 2015).

*Figure 2.* Market distribution of green building practices. Adapted from “Designing for health: Promoting public health through built environment practice” by M. Trowbridge, C. Pyke, K. Worden, & D. Lau, 2017.

Figure 2, produced by the Green Health Partnership, shows that 70% of the building market falls within the standard practices, using minimal green design, only what is required by building codes (Trowbridge, Pyke, Worden & Lau, 2017). Twenty percent of the market is considered market leaders, and 5% are considered innovators, using the most rigorous and thorough green and healthy practices (Trowbridge et al., 2017). The other 5% of the market constitutes the substandard practices or the “law breakers” who do not meet all required building codes (Trowbridge et al., 2017). The ultimate goal of green building programs is to make green and healthy practices the standard for all developments. These green building programs serve as
effective practical tools for developers of affordable housing to incorporate healthier materials and improve occupant health.

**Barriers to using healthy building materials.** Barriers to using healthy materials include:

- Cost of healthier materials
- Cost of green certification processes
- Lack of chemical disclosure
- Lack of government regulation
- Lack of toxicity information and information on health impacts

**Policy: Leveraging Government Housing Funds**

Decision makers that shape the built environment are shown in Figure 3. They include practitioners like architects and construction teams; policy makers; and owners and investors (Trowbridge et al., 2017).

*Figure 3. Decision makers that shape the built environment. Adapted from “Designing for health: Promoting public health through built environment practice” by M. Trowbridge, C. Pyke, K. Worden, & D. Lau, 2017.*
Looking upstream, the investors of affordable housing play a significant role in setting the goals for a new development project, including building standards to be achieved. Most affordable housing projects are funded through a mix of private investment capital and government funding sources. These include federal tax credits like the low-income housing tax credit distributed through state allocation plans and local housing funds awarded through requests for proposals (RFP) and notices of funding available (NOFA). Policies requiring healthy building materials and green building standards can be implemented as criteria for these public housing funds. In other words, these sources of government funding can be leveraged to promote occupant health.

A major source of funding for affordable housing projects is the federal low-income housing tax credit (LIHTC) administered through the U.S. Department of Housing and Urban Development (HUD). The LIHTC was created from the Tax Reform Act of 1986 and produces the equivalent of $8 billion annually in funding for low-income housing development (HUD, 2017). The tax credits are allocated to state housing finance agencies by the Internal Revenue Service based on each state’s population, and the state issues the tax credits to housing investors based on criteria set in a qualified allocation plan (QAP). To be eligible for the LIHTC, developments must include 40% affordable units (Office of the Comptroller of the Currency, 2014). In California, the Tax Credit Allocation Committee (TCAC) sets the QAP criteria for LIHTC eligibility. Currently the California QAP requires minimum construction standards such as energy efficient strategies and low-emitting insulation. Priority points are awarded for developers who achieve LEED, WELL, Enterprise Green Communities, Living Building Challenge, or GreenPoint Rated certification (California Tax Credit Allocation Committee,
By prioritizing projects that incorporate these green building standards, the state is leveraging tax credits to promote health.

In San Francisco, an additional source of funding for affordable housing development is the San Francisco Mayor’s Office of Housing and Community Development (MOHCD). MOHCD funds are typically awarded through a Notice of Funding Available (NOFA) or Request for Proposal (RFP) process in which developers apply and compete for limited funds. San Francisco building codes already require multi-unit residential buildings to be LEED or GreenPoint Rated certified. However, MOHCD funds could be leveraged to further prioritize or require projects that demonstrate a commitment to using healthy, non-toxic building materials, even beyond the scope of LEED. Other local measures could be taken to incentivize healthy building materials such as expedited plan review or reduced permit fees.

**Recommendations**

San Francisco and California are leading the movement towards promotion of healthy building materials. However, there is room for improvement in research, practice, and policy. More health impact assessments are needed to measure the health outcomes of using healthy materials and implementing green building standards. Additionally, more toxicological and epidemiological data is needed to better understand the health effects of the chemicals in building materials. This gap in data represents an opportunity for public health professionals to collaborate with architects, designers, developers, and local governments to address health outcomes in relation to the built environment.

Local policies and green building programs should incorporate the Six Classes approach to chemical consideration in building products. Current efforts mainly focus on specific chemicals or broad chemical terms like VOCs. The Six Classes approach is not only an effective way to
reduce harmful chemical in building products, it is also a simple way to categorize and understand chemicals. The Six Classes also capture to less known, yet potentially harmful, classes of chemicals such as antimicrobials, which are not currently addressed in any green building programs.

Finally, a medical-legal partnership (MLP) could be developed in San Francisco to translate health impact data into new policies and building standards that address long-term indoor chemical exposures. A MLP is a healthcare delivery model where a health organization or clinic partners with a legal team to address the underlying socioeconomic conditions that contribute to poor health outcomes. Using this model, a local San Francisco clinic that serves low-income individuals and residents of affordable housing would collect longitudinal data on the patients, noting conditions such as asthma, cancer rates, and endocrine issues. The legal team could then analyze and use this data to fortify existing building standards. Under current California law, landlords are required to maintain habitability and address short-term and immediate threats to occupant health and safety such as gas leaks, faulty electrical wiring, and unsafe structures (California Department of Consumer Affairs). However, there is opportunity to incorporate consideration for long-term health effects including the impact of building materials. A MLP is already in place between Zuckerberg San Francisco General and Bay Area Legal Aid, and this partnership already addresses housing conditions as a factor affecting health. Utilizing this existing asset could offer a concrete solution for the collaboration between public health, building design, and local policy.
Conclusion

The results of this assessment show that healthy building materials are slowly becoming a priority for research, green building practice, and housing policy. Collaboration between sectors like public health, green building design, and local housing advocates present a unique opportunity to improve the health of low-income populations. With thousands of new affordable housing units coming down the pipeline in San Francisco, it will be important to strengthen local incentives to incorporate healthy design and address these long-term chemical exposures in the home. San Francisco has the potential to be the model city for healthy building promotion and to ensure that health disparities are addressed directly, starting in the home.
References


https://www.usgbc.org/Docs/Archive/General/Docs10107.pdf

https://www.usgbc.org/articles/business-case-green-building
Appendix A: Final Learning Objectives

Staci Hoell

Fieldwork Experience at the Green Science Policy Institute

<table>
<thead>
<tr>
<th><strong>Goal 1:</strong> Create and publish supporting documents to complement and publicize the Florence Statement on Triclosan and Triclocarban, a scientific consensus statement aimed at informing policy and purchasing.</th>
<th><strong>Activities</strong></th>
<th><strong>Start/End Date</strong></th>
<th><strong>Who is Responsible</strong></th>
<th><strong>Anticipated Hours</strong></th>
<th><strong>Tracking Measures</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Create and organize extensive bibliography on triclosan, triclocarban, monotriazine, and quaternary ammonium compounds.</td>
<td>Research and find peer-reviewed studies on antimicrobials; Categorize supporting references by chemical type and by health/environmental issue.</td>
<td>March-May 2017</td>
<td>Staci</td>
<td>25</td>
<td>Weekly check in meetings</td>
</tr>
<tr>
<td>Create webpage on antimicrobials for GSP website.</td>
<td>Summarize and simplify scientific concepts and health takeaways from the Florence Statement; Draft webpage text; Find photos for webpage; Create &quot;In the Media&quot; section with news articles on antimicrobial chemicals.</td>
<td>March-May 2017</td>
<td>Staci</td>
<td>25</td>
<td>Weekly check in meetings</td>
</tr>
<tr>
<td>Recruit and collaborate with Dr. Barbara Sattler and the Alliances of Nurses for Healthy Environments (ANHE).</td>
<td>Draft quote on antimicrobial efficacy; Request permission from Dr. Sattler to be quoted in the press release; Request for collaboration and promotion of the Florence Statement via ANHE.</td>
<td>April 2017</td>
<td>Staci</td>
<td>5</td>
<td>Weekly check in meetings</td>
</tr>
<tr>
<td>Draft social media posts to promote the Florence Statement and antimicrobials webpage.</td>
<td>Draft at least 10 Tweets and 5 Facebook posts on health harm, environmental harm, lack of efficacy, and antimicrobial resistance; Send a few social media posts to ANHE to share with their networks.</td>
<td>May-June 2017</td>
<td>Staci</td>
<td>5</td>
<td>Weekly check in meetings</td>
</tr>
<tr>
<td>Create an infographic on antimicrobials intended for the general public education.</td>
<td>Define specific infographic topic (health concerns vs environmental harm); Select relevant information from Florence Statement, bibliography, and webpage to use in infographic; Use Canva to create an infographic.</td>
<td>May-July 2017</td>
<td>Staci</td>
<td>25</td>
<td>Weekly check in meetings</td>
</tr>
<tr>
<td>Write follow up blog post on antimicrobials</td>
<td>Research regulatory updates on antimicrobials; Co-author blog post to mark one-year anniversary of 2015 FDA decision on antimicrobial soaps</td>
<td>Oct-Nov. 2017</td>
<td>Staci</td>
<td>80</td>
<td>Weekly check in meetings</td>
</tr>
</tbody>
</table>
### Goal 2: Research chemicals in indoor built environment for potential research projects in collaboration with Healthy Building Network to inform purchasing decisions and policy changes to reduce household exposures.

<table>
<thead>
<tr>
<th>Objectives (S)</th>
<th>Activities</th>
<th>Start/End Date</th>
<th>Who is Responsible</th>
<th>Anticipated Hours</th>
<th>Tracking Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform background research on chemicals in building materials.</td>
<td>Create an abbreviated literature review on PFAS in carpet.</td>
<td>July-Sept 2017</td>
<td>Staci</td>
<td>30</td>
<td>Weekly check in meetings; Present findings to Tom (GSP)</td>
</tr>
</tbody>
</table>

### Goal 3: Create supporting documents for the Safer Insulation Solution project, that aims to safely reduce use of and exposure to hazardous flame retardants.

<table>
<thead>
<tr>
<th>Objectives (S)</th>
<th>Activities</th>
<th>Start/End Date</th>
<th>Who is Responsible</th>
<th>Anticipated Hours</th>
<th>Tracking Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update health and ecological impact information for flame retardants (TCPF, HBCD, and Poly FR.)</td>
<td>Do literature review of latest research on health and ecological impacts of flame retardants; Update bibliography for flame retardants in insulation.</td>
<td>Nov. 2017</td>
<td>Staci</td>
<td>60</td>
<td>Weekly check in meetings; Present findings to Tom (GSP)</td>
</tr>
</tbody>
</table>
# Appendix B: Fieldwork Time Log

**Master of Public Health Program**  
**FIELDWORK TIME LOG**

<table>
<thead>
<tr>
<th>Student</th>
</tr>
</thead>
</table>
| **Student's Name:** Staci Hoell | **Campus ID #:** 20192479  
| **Student's Phone:** 252-241-3086 | **Student's Email:** shoell@usfca.edu  
|  
| Preceptor |  
| **Preceptor's Name:** Avery Lindeman | **Preceptor's Title:** Deputy Director (Mar-Nov); Senior Scientist (Nov-present)  
| **Preceptor's Phone:** 520-241-6118 | **Preceptor's Email:** avery@GreenSciencePolicy.org  
| **Organization:** Green Science Policy Institute |  
| **Student's Start Date:** March 2017 | **Student's End Date:** Hours/week: Dec. 22, 2017  

**Time Log for (Check One):**  
__X__ Spring 2017  
__X__ Summer 2017  
__X__ Fall 2017  
___Spring 2018

<table>
<thead>
<tr>
<th>Month</th>
<th>Total # of Hours for Month</th>
<th>Preceptor Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>8.5</td>
<td>AEL</td>
</tr>
<tr>
<td>April</td>
<td>21.5</td>
<td>AEL</td>
</tr>
<tr>
<td>May</td>
<td>21</td>
<td>AEL</td>
</tr>
<tr>
<td>June</td>
<td>30</td>
<td>AEL</td>
</tr>
<tr>
<td>July</td>
<td>10</td>
<td>AEL</td>
</tr>
<tr>
<td>August</td>
<td>8.5</td>
<td>AEL</td>
</tr>
<tr>
<td>September</td>
<td>15.5</td>
<td>AEL</td>
</tr>
<tr>
<td>October</td>
<td>88.5</td>
<td>AEL</td>
</tr>
<tr>
<td>November</td>
<td>70</td>
<td>AEL</td>
</tr>
<tr>
<td>December</td>
<td>26.5</td>
<td>AEL</td>
</tr>
</tbody>
</table>

Signature: [Signature]
Appendix C: Student Evaluation of Fieldwork Experience

<table>
<thead>
<tr>
<th>Student Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Student’s Name:</td>
<td><strong>Staci Hoell</strong></td>
</tr>
<tr>
<td>Student’s Phone:</td>
<td><strong>252-241-3806</strong></td>
</tr>
<tr>
<td>Campus ID #</td>
<td><strong>20192479</strong></td>
</tr>
<tr>
<td>Student’s Email:</td>
<td><strong><a href="mailto:slhoell@usfca.edu">slhoell@usfca.edu</a></strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preceptor Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preceptor’s Name:</td>
<td><strong>Avery Lindeman</strong></td>
</tr>
<tr>
<td>Preceptor’s Phone:</td>
<td><strong>520-241-6118</strong></td>
</tr>
<tr>
<td>Preceptor’s Title:</td>
<td>Deputy Director (Mar-Nov); Senior Scientist (Nov-present)</td>
</tr>
<tr>
<td>Preceptor’s Email:</td>
<td><a href="mailto:avery@greensciencepolicy.org">avery@greensciencepolicy.org</a></td>
</tr>
<tr>
<td>Organization:</td>
<td>Green Science Policy Institute</td>
</tr>
<tr>
<td>Student’s Start Date:</td>
<td><strong>March 1, 2017</strong></td>
</tr>
<tr>
<td>Student’s End Date:</td>
<td><strong>Dec. 22, 2017</strong></td>
</tr>
<tr>
<td>Hours/week:</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Please use the following key to respond to the statements listed below.

SA = Strongly Agree  A = Agree  D = Disagree  SD = Strongly Disagree  N/A = Not Applicable

<table>
<thead>
<tr>
<th>My Field Experience...</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributed to the development of my specific career interests</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Provided me with the opportunity to carry out my field learning objective activities</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Provided the opportunity to use skills obtained in MPH classes</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Required skills I did not have Please list:</td>
<td></td>
</tr>
<tr>
<td>Required skills I have but did not gain in the MPH program Please list:</td>
<td></td>
</tr>
<tr>
<td>Added new information and/or skills to my graduate education Please list:</td>
<td></td>
</tr>
<tr>
<td>Creation of fact sheet and infographic; Maintaining large scale bibliographies with reference management software</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Challenged me to work at my highest level</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Served as a valuable learning experience in public health practice</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>I would recommend this agency to others for future field experiences.</td>
<td>Yes NO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>My preceptor...</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Was valuable in enabling me to achieve my field learning objectives</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Was accessible to me</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Initiated communication relevant to my special assignment that he/she considered of interest to me</td>
<td>SA A D SD N/A</td>
</tr>
<tr>
<td>Initiated communication with me relevant to general functions of the agency</td>
<td>SA A D SD N/A</td>
</tr>
</tbody>
</table>
2. Would you recommend this preceptor for future field experiences? Please explain.

_____ Yes  _____ No  _____ Unsure

Yes, Avery was extremely patient and helpful as I learned the operations of Green Science Policy Institute. She is very knowledgeable about environmental health issues and policies and was eager to share her knowledge with me.

3. Please provide additional comments explaining any of your responses.

Because of my job, I had to do most of my fieldwork remotely. While Avery and I did communicate often via phone calls, I wish that I had been able to spend more time in the GSP office and interact with the whole team.

4. Summary Report: All students are required to prepare a written summary of the field work to be submitted with this evaluation form. See Appendix D.

Staci L. Hoell  12/5/17
Student Signature  Date
Appendix D: Summary of Fieldwork Experience

Staci Hoell

Green Science Policy Institute

I completed my fieldwork experience at the Green Science Policy Institute, which is a non-profit organization in Berkeley, CA. The mission is to facilitate the responsible use of chemicals and to protect human health and the environment. The Institute achieves this through research, policy, and partnerships. While there, I created translational and educational materials for several projects dealing with different chemical classes. First, I created supporting documents to complement and publish alongside the publication of a scientific consensus paper called, “The Florence Statement on Triclosan and Triclocarban.” These documents included an infographic explaining the health and ecological impacts of the chemicals, an extensive bibliography to support this information, and webpage content for a new section on antimicrobials. Later, I co-authored a blog post about policy and consumer market updates on antimicrobials. I then performed an extensive literature review on chemicals in building materials, specifically for highly fluorinated chemicals in carpet products. This literature review was intended to assess current knowledge on exposure, health outcomes, and efficacy of these chemicals. This work supported a research grant partnership that GSP has with Healthy Building Network. Finally, I did another literature review for flame retardants in insulation and created a new fact sheet to support the Safer Insulation Solution project. In summary, I felt that I was a valuable asset to the Institute, because I was able to use my public health training and lens to translate dense scientific information into easy-to-read materials intended for the general public, policy makers, and purchasers. These materials highlighted the public health implication of hazardous chemicals in products.