‘Safe Couch, Safe House’ Program (SCSHP): Reducing Exposure To Toxic Flame Retardants For Children In A Low-Income Public Housing At Hunters View, Bayview-Hunters Point, San Francisco.

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‘Safe Couch, Safe House’ Program (SCSHP): Reducing Exposure to Toxic Flame Retardants for Children in a Low-Income Public Housing at Hunters View, Bayview-Hunters Point, San Francisco.

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Abstract

Since the 1970s, flame retardants have been used extensively in consumer goods, including furniture, textile, and electronics, to meet California’s flammability standards. (Gibson et al., 2019) Polybrominated Diphenyl Ethers (PBDEs), once the most widely used flame retardants being used in consumer products, were phased out from use in manufacturing as evidence emerged about PBDEs persistence and toxicity. (Hoffman et al., 2017) PBDEs were replaced by Organophosphate Flame Retardants (OPFRs), which has proven to be a case of ‘regrettable substitution’ as exposure to OPFRs is ubiquitous and pervasive in humans due to their volatility and propensity to leach from products into the environment.

Emerging evidence also points towards neurodevelopmental delays in children exposed to OPFRs. Evidence suggests that children ages 0 to 5 are at a much higher risk of exposure as they are mostly indoors in proximity to a significant source of these flame retardants, such as upholstered furniture found in most houses.

From 2020, laws in California have banned production and sale of upholstered furniture containing flame retardants. However, exposure to OPFRs from older furniture presents a public health problem as children and families in low-income communities are more likely to use older furniture and are thus still susceptible to high levels of exposure to flame retardants.

This investigation lays out evidence and risks of exposure to OPFRs and recommends a pilot program to reduce exposure to flame retardants in children living in low-income housing in City of San Francisco.
Keywords: Flame Retardants, Organophosphate Flame Retardants (OPFRS), Polybrominated diphenyl ethers (PBDEs), Prenatal and Post Natal Exposure, Mothers, Children, Neurodevelopmental Delays, Behavioral Delays, Cognitive Delays, ADHD, Low-income communities in City of San Francisco, Upholstered Furniture

Flame Retardants and Their Uses

Flame retardants are chemicals that are added to consumer products to reduce their flammability and make them safer for use. There are many types of flame retardants, categorized according to their chemical makeup. Two of the most common flame retardants are Polybrominated Diphenyl Ethers (PBDEs) and Organophosphate Flame Retardants (OPFRs).

PBDEs are manmade chemicals that started being used in consumer goods in the 1970s, most commonly in building materials, automobiles, electronics, children’s products, and furniture. (Blum et al., 2019) PBDEs are additive and do not chemically bind to the products they are added to, which makes them easy to leach and migrate into the environment. Furthermore, due to their low solubility in water, PBDE particles accumulate in water bodies, such as rivers and lakes, and have been found in both humans and animals (Flame Retardants, n.d.). After extensive research, PBDEs were found to be persistent, bio-accumulative, and toxic (Blum et al., 2019) and associated with adverse health impacts, such as impaired neurological development in children.

OPFRs have been used as replacements for PBDEs after the latter was phased out of production due to its toxicity. Commercial flame retardants that contain mainly OPFRs are used in residential furniture, among other consumer products, such as electronics and baby products.
OPFRs are also physically added to products hence are easily released into the environment due to process of volatilization, abrasion, and leaching. (Du et al., 2019b)

Understanding the exposure pathways and toxicity of OPFRs may help address the goals of reducing exposure of vulnerable populations to potential toxicant present in their daily lives.

California’s Policies Regulating Use of Flame Retardants in Residential Upholstered Furniture

California being the only state with a residential upholstered furniture flammability standard since 1975, it’s upholstered furniture market has been dictated by these flammability standards developed by Bureau of Electronic & Appliance Repair Home Furnishings & Thermal Insulation (BEARHFTI). (BEARHFTI, 2013)
California’s Technical Bulletin 117(TB-117), passed in 1975, required that all upholstered furniture filling undergo testing to ensure it protects from open flame sources, such as a candle, and smolder sources, such as cigarettes. (BEARHFTI, 2013) The product had to pass this testing to be sold in California.

However, BEARHFTI found that this standard does not adequately address the flammability performance of the upholstery cover fabric and its interactions with the underlying filling materials. (BEARHFTI), 2013) Hence, it may not be an accurate depiction of how fire behavior is in real life. (Blum et al., 2019)

“A severe fault of the TB117 test is that the foam alone is exposed to a small burner flame, rather than the composite piece of furniture. Under such conditions, TB117 foam with 3 to 5 % of FR additive can resist a small open flame. But actual upholstered furniture always consists of a composite of at least two layers, with a fabric cover on top of foam. Furthermore, fabrics are thin membranes of about 1 mm that do not serve as a barrier to the flow of heat from the outside to the foam and it is common for the upholstery fabric itself to ignite from small flame sources such as a candle or a lighter. Once the fabric is burning, the foam is presented with a flame challenge which is many times larger than the cigarette lighter flame which may have originally ignited the fabric”. (Babrauskas et al., 2011)
According to research, smoldering sources, and not open flames, were the leading ignition source of fires. (BEARHFTI, 2013) California’s Technical Bulletin 117-2013 (TB117-2013) updated the flammability standards by allowing BEARHFTI to conduct smolder resistance testing of each component of the products for the purpose of protecting consumers from fires ignited by only smoldering sources, such as cigarettes. This change led to a reduction in the use of flame retardants, as materials were no longer needed to withstand open flame testing.

It was recommended, however not mandated, that alternative methods were used for fabrics that did not pass the smolder test, to make the furniture piece compliant to the flammability standard. These alternative methods, usually through innovation in design, made the furniture flame resistant without the use of additive flame retardants. (Green Science Policy Institute, 2014)

As TB 117-2013 could be met by manufacturers with or without the use of flame retardants, this information needed to be disclosed to consumers so informed decisions could be made with respect to safer buying practices. Senate Bill 1019 (SB 1019), passed in 2014, required a label to indicate whether flame retardant chemicals were added to newly manufactured upholstered furniture. (Leno, n.d.) Manufacturers were required to check “YES” or “NO” on the label, irrespective of what chemical was used in the product as a flame retardant. If all flame retardants added to the product were below 1,000 ppm, the product was considered not to contain flame retardants and the “NO” box was checked.

Assembly Bill 2998 (AB 2998) was passed in 2018 and implemented in 2020, which applied to all furniture subject to compliance of TB 117-2013 and stated that all separate constituent parts of upholstered furniture sold in California, as identified in TB 117-2013,
specifically cover fabrics, barrier materials, resilient filling materials, and decking materials, are subject to requirements of AB 2998. This bill prohibited the sale or distribution of covered products that contain flame retardants in amounts greater than 1,000 ppm. (Bureau of Household Goods and Services, 2019)

It is worth noting that no policy exists in California to regulate the resale of used upholstered furniture in the secondhand market that could potentially contain harmful flame retardants. The resultant long-term exposure to PBDEs and OPFRs, especially in low-income communities, is thus a serious public health concern. (Blum et al., 2019)

Flame Retardants in Residential Upholstered Furniture: PBDEs and OPFRs

After the adoption of TB117 in 1975, PBDEs were used extensively in upholstered furniture to meet California’s flammability standards. To meet this standard, furniture manufacturers started using flame retardants in their furniture sold throughout North America, not just in California, to avoid the cost of maintaining double inventory. Thus, TB117 became a de facto national standard, with flame retardants used to meet it being found in most upholstered furniture containing polyurethane foam sold in the US and Canada. (Babrauskas et al., 2011)

PBDEs have been linked to neurodevelopment disorders and are known to bioaccumulate and are persistent and toxic. (Zengwei et al., 2021) A health cost analysis estimated PBDEs led to $166 billion in disease costs in the US in 2010, largely due to its link to neurodevelopmental toxicity leading to loss of IQ. (Attina et al., 2016) As concerns became apparent for PBDEs,
PBDEs were phased out of use when California banned the use of two primarily used commercial mixtures, PentaBDE and OctaBDE in 2004. (Zengwei et al., 2021) Subsequently, both Penta- and OctaBDE were placed under a strict ban after being included in Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs) in 2009 and 2017 respectively. (Bajard et al., 2019)

After California’s flammability standard, TB117, was revised in 2013, it led to a decrease in the amount of flame retardants used in consumer products. Prior to this change, large quantities of flame retardants were added to upholstered furniture’s foam. (Rodgers et. al, 2021) One study found that the amount of flame retardants used was up to five percent of weight in furniture foam. (Stapleton et al., 2009)

After the phase out of PBDE’s, due to regulatory actions and voluntary phase out by manufacturers, the use of OPFRs increased sharply, replacing PentaBDE as the primary flame retardant used in residential furniture. (Blum et al., 2019). OPFRs are a class of flame retardants that derive from organophosphorus compounds, which contain carbon, hydrogen, and phosphorous compounds. (Huang et al., 2022)

According to one study, the global annual production volume of flame retardants reached six billion pounds by 2019, 16% of which was phosphorous-based flame retardants. (Yang et al., 2019) As of 2020, 367 factories manufacture OPFRs globally, 201 of which are in China. A little over 431,000 metric tons of these flame retardants were produced from the 201 factories in China alone. (Huang et al., 2022) Remaining 166 factories are spread in 23 countries, more than half of which are distributed in the U.S.
Problem Statement

The current knowledge regarding the prevalence and potentially toxicant nature of OPFRs suggests that they might not be a risk-free replacement for PBDE flame retardants and might be a “regrettable substitution”, pointing towards possible carcinogenic, neurological, developmental, and reproductive toxicity. (Doherty et al., 2019) As research continues, there needs to be policy changes to minimize the effects of exposure on the most vulnerable populations.

Literature Review

Methods

A systematic literature review was conducted through PubMed, Scopus and Fusion to find published research for the years 2014-2023. Text words “Organophosphate Flame Retardants”, “OPFRs”, “organophosphate esters”, “neurotoxicity”, “neurodevelopment”, “autism”, “cognitive development”, “behavioral development”, “maternal exposure”, and relevant variants were used in this literature search.

24 epidemiological studies were shortlisted. Animal studies were analyzed, however, were left out of this review to not draw inconsistent conclusions on connections between animal and human studies. Already existing literature reviews were used to make sure all previous relevant studies were included in this review; however, these were not counted in the shortlisted studies.
**OPFRs in the Environment**

Multiple measurements show that concentrations of OPFRs are higher in magnitude, and much more widespread due to their long-range transport, than those of PBDEs ever were at peak use. (Blum et al., 2019) OPFRs are documented to be environmentally persistent and are detected in various environmental media such as indoor dust, air, water, soil, and sediment (Du et al., 2019). Due to their high solubility and persistence in water, OPFRs can undergo long-range transport via waterborne routes, which is a major cause of concern. (Blum et al., 2019) The presence of OPFRs has also been reported in food such as butter, fish, drinking tap water, and bread bags. (Daft, 1982; Williams & LeBel, 1981; Lambardo, 1979)

**Human Exposure to OPFRs**

Humans are exposed to OPFRs through dermal absorption, non-intentional ingestion, and inhalation of dust particles in indoor environments. (Yang et al., 2019) Metabolites of OPFRs are routinely found in human urine, blood, placental tissue, and breast milk across the globe. (Patisaul et al., 2021) Household dust is an important exposure pathway, particularly for children as they have more hand-to-mouth contact.

There is evidence showing that children are disproportionately exposed to OPFRs. This could be due to their indoor environment and their 'proximity to dust and hand-to-mouth activity'. (Gibson et al., 2019) High exposure dose, highly vulnerable immune systems, or aged-related behaviors such as hand-to-mouth activity make children 0-5 years of age susceptible to high risk of OPFR exposure. (Zhang et al., 2018)
In a study, the occurrence of metabolites of OPFRs (mOPFR) in urine, from a mother-child cohort, were analyzed. Levels of OPFRs were also measured in air and dust collected in living rooms of participants residences. The study showed that the concentrations of mOPFRs in urine were significantly higher in children than in their mothers. Furthermore, children’s exposure to these OPFRs correlated with OPFRs in dust and air. (Cequier et al., 2015) In another study, exposure to OPFRs was measured by use of wristbands and mOPFRs in urine, in mothers and their children. Results showed the detection of mOPFRs was higher in children than their mothers, hence providing further evidence that children are susceptible to higher exposure than their mothers. (Gibson et al., 2019)

To assess if human exposure is increasing, one study shows that concentrations of OPFRs has increased dramatically from 2002 to 2015. Urinary concentrations of metabolites of TDCIPP, was 16.5 times higher in 2015 than for those collected in 2002-2003. For children, concentrations of mOPFRs were 3.9 times more in 2015 than those collected in 2010. (Hoffman et al., 2017)

There is also an observed difference in regional trends according to a study that was conducted to examine urinary levels of mOPFRs in mother-child pairs in California, USA collected in 2015. Results were compared to levels measured in mother-child pairs in another study from New Jersey conducted in 2014. (Butt et al., 2014; Butt et al., 2016) Urinary levels of mOPFRs were higher in California children than New Jersey children. (Butt et al., 2016) This, according to the study, could have been attributed to the strict flammability standards in California at that time. As laws have changed in California since this study regarding the use of flame retardants in consumer products, the trends might have changed.
Evidence also suggests greater exposure for BIPOC communities and communities with lower socio-economic conditions. After adjustment for other covariates (i.e., maternal education, child’s age and sex, and average temperature during sample collection), non-Hispanic black or Hispanic race and ethnicity was generally associated with higher concentrations of urinary biomarkers than non-Hispanic white race. (Hoffman et al., 2018) The same study concluded that higher maternal education, (at least 4 years college), tended to be associated with decreases in urinary concentrations of some mOPFRs. (Hoffman et al., 2018)

Furthermore, there is evidence that suggests that if indoor air is not regulated through cooling units, exposure to semi-volatile nature of OPFRs makes them more susceptible to being released in indoor air. (Hoffman et al., 2018) This could be more so the case in lower socio-economic conditions due to inability to maintain efficient and workable cooling units.

**Neurodevelopmental Effects of Exposure to OPFRs in Children**

Neurodevelopmental outcomes are currently the endpoint for children's health that is most well-characterized in relation to OPFRs to date. (Doherty et al., 2019) Multiple studies have investigated the associations between neurodevelopmental outcomes and prenatal and postnatal OPFR exposure. These studies reported associations between higher concentrations of mOPFRs and adverse cognitive development, working memory, intelligence quotient, increased risk of attention-deficit/hyperactivity disorder (ADHD), and behavioral problems in children.
OPFR Exposure and Cognitive Abilities of Children

There is evidence to suggest that prenatal exposure to OPFRs is associated with cognitive delays in children. A study of prenatal OPFR exposure provided evidence that elevated exposure to OPFRs might be inversely associated with childhood development measured at 2 years of age. Childhood development was studied using the Mental Development Index and the Psychomotor Development Index. These scales together evaluate and assess children’s cognition, language and social development, and fine and gross motor development. (Liu et al., 2021) In another study that investigated the relationship between prenatal maternal exposure to OPFRs on cognitive abilities of children at age 7, an association between concentrations of mOPFRs detected in mother’s urine and IQ scores of children. The decreased Full Scale Intelligence Quotient (Full Scale IQ) of children was associated with an increase in prenatal concentrations of mOPFRs. Full Scale IQ was measured using the Wechsler Intelligence Scale for Children which measures verbal comprehension, perceptual reasoning, working memory and processing speed. (Castorina et al., 2017) Yet another study found evidence that prenatal exposure to OPFRs may negatively impact executive function in preschoolers. (Hall et al., 2023) Executive function refers to ‘a group of cognitive processes that measure planning, problem-solving, task completion, goal setting, and thought/behavior regulation’. (Diamond, 2013) Finally, one study found that higher concentrations of mOPFRs in mother’s urine were associated with poorer scores on cognitive assessments, poorer fine motor and language skills. (Doherty, Hoffman, et al., 2019a)

OPFRs and Behavioral Development in Children

Studies have evaluated prenatal exposure to OPFRs in relation to clinically assessed attention-deficit hyperactivity disorder (ADHD) and other measures of behavioral development. ADHD is
one of the most prevalent neurodevelopmental disorders of childhood. Children with ADHD may have trouble paying attention, controlling impulsive behaviors (may act without considering the consequences), or be overly active. *(What Is ADHD?, 2021)*

There is evidence of increased risk of ADHD due to prenatal exposure to OPFRs *(Choi et al., 2021)*. A study found that higher prenatal concentrations of mOPFRs were associated with adverse behavioral symptoms such as attention problems, depressions, hyperactivity, and aggression in the offspring. *(Doherty, Hoffman, et al., 2019)* A different study evaluated how prenatal and postnatal OPFR exposure impacts parent-reported child behavior at 3 and 8 years of age. The study showed that OPFR metabolite concentrations were associated with ‘child internalizing, externalizing and overall negative behaviors at 3 and 8 years. Internalizing problems included anxiety and depression. Externalizing problems included aggression and hyperactivity. In this study, prenatal exposure had a greater association with adverse outcomes compared to childhood exposure. *(Percy et al., 2023)*

There are also studies that have pointed towards an association between childhood exposure to OPFRs and behavioral and cognitive development of school-aged children. In a study on preschool aged children, a cross-sectional association was observed between children’s exposure to flame retardants and teacher rated social behaviors. Children who were measured to have higher levels of exposure to flame retardants were observed to have less responsible behavior, more externalizing behavior problems and were rated by teachers as less assertive. *(Lipscomb et al., 2017)* In a study to investigate the relationship between school indoor air pollutants and cognitive performance in elementary school, analysis showed significant correlations between
suspended OPFR particles in indoor environment and school dust samples and cognitive performance. (Hutter et al., 2013)

**Modification by Socioeconomic status on OPFR exposure and Neurodevelopmental Delay**

In a study to determine how OPFR exposure during early childhood affects neurodevelopmental outcomes, mOPFRs concentrations at ages 1-5 years and cognitive abilities at 8 years were measured. This study showed that socio-economic variables modified associations between OPFR exposure and child IQ with adverse associations being stronger in socioeconomically disadvantaged children than in others. There was a 1-to-2-point decrease in Full Scale IQ for every log-unit increase in concentrations of OPFR in participants of non-white race, who lived in deprived neighborhoods, had lower maternal education and lower income. (Percy et al., 2022)

Social, behavioral, and cognitive skills are important for a child’s ability to succeed in school and in life. (Patisaul et al., 2021) Evidence suggests that pre- and post-natal exposure to OPFRs increases the risk of neurodevelopmental delays in children. There is also evidence that children living in low socio-economic conditions are disproportionately affected.

**Evidence-based Intervention**

Polyurethane furniture foam in upholstered furniture is considered the main source of OPFRs in indoor environments. (Babrauskas et al., 2011) There is evidence that suggests that replacement of upholstered furniture that uses flame retardants with furniture that does not contain flame retardants can have significant impact on indoor home environment.
A study by Rodgers et al. (2021) aimed to investigate and quantify the effects of replacing older upholstered furniture or furniture foam on levels of flame retardants in house dust. Participants were recruited from Northern California who were replacing either the older upholstered furniture or furniture's seating foam in their main living area. Older furniture or furniture foam that contained flame retardants was replaced by products that were flame retardants free. The Green Science Policy Institute (GSPI)'s program Safer Sofa Foam Exchange Program (Green Science Policy, 2019) purchased sofas for those that enrolled and were not volunteering to exchange themselves. This group of participants lived in affordable housing complexes.

Study analyzed the changes in indoor dust concentrations 6, 12 and 18 months after replacement. The study measured concentrations of several flame retardants, including PBDEs and OPFRs, both of which were commonly detected in participant homes prior to replacement.

The key finding of the study was that all measured flame retardants decreased in almost all homes after the older upholstered furniture was replaced, regardless of whether entire pieces of furniture were replaced or just the furniture foam. This demonstrates that replacing older upholstered furniture or foam significantly reduces the concentrations of various flame retardants in indoor environments. The study also highlighted that foam replacement could be an alternative, generating less waste.

In summary, this research provides valuable evidence which suggests that replacing older upholstered furniture or foam with flame retardant-free options can effectively lower concentrations of flame retardants in indoor environments.
“Safe Couch, Safe House” Program (SCSHP)

There is a much higher risk of exposure to flame retardants in BIPOC and low-income communities as financial constraints lead them to buy used furniture in second-hand markets or it is donated to them through local welfare organizations. In California, there is a higher probability that older used furniture was produced prior to the ban on flame retardants in 2020.

This study proposes a pilot program, ‘Safe Couch, Safe House’ Program (SCSHP) designed on the premise that older furniture containing flame retardants is a public health concern, especially for children from the ages 0 to 5, in low-income and BIPOC communities. Furthermore, this investigation suggests replacement of old, flame retardant containing furniture, with upholstered flame retardant-free furniture. This intervention can lead to a reduction in exposure to flame retardants in households.

Community Analysis and Target Population

According to Community Health Needs Assessment 2019, San Francisco has the highest income inequality in California where the wealthiest 5% of households in San Francisco earn 16 times more than the poorest 20% of households. (San Francisco Department of Public Health, 2019) City of San Francisco has an estimated 11.3 percent of its residents living in poverty in 2021, a substantial increase from 9.5 percent in 2019. These numbers are skewed by race as 33.4 % of Black and African American resident’s lives in poverty, compared to Hispanic at 15.4 % and White at 7.1% in 2021. Women experience poverty more than men at 11.8 % compared to
10.9% of men who lived in poverty in 2021. 10.6% of those living in poverty are children under the age of 18. (Poverty in San Francisco | City Performance Scorecards, n.d.)

Fig.1 Source: (San Francisco Planning Department, 2020)
Most of affordable housing occupied by Black/African American community, as well as Hispanic/Latino community is in Bayview-Hunters Point. *(Bayview Hunters Point | San Francisco General Plan, n.d.)* According to CHNA 2019 report, Bayview-Hunters Point (BVHP) is also one of the neighborhoods with the greatest proportion of children *(San Francisco Department of Public Health, 2019)*. Hunters View is also near Hunters Point Naval Shipyard, a Superfund site, making this community highly susceptible to toxic chemical exposure. *(Hunters Point, a Superfund Site in San Francisco Bay, California | U.S. Geological Survey, 2011)* Taking
our target population into account, this program will focus on affordable housing units in Bayview-Hunters Point, Zip Code 94124.

To ensure equity, it is important for SCSHP to target a population that is financially burdened. Affordability and insecurity of housing is a major issue for residents in BVHP. Less than 25% of Black/African American, Latinx, and Native American residents own their homes. According to 2022 Housing element, 80% of very low-income renter households in San Francisco are rent burdened (paying more than 30% of their income on rent). More than half of Black households are rent burdened, and households of color overall are more likely to be rent burdened compared to white households. Black and Latino are the most susceptible to being evicted or having the threat of eviction due to late rent payments. If evicted, this low-income group is most likely to end up homeless. (Housing Element: Goals, Objectives and Policies | San Francisco General Plan, n.d.)

This program will focus on residents in affordable public housing in BVHP which are funded by the Mayor’s Office of Housing, the San Francisco Housing Authority and HOPE SF. Under HOPE SF, four low-income communities are undergoing revitalization and rebuilding. Two communities that are currently being rebuilt by HOPE SF in BVHP are Alice Griffith and Hunters View. SCSHP in its pilot stage will focus on Hunters View, which has 267 public housing units. SCSHP will leverage its partnership with HOPE SF in working towards creating a healthy community for its low-income residents of Hunters View.
Asset Mapping

There are not many resources for low-income households to buy furniture in BVHP. Goodwill Store, Kevin G's Custom Upholstery, Andrew Woodside Carter upholstery are only the few resources available where upholstered furniture could possibly be procured from in ZIP code 94124.

Organizations such as Bay Area Furniture Bank or Make it Home provide furniture and operate in the Bay Area. These organizations redirect donated furniture at low cost to low-income families. These organizations promote stability in the community by providing a safe and livable environment in homes. Furniture banks are environmentally friendly as they redirect furniture that could end up in landfills to homes where they are given a second life. However, it is unclear if the furniture being reused is in accordance with guidelines regarding flame retardants.

Three furniture banks service San Francisco. They operate in San Rafael, CA, Walnut Creek, CA, and Los Altos, CA. (Fig.3) There is no such furniture bank within the City of San Francisco. (Find a Furniture Bank – the Furniture Bank Network, n.d.)
Furniture banks work through referrals from social welfare agencies they partner with. A family in need of furniture would need to work with a case worker from one of these partner agencies, who determine eligibility and budget on a case-to-case basis. If the family is deemed eligible, and there is budget and ability of family to cover the remaining cost, furniture banks take the order and deliver the furniture to the family’s home.

City of San Francisco Waste Management has an exclusive partnership with a waste management company called Recology. (Brigham, 2018) Currently Recology offers curbside pick-up service for bulky items, which includes furniture. However, this furniture, once picked up by Recology is directed to landfills.

One of the programs Recology runs, called the Recology Artist in Residence (Air) Program, supports local artists who create work using discarded materials. (Recology, 2022) This program is promising for SCSHP as discarded furniture could be used as a medium of art if reupholstered through the Air program using local designers who need materials to work with.
**Socio-Ecological Influences and Behavior Change**

It is important to study the socio-ecological influences that would drive consumer behavior in low-income communities and their decision in buying upholstered furniture for their homes.

![Socio Ecological Model](image)

**Fig.4 Socio Ecological Model**

**Individual Level Influences**

Some of the main influences are lack of knowledge about dangers of exposure, lack of awareness of options available for cleaner consumption and high economic costs of buying newer furniture. Research shows that when consumers are made aware of the benefit of buying products that are safe for the environment, as well as their own health, they tend to prefer to buy those products.
However, there still exists a gap between attitude and behavior, which is called the ‘green gap’. (Gleim & Lawson, 2014) A green gap exists because when consumers set out to buy these safer products, they often face tradeoffs such as paying a high price, time spent researching, or having to visit a specialized store. Hence, products that are of genuine environmental concern, make a tangible difference in their lives and require minimal compromise tend to be more convincing to consumers. (Peattie, 1999)

**Interpersonal Influences**

Behavior of individuals when buying safer and cleaner products is also affected by what the social norm is. (Gleim & Lawson, 2014) Families that reside in public housing would consider education and spending on safer furniture buying as frivolous. Unless there is a community-wide drive to educate and change indoor environments through changes in upholstered furniture, SCSHP will likely not be successful.

**Community-Level Influences**

Having access to furniture banks or other donor organizations would allow the community to buy furniture free of flame retardants. However, that is not the case in Hunters View. Furthermore, in the absence of community-wide educational programs about importance of having a flame-retardant free household, there is no drive to move towards cleaner buying.

**Organizational Level**

Healthcare providers can be sources of information for their patients about the dangers of having toxic chemicals-containing products in their homes. However, hospitals and clinics in low-income communities could also be underbudgeted and would lack the resources and time to educate their patients in every aspect needed.
Manufacturers of furniture have also had the least amount of responsibility in terms of making sure their products are free of substances that could cause harm to humans. Their priority has been to pass minimal safety checks; hence products are out on the market years before any real evidence is found of toxicity.

**Policy Level**

The Toxic Substances Control Act (TSCA) has been notoriously slow in protecting the public from potentially toxic chemicals used in consumer goods. The Environmental Protection Agency (EPA) has approximately 85,000 chemicals on the TSCA inventory by 2017 and due to lack of human resources and data, assessments of these chemicals are a daunting task. (Krimsky, 2017) It is also important to note that historically, the burden of proof has been placed on the TSCA, rather than the manufacturers. In the U.S, chemicals are deemed safe for commercial use until proven unsafe. (Krimsky, 2017)

There also has been a lack of public awareness campaigns about the use of flame retardants in upholstered furniture. A public health campaign to create awareness around the use of flame retardants in consumer products would allow consumers to make informed decisions about what they place in their homes.

SCSHP uses these levels of influences to create a program that focuses on raising awareness on risks of exposure to flame retardants in children. SCSHP will work towards rehabilitation of households by placing free of cost (FOC) upholstered couches in 267 public housing units in Hunters View.
Logic Model

SAFE COUCH, SAFE HOUSE PROGRAM

LOGIC MODEL

INPUTS
- Grants from CalEPA, First Five California, CDPH-MCHD, DHHS
- Partnership with Furniture Bank Network, Recology, Green Science Policy Institute, UC Davis
- Community partnerships for raising awareness about dangers of exposure to flame retardants

ACTIVITIES
- Pick up old flame retardant containing furniture from homes.
- Furniture Bank provides new furniture.
- Reupholster and sell old furniture with the help of Recology Air Program
- Educational materials to raise awareness about risks of exposure to flame retardants

OUTPUTS
- Old flame retardants containing furniture will be out of homes replaced by new furniture without flame retardants
- Furniture containing flame retardants will remain out of landfills
- Increased awareness about the dangers of exposure to flame retardants in children and mothers

SHORT TERM OUTCOMES
- Exposure to flame retardants at home will be reduced, i.e., exposure of children to flame retardants will be reduced
- Proper disposal of flame retardant containing furniture will ensure least damage to the environment

LONG TERM OUTCOMES
- Decreased adverse neurodevelopmental delays in children and other adverse health outcomes due to exposure to flame retardants
- Decreased environmental damage due to improper disposal of furniture containing flame retardants

Potential Funding Sources

Local: San Francisco Environmental Department

San Francisco Environment Department (SFED) has provided approximately $23 million in grant funding to local non-profits and invested more than $45 million in local businesses and organizations for environmental services. (Grants and Contracts, 2023) As SCSHP focuses on not only decreasing exposure to potentially toxic flame retardants in indoor environment, but it also focuses in minimizing air pollution through improper waste disposal of flame retardant
containing furniture, SCSHP is an environmentally friendly program. One of the grants SFED is the Environmental Justice Grant which has historically been awarded to programs that serve BVHP communities in improving quality of life and building resilient and sustainable communities.

**State: The California Environmental Protection Agency (Cal-EPA), First Five California, California Department of Public Health, Maternal, Child and Adolescent Health Division (CDPH-MCAH)**

Cal-EPA has funded programs that have a focus on disadvantaged communities and guarding these communities from exposure to a potential toxicant. One such grant by Cal-EPA has been the Environmental Justice Small Grants Program. Through SCSHP’s focus on residents of Hunters View, SCSHP will be able to leverage a partnership with Cal-EPA to bring about tangible change in the lives of children in low-income community of Hunters View.

*(Environmental Justice Small Grants Program | US EPA, 2023)*

SCSHP would also benefit from a partnership with First 5 California to generate awareness among the residents of Hunters View public housing. First 5 California is a state program that advocates for and funds programs which have an emphasis on improving the lives of children prenatal through age 5 and their families (California, n.d.). Through a shared mission of reducing children’s exposure to potentially neurotoxic effects of exposure to flame retardants in children, SCSHP can bring about a positive change in the families living in Hunters View.
California Department of Public Health-Maternal, Child and Adolescent Health Division (CDPH-MCAH), through its Maternal and Child Health Block Grant has provided funding to programs that improve the health and well-being of mothers, infants, children, and youth. As SCSHP is a program aimed to improve health outcomes of children living in low-income housing in Hunters View, a partnership with CDPH-MCAH would be beneficial to both entities. (Department of Public Health, n.d.)

**Federal: Department of Health and Human Services**

Through the Department of Health and Human Services, SCSHP could procure federal grants aimed at eliminating health disparities and improving health outcomes in children. One such funding source is the program called, Healthy Start Initiative: Eliminating Disparities in Perinatal Health which has an estimated total program funding of $113,645,000. The purpose of the Healthy Start Initiative – Eliminating Racial/Ethnic Disparities program is to improve health outcomes before, during, and after pregnancy and to reduce racial/ethnic differences in rates of infant death and adverse perinatal outcomes. As SCSHP aims to reduce health disparities and improve health outcomes by eliminating sources of exposure to potential toxicants in mothers and children, this grant is a potential source of funding for SCSHP.
SCSHP Vision, Mission and Goals

Vision: Children living in San Francisco are given a safe and toxic-free home environment.

Mission: SCSHP aims to promote health equity and child health by providing children and families in low-income communities, particularly those of predominantly BIPOC communities, a safe and toxic-free home environment to ensure that children develop optimally.

Goals:

1. Generate awareness among families living in public housing community in Hunters View about the health risks in children of exposure to flame retardants in upholstered furniture through partnership with First Five California and San Francisco Environmental Department.
   ➢ SMART Objective: Increase awareness by 95%.

2. Support families living in Hunters View to procure free of cost flame retardant-free upholstered sofa by referring them to Furniture Bank Network outlet nearest to their location.
   ➢ SMART objective: Improve indoor environment by reducing concentrations of flame-retardant particles by at least 25%.

3. Ensure proper disposal of old furniture and foam that contains flame retardants through partnership with Recology for free pick up and disposal, San Francisco Waste Department, Recology, and San Francisco Environmental Department to ensure proper disposal.
SMART Objective: Save 100% of all disposed upholstered furniture containing flame retardants from reaching landfills.

Proposed Program Budget: 3-Years SCSHP Pilot Stage

Inventory

267 households at $900 avg per household = $240,300

A Google search was conducted to determine the average cost of an upholstered sofa. The cost of sofas can range from $300-$3000. To provide a good starting point for families to furnish their homes with furniture that complies with flammability standards, a 3-seater sofa could cost from $300-$1500 (Carroll, 2023), which would be an average of $900. Companies that provide cleaner options can be partnered with for the pilot program to provide consumers with cleaner options. These can be the same companies recommended by Green Science Policy Institute (PFAS-Free Products - PFAS Central, n.d.).

Personnel

Liaison Officer (part-time), $50,000 annual pay, Total $150,000

Project Manager (full-time), annual pay $65,000, Total $195,000

Project Manager oversees the program's strategy. Produces and manages health education material. Conduct all evaluations for the program, developing evaluations bi-annually and developing pre-and post-surveys.

The Liaison Officer is responsible for providing culturally competent customer service to families and managing appointments. Coordinates to ensure families are referred to furniture banks.
**Equipment**

Google Voice business phone number: ($20 per month, $720 total): For communicating with organizations and participants.

2 Laptops: ($950 each, $1,900 one-time cost in Year 1 only): Each personnel will have their laptop, best for data analysis, used for collecting data from screening results, surveys/questionnaires, and evaluation. Primarily for program research and data collection/analysis.

**Materials**

Print pamphlets/educational materials (posters, flyers, etc.): ($3,000 for the entire program)

**In-Kind Contributions**

Furniture Bank Network: ($0)

Furniture Bank Network will provide its already existing infrastructure and personnel to cater to the influx of new clients from Hunters View that will be referred to their organization through SCSHP. Furniture Bank will also hold the new flame-retardant free furniture in its warehouse.

Green Science Policy Institute and UC Davis: ($0)

Green Science Policy and UC Davis will aid program managers in carrying out pre- and post-intervention evaluation.
Recology: ($0)

Recology will pick up and reuse discarded furniture for refurbishment in order to stop older furniture from reaching landfills.

Total Estimated Cost of Program: $590,920

**Implementation**

SCSHP is estimated to complete in 3 years in its pilot stage, after funding is secured.

**Development- Year 1- 6 months**

- Onboarding and Training staff (Project Manager, Liaison Officer)
- Solidifying community partnerships with First Five California, Furniture Bank Network, Recology, Green Science Policy Institute and UC Davis.
- Pre-test evaluation survey conducted in Hunters View to gauge knowledge about the dangers of flame retardants in household furniture.
- Development and production of catalog of furniture pieces to allow participants to choose their furniture piece.
- Development of educational materials on dangers of exposure to flame retardants.
- End of the year evaluation of program.

**Registration and Selection-Year 1, 2 and 3**

- Registration of households at Furniture Bank Network and participating household is allowed to choose a 3-seater upholstered furniture from a pre-designed catalog.
- Educational material is provided to all households registered in the program.
• Engage Recology to pick up old furniture in need of disposal.
• Bi-annual evaluations.

Final Evaluations and Planning- 3- 6 months
• Conduct final post-test survey on all participating households.
• Analyze data and outcomes.
• Present Program findings
• Generate evaluation reports.

Program Evaluation

Formative evaluation would better inform and guide the development and implementation of the program as it unfolds and allow for adjustments. Research indicates health risks of exposure to flame retardants in upholstered furniture, especially for children. However, the question remains about how aware are families residing in Hunters View about these risks? Does education through partner organizations increase awareness among the priority population? Does SCSHP provide culturally appropriate services based on the preferences of the priority population? Does First Five California provide the resources needed to educate families about the potential toxicants that are found in their furniture? Are the participants happy with the professionals they interact with during the program? Are they satisfied with the services?

An internal evaluation in the form of a pre/post questionnaire would be conducted under the supervision of Green Science Policy Institute and UC Davis. The program manager will
conduct the survey, analyze responses, and recommend and implement any adjustments required.

Process evaluation is critical to the program's success. The first process objective is recruiting participants from Hunters View. This measurement ensures that the reach matches the priority population and makes benefits of the program equitable. Another aspect with participants is tracking the disposal of previously owned furniture that could be a potential source of flame retardants. The liaison officer will survey households, with guidance from Green Science Policy Institute to check if there is a piece of upholstered furniture that does not comply with most recent laws regarding flame retardants.

Program evaluations, starting from year 1, will examine the effectiveness of health education materials and how many participants were influenced by the posters and flyers distributed. Each household will complete a survey after they go through the program to gauge their knowledge on flame retardants and if they will refer their friends and families to the program or to make the change.

Bi-annual evaluations will be conducted and will focus on examining the effectiveness of the selection, delivery, and pick-up of furniture process. The cost of process evaluation is included in the Project Manager's time, and the time of the Liaison officer for collecting and administering surveys and equipment.

SCSHP will recruit staff in the first two before the start of any implementation and train staff for the next five months. The budget for staff is in adequate range for the cost of the positions, providing fair wages. SCSHP will also provide all the supplies staff need to achieve their duties proficiently.

To deduce the program's effectiveness, three outcome objectives were used:
1. Increase awareness of risks of exposure to organophosphate flame retardants or any flame retardants by at least 95%.

2. Improve indoor environment by reducing concentrations of flame-retardant particles by at least 25%.

3. Save 100% of all disposed upholstered furniture containing flame retardants from reaching landfills.

SCSH Pilot Program aims to conduct a quasi-experimental pretest-posttest design using a comparison group to identify if there is an increase in awareness. Pretest and posttest evaluations of experimental designs would allow SCSHP to measure the changes in knowledge of those families who went through the program. Adjustments would also be made for those households who volunteered to dispose of a furniture piece that was not compliant (contained flame retardants). A comparison group that could be used would be an equal number of households in BVHP affordable housing under HOPE SF. Focus group interviewing would be used to obtain qualitative information regarding changes in perceptions, opinions, and attitudes toward the risk associated with exposure to flame retardants.

Green Science Policy Institute and UC Davis will be engaged to carry out a pre and post test to determine if replacing older furniture with new flame-retardant free furniture decreased the concentration of flame-retardant particles in indoor dust and air.

To ensure no discarded furniture pieces reach landfills, a partnership with Recology Air Program will ensure that not only older furniture pieces are discarded from homes, but are reupholstered using flame retardant-free materials, ready to be sold.
Implications

Short Term Outcomes

Evidence indicates that concentrations of flame retardants in household dust samples clearly declined after six months of furniture replacement (Rodgers et al., 2021). This would lead to an immediate effect on the health risks of children living in these households. Education about dangers of flame retardants and the potential exposure pathways could further lead to a decrease in exposure in indoor environments. Furthermore, reupholstering discarded furniture with flame retardant-free materials can give the furniture a new life, stop it from reaching landfills, and support local artisans.

Long Term Outcomes

SCSHP aims to decrease the risk of adverse health outcomes in children due to exposure to potentially toxic chemicals that are found in households. If successful, this program can be introduced in other communities in BVHP.

Research suggests that waste dumpsites and landfills constitute a potential source of OPFRs seeping into the soil and the air (Ma et al., 2022). Safer disposal of older furniture containing flame retardants is also beneficial to the environment.

SCSHP also aims to provide an equitable solution to health concerns of low-income communities of San Francisco. By focusing on Hunters View public housing, benefits of this program will be reaped by some of the most disadvantaged populations of San Francisco.
Discussion and Conclusion

As evidence on health risks of exposure to OPFRs is accumulating, it is imperative that steps are taken to mitigate exposure in children, especially of low-income communities that could have a disproportionate exposure to flame retardants. SCSHP is an evidence-based intervention based on the premise that replacing furniture containing flame retardants with furniture that is flame retardant-free can have a significant effect on decreasing exposure levels.

Furthermore, SCSHP partnership with Recology Air Program could further lead to taking furniture that contains flame retardants out of circulation. However, as furniture is rid of material containing flame retardants, that material needs to be disposed of safely. Future efforts should be made to prevent this material from reaching waste sites.

SCSHP in its pilot stage will provide furniture free of cost to 267 residences in Hunters View, one of the many public housing communities in San Francisco. For the program to be sustained and expanded to other low-income communities, the program will face financial constraints. SCSHP will need to be funded through local, state, and federal agencies to allow it to maintain its operations.

Residents of Hunters View are already faced with enormous environmental challenges due to its proximity to Hunters Point Shipyard, a Superfund site where the Navy and the EPA have been cleaning up extensive radiological and chemical contamination. (Hunters Point, a Superfund Site in San Francisco Bay, California | U.S. Geological Survey, 2011) A program like SCSHP would be a small but significant step in improving the health outcomes of children and families living in this community.
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### Appendices

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>SCSHP</td>
<td>‘Safe Couch, Safe House’ Program</td>
</tr>
<tr>
<td>BEARHFTI</td>
<td>Bureau of Electronic &amp; Appliance Repair Home Furnishings &amp; Thermal Insulation</td>
</tr>
<tr>
<td>GSPI</td>
<td>Green Science Policy Institute</td>
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<tr>
<td>TB 117</td>
<td>Technical Bulletin 117 requiring open flame and smolder test of foam used in upholstered furniture.</td>
</tr>
<tr>
<td>SB 1019</td>
<td>Senate Bill 1019 requires furniture manufacturers to place labels on products to indicate if the product has flame retardants or not.</td>
</tr>
<tr>
<td>AB 2998(Bloom)</td>
<td>Assembly Bill 2998 banning the use of flame retardants in upholstered furniture.</td>
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<tr>
<td>PBDEs</td>
<td>Polybrominated Diphenyl Ethers</td>
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<tr>
<td>PentaBDE</td>
<td>Commercially used PBDE phased out in 2004 in California</td>
</tr>
<tr>
<td>OctaBDE</td>
<td>Commercially used PBDE phased out in 2004 in California</td>
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<tr>
<td>OPFRs</td>
<td>Organophosphate Flame Retardants</td>
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<tr>
<td>mOPFRs</td>
<td>Metabolites of OPFRs</td>
</tr>
<tr>
<td>TDCIPP</td>
<td>Flame retardant used in residential furniture</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>Cal-EPA</td>
<td>California Environmental Protection Agency</td>
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<tr>
<td>BIPOC</td>
<td>Black, Indigenous, People of Color</td>
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<tr>
<td>ADHD</td>
<td>attention-deficit hyperactivity disorder</td>
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<tr>
<td>TSCA</td>
<td>Toxic Substances Control Act</td>
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<tr>
<td>BVHP</td>
<td>Bayview-Hunters Point</td>
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<tr>
<td>CDPH-MCAH</td>
<td>California Department of Public Health-Maternal, Child, Adolescent Health Division</td>
</tr>
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</table>
## MPH Foundational Competencies

<table>
<thead>
<tr>
<th>Foundational Competency</th>
<th>Description of how used for Capstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence-based Approaches to Public Health</td>
<td></td>
</tr>
<tr>
<td>1. Apply epidemiological methods to the breadth of settings and situations in public health practice</td>
<td></td>
</tr>
<tr>
<td>2. Select quantitative and qualitative data collection methods appropriate for a given public health context</td>
<td>Literature Review was conducted using PubMed, Scopus and Fusion</td>
</tr>
<tr>
<td>3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software as appropriate</td>
<td>Epidemiological studies were included in literature review. Knowledge of biostatistics and epidemiology allowed analyses of the studies.</td>
</tr>
<tr>
<td>4. Interpret results of data analysis for public health research, policy and practice</td>
<td>Literature Review and Policy Analysis</td>
</tr>
<tr>
<td>Public Health &amp; Health Care Systems</td>
<td></td>
</tr>
</tbody>
</table>
5. Compare the organization, structure and function of health care, public health and regulatory systems across national and international settings

Policy analysis was conducted to evaluate policy gaps that exist in California.

6. Discuss the means by which structural bias, social inequities and racism undermine health and create challenges to achieving health equity at organizational, community and societal levels

Socio-Ecological Model was used to analyze influences that shape consumer behavior in low-income communities. Community analysis was also conducted to understand the target population.

<table>
<thead>
<tr>
<th>Planning &amp; Management to Promote Health</th>
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<tbody>
<tr>
<td>7. Assess population needs, assets and capacities that affect communities’ health</td>
</tr>
<tr>
<td>Asset mapping and socio-ecological model was used to assess population assets, needs and capacities.</td>
</tr>
<tr>
<td>8. Apply awareness of cultural values and practices to the design or implementation of public health policies or programs</td>
</tr>
<tr>
<td>9. Design a population-based policy, program, project or intervention</td>
</tr>
<tr>
<td>Designed evidence-based intervention - ‘Safe Couch, Safe House’ Pilot Program</td>
</tr>
<tr>
<td>10. Explain basic principles and tools of budget and resource management</td>
</tr>
<tr>
<td>A 3-year budget was proposed, along with potential funding sources.</td>
</tr>
<tr>
<td>11. Select methods to evaluate public health programs</td>
</tr>
<tr>
<td>Program evaluation included.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Policy in Public Health</th>
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<tbody>
<tr>
<td>12. Discuss multiple dimensions of the policy-making process, including the roles of ethics and evidence</td>
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<td>15.</td>
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<td><strong>Leadership</strong></td>
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<td>16.</td>
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<td>17.</td>
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<tr>
<td><strong>Communication</strong></td>
</tr>
</tbody>
</table>
| 18. | Select communication strategies for different audiences and sectors | | }
| 19. | Communicate audience-appropriate public health content, both in writing and through oral presentation | Outlined, drafted and finalized Capstone paper including a literature review, recommendations and implications on a current public health problem. Created a slide deck based on the Capstone paper and delivered an oral presentation at Health Professions Day in front of an interprofessional audience. |
20. Describe the importance of cultural competence in communicating public health content

The Liaison Officer would be trained in cultural competency to help communicate with participants in the program to build trust and drive behavior change.

Interprofessional Practice*

21. Perform effectively on interprofessional teams

Literature review and preliminary research conducted through UC Davis MIND Institute.

Systems Thinking

22. Apply systems thinking tools to a public health issue

Logic Model

**Health Policy Leadership Concentration Competencies**

<table>
<thead>
<tr>
<th>Competency</th>
<th>Anticipated FW Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Apply economic concepts to understand the effect of changes in policies at the government, health systems, and public health sectors</td>
<td>Understanding of ‘Green Gap’ and how could help drive behavior change when attitudes and actions do not match.</td>
</tr>
<tr>
<td>2. Synthesize economic concepts to assess equity and efficiency in making health policy recommendations in underserved communities</td>
<td>Consumer Behavior Influences using Socio-Economic Model. Rent burden in low-income communities</td>
</tr>
<tr>
<td>3. Formulate efficient health policy change recommendations through the analysis of proposed health policy initiatives that could affect health outcomes of vulnerable populations</td>
<td>Proposed program that would affect health outcomes in low-income communities in City of San Francisco</td>
</tr>
<tr>
<td>4. Develop recommendations to improve organizational strategies and capacity to implement health policy</td>
<td></td>
</tr>
<tr>
<td>5. Analyze policy options to address environmental health needs at the local, state, and federal levels</td>
<td>Discussion on how environmental health should be taken into consideration. Partnership with San Francisco Waste Management Department and Recology air program</td>
</tr>
</tbody>
</table>