Particulate Policy

An argument for a regulatory approach to transportation-related ultrafine particle exposure

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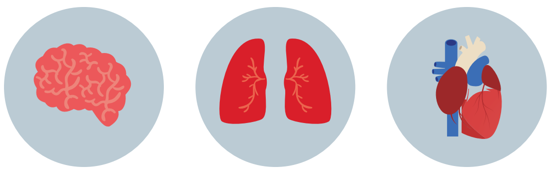
Executive Summary
Particulate Policy

Particulate matter (PM) pollution is the most serious environmental health risk in the world, causing more deaths than poor diet or lack of exercise.



Exposure to fine particles (PM2.5) has been linked to disease and early death through extensive research. Ultrafine particle pollution (UFP), which is smaller than PM2.5, is also a serious health concern. Due to their small size, UFP can easily get into people's lungs, blood and brain where they have been linked to increased risks for disease and early death.

In Massachusetts, particle pollution arises mostly from combustion-powered transport, such as cars and trucks. While PM2.5 spreads widely, UFPs usually concentrate close to sources. This means that residents living within 500 feet of busy roads breathe more polluted air and face increased health risks.

In Massachusetts, near-roadway PM pollution is an environmental justice concern. Due to racially inequitable transportation and housing policy, more residents of color live close to high-polluting roads and breathe polluted air, indoors and outdoors.

RECOMMENDATIONS

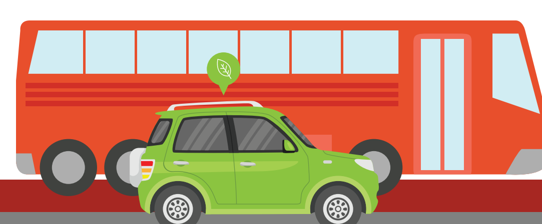
Unlike PM2.5, UFP are not federally regulated. Local, regional, and state policy can and should develop in the absence of national policy to protect Massachusetts residents. Solutions to protect people from near-road pollution include:

- Establish high-efficiency air filtration and ventilation standards for new buildings.
- Use portable air filters in existing buildings.
- Locate housing, schools, and parks away from highways or busy streets.
- Build noise barriers.

It is critical to also address air pollution's root cause: Our reliance on fossil fuel powered, single-occupant vehicle trips. Policymakers can encourage a mode shift to cleaner transportation by improving our public transit, pedestrian, and bicycle infrastructure, and encouraging use of electric vehicles.

Necessary enabling actions in Massachusetts include:

- Modify the State Building Code to require high efficiency filtration in new and renovated buildings.
- Push for the International Building Code and Energy Conservation Code to require high efficiency filtration in new and renovated buildings.
- Revise the MassDOT eligibility standards for noise barriers.
- Expand low-income home energy assistance programs to subsidize utility costs for running portable air filters or air conditioning.



Introduction

In the context of the current COVID-19 pandemic, the role of air pollution as a risk factor associated with COVID-19 deaths has been given a lot of attention. Even before our current crisis, it had been demonstrated that air pollution, both outdoor and indoor, posed a major threat to health.

This white paper will focus on particle matter, a subset of air pollutants, but one of special concern due to their small size and ability to penetrate tissues and organs.

In the Metro Boston region, as in Massachusetts and the US, road vehicles are a major source of particle pollution. Consequently, residents living adjacent to high volume roadways are exposed to significantly increased levels of this type of pollution. States and local governments have an important role to play in advancing building design, land use practices, and transportation policies that reduce exposure to pollution.

This summary report provides a background on particle matter air pollution and associated health outcomes and share examples of state and local policies and programs to reduce exposure to particle air pollutants.

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Types and sources, especially traffic, of PM air pollution

KEY TAKEAWAYS

- Particle pollution is the most serious environmental health hazard in the world and, in the Boston Area, most of this pollution comes from combustion of fuels used in transportation.
- Research on the death and illness caused by breathing fine particle pollution ($PM_{2.5}$) is extensive and underlies the justification for federal regulation of $PM_{2.5}$ in the United States, but there is evidence suggesting that exposure to ultra-fine fine particle pollution (UFP) is another serious health concern.
- UFP are so small they easily get into people's lungs, blood and brain where they have been linked to increased risks for respiratory disease, heart disease, and neurological health conditions.
- While $PM_{2.5}$ spreads out over multiple neighborhoods or towns, UFP are usually much more concentrated in the immediate vicinity of sources, including, most notably, roadway corridors. Consequently, residents living adjacent to high volume roadways are exposed to significantly increased levels of UFP pollution.

According to all recent estimates, air pollution composed of particulate matter (PM), tiny bits of solid or liquid suspended in air, is by far the most serious environmental health hazard in the world (Murray et al. 2020). In fact, this pollution is one of the leading causes of death and illness overall, on a par with behavioral risk factors such as poor diet and low physical activity. In high-income countries, including the US, and therefore in Massachusetts and in the Boston Metropolitan Area, PM pollution arises mostly from combustion-powered transport, including cars, trucks, buses, diesel trains and airplanes (Fuller 2021).

Not all PM is the same: Components and size classes of PM

Particles from different sources and aged in the atmosphere for varying lengths of time under diverse conditions have distinct characteristics. The two ways by which PM is usually classified are size and chemical composition. Although all PM is extremely small, particles occur along a continuum of sizes. The relatively "large" PM is 10 microns (one millionth of a meter) in diameter or less. The Environmental Protection Agency (EPA) regulates this particular matter (PM_{10}) the US. The next smaller size class is $PM_{2.5}$, which is less than 2.5 microns in diameter or less. $PM_{2.5}$, or "fine PM", is also regulated by the EPA and is broadly considered to be a proven toxin and health hazard (Hersey 2021).

In neighborhoods next to highways and in close proximity to other vehicular sources of PM, an additional unregulated size class of PM is of concern. These are the ultrafine particles (UFP), the tiniest of all particles being 0.1 microns in diameter or less (see Figure 1). They are a concern that has emerged in recent years due to gowing evidence of high exposures to some populations as well as evidence of associations with adverse health effects. UFP are the focus of study in the Boston Area by the Community Assessment of Freeway Exposure and Health (CAFEH) series of studies, described more below (Fuller et al. 2013).

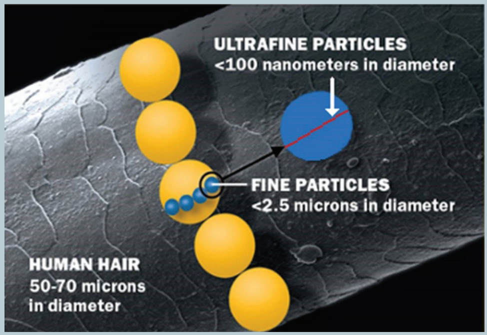

Figure 1. Illustration comparing the size of Ultrafine Particles (UFP) and Fine Particles ($PM_{2.5}$) to the width of a human hair.

Image Credit:
Based on and modified from US EPA.

Figure 2. Living next to a highway, the State Streets neighborhood in Somerville, MA

Image Credit: Wig Zamore

In addition to size, PM varies in its composition. Most of the $PM_{2.5}$ and UFP in the urban environment comes from combustion of fuels used in transportation. However, they are also created by burning home heating oil, cooking at home (indoors) or in restaurants (exhausted outdoors), tobacco smoke, and other combustion activities. Because these particles are produced by burning, they are composed of carbon, metals and organic molecules, all of which are known to be toxic on their own (Scott 2021).

In contrast, PM_{10} is mostly what we commonly think of as dust. PM10 comes from friction surfaces such as motor vehicle brakes and tires as well as bits of gravel, asphalt and even road paint, crushed by traveling vehicles (i.e. "road dust").

Evidence of PM2.5 health impacts

Research about $PM_{2.5}$ is extensive. There is a large and convincing body of scientific evidence about its health consequences, and it is this body of evidence that underlies the justification for federal regulation of $PM_{2.5}$ in the United States.

Fine air pollution is causally associated with cardiovascular and respiratory diseases such as heart attacks, strokes, lung cancer and asthma. New research increasingly finds that $PM_{2.5}$ also has neurological effects, although at least some of that health impact might be due to UFP. In fact, the evidence base for health effects of $PM_{2.5}$ continually strengthens and, as it does, risk has been documented at concentrations – and particulate matter sizes - in the air even below existing regulatory limits (EPA 2019).

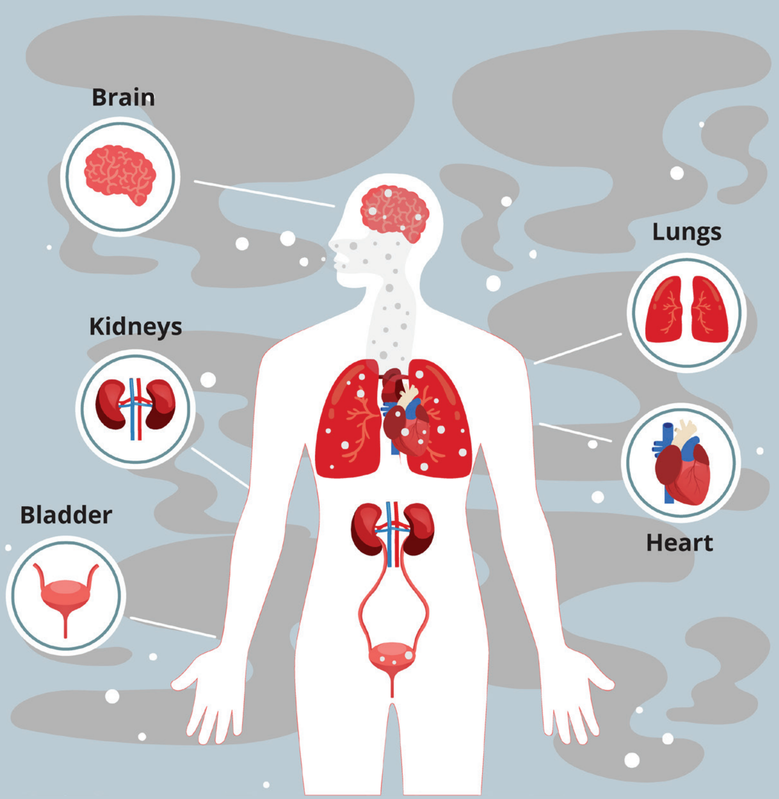

Figure 3. Illustration showing the organs impacted by particle pollution

Image Credit: Kit Un

Areas of exposure to traffic-related UFP

While $PM_{2.5}$ spreads out over multiple neighborhoods or towns, UFP often have large concentration gradients in the immediate vicinity (300-500 feet, or one-tenth of a mile) of sources, including, most notably, roadway corridors (Patton et al. 2014).[1] In the immediate vicinity of highways and major roadways, UFP concentrations are often elevated above levels further away (> half mile, for example).

Numerous factors influence the concentration gradients of UFP (e.g., wind, local topography). Of course, traffic volume is important because without high levels of vehicular travel there would not be a strong source. However, surprisingly perhaps, in proximity to a major traffic pollution source, meteorology plays a dominant role. Wind direction and speed along with temperature are critical. A light breeze from the direction of the highway in colder weather will produce very high concentrations of UFP in the downwind neighborhoods. Whereas the opposite, strong wind away from the highway together with warm air will produce the lowest concentrations (Simon et al. 2018). One exception to these patterns is that in the summer under the right atmospheric conditions there can be regional "blooms" of UFP that are spread more broadly like $PM_{2.5}$.

UFP exposure variables

Because UFP concentrations can fluctuate rapidly in space and time, assigning exposure accurately is more difficult, especially as compared to $PM_{2.5}$, which, as has been noted, spreads out over large geographical areas. Making the task even harder is that people move in and out of fields of high and low exposure as they go about their lives. A person might drive on a highway for a short time receiving a high exposure. After which they could arrive at work or school and spend most of their day in a building that has mechanical air handling system with filtration that results in very low levels of UFP (Lane et al. 2015). An additional factor is respiratory rate, which is how deeply and often people breathe. A person might breathe lightly while sitting and much more deeply while running. More respiration means more inhaled particles (Corlin et al. 2019).[2]

AIR POLLUTION AND ENVIRONMENTAL JUSTICE

In Massachusetts, there are clear disparities by which residents of color tend to live in closer proximity to major vehicular traffic corridors (Gately and Reardon 2020). The recruitment of CAFEH participants intentionally focused on neighborhoods that are environmental justice communities. Thus, findings of adverse health effects and the intervention techniques tested are directly relevant to the struggle to create a healthy environment for all of the Commonwealth's residents, especially those who have been denied the opportunity to live, work, and play in an environment free from pollution due to their race, income, or citizenship.

1 UFP along roadway corridors in the Boston area have been well-documented by the CAFEH studies. See https://www.cafehresearch.org/

2 The CAFEH studies of individual exposure and health effects of UFP, the outcomes of which we will describe below, went to extensive lengths to take changing concentrations of UFP in space and time into account. This research also assessed how UFP gradients interfaced with time activity patterns of study participants in order to assign exposures that were more accurate. The study participants were recruited for CAFEH from Boston, Somerville, and Chelsea making the findings highly relevant to policy and practice considerations in Eastern Massachusetts.

Evidence of health effects of UFP

Recent reviews of the health effects of UFP have shown that there is growing evidence that UFP are associated with the onset of disease and disabilities. The case for health risk of UFP from motor vehicles begins with **conclusive evidence that living near highways and busy major roads (i.e., roads carrying 25,000 vehicles or more per day) is associated with numerous illnesses and health risks.** Similar to the effects of PM in general, traffic proximity is associated with cardiovascular, respiratory and neurological health outcomes (see Table 1). These findings were the starting place for the CAFEH studies in and around Boston.[3]

Table 1. Estimated New Cases for Somerville Residents Living within 400 meters of I-93 over 5 Years

Condition	Number (range) of New Cases
Coronary Heart Disease[4]	22 (0 to 52)
Death from Coronary Heart Disease[5]	44 (17 to 78)
Ischemic Stroke[6]	32 (1 to 78)
Post-Stroke Mortality[7]	5 (0 to 11)
Type 2 Diabetes[8]	100 (7 to 256)
Lung Cancer[9]	16 (2 to 36)
Childhood Asthma[10]	52 (3 to 138)
Childhood Autism[11]	4 (0 to 11)

See technical details for table sources and methods.

A book published in 2021, Ambient Combustion Ultrafine Particles and Health summarized the evidence for health effects of ambient combustion-related UFP. The book, a first to bring together chapters by experts across the disciplines relevant to UFP, covered a huge body of literature and summarized it in an academic framework. Despite lack of seminal national level studies of the sort that EPA prefers, the book showed that there are hundreds of studies that, when combined, provide considerable evidence for health risk from UFP exposure (Brugge and Fuller 2021).

Perhaps the most convincing evidence for UFP health effects is for cardiovascular outcomes; a finding that is not surprising since $PM_{2.5}$ has been shown to cause heart-related diseases. In addition, because they are easier to conduct, there are more studies of associations between UFP and cardiovascular health for short term than for long-term exposures. Studies of biomarkers (e.g., C-reactive protein, which is released in response to injury or infection) rather than heart attacks or deaths are simpler to investigate, so also relatively common (Flora Berklein et al. 2021).

3 While proximity is clearly a risk factor, these associations do not, by themselves, indicate what specific aspect of traffic is responsible. Without further research UFP and other pollutants, noise or risks associated with lower income are all viable hypotheses.

4 (Kan et al. 2008)

5 (Gan et al. 2010)

6 (Kulick et al. 2018)

7 (Wilker et al. 2013)

8 (Zhao et al. 2017)

9 (Nyberg et al. 2000)

10 (Gauderman et al. 2005)

11 (Volk et al. 2011)

Evidence also exists for respiratory effects of UFP. Like the evidence for cardiovascular health, more of the studies are short term and of biomarkers rather than outcomes that require emergency or ongoing medical treatment. Overall, there are fewer studies of respiratory than of cardiovascular health. Asthma appears to have the most evidence for risk from UFP, but there is a need for more and better research (Turner and Ryan 2021).

As mentioned above for $PM_{2.5}$, evidence has emerged quite recently for neurological effects of UFP, generating a compelling concern. PM in general is associated with delays in cognitive development in children and accelerated cognitive decline in older adults. UFP are expected to contribute to these effects because studies that have shown that they can cross biological barriers (e.g., cell membranes) and travel to places in the body that might not have been expected. It is now clear that UFP can reach the brain directly through the olfactory nerve at the back of the nose. PM is also found inside cells and inside organelles within cells (Lilian Calderón-Garcidueñas et al. 2021).

POTENTIAL FOR REGULATION OF UFP

The EPA Integrated Science Assessment evaluates a large body of scientific literature to form the scientific foundation for a review of National Ambient Air Quality Standards (NAAQS), the EPA standards that protect public health from damage due to exposure to air pollutants. The recently completed review (2019) focused on $PM_{2.5}$, given the strength of evidence for its health effects, but also addressed UFP and PM_{10}. The review concluded that there was evidence for respiratory, cardiovascular and neurological health effects of UFP, but that the evidence not yet strong enough to regulate UFP at the federal level (EPA 2019).

The EPA based their determination for UFP on what the agency considers solid evidence in animal studies for toxicity of UFP, but weaker epidemiological evidence in humans as well as air pollution monitoring that was too sparse to assess exposure across the entire US. It is likely that regulation of UFP will require large-scale studies of hard health outcomes, including mortality, combined with high quality exposure assessment. Regardless of the national level policy picture, local, regional and state policy can develop in advance of national policy in places hosting UFP research such as Southern California and Eastern Massachusetts.

Options for reducing exposure to UFP

KEY TAKEAWAYS

- Indoor air filtration has emerged as a leading option for reducing exposure to UFP in homes, schools and other occupied buildings that are in close proximity to highways and major roadways.
- For buildings without forced air systems, portable air filtration units, perhaps in combination with window upgrades that reduce infiltration, are likely the most feasible approach.
- Noise barriers and setting standards for the siting of buildings and parks back from transportation corridors is another potentially helpful approach to reducing exposure to elevated gradients of UFP.
- Necessary actions in Massachusetts to implement these interventions include a statewide revision to the building code to require MERV-16 HVAC and/or building siting requirements, and a revision of the MassDOT process for designating Noise Barrier eligibility.
- It is critical to also address air pollution's root cause: a fossil fuel powered, single-occupant vehicle fleet. Policymakers can take steps towards broad systemic changes by encouraging mode shift to cleaner means of transportation, improving our public transit, pedestrian, and bicycle infrastructure, and shifting to electrification.

Filtration standards for building

Indoor air filtration has emerged as a leading option for reducing exposure to UFP in homes, schools and other occupied buildings that are in close proximity to highways and major roadways. The two types of buildings that must be considered are those with mechanical air handling systems and those without. Buildings with air handling systems actively move air into and out of rooms, usually by fans pulling air through ductwork. If the air handling system is of quality design and in good condition, it is possible to reduce indoor UFP concentrations by installing new or enhanced filtration in the path of airflow.

Designing or retrofitting air handling systems to substantially reduce infiltration of traffic-related UFP near highways is feasible. However, there may be some practical issues to resolve. Standard building practices usually use filters that do not sufficiently remove fine and ultrafine particles so they require adjustments to include filters of sufficient quality (MERV 13 or 16). Inclusion of quality filters is easier in new construction than with retrofits. When designing these systems (new or retrofit), it is also important to consider location of outside air intakes so that they are farthest from or shielded from traffic-generated pollution.

Mandating stricter building code or standards, such as would be required to ensure quality filtration, is not possible at the municipal level in Massachusetts, although it can be incentivized[12]. One approach would be to push for changes of the International Building Code, which forms the basis of the Massachusetts' building code and many other jurisdictions across the country[13]. Policymakers can also

12 Hull, MA - a town subject to frequent inundation from storms – has incentivized the adoption of enhanced flood-protection building techniques by providing credits towards permitting costs for those who elect to incorporate 2 feet of freeboard into the construction. Learn more: https://www.fema.gov/case-study/high-marks-building-higher-hulls-freeboard-incentive-program

13 An example of this is MAPC's work with the Energy Efficient Codes Coalition (EECC) and other partners to prepare communities to advocate and vote for a more energy efficient code. Learn more: https://www.mapc.org/planning101/getting-to-net-zero-how-your-municipality-can-help-improve-the-building-code/

mandate health protective levels of filtration through modification of the state building code to establish higher filter efficiency requirements for new construction and major renovations. Finally, the state or a municipality could require quality filtration for certain businesses, like childcare facilities, as a condition of licensure.

Nationally, jurisdictions have adopted codes which required quality filtration throughout a state or only in areas most affected by high levels of outdoor PM. California, another state with leading edge air pollution and health research, ultimately rejected a location-specific approach for filtration. Instead, the state adopted filtration requirements through the energy portion of their building code. Effective January 1, 2020, the 2019 California Energy Code requires filters with a MERV 13 or greater particle removal efficiency (when tested per ASHRAE 52.2) in all low-rise and high-rise residential and commercial construction subject to the code (California 2018).

Several Massachusetts jurisdictions have adopted green-building policies that, unfortunately, do not adequately address infiltration of polluted air from outdoors as currently written but could present an opportunity to improve indoor air quality. Many of the common green-building standards offer credits or recommend air filters rated MERV 13 or higher, but do not require projects to include higher efficiency filtration. Policymakers could strengthen current policies by requiring that developments under their green-building policy meet optional high-efficiency filtration recommendations (ELI 2020).

Filtration for existing building without mechanical air systems

For buildings without forced air systems, portable air filtration units, perhaps in combination with window upgrades that reduce infiltration, are likely the most feasible approach. The portable units can reduce PM, including UFP, in the room in which they are situated provided the unit is rated for the room volume (i.e., volume of the room in cubic feet). The ability of portable air filtration units to prevent health effects of UFP is not yet proven. The main threats to their usefulness are that they may be turned off, windows can be opened (which compromises air cleaning) and people may not spend enough time in the room with the filter. A CAFEH –supported clinical trial is currently testing these issues.

Portable air filters also come with costs to the resident who have to purchase and operate them. Costs include the unit itself ($200 and up), electricity and replacement filters. For residents who work in lower wage occupations or have limited forms of income, who also typically make up a disproportionate number of households living near highways, the financial costs would need to be addressed. Policymakers could expand existing low-income home energy assistance programs to subsidize utility costs for running portable air filters or air conditioning.

Land use practices to mitigate traffic related air pollution exposure

Noise barriers adorn sections of highway in many places in Massachusetts. The process for choosing locations and building these barriers is based on an outdated list of sites designated decades ago. Moreover, the Massachusetts Department of Transportation (MassDOT) considers the installation of noise barriers only to provide mitigation of highway traffic noise. MassDOT considers installation of noise barriers for highways that meet one of the following standards:

1. New highway construction or substantial alteration in situations where noise exceeds a threshold standard (Type I Projects)
2. Existing Interstate highways where noise exceeds a threshold standard (Type II Projects)

MassDOT's Noise Abatement Program for both Type I and II projects uses Federal Highway funds for the mitigation of highway traffic noise. The Federal Highway Administration (FHWA) is the federal agency responsible for administering the program. Therefore, compliance with FHWA regulations is a prerequisite for the granting of federal funds for construction or reconstruction projects. MassDOT limits its Type II Noise Abatement Program to locations that are on its Type II Noise Barrier Priority List. This list originates from a 1988 statewide noise study which designated areas most adversely affected by highway traffic noise. The current Type II Noise Barrier Priority List includes 53 locations and 17 additional locations from the former Massachusetts Turnpike Authority. Mass DOT does not recognize air pollution as a valid basis for sound walls.

Noise barriers are a fitting option in locations such as the States Ave. neighborhood in Somerville, a study area of the CAFEH studies (See Appendix A), where the orientation of the highway relative to prevailing wind and local street geography are appropriate to reduce both noise and air pollution for adjacent residents.

Setting standards for the siting and design of buildings and parks along transportation corridors through neighborhood plans, zoning code or site plan and subdivision review is another potentially helpful approach to reducing exposure to elevated gradients of UFP. For example, zoning could locate occupied buildings as far as possible from the edge of the highway, restrict balconies over busy roads or encourage site plans that offer protection by placing parking structures next to the highway to shield the residential building. Parks near busy roads could include a barrier (such as climbing walls or thick vegetations) alongside the road to protect users (Maria Pilar Botana, Martinez, & Ginzburg, 2021).

Transportation policy

Policymakers and transportation planners should also take into consideration the impact of air pollution in the immediate vicinity of new or revised roadways and take action to protect current and future residents. Implementing traffic management solutions, such as reducing local truck traffic, can make a difference locally.

However, it is critical to address air pollution's root cause: a fossil fuel powered, single-occupant vehicle fleet. Policymakers can take steps towards broad systemic changes by encouraging mode shift to cleaner means of transportation, improving our public transit, pedestrian, and bicycle infrastructure, and shifting to electrification. They could also participate in regional policy initiatives such as the Transportation Climate Initiative, a 12-state collaboration aimed at reducing transportation-related emissions (Gately and Reardon 2020).

Conclusions

Air pollution is a leading cause of illness and death worldwide. There is national regulation of regional air pollution that requires measures be taken to reduce exposure. However, there is no regulation for locally elevated air pollution, including UFP. This is despite growing evidence of health risks, including a robust body of local research conducted within the CAFEH studies. In the absence of federal regulation and in the face of transportation impacts that cannot be reduced substantially by local or state initiatives, there is a need for alternative mitigation strategies. Fortunately, a number of options exist, including filtration in HVAC systems, portable air filtration units, noise barriers along highways, and building and urban planning approaches. There is a need to consider these strategies in the Boston Area and Massachusetts more generally.

Appendix A
Traffic UFP studies in Eastern Massachusetts

KEY TAKEAWAYS

- CAFEH has documented elevated UFP levels in near-roadway neighborhoods of Boston.
- People with who spent more time in the near-highway neighborhoods with high UFP concentrations had higher levels of bio-markers of inflammation, which is associated with cardiovascular risk.
- High-efficiency filtration and noise barriers reduce exposure to and risk from UFP, research on the efficacy of portable air filtration is ongoing.
- CAFEH's air pollution research on roadway corridors in the greater-Boston is highly relevant to policy and practice considerations for Eastern Massachusetts.

As mentioned above, the CAFEH series of research studies was conducted in and near Boston, MA. The National Institute of Health (NIH), the Department of Housing and Urban Development (HUD) and the EPA funded the CAFEH research through competitive grants that met the highest standards of scientific rigor. Multiple universities, in collaboration with local community-based organizations and municipal agencies, were prompted by community requests for research on the health effects of their highways. The approach was community-based participatory research (CBPR); a partnership approach to research that strives to involve community members and organizational representatives as peers on the academic team. CBPR has the goal to inform and influence local and regional policy and practice.

The CAFEH studies have several features that make them particularly amenable to translation into local action. First, the studies focus on the neighborhood and involve impacted residents unlike most other air pollution research. Second, the studies developed an approach that estimated UFP exposure for individuals in locations where they spent time for every hour for a year. Third, the health outcomes were biomarkers of cardiovascular risk, the most significant health impact of air pollution. Finally, this line of research evolved to develop and test approaches that could reduce exposure and the associated risk.

UFP health risks in near-highway neighborhoods

The first study in the CAFEH series assigned individualized UFP exposure to 408 residents living in Somerville, the Boston neighborhoods of Chinatown and Dorchester as well as Malden. In a paper published in 2016 (Lane et al. 2016), the study reported that UFP exposure was associated with a blood inflammatory biomarker (C-reactive protein) that indicates risk of cardiovascular disease. (see Figure 4). This study was one of the first epidemiology studies, all of which came out within a year of each other, showing associations of long-term exposure to UFP with health risk.

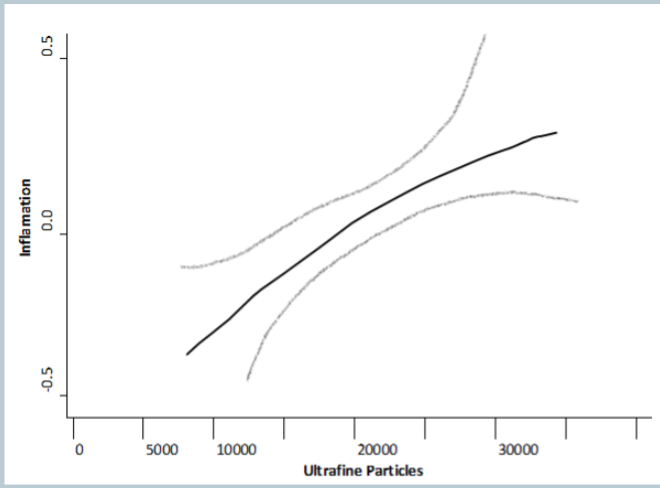

Figure 4. This graph shows that higher annual exposure to UFP is associated with higher levels of inflammation in blood samples, including many from Somerville and Boston Chinatown (Redrawn from Lane et al., 2016).

Secondary analysis of the first CAFEH study showed further associations with blood pressure, hypertension and heart disease (Li et al. 2017, Corlin, Ball, et al. 2018). An additional analysis of a subset of the stored blood samples found associations with biological pathways that were consistent with inflammation and cardiovascular effects.

The second large study from CAFEH built another set of UFP air pollution models and assigned exposure to participants to participants in the Boston Puerto Rican Health Study who lived in Boston and Chelsea. This work also found associations with biomarkers of cardiovascular risk, although not as robust as the original study (Corlin, Woodin, et al. 2018). This is probably because time activity data was not available and thus the exposure assessment was likely less precise.

Methods to reduce exposure

From these studies, CAFEH took up research on methods to reduce exposure through use of indoor portable air filtration in homes. CAFEH research teams undertook two pilot studies of filtration in homes in Boston, Somerville and Chelsea. These studies showed that filtration could reduce indoor levels of UFP, including in homes near highways. However, these relatively small studies were unable to show a health benefit (Brugge et al. 2017).

Recently CAFEH research was published in a major medical journal on 77 participants who spent 2 hours on three different occasions in community rooms next to the highways in Somerville and Boston Chinatown. The study used air filters to create exposure levels that were low, medium and high. The researchers measured blood pressure measured every 10 minutes and found that it was lowest with low levels of UFP and highest when UFP levels were highest (see Figure 5; (Hudda et al. 2021)). This research shows that under highly controlled conditions reducing UFP concentrations can be beneficial for blood pressure.

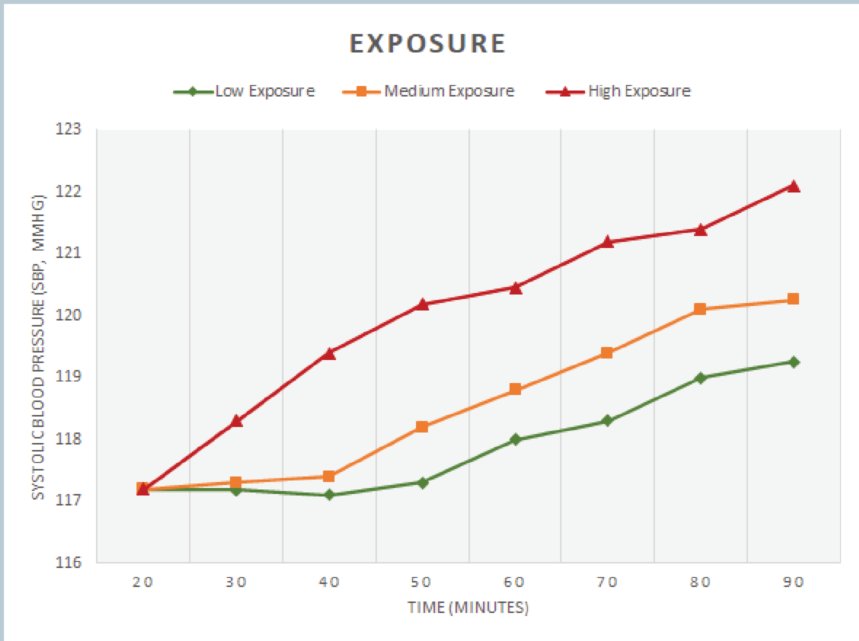

Figure 5. This graph shows that under highly controlled conditions in rooms near the highways in Somerville and Boston Chinatown, higher levels of UFP exposure results in higher blood pressure (redrawn from Hudda et al., 2021).

However, tightly controlled studies of this sort cannot confirm whether filters are effective in homes under regular living conditions. Many factors, including resident behaviors, might render filtration ineffective. To address this problem, CAFEH research teams are currently conducting a larger clinical trial of in-home air filtration in Somerville. The results will not be reported for several years. Once available, they should be a convincing test of the feasibility and efficacy of portable air cleaners in homes near the highway to reduce cardiovascular risk from traffic UFP.

Research to action

CAFEH has also explored urban planning and building design as ways to reduce exposure to and risk from UFP. In Somerville, CAFEH, with leadership from the Metropolitan Area Planning Council (MAPC) conducted a yearlong “health lens analysis” that considered options and designs for noise barriers along the highway (Figure 6; (Martinez et al. 2020, Ron et al. 2021)). The outcome was a report that indicated feasibility and acceptability along the States Ave. neighborhood. Unfortunately, the Mystic Apartments area in Somerville is not well suited for noise barriers due to the configuration of the highways and side streets. Regrettably, there are also impediments to implementation of noise barriers due to state rules for selecting locations for sound barrier construction.

Figure 6. Conceptual ideas for reducing noise and air pollution exposures along I-93 in Somerville (from Ron et al., 2021)

In Boston Chinatown, CAFEH conducted another health lens analysis, again with MAPC guidance, that led to incorporation of air pollution concerns in the 2020 masterplan for the community. In both Somerville and Boston Chinatown, CAFEH researchers and community partners have provided technical assistance to developers of several near highway buildings resulting in decisions to incorporate high-grade filtration as a protective measure.

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