Particulate Matter Air Quality in the San Gabriel Valley Evaluating PM2.5 Hotspots and Indoor Air Filters using PurpleAir Sensors

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Abstract

Air pollution, particularly fine particulate matter (PM2.5), poses significant health risks, especially in disadvantaged communities with limited air quality monitoring. This study evaluates PM2.5 concentrations in the San Gabriel Valley cities of Alhambra and Monterey Park through two community-engaged research efforts: (1) monitoring PM2.5 levels at identified pollution hotspots and (2) assessing the effectiveness of indoor air filtration methods.

Using PurpleAir sensors, Study 1 measured PM2.5 levels at four community-identified hotspots over one year. Results indicated that average daily PM2.5 levels at these hotspots frequently exceeded EPA air quality standards, particularly in cool months, highlighting potential underestimation of localized pollution by regional monitoring stations. Peak PM2.5 levels occurred during morning and evening commute hours, raising concerns about exposure risks for children and other vulnerable populations.

Study 2 examined the impact of indoor air filtration in households within SB535-designated areas. The findings revealed that homes equipped with air filters—both commercial HEPA purifiers and DIY box fan filters—experienced significantly lower indoor PM2.5 levels compared to homes without filters. DIY air filters performed comparably to commercial units, providing an affordable and effective solution for reducing indoor air pollution.

These findings emphasize the need for expanded community-driven air quality monitoring and policy interventions to address environmental health disparities. Future efforts will focus on increasing air sensor coverage, educating residents on air filtration strategies, and advocating for targeted pollution mitigation measures.

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Participating Organizations

Special Service for Groups, Inc. (SSG)

Special Service for Groups, Inc. (SSG) is a nonprofit organization dedicated to providing community-based solutions to the social and economic challenges facing those most in need. SSG fosters self-sufficiency by developing and managing programs that serve diverse populations while bridging cultural and geographic divides. For more information, visit www.ssg.org.

Asian Pacific Islander Forward Movement (APIFM)

Asian Pacific Islander Forward Movement (APIFM), a division of SSG, is committed to cultivating healthy, long-lasting, and vibrant Asian and Pacific Islander communities through community-centered engagement, education, and advocacy in environmental justice and health equity. Since 2013, APIFM has led air quality advocacy efforts in the San Gabriel Valley, equipping residents with tools and knowledge to protect their health and advocate for cleaner air. The Clean Air SGV program builds on these efforts by informing, equipping, and activating Alhambra and Monterey Park residents to address air pollution impacts in their communities. The program follows a community-based participatory research (CBPR) approach, equitably involving community members, organizational representatives, and academic researchers. For more information, visit www.apifm.org/cleanairsgv. The program's key objectives are to:

- Raise awareness of local air pollution sources and their health impacts.
- Engage community members in hands-on air monitoring and air filter initiatives.
- Develop community-led solutions by leveraging air quality data to inform policy discussions and advocate for stronger environmental protections.

Environmental Justice Research Lab

The Environmental Justice Research Lab (EJRL), directed by Dr. Jill Johnston at the University of Southern California Keck School of Medicine, works in low-income communities of color and develops novel methods to assess exposures and measure health outcomes among populations impacted by industrial pollution and burdened by multiple social and economic stressors. Our team collaborates in partnerships with communities to engage in community-driven epidemiology and action-oriented research.

Acknowledgements

Funding for this project was provided in part by the National Institute of Environmental Health Sciences (5P30ES007048) and also by the California Climate Investments (CCI), a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in disadvantaged communities.

Introduction & Community Context

Los Angeles, California (CA) is home to many communities facing significant environmental health disparities.[1] Alhambra and Monterey Park are two cities in the San Gabriel Valley region of LA County that are disproportionately burdened by air toxins, including fine particulate matter (PM2.5).[2] Alhambra is home to census tract 6037481500, a disadvantaged community identified as among the top 25% highest scoring tracts in CalEnviroScreen 4.0, a statewide tool to map neighborhood-level environmental health risks. Senate Bill 535 (SB535) targets communities like these for investment in the proceeds of California's Cap-and-Trade program.[3] Both cities have large Asian Pacific Islander (API) and Latinx communities and experience high levels of toxic air emissions due to neighboring industrial facilities, heavy vehicle traffic, SR-19 (a significant transportation route), and major freeways, including SR-60, SR-710, and I-10, which is also one of the busiest corridors transporting goods across our country.

The Clean Air SGV Program was developed by the Asian Pacific Islander Forward Movement (APIFM) to address air pollution and advocate for improved air quality in the San Gabriel Valley, which encapsulates both Alhambra and Monterey Park. While working with high school students at Mark Keppel High School (MKHS), APIFM was made aware of the growing concerns about local air pollution. MKHS is located less than 100 feet from the I-10 freeway, one of the most congested freeways in the Los Angeles region. To address this issue, APIFM took a multi-pronged approach, working on educating the community on the issues of air quality in our region, deploying PurpleAir (PA) sensors to measure air quality, and creating a stakeholder group made of residents to advocate for air quality policy solutions. The curriculum taught how the sensors and data collected were used and what the sensors measured. The curriculum also taught what particulate matter was, the types of particulate matter that exist in the air, where it comes from, and some of its impacts on community health. By 2017, APIFM had distributed 81 PA sensors throughout Alhambra and Monterey Park. In 2019, Clean Air SGV's outreach efforts resulted in 13 full-length educational workshops and four informational presentations with 212 community members. Additionally, APIFM attended community events to drive awareness of our Clean Air SGV efforts and PA Sensor installations. From January 2020 to March 2021, Clean Air SGV's outreach efforts resulted in 15 full-length educational workshops with 206 community members. In January 2021, we recorded and published the Clean Air SGV educational workshop on API Forward Movement's YouTube channel, @ForwardAPI.

The Clean Air SGV Program previously conducted an air quality study that analyzed data collected from 27 PA sensors (24 outdoor and three indoor) to investigate air quality trends in Alhambra and Monterey Park between January 2019 and July 2020.[4] These data showed that air quality appears to be the worst in the summer through early winter (June-December), and the pandemic lockdown decreased poor air quality and PM levels. This effort has enabled APIFM to continue to build a robust and expansive community air sensor network that is accessible for community members to view and monitor.

This effort has allowed for the evaluation of annual, seasonal, and diurnal variations of $PM_{2.5}$ in the Alhambra-Monterey Park community, something that would not be feasible due to the lack of EPA monitoring in the community. The Clean Air SGV project showed a need for deploying even more PA sensor networks in hotspot census tracts to better understand the origin of the association between $PM_{2.5}$ concentrations and socioeconomic factors. The SB535 communities in the area were not covered by the PA network, nor do they contain any regulatory air monitors.

The goals of these current studies was to expand the Clean Air SGV project and facilitate community-engaged research to 1) deploy air sensors in the SB535 communities located in the north eastern parts of the Alhambra and Monterey Park region to address the lack of air monitoring sensors in these vulnerable areas and 2) conduct simultaneous outdoor/indoor air quality monitoring to assess the efficacy of indoor air filters in homes in these areas. By further engaging community stakeholders, giving them educational resources, and holding space for community-centered input and feedback, Clean Air SGV aimed to meaningfully inform environmental policy and planning moving forward. Community-engaged research and community-owned data can help enable residents to educate themselves regarding the major sources of air pollution and important influential factors. These efforts aim to help the community gain a better understanding of air quality in the region, as well as enhance personal air quality monitoring and social and environmental justice awareness across the community.

Methods

Community Engagement

This project aimed to expand APIFM's current network of air sensor "hosts" – local residents who installed air sensors at their homes – and to target "hotspots" in disadvantaged communities and locations with sparse air monitors in Alhambra and Monterey Park. This work was informed by the Sustainable San Gabriel Valley Coalition, as members help identify data gaps on available air quality data and identify potential new sensor hosts within those "hotspots."

Outreach and recruitment of air sensor hosts for this project began in Spring and Summer 2023. Recruitment efforts utilized a multi-pronged approach to ensure broad community participation. Methods included tabling at community events, such as the Alhambra EcoFair and public library workshops, door-to-door canvassing, which was the most effective method, particularly in SB535-designated areas, social media posts and email campaigns to reach a wider audience, and word-of-mouth recruitment through Clean Air SGV network members. The combination of direct engagement and digital outreach ensured that the study reached a diverse group of residents concerned about air quality.

We outreached in person at local events, such as Alhambra's annual EcoFair and presenting at local libraries. Before confirming host selection, we confirmed participants' ability to attend our air quality workshops, where we explained the studies and their purposes. Hosts were confirmed via email, which was our main form of communication. Host selection varied between the two studies, described below. We required all of our hosts to attend an APIFM Air Quality 101 workshop, which goes over general local air quality issues. We reached out to hosts monthly for check-ins; most responses were by email, but some hosts chose to schedule virtual or phone calls. Notes for each check-in were recorded.

Purple Air Sensors

For this project, air pollution was measured using PurpleAir (PA) sensors, low-cost air quality monitors widely deployed in the U.S. and worldwide. The latest model (PA-II-SD) contains two PMS5003 sensors (Plantower, Beijing, China), which estimate particle mass concentrations by measuring the amount of light scattered at ~680 nanometers. Greater details regarding the lab evaluation by South Coast Air Quality Management District (AQ-SPEC team) can be found elsewhere.[5] Although PurpleAir sensors report PM mass concentrations of three size fractions, i.e. PM less than 1 µm, less than 2.5 µm ($PM_{2.5}$), and less than 10 µm, we focused on $PM_{2.5}$ in this study mainly due to three reasons:

1) among the three size fractions $PM_{2.5}$ has been mostly associated with adverse health outcomes;
2) $PM_{2.5}$ is regulated and routinely monitored by the U.S. EPA; and
3) PM concentrations from the three size fractions are highly correlated with one another in the PurpleAir data (more than 0.9 correlation coefficient between different size fractions).

In addition to PM, PurpleAir sensors measure humidity and temperature. PurpleAir measurements are recorded through two separate channels and are automatically uploaded to purpleair.com, which become open source data that are publicly available.

APIFM has deployed 78 PurpleAir sensors that have been continuously measuring air pollution levels within the cities of Alhambra and Monterey Park since 2017. PurpleAir sensors are relatively inexpensive compared to other air quality instruments and sensors while still exhibiting reasonable correlation with more expensive reference instruments, thus making them ideal for large-scale community-based data collection.

Study 1: Hotspots

The first study focused on measuring outdoor ambient levels of $PM_{2.5}$ in community-identified hotspots over the course of one year, focusing on temporal and spatial patterns.

The UCI report on spatial and temporal variation of $PM_{2.5}$ helped track the air quality before and during the COVID-19 lockdown. However, the report's analysis of air quality trends was limited to the areas where SSG/APIFM could install air quality sensors; parts of both cities were missing air quality sensor coverage. This led to critical data gaps that may obscure air quality disparities within the region. Based on feedback from the SSGV Coalition and residents, SSG/APIFM studied $PM_{2.5}$ concentrations within community "hotspots." Hotspots are areas within the community that may have higher $PM_{2.5}$ concentrations due to a variety of factors such as proximity to: (1) a freeway or large arterial street, (2) a school drop off/pick up zone, (3) an industrial or commercial zone, (4) a construction area or project, etc.

SSG/APIFM engaged residents of Alhambra and Monterey Park to identify four areas of concern (two in each city) that residents believe may have high levels of $PM_{2.5}$ due to heavy vehicle traffic, industrial emissions, or related contributing factors. Hotspots were identified through a community mapping activity conducted at outreach and tabling events. During these events, a large map of the West San Gabriel Valley was displayed, and residents of Alhambra and Monterey Park were invited to place pins on locations in their cities where they believed air pollution was the worst. Our directions included identifying sites with high traffic or human activity. The most commonly identified hotspots included freeway corridors, industrial zones, school pickup and drop-off areas, and high-traffic commercial areas.

In consultation with USC EJRL researchers, SSG/APIFM determined that two PA sensors would be located near each hotspot to adequately measure and record variation in the levels of $PM_{2.5}$. Hosts in this study were chosen based on their proximity to the hotspots being monitored to ensure data collection from areas affected by high traffic, industrial emissions, and other pollution sources. Our criteria for these hosts required one northeast and southwest of each hotspot site. This positioning accounted for the general wind directions of the West SGV, so the data collected was accurately representative of each hotspot.

Study 2: Indoor Air Filters

The second study targeted SB535 areas of the community. The study focused on assessing:

1) the ambient $PM_{2.5}$ concentrations both outside of and within participants' homes
2) the effect of air filtration on indoor $PM_{2.5}$ levels under varying outdoor $PM_{2.5}$ conditions, and
3) the comparative effectiveness of DIY versus commercially-available air filtration units in mitigating indoor $PM_{2.5}$ levels

Study 2 hosts were selected based on specific criteria, including residency in SB535-designated areas, presence of gas stoves, availability of central AC, and willingness to run air filters daily and provide feedback. This careful selection process ensured representative data on air quality challenges in pollution-impacted areas. For our second study, all hosts were required to attend our Study 2 workshop, which included a DIY air filter demonstration. While most hosts were able to join in-person, we scheduled online presentations for hosts who were unable to attend in-person.

We enrolled a total of 10 participants that lived within the study area. All study participants received two Purple Air sensors, one to be placed outdoors, and one to be placed indoors in a high-trafficked area of the home. The study was initially planned for six full months, from early October 2023 through the end of April 2024. We provided participants the opportunity to extend the study through the end of June 2024.

Upon enrollment in the study, participants were assigned a filter: commercial HEPA, do-it-yourself (DIY), or none (control). The DIY filter consisted of a box fan and four MERV 13 filters. The Morento Air Purifier was selected for this study based on its HEPA H13 filtration capabilities, affordability, and effectiveness in reducing indoor air pollution. The selection process considered cost, filter performance, and accessibility for community members, ensuring that participants could easily use and maintain the units throughout the study. The Morento Air

Purifier includes a 4-stage filtration system, coverage for spaces up to 1,076 sq. ft., low noise operation (24 dB) and auto mode, and a filter replacement indicator. At the time of purchase, each Morento Air Purifier cost $129.99, and replacement filters ranged between $21.98 and $29.99 per set. Assignment was initially randomized; however, some participants felt strongly about their interest in using DIY versus commercial air filters. In October, three participants began using commercial air filters and three participants began using DIY air filters. One of the participants assigned to the commercial air filter group chose to leave the study at the end of April. Four participants used no air filters as a control group. One control participant chose to leave the study at the end of April, and the remaining three control participants were provided DIY filters in early May 2024.

Participants in filter assignment groups were expected to run their air filters during the entirety of the study period. All participants received monthly check-ins to assess their experiences. Check-ins focused on how well the filter reduced indoor pollutants, any noticeable improvements in air quality, particularly after cooking or during high outdoor pollution days, and filter maintenance or technical issues. Hosts responses were typically in email form; other responses include virtual meetings or phone calls. Participants were advised to replace filters every 3–6 months or otherwise as needed. In total, we used 19 DIY air filter units. We replaced DIY air filters over 12 times for our original three DIY air filter hosts and the additional three hosts who changed roles when we extended this study. For our commercial air filter hosts, we provided two air filter replacements to hosts.

Data Analysis

All PurpleAir data for the sensors located at the homes in both studies was retrieved for the entire study period, beginning October 1st, 2023 for both studies and ending in September 2024 for Study 1 and in June 2024 for Study 2. The raw data from PurpleAir was downloaded as measures in 2-minute increments. Prior to analysis, we conducted quality control checks by comparing the data from the "A" and "B" channels for each sensor. We removed data points where both of the following were true:

1) the PM2.5 level for each channel (abs[*pm2.5_alt_a– pm2.5_alt_b*]) differed by ≥ 5 ug/m3 AND
2) the difference between the A and B channels was greater than 50% different from the average of the A and B channels

Subsequent analysis were conducted using the cleaned datasets.

For Study 1, the EPA correction factor[6], which accounts for variation in the impact of relative humidity (RH) on accuracy of PA sensor measures at different concentrations of PM2.5, was applied to the *pm2.5_atm* data rows. This correction makes PA sensor measurements more comparable to measurements from EPA and SCAQMD regulatory monitors. The measures from the two sensors at each hotspot were averaged to a single hotspot dataset, from which hourly, daily, and monthly average $PM_{2.5}$ measures were calculated for each hotspot.

We additionally downloaded the daily average $PM_{2.5}$ data from the nearest regulatory monitors located in Pasadena, Downtown Los Angeles (DTLA), Pico Rivera, and Glendora (Figure 1) from October 2023-September 2024.

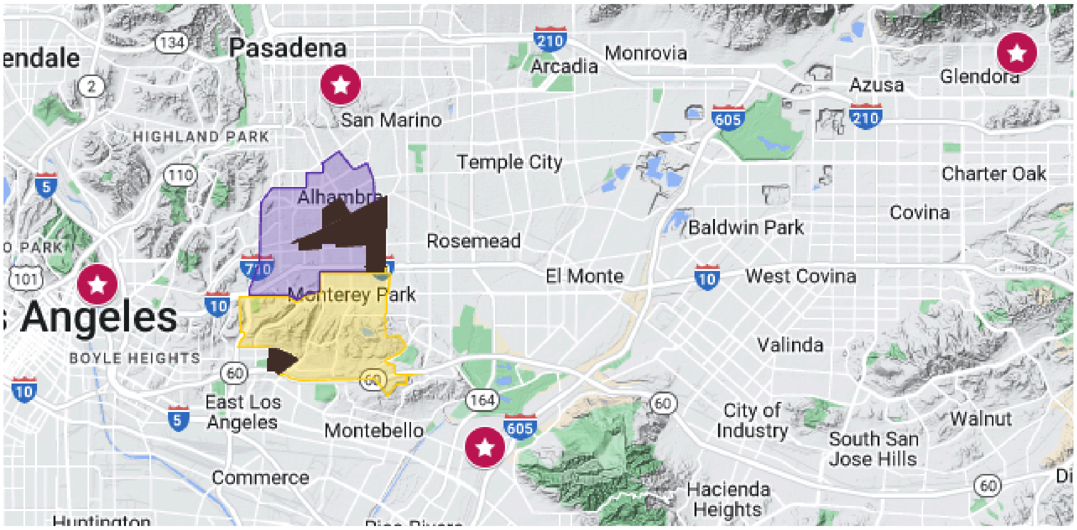

Figure 1. Map of Study Area.

Alhambra is indicated in purple shading, and Monterey Park is indicated in yellow shading. SB535 communities are indicated by brown shading. Locations of EPA and SCAQMD PM2.5 monitors are indicated by red stars

No single nearby monitor offers an ideal comparison for this study. Although the monitor located in Pasadena is both located near the communities of interest and reflects the geography and air quality in the San Gabriel Valley, it only reports daily $PM_{2.5}$ measures every three days, and no data has been reported from that monitor since June 2024. The monitor located in DTLA is also relatively near the communities of interest, but it captures air pollution from the dense urban center of the city, which varies in sources and geography from the San Gabriel Valley. The next nearest monitor in Pico Rivera also only captures daily $PM_{2.5}$ every three days, and the monitor in Glendora, which records daily average $PM_{2.5}$ for the entire study period, is substantially further from Alhambra and Monterey Park. To account for the variation in the missingness and comparability of the regulatory monitors, we averaged the daily $PM_{2.5}$ measures from all four regulatory monitors. The differences in daily average $PM_{2.5}$ levels measured at each hotspot were compared to the daily average $PM_{2.5}$ levels measured at the Pasadena monitor on days for which data is available, and at all monitors combined for the entire study period, using paired t-tests.

For Study 2, the *_alt* $PM_{2.5}$ levels reported in the PurpleAir sensor datasets were used to calculate the difference between indoor and outdoor $PM_{2.5}$ levels for each participant. These data were summarized to hourly, daily, and monthly averages. The average difference was calculated for each type of filtration used (DIY, commercial, or none) for the study overall and by day of the week and time of day. One-way ANOVA analyses and Tukey's HSD tests for multiple comparisons were used to determine whether the daily average differences between indoor and outdoor $PM_{2.5}$ levels statistically significantly differed by filter type.

Analyses were conducted in R version 4.4.1 and SAS version 9.4.

Results

Study 1: Hotspots

There were 358 days of PM2.5 data recorded between October 2023 to September 2024. The average PM2.5 level at every hotspot in the study during this time period, and every monitoring location except Pasadena, exceeded the EPA/SCAQMD annual standard of 9 $\mu g/m^3$ (Table 1).

Table 1. Average daily $PM_{2.5}$ levels ($\mu g/m^3$) at hotspots and monitoring locations

Variable	Days of data	Mean (Std. Dev.)	Minimum	Maximum
Garfield & Main*	358	11.4 (8.8)	0.2	127.8
Fremont Elementary*	358	11.3 (8.4)	0.6	121.7
ELAC*	358	10.7 (7.5)	0.2	95.8
MKHS*	358	10.2 (7.6)	0.5	106.7
Pasadena monitor	87	8.9 (4.3)	2	18.8
Average of all nearby monitors	357	10.9 (7.1)	1.6	108.4

**applying EPA correction factor*

For the hotspots at Garfield & Main and Fremont Elementary, more than half of the days in the study had daily average PM2.5 levels above 9 $\mu g/m^3$ (Table 2). Every hotspot had at least one day above the EPA/SCAQMD 24-hour standard.

Table 2. Number of days with high air pollution at each hotspot:

	Garfield & Main	Fremont Elementary	ELAC	MKHS
Days > 9 $\mu g/m^3$	189 (52%)	189 (52%)	171 (48%)	161 (45%)
Days > 35 $\mu g/m^3$	1	1	2	1

The day during the study period with the highest level of PM2.5 at every hotspot was July 5th (Figure 2). These high levels are likely caused by fireworks set off around LA County, including in many neighborhoods in and around Monterey Park and Alhambra.

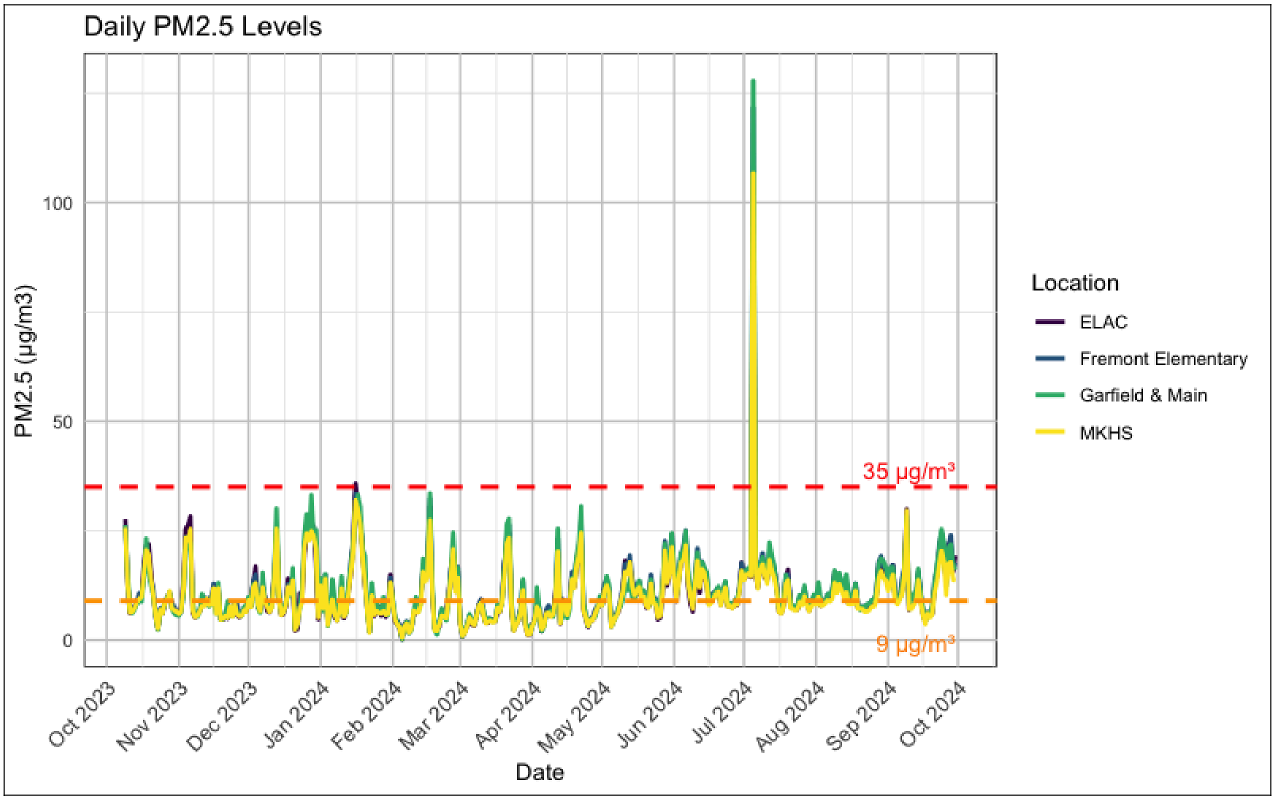

Figure 2. Time series of PA monitor data during Study 1.

The levels of $PM_{2.5}$ at each hotspot varied over the course of the whole study, with similar patterns observed across the hotspots. At every hotspot, average $PM_{2.5}$ levels rose and fell throughout the day, with peaks early in the morning and again in the late afternoon, coinciding with rush hour commute hours (Figure 3).

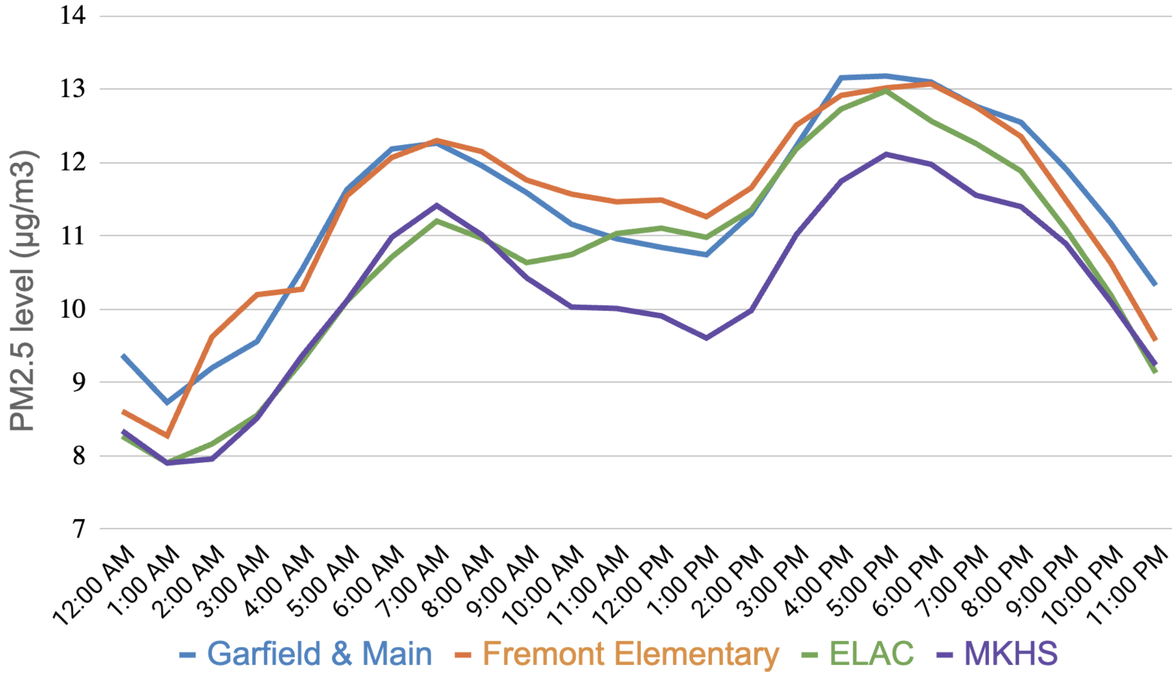

Figure 3. Hourly average $PM_{2.5}$ levels at each hotspot.

Daily average $PM_{2.5}$ levels on weekdays were higher than on weekends at every hotspot (Figure 4), though differences were small.

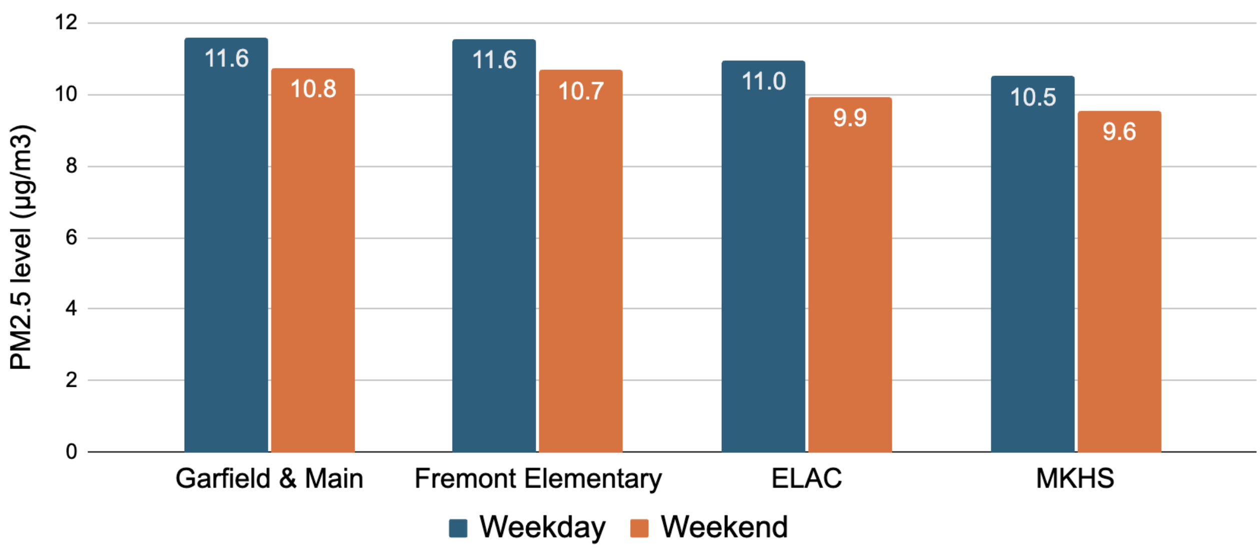

Figure 4. Daily average $PM_{2.5}$ levels at each hotspot, weekdays v. weekends.

Daily average $PM_{2.5}$ levels were statistically significantly higher at all hotspots than at the Pasadena monitor during the days for which there is data during the study period (Table 3). $PM_{2.5}$ levels were also higher at Garfield & Main and at Fremont Elementary than the daily average levels from all four nearby monitors combined. The levels of $PM_{2.5}$ measured by PurpleAir sensors at the hotspots were consistently higher than those measured at all EPA monitors combined during the cool months (October-March). During warmer months (April-September), $PM_{2.5}$ levels at ELAC and at Mark Keppel High School were lower than daily average $PM_{2.5}$ levels of nearby monitors.

Table 3. Difference in average daily $PM_{2.5}$ levels measured by PurpleAir sensors at each hotspot compared to levels measured in Pasadena and all other nearby monitors, stratified by season.

	Comparison monitor(s)					
Hotspot	Pasadena monitor			All near monitors		
	Overall	Cool season	Warm season	Overall	Cool season	Warm season
Garfield & Main	1.9 (1.0, 2.8)	2.6 (1.5, 3.7)	0.6 (-0.9, 2.1)	0.5 (0.0, 0.9)	1.6 (3.9, 0.3)	-0.6 (-1.3, 0.1)
Fremont Elementary	2.0 (1.1, 2.8)	2.5 (1.5, 3.6)	0.8 (-.6, 2.1)	0.4 (0.0, 0.8)	1.4 (0.9, 1.9)	-0.6 (-1.2, 0.1)
ELAC	1.4 (0.5. 2.3)	2.3 (1.1, 3.4)	-0.2 (-1.5, 1.1)	-0.2 (-0.7, 0.2)	1.1 (0.6, 1.6)	-1,5 (-2.2. -0.9)
MKHS	1.1 (0.3, 1.9)	1.8 (0.9, 2.8)	-0.4 (-1.6, 0.9)	-0.7 (-1.1. -0.2)	0.8 (0.3, 1.3)	-2.0 (-2.6, -1.5)

Study 2: Indoor Air Filters

Between October 2023 to June 2024, ten residents participated in the study of indoor air filtration. During the study period, outdoor $PM_{2.5}$ levels were similar across all homes (Table 4). Average daily indoor $PM_{2.5}$ levels were lower than outdoor levels across all filter types, but homes with indoor filters showed greater differences in indoor $PM_{2.5}$ levels than homes without filters. In homes with filters, indoor average daily $PM_{2.5}$ levels were approximately 5-6 $\mu g/m^3$ lower than outside levels. In homes without filters, indoor average daily $PM_{2.5}$ levels were only ~1 $\mu g/m^3$ lower than outside levels.

Table 4. Average daily $PM_{2.5}$ levels indoors and outdoors by indoor filter type.

	Observations	Outdoor	Indoor	Difference
No air filter	954	7.6 $\mu g/m^3$	6.7 $\mu g/m^3$	0.8 $\mu g/m^3$
Commercial HEPA filter	722	8.6 $\mu g/m^3$	3.7 $\mu g/m^3$	4.9 $\mu g/m^3$
DIY air filter	881	8.7 $\mu g/m^3$	2.9 $\mu g/m^3$	6.0 $\mu g/m^3$

The mean value of the average difference between daily indoor and outdoor $PM_{2.5}$ levels was significantly different between all filters (Table 5).

Table 5. Mean difference (95% CI) in daily indoor and outdoor $PM_{2.5}$ levels by filter type

Comparison	Overall	Sensitivity analysis*	Warm months*	Cool months*
DIY - none	5.2 (4.5, 5.9)	3.4 (2.7, 4.0)	4.4 (3.2, 4.5)	3.1 (2.3, 4.0)
HEPA - none	4.1 (3.3, 4.8)	2.2 (1.5, 3.0)	3.5 (2.2, 4.7)	1.9 (1.1. 2.8)
HEPA - DIY	-1.2 (-1.9, -0.5)	-1.2 (-1.8, -0.6)	-1.0 (-1.8, -0.1)	-1.2 (-2.0 -0.4)

*excluding one participant who reported regularly smoking on his balcony

The mean difference between daily indoor $PM_{2.5}$ levels and daily outdoor $PM_{2.5}$ levels was 5.2 $\mu g/m^3$ greater in homes with DIY filters compared to homes without filters. As a sensitivity analysis, we removed data from one participant assigned to no air filter who reported smoking on his balcony, which attenuated results somewhat. We additionally evaluated differences stratified by season. The differences between indoor and outdoor $PM_{2.5}$ levels in homes with air filters compared to homes with no filters appeared to be greater in warm months (April through June) than in cool months (October through March).

For all homes in the study, outdoor $PM_{2.5}$ levels tended to be lowest on Sundays and highest in the middle of the week, though there was somewhat less variability by weekday outside of homes that were assigned no air filters (Figure 5). Outdoor $PM_{2.5}$ levels tended to be lower for homes that had no filters.

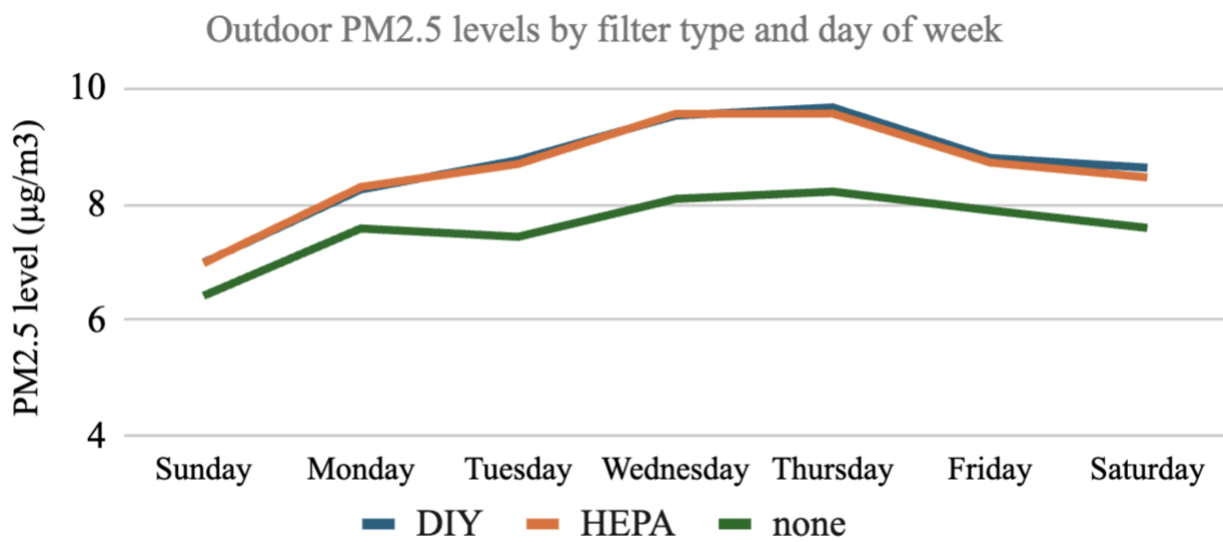

Figure 5. Outdoor $PM_{2.5}$ level by filter type and day of week.

This pattern was also seen in the indoor $PM_{2.5}$ levels in homes with no air filters (Figure 6). However, indoor $PM_{2.5}$ levels were fairly stable in homes with either HEPA or DIY filters, regardless of the day of the week, and levels were consistently lower than those observed inside homes without filters.

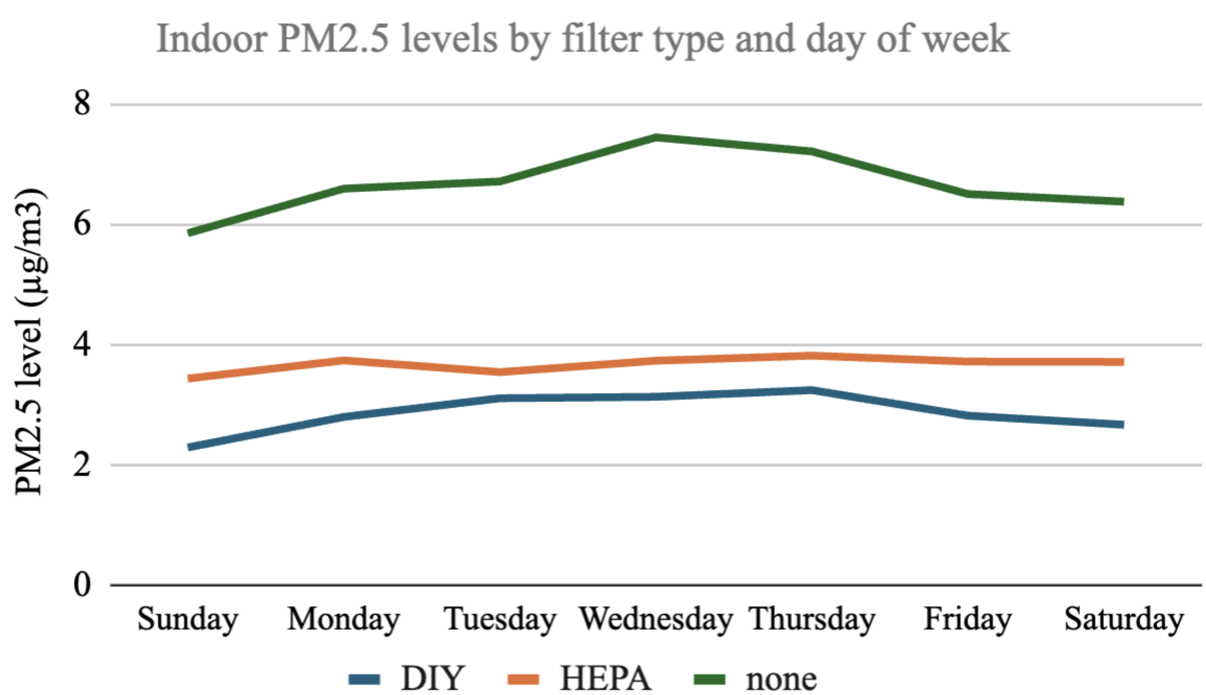

Figure 6. Indoor $PM_{2.5}$ level by filter type and day of week.

Figure 7 shows that regardless of the day of the week, average daily outdoor $PM_{2.5}$ levels were approximately 3-7 µg/m^3 higher outside than indoors at homes with DIY or HEPA filters, whereas average daily $PM_{2.5}$ levels indoors were within approximately 1 µg/m^3 of levels outdoors at homes with no air filters.

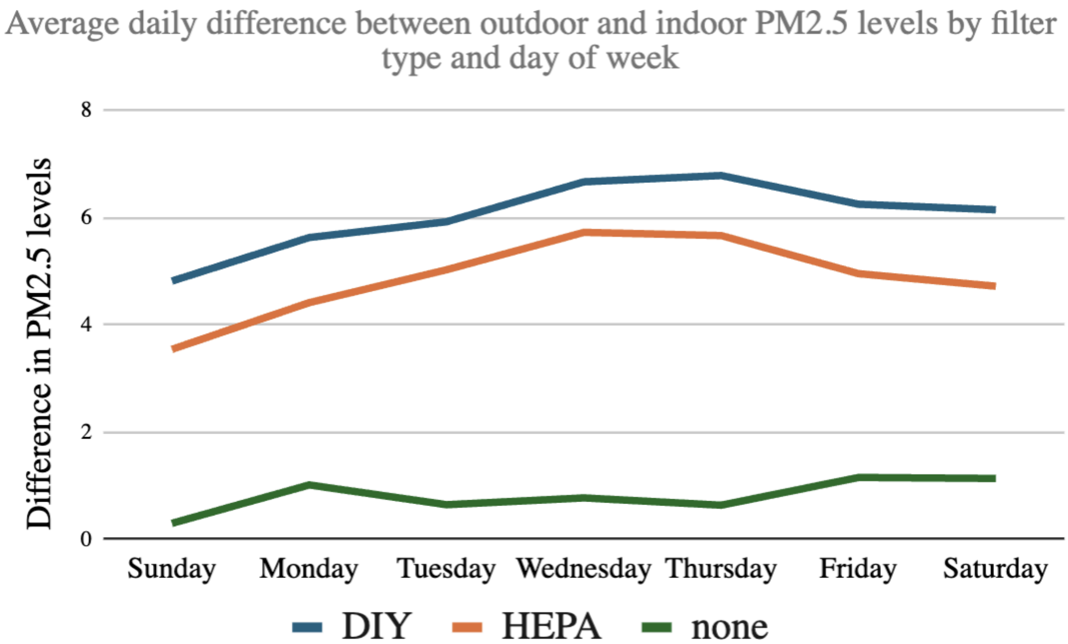

Figure 7. Average daily difference in outdoor versus indoor $PM_{2.5}$ level by filter type and day of week.

There was variability in outdoor $PM_{2.5}$ levels by time of day, with levels peaking early in the morning and then again in the afternoon, regardless of filter assignment (Figure 8).

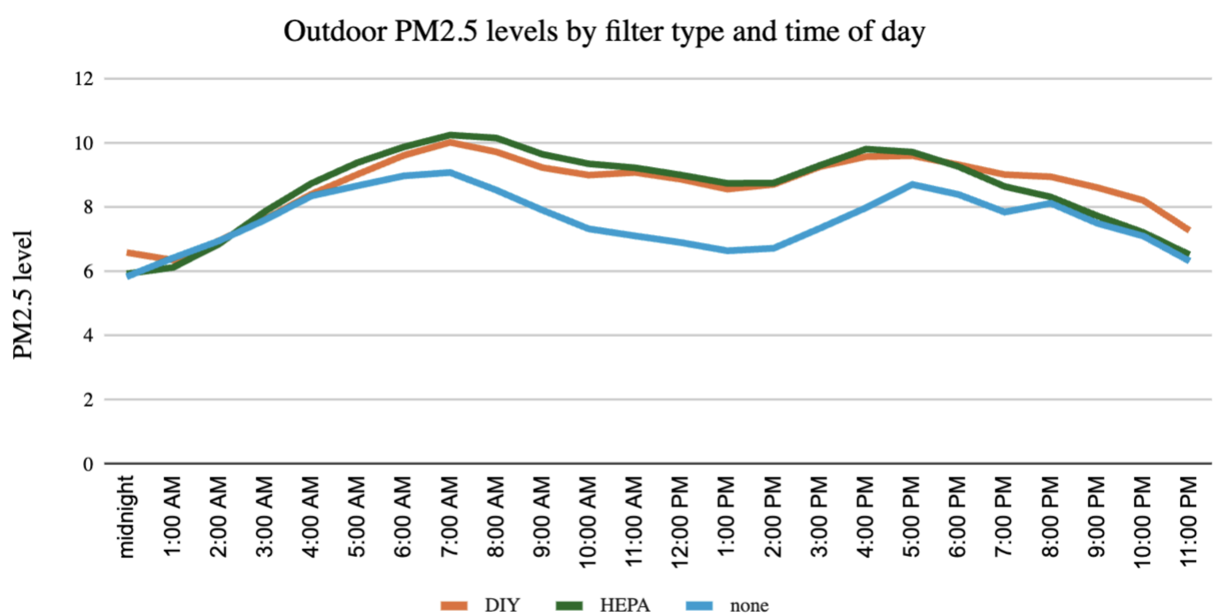

Figure 8. Average hourly outdoor $PM_{2.5}$ level by filter type.

Indoor $PM_{2.5}$ levels varied by time of day. For homes without air filters, indoor $PM_{2.5}$ levels peaked very late at night and in the afternoon. For homes with air filters, indoor $PM_{2.5}$ levels were highest in the afternoon, but were still lower than in homes with no filters.

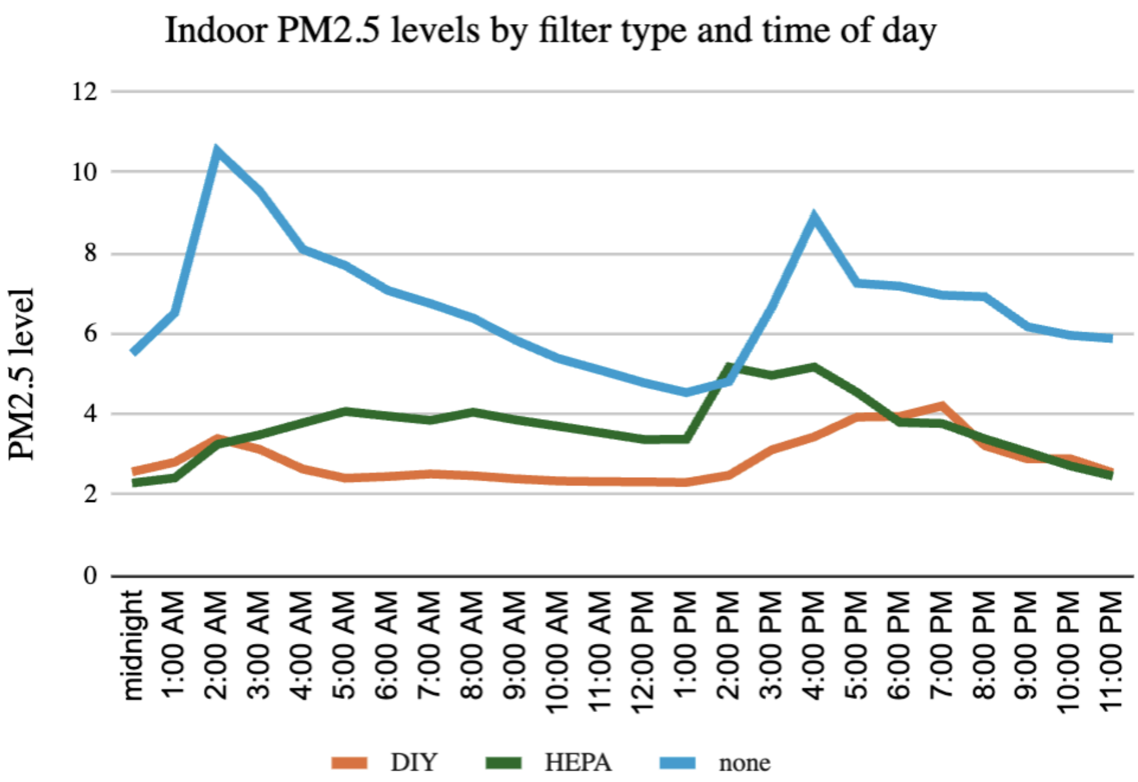

Figure 9. Average hourly indoor $PM_{2.5}$ level by filter type.

Figure 10 shows that regardless of the time of day, average hourly outdoor PM2.5 levels were higher outside than indoors at homes with DIY or HEPA filters, with the greatest differences occurring in the morning. In contrast, average hourly PM2.5 levels indoors were up to 5 μg/m^3 higher than outdoors at homes with no air filters.

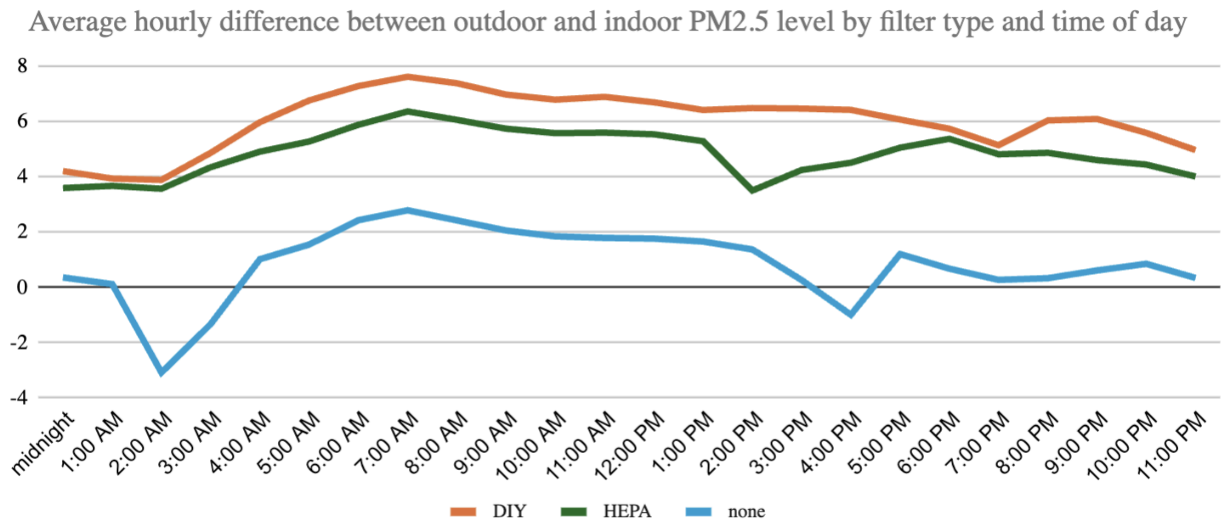

Figure 10. Average hourly difference between outdoor and indoor $PM_{2.5}$ level by filter type.

Discussion & Future Work

This series of air quality studies in the San Gabriel Valley cities of Alhambra and Monterey Park documented $PM_{2.5}$ trends at community-identified hotspots and effectiveness of indoor air filtration.

The results of Study 1 show that average daily levels of $PM_{2.5}$ at community-identified local hotspots of air pollution are higher than those measured at nearby monitoring stations, validating community concerns about these locations. However, EPA monitor readings of daily average $PM_{2.5}$ levels were not consistently lower than PurpleAir sensor levels at the hotspots identified in this study. Rather, in cool months, which tend to see lower regional $PM_{2.5}$ levels, $PM_{2.5}$ levels at hotspots were consistently higher than those recorded at local EPA monitors. In warmer months, when $PM_{2.5}$ levels are higher across the region, levels at hotspots are similar to, or slightly lower, than those recorded at monitors. These results suggest that regional metrics of air pollution that rely on EPA monitors, such as the Air Quality Index (AQI), may underestimate the health risk from air pollution at local hotspots during cooler months.

Further, the highest average hourly levels of $PM_{2.5}$ at all hotspots occurred during the late afternoon into the evening, from ~3 pm-8 pm, when children are frequently outside and engaged in extracurricular activities after school hours. Children are highly susceptible to the impacts of air pollutants, as their lungs and immune systems are still developing. Exposure to air pollutants has been linked to acute adverse respiratory effects, such as asthma exacerbations and respiratory distress, while early life insults to the lung may elevate the risk of long-term disease.[7] Children may be at greatest risk of long-term effects of air pollutant exposures, such as deficits in lung growth, airway inflammation and new onset asthma.[8] Over 6 million children in the US are living with asthma,[9] making it the most commonly diagnosed chronic childhood disorder. As the prevalence of pediatric asthma continues to rise, trends suggest widening racial, ethnic and economic disparities.[9,10] Two of the hotspots in this study are schools, Fremont Elementary School and Mark Keppel High School. These locations cannot simply be avoided by children; rather, the results of this study suggest that further efforts are required to reduce particulate matter pollution around these areas to protect children's health.

The results of Study 2 suggest that indoor air filtration may be an effective household-level tool to address particulate matter pollution in the San Gabriel Valley. Homes with indoor air filtration units, both HEPA and DIY, had consistently lower indoor levels of $PM_{2.5}$, despite having higher average outdoor $PM_{2.5}$ levels, than homes with no filtration systems. Filters made from box fans and MERV-13 filters showed a slight advantage in reducing indoor $PM_{2.5}$ levels compared to the commercial units. However, this study was limited by a very small sample size of ten total participants, and we were therefore unable to adjust for other factors that may have contributed to the effectiveness of air filters. We note that only one participant reported smoking, and that removing their data did not materially change the conclusions of the study.

These Clean Air SGV studies provided insights into air quality disparities and effective solutions for reducing PM2.5 exposure. Key takeaways include identifying high PM2.5 outdoor areas and their impact on community health, confirmation that DIY air filters are an effective, low-cost alternative to commercial air purifiers, and community-driven policy recommendations for cleaner air and public health protections. These recommendations include expanding air sensor coverage in additional high-impact locations, increasing public education efforts on air quality mitigation strategies, and advocating for policy-driven improvements. Clean Air SGV aims to continue engaging policymakers, expanding air monitoring, and educating residents to improve air quality in Alhambra and Monterey Park.

Building on our study's confirmation that air filtration can effectively reduce indoor pollution, we are focusing on two key areas for future work: supporting wildfire-impacted communities and empowering youth to advocate for cleaner air. We aim to leverage our air filter study findings to support communities affected by recent wildfires, notably the Eaton Fire and its cleanup efforts. Wildfire smoke significantly impacts air quality, introducing harmful particulates into homes. Since our study confirmed that DIY and commercial air filters effectively reduce indoor $PM_{2.5}$ levels, we will educate residents on air filtration solutions and indoor air quality improvements. This includes community workshops, multilingual educational materials, and outreach in affected areas to promote air filters as a mitigation tool.

Additionally, we are committed to empowering youth through Clean Air SGV programming by integrating air quality education into our youth initiatives. Through hands-on learning, workshops, and advocacy training, we equip young leaders with knowledge and tools to promote clean air solutions, educate their communities, and advocate for policy changes. By using our air filter findings to support wildfire-impacted residents and strengthening youth engagement in air quality advocacy, we ensure that Clean Air SGV remains a responsive, community-driven initiative, addressing both immediate environmental hazards and long-term public health challenges.

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