Social Justice and Environmental Quality in Denver (SJEQ-D):

Well-being and Air Pollution Exposure During Major Construction in an Environmental Justice Community

Dr. Nicholas Clements

University of Colorado Boulder

CDC Built Environment Working Group

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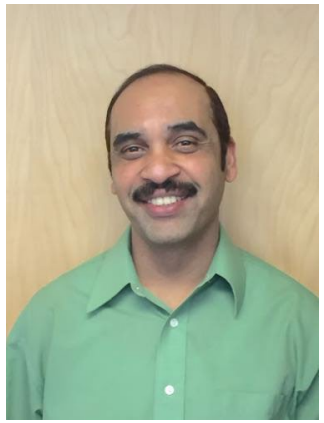
University of Colorado Boulder

Denver CU IN THE CITY

NSF

SJEQ-D Study Team

Environmental Engineering
CU Boulder
PI: Prof. Shelly Miller
Dr. Nicholas Clements
Dr. Sumit Sankhyan
Aniya Khalili
Allison Heckman
Dulce Gonzalez-Beltran
Sophie Castillo



Technology
CU Boulder
PI: Prof. Shivakant Mishra
Omar Hammad
Gopala Kanugo
Rezwan Rahman
Jacob McKinney

NSF Evaluator
CU Boulder
Dr. Daniel Knight

Social Science
CU Denver
PI: Prof. Esther Sullivan
Prof. Marisa Westbrook
Valentina Serrano-Salomon
Jose Puente Puente
La-Doniea Nisbeth
Noemy Perez
Jay Pecenka
Emily Evans

SJEQ-D Study Collaborators

External Outreach and Collaboration

- **Groundwork Denver**
  - Cindy Chang
  - Erika Delzell
  - Rey Gallegos
- Green Latinos
- Growhaus
- Cultivando
- Compost Colorado
- GES Coalition
- Swansea Elementary
- Garden Place Elementary
- DSST Cole School
- Valdez-Perry Library
- Denver DPHE
- Colorado DPHE
- CDOT
- Denver City Council, D9
- CO School of Public Health
- CSU
- Birdseed Collective
- Energy Outreach CO
- CREA Results
- EGS & Partners

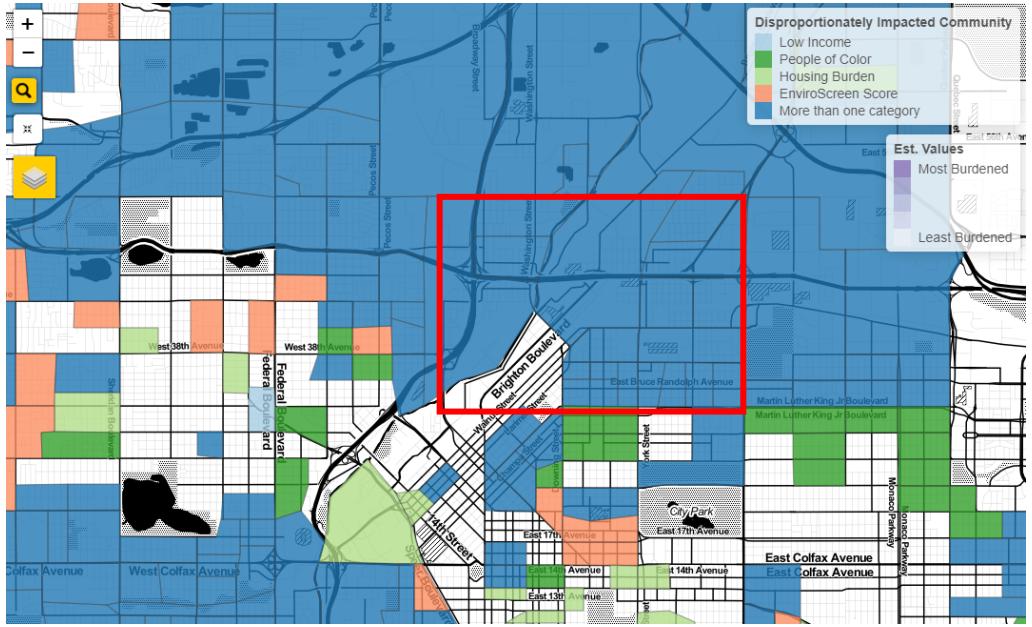
Motivation

- North Denver Communities of **Globeville, Elyria-Swansea, Cole, and Clayton** are disproportionately impacted by industrial and traffic pollution and have elevated asthma and COPD rates compared to other regions in Colorado
- Construction in the area (I-70) exacerbates existing environmental injustices

Motivation

In the state of Colorado, the neighborhoods of Globeville, Elyria-Swansea, Cole, and Clayton are categorized as Disproportionately Impacted Communities

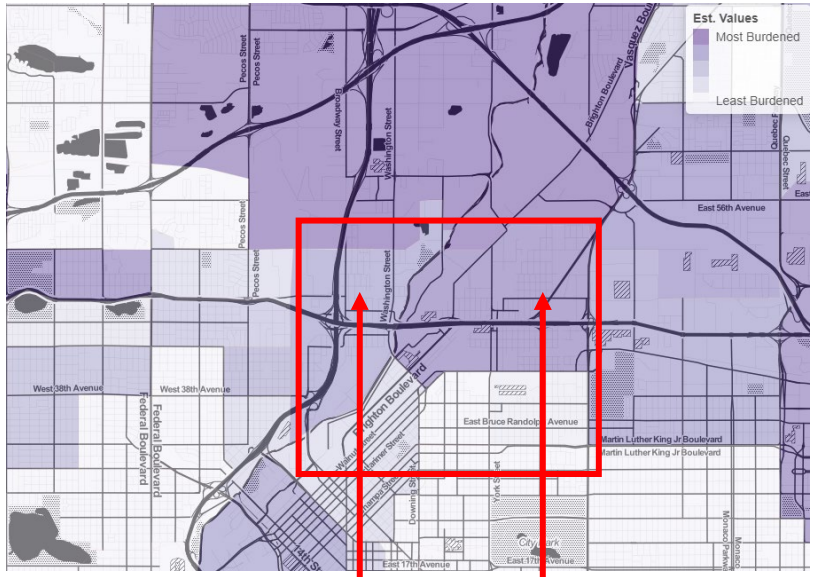
	Globeville	Elyria-Swansea	Cole	Clayton
Over 40% of Households are Low Income	Yes (44%)	No (34%)	Yes (57%)	Yes (50%)
Over 40% of Households are People of Color	Yes (73%)	Yes (69%)	Yes (78%)	Yes (62%)
Over 40% of Households are Housing Burdened	No (30%)	No (34%)	No (25%)	No (22%)
EnviroScreen Score (Percentile) is over 80	Yes (90%)	Yes (92%)	No (77%)	Yes (81%)



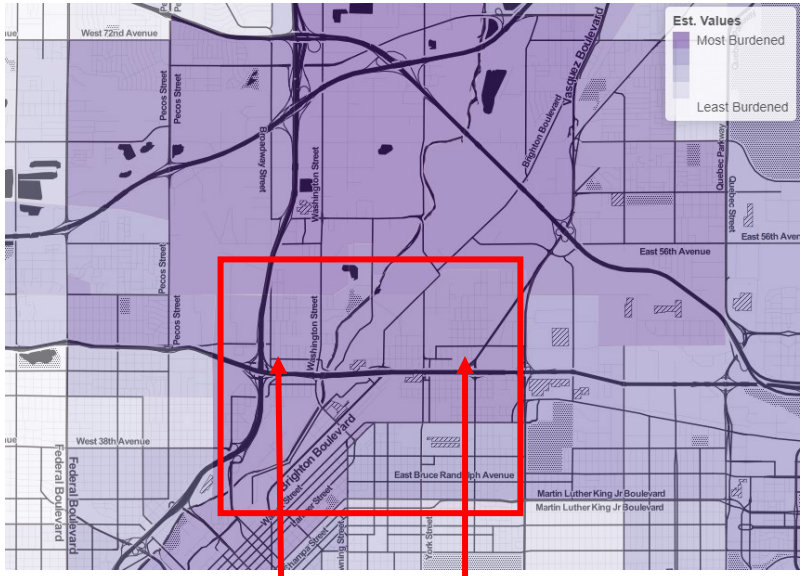
Source: [Colorado EnviroScreen]

Motivation

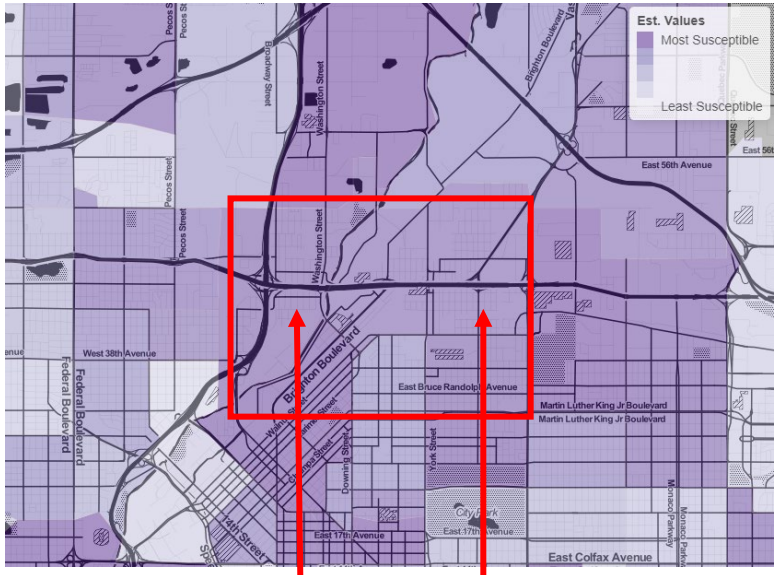
Air Toxics



SO_2, NO_x, PM_{10}



Asthma Hospitalization



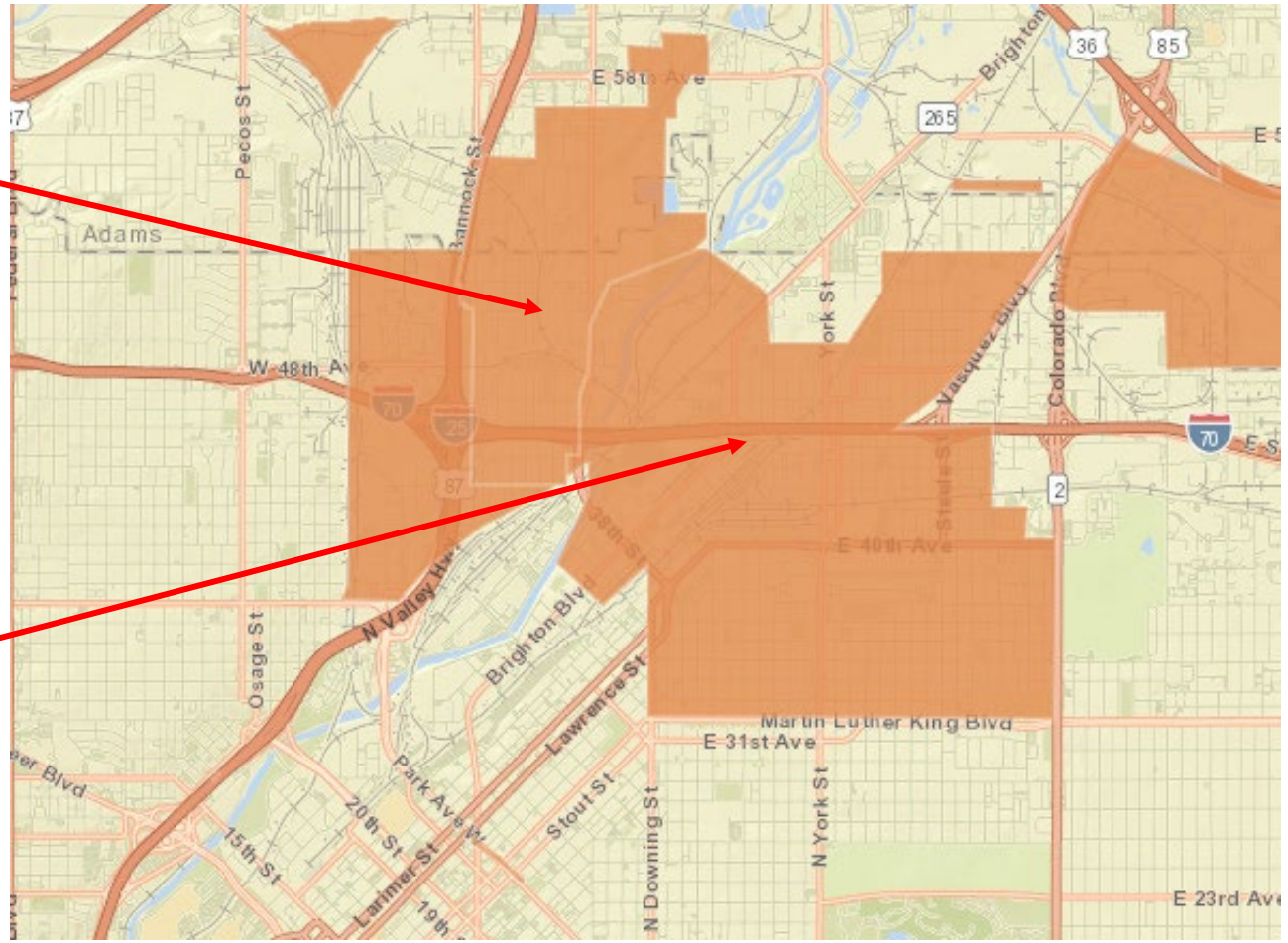
Source: [Colorado EnviroScreen]

Motivation

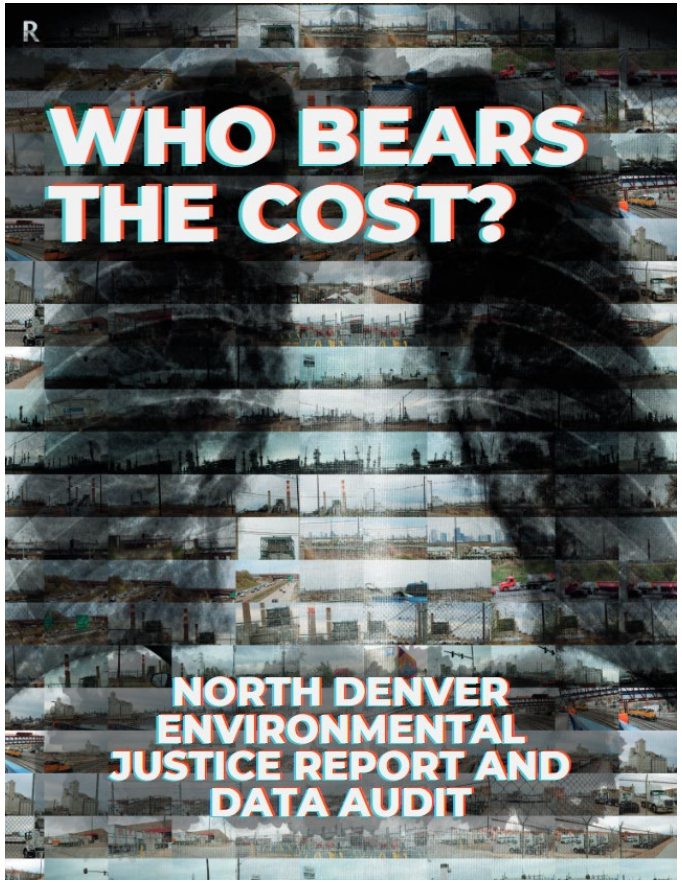
CDPHE Colorado Superfund Sites (NPL NRD): ASARCO GLOBEVILLE **SMELTER**

CDPHE Colorado Superfund Sites (NPL NRD): Vasquez/VAS **SMELTER**

Superfund Sites



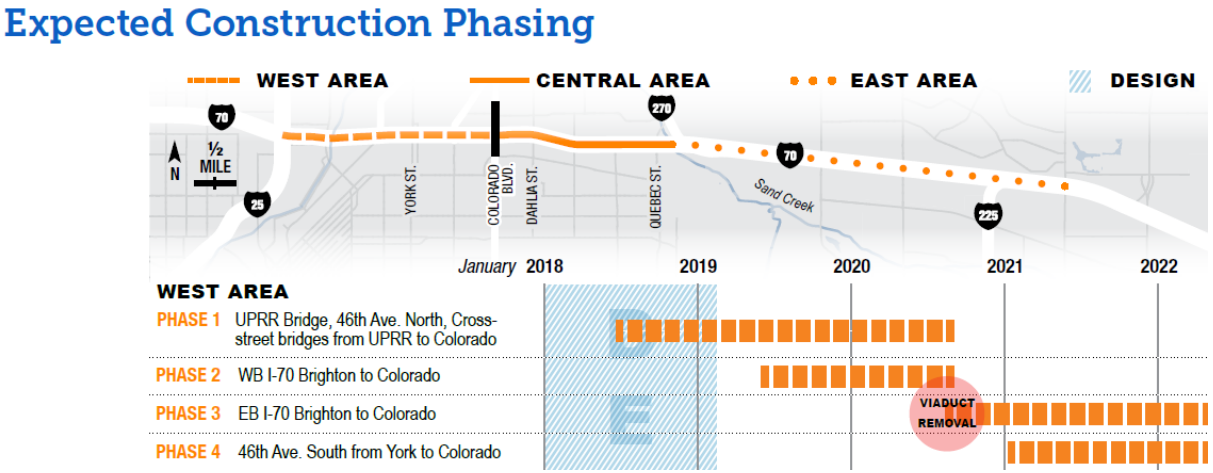
Source: [CDPHE]



Source: [Green Latinos]

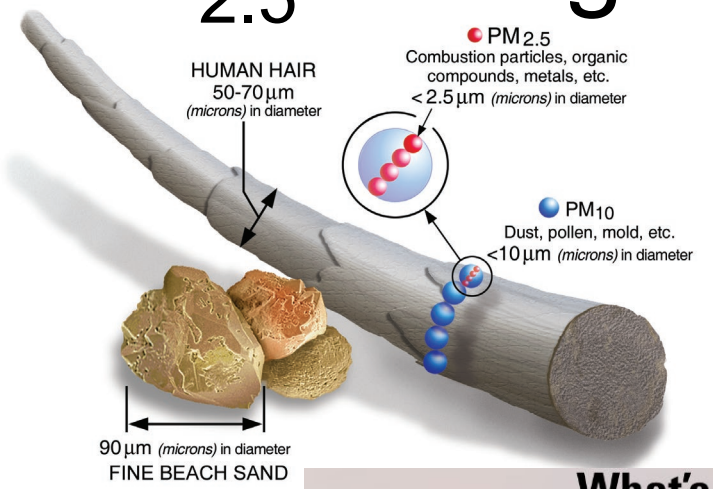
Motivation

Central I-70 Project

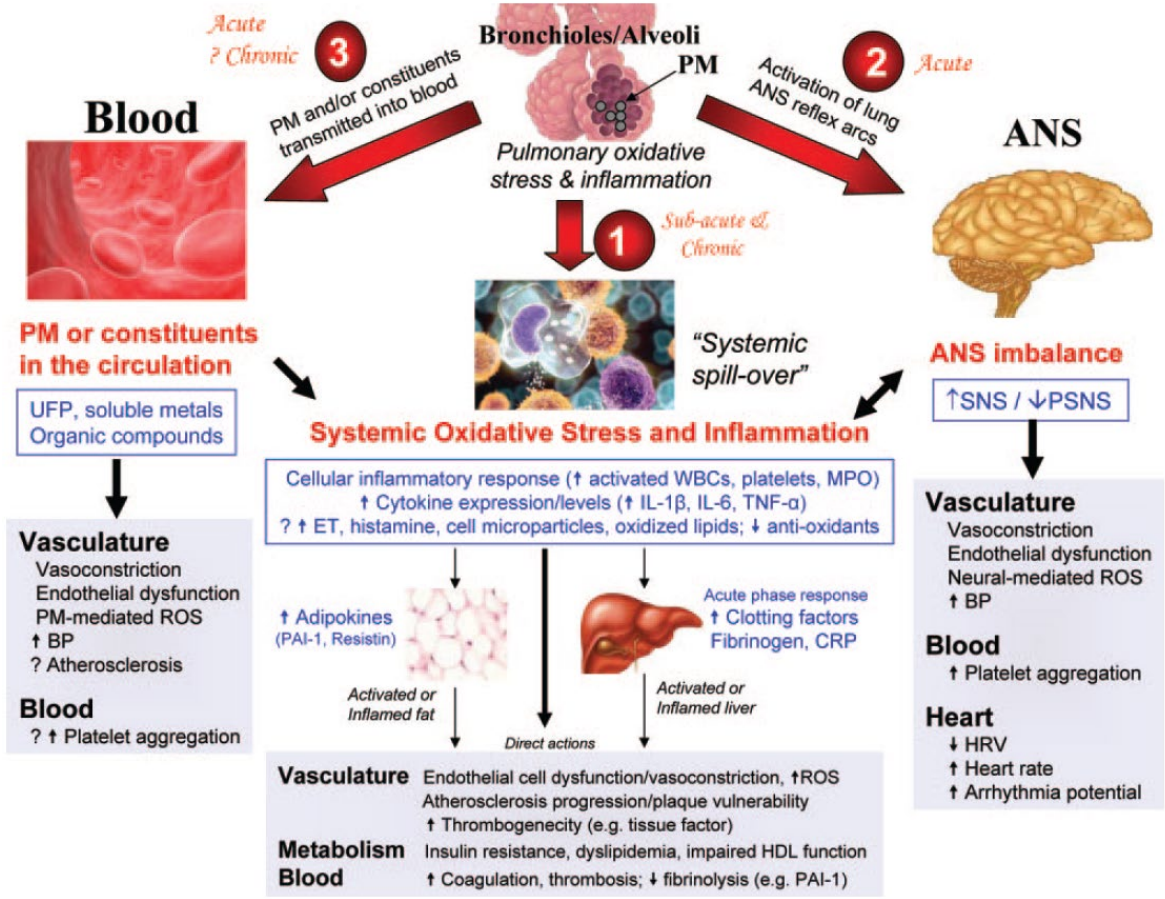


Source: CDOT

$PM_{2.5}$ Background



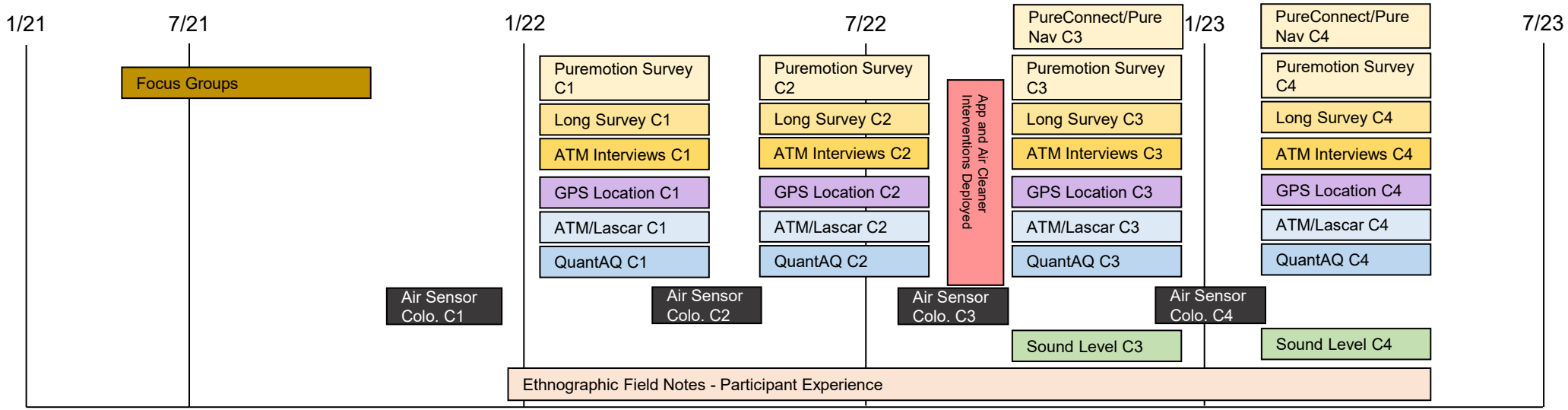
Source: [US EPA]



Source: [Brook et al. 2010, Circulation]

SJEQ-D Study Design

https://www.sjeqdenver.com/



Social Science Data Sets

- Focus Groups
- Long Survey
- Atmotube User Interviews
- Ethnographic Field Notes

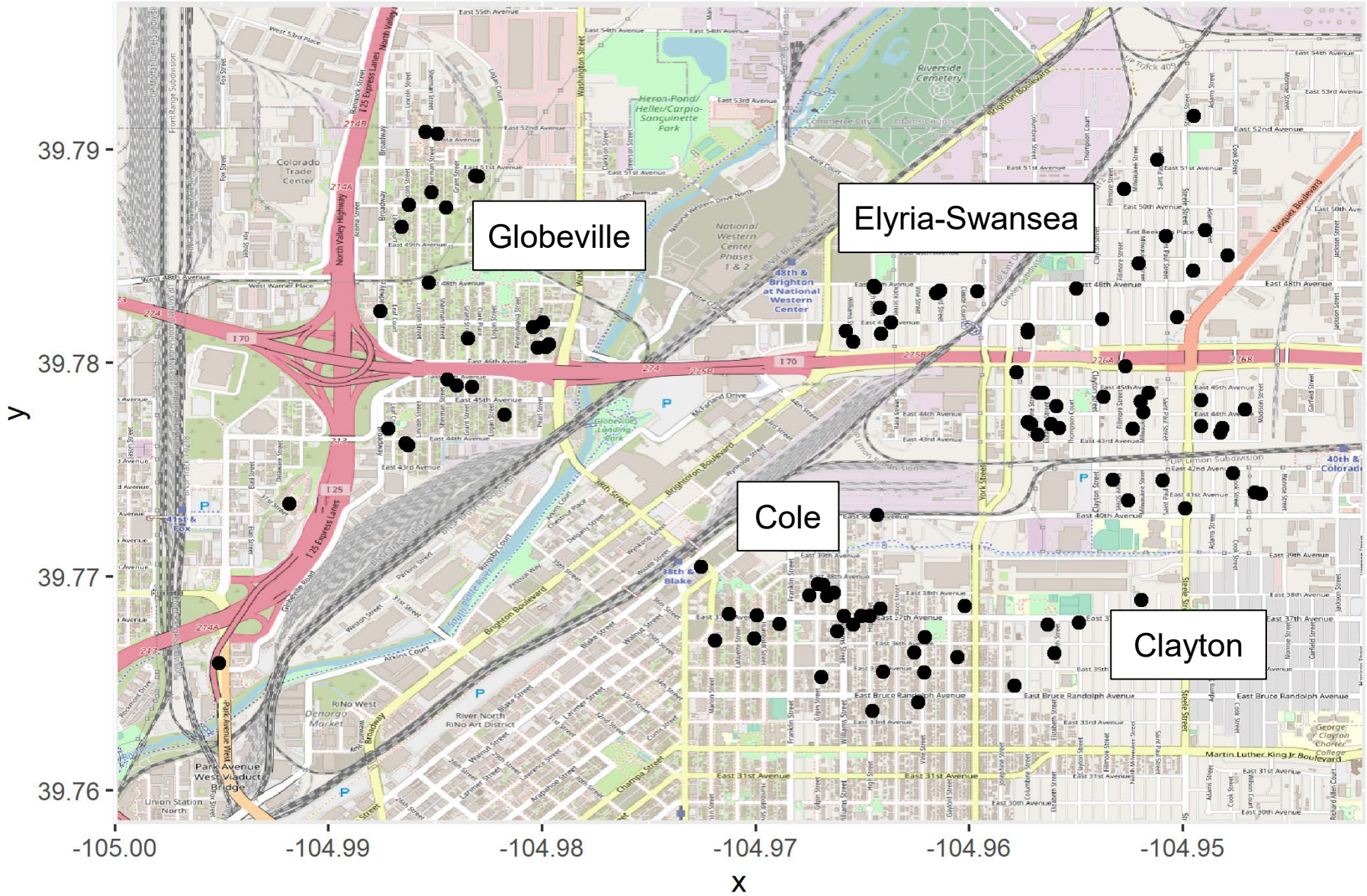
Env. Eng. Data Sets

- Atmotube Personal Exposure Monitoring
- QuantAQ Ambient Monitoring
- Sensor Colocation Testing
- Sound Level Monitoring
- DIY Air Cleaner Intervention

Tech. Data Sets

- Puremotion Surveys (EMA)
- GPS Location Tracking
- PureConnect (Slack) Participant Communication Intervention App
- PureNav (Slack) Trip Planning Intervention App

Participant Spatial Distribution



Note: Points are jittered to anonymize participant home locations

Focus Groups

Participants: 32 Residents of Globeville, Elyria-Swansea, and Cole neighborhoods

Construction Issues

- Major concerns related to traffic and road closures
- Increased time spent commuting and unanticipated delays
- Constant noise and increased dust

Health Impacts of Construction

- Increased experiences of frustration, annoyance, more daily stress, depression, anxiety
- Concerned about personal and family health and wellbeing
- Reported worsening asthma, respiratory issues, allergies, dry throat, cough, headaches

Community Belonging

- Don’t feel listened to by the city/government agencies, feeling overlooked
- Neighborhood doesn’t feel the same anymore since construction started

Focus Groups

Challenges we learned about during conversations with community collaborators:

*"Building **trust** with the community will be critical, as this community has been engaged for environmental justice research in the past, but that research has not always been to the **benefit of the community**. Some community members may be getting **burnt out** from such efforts (e.g., being over-surveyed). Community should not feel like **'test subjects'** in an experiment providing no benefit to them."*

Long Survey – Demographics (Cohort 1)

What gender do you identify as?	Frequency	Percent
Man	20	21.7%
Woman	72	78.3%
Total	92	100.00%

Age	n	Mean	Std. Dev.	Min	Max
What is your birth year?	92	1982	12	1942	2002

What is your current employment status?	Frequency	Percent
Full-time	56	59.0%
Part-time	9	9.50%
Unemployed, laid off	1	1.10%
Temporarily not working	7	7.40%
Retired	6	6.30%
Keeping house	12	12.6%
Other	4	4.10%
Total	95	100.00%

What is your highest education degree?	Frequency	Percent
Less than high school	9	9.50%
High school diploma or GED	12	12.6%
Some college, no degree	19	20.0%
Associates degree	6	6.30%
Bachelors degree	31	32.6%
Graduate degree or professional degree	18	19.0%
Total	95	100.00%

Respondent's race-ethnicity	Frequency	Percent
Non-Hispanic White	47	49.5%
Non-Hispanic Black	3	3.20%
Hispanic	37	38.1%
Other	8	8.40%
Total	95	100.00%

How much total combined income did all members of your household make last year	Frequency	Percent
0-$9,999	5	5.30%
$10,000-24,999	14	14.9%
$25,000-49,000	17	18.0%
$50,000-74,999	18	19.2%
$75,000-99,999	14	14.9%
$100,000-124,000	8	8.50%
More than $125,000	18	19.2%
Total	94	100.00%

Long Survey – Demographics/Health (Cohort 1)

What year was your home built?	Frequency	Percent
I don't know	22	24.2%
1919 or before	25	27.4%
1930s-1920s	14	15.4%
1950s-1940s	12	13.2%
1970s-1960s	2	2.20%
1990s-1980s	3	3.30%
2000 or after	13	14.3%
Total	91	100.00

Do you smoke or use vaporizers to consume tobacco, nicotine, marijuana, or other	Frequency	Percent
No	70	76.9%
Yes	21	23.1%
Total	91	100.00%

In what type of home are you living?	Frequency	Percent
Single family home	72	79.1%
Mobile home	2	2.20%
Apartment	4	4.40%
Townhome	8	8.8%
Other	5	5.50%
Total	91	100.00%

Have you or a member of your household ever been told by a doctor or other health professional that you have any of the following respiratory conditions:	Frequency	Percent
No respiratory health conditions	63	70.8%
Asthma	20	22.5%
Chronic Obstructive Pulmonary Disease (COPD)	2	2.20%
Emphysema	0	0.00%
Chronic Bronchitis	0	0.00%
Other	4	4.50%
Total	89	100.00%

Long Survey – Wellbeing (Cohort 1)

During the past 30 days, about how often did you feel-Nervous?	Frequency	Percent
None of the time	21	23.3%
A little of the time	24	26.7%
Some of the time	33	36.7%
Most of the time	7	7.80%
All of the time	5	5.50%
Total	90	100.00%

During the past 30 days, about how often did you feel-Hopeless?	Frequency	Percent
None of the time	46	53.5%
A little of the time	18	20.9%
Some of the time	18	20.9%
Most of the time	2	2.35%
All of the time	2	2.35%
Total	86	100.00%

During the past 30 days, about how often did you feel-Worthless?	Frequency	Percent
None of the time	60	68.97
A little of the time	2	2.30
Some of the time	4	4.60
Most of the time	6	6.90
All of the time	15	17.24
Total	87	100.00

During the past 30 days, about how often did you feel-That everything was an effort?	Frequency	Percent
None of the time	26	30.2%
A little of the time	4	4.60%
Some of the time	7	8.10%
Most of the time	22	25.7%
All of the time	27	31.4%
Total	86	100.00%

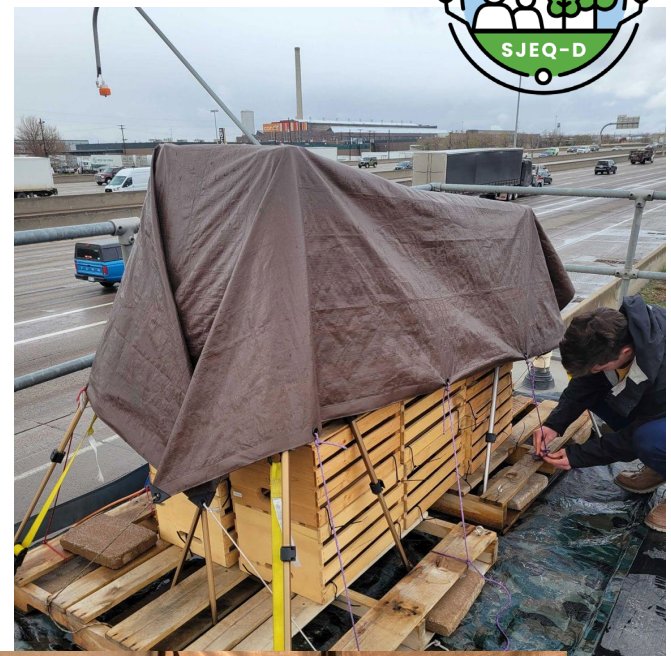
During the past 30 days, about how often did you feel-So depressed that nothing could cheer you up?	Frequency	Percent
None of the time	56	63.6%
A little of the time	1	1.10%
Some of the time	8	9.10%
Most of the time	7	8.00%
All of the time	16	18.2%
Total	88	100.00%

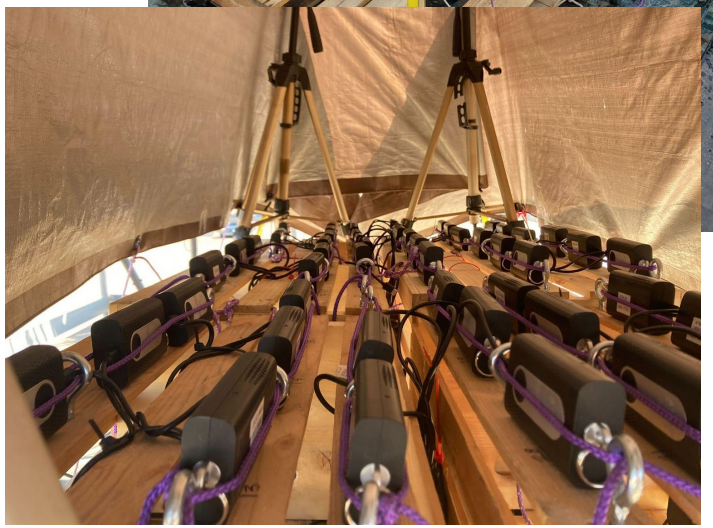
Personal Exposure Sensor Selection

- Two commercial-grade personal exposure sensors, **Flow 2 and Atmotube Pro**, were evaluated in chamber testing and via collocation with reference instruments summer 2021
- The Atmotube Pro was selected for personal exposure measurements based on:
  - Ease of use
  - App quality
  - Data availability
  - Sensor accuracy
  - Measures **PM1, PM2.5** mass concentrations via nephelometry (Sensirion SPS30)
  - Measures **total volatile organic compounds** (TVOCs) with a metal-oxide sensor (Sensirion SGPC3)
  - GPS location tracking
- We measure ambient air quality at 5 locations in the community using QuantAQs
  - Combines a nephelometer and optical particle counter to measure **PM1, PM2.5, and PM10** mass concentrations

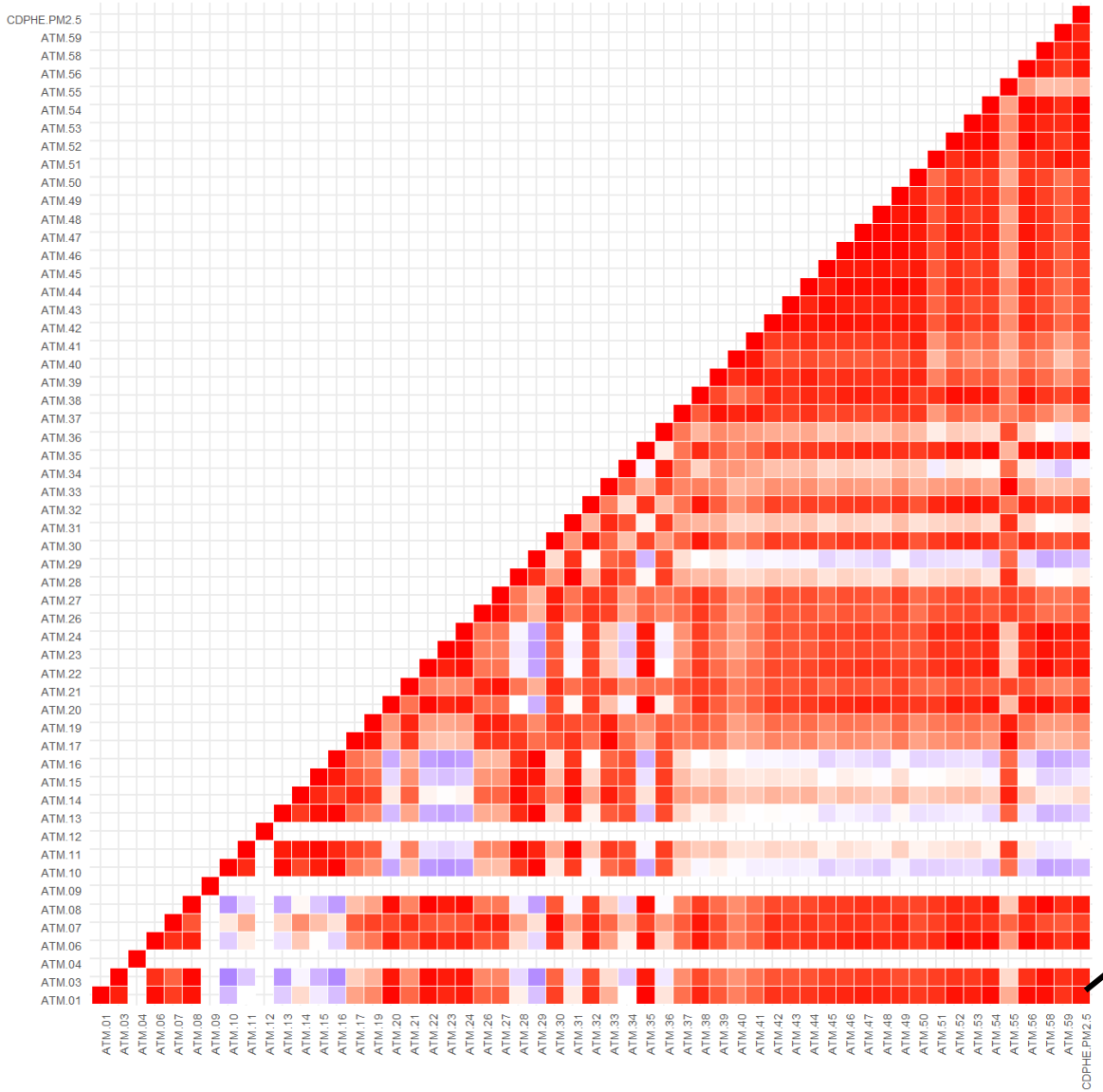
Air Sensor Colocation

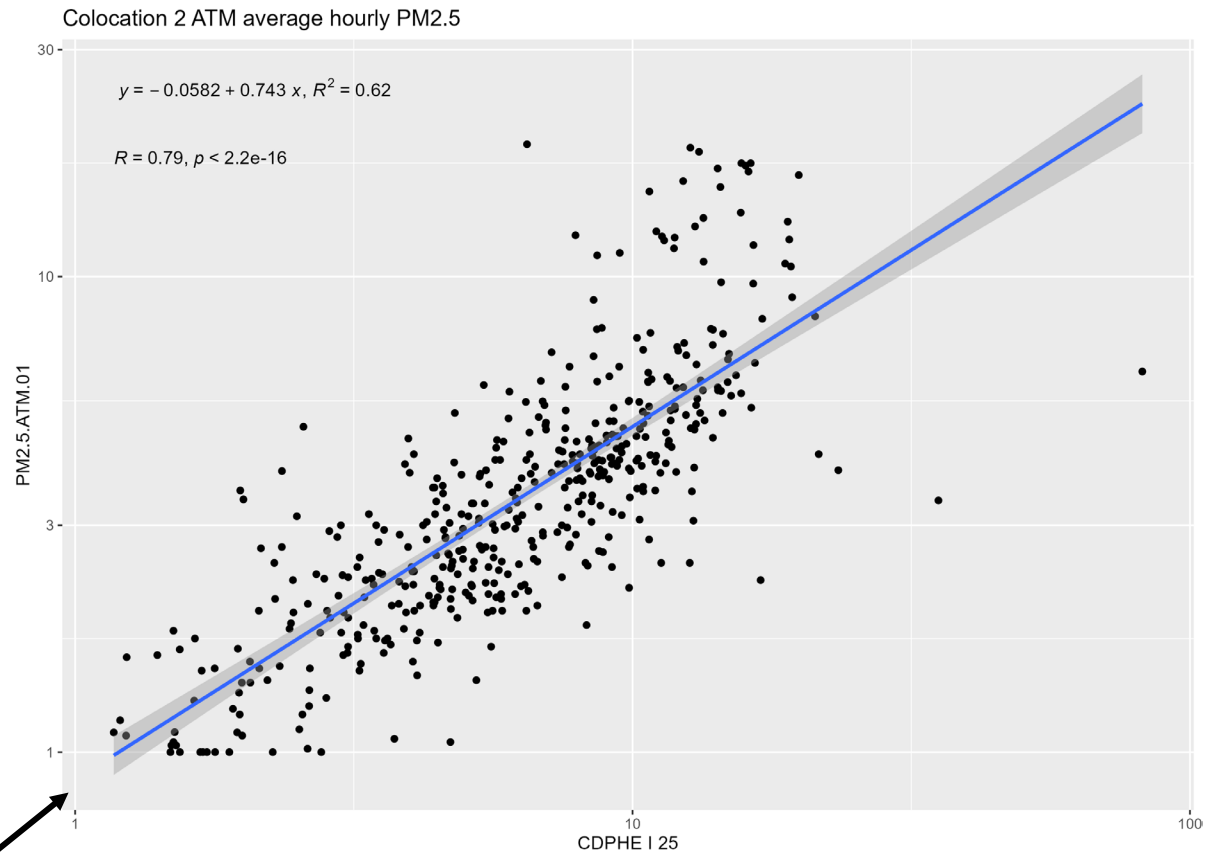
- To determine accuracy of Atmotube and QuantAQ, sensors were installed at CDPHE/DDPHE sites with reference $PM_{2.5}$ instrumentation (GRIMM EDM180) for multiple weeks
- Data are used to create calibration equations for low-cost PM sensors
- **Summer 2021: Pilot colocation** CDPHE Globeville (6 days) and Swansea Elementary and I70 (DDPHE, 4 days)
- **Fall 2021**: Colocation at CDPHE Globeville for two weeks
- **Spring 2022:** Colocation at CDPHE Globeville for three to four weeks
- **Fall 2022:** Colocation at CDPHE Globeville for four weeks
- **Winter 2023:** Colocation at CDPHE Globeville for four weeks



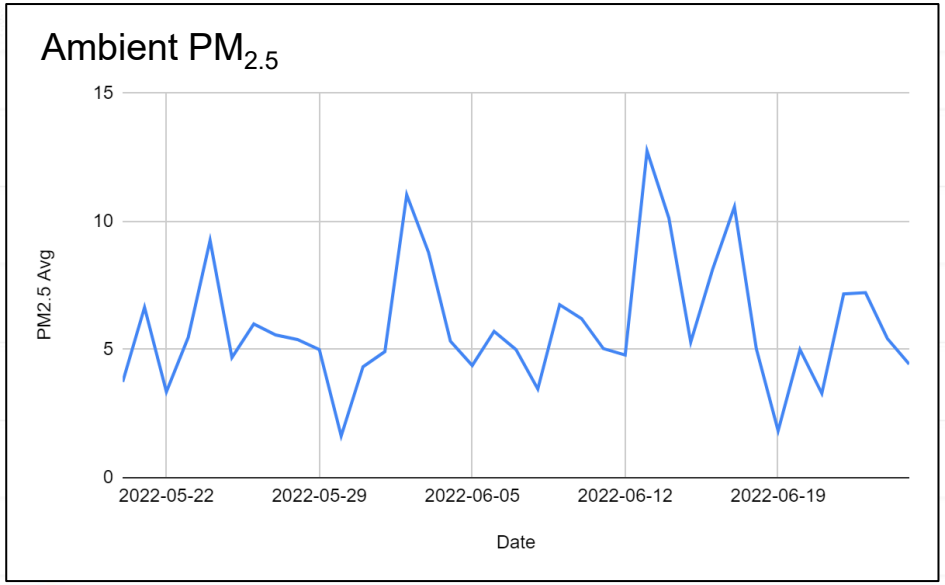


Air Sensor Colocation





Personal Exposure



Personal $PM_{2.5}$

Time
May

Avg. Pm25
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
20
21
22
23
24
25
26
27
28
29
30
31

Label
ATM-01
ATM-03
ATM-04
ATM-06
ATM-07
ATM-08
ATM-09
ATM-10
ATM-11
ATM-12
ATM-13
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ATM-51
ATM-53
ATM-55
ATM-56
ATM-57
ATM-58
ATM-59

Average of Pm25 for each Time Day broken down by Time Month. Color shows details about Label. The view is filtered on Time Month, Time Day, Exclusions (DAY(Time),Label,MONTH(Time)) and Label. The Time Month filter keeps May. The Time Day filter keeps 12 members. The Exclusions (DAY(Time),Label,MONTH(Time)) filter specifies a set. The Label filter has multiple members selected.

Personal Exposure

Your $PM_{2.5}$ Personal Exposure Data

ATM #01 User

These plots summarize your $PM_{2.5}$ personal exposure data measured by your atmotube.

Figure 1 shows your average $PM_{2.5}$ personal exposure during cohort one (January 17th-March 4th 2022), cohort two (May 20th-June 25th 2022), and cohort three (October 10th - November 10th). The horizontal axis shows the month and the vertical axis shows your average $PM_{2.5}$ personal exposure during each month in units of microgram per cubic meter ($\mu g/m^3$). Cohort three included an intervention method provided by the SJEQ team. A Do-It-Yourself (D.I.Y.) Air Cleaner was used during the third cohort to decrease the PM 2.5 levels in homes. The US EPA National Ambient Air Quality Standard for average annual $PM_{2.5}$ concentration is 12 $\mu g/m^3$.

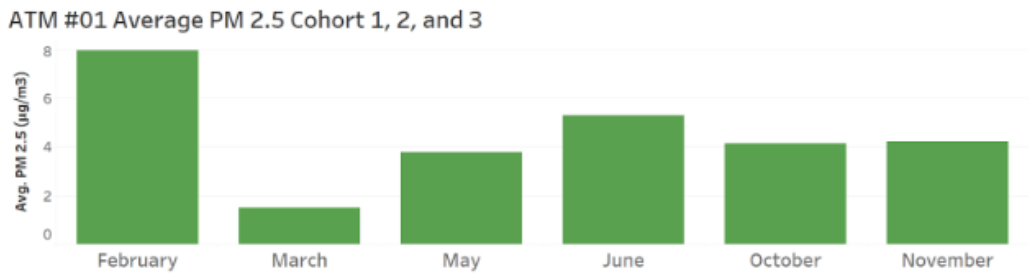


Figure 1.

Figure 2 shows your overall PM2.5 exposure during cohort one (January 17th - March 4th, 2022), cohort two (May 20th - June 25th, 2022), and cohort three (October 10th - November 10th, 2022). Individual blue circles show your daily average PM2.5 personal exposure for the days in each month you synced your Atmotube.

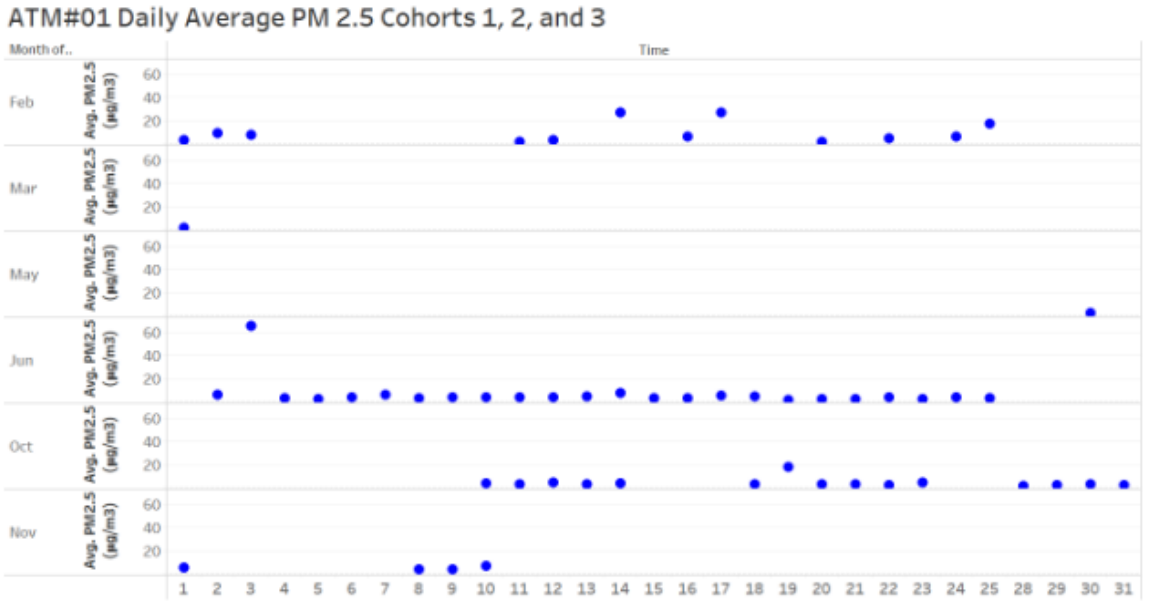
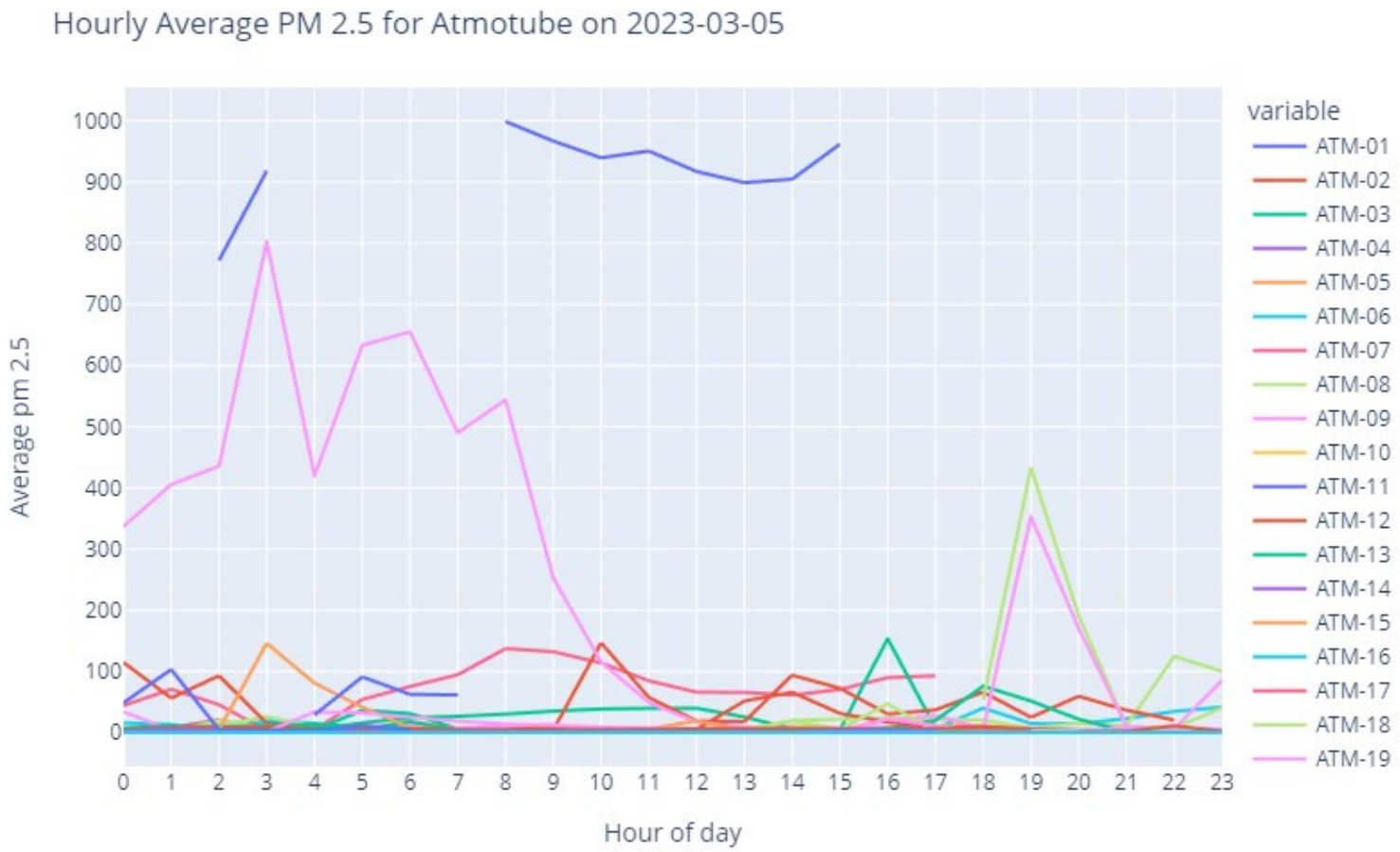


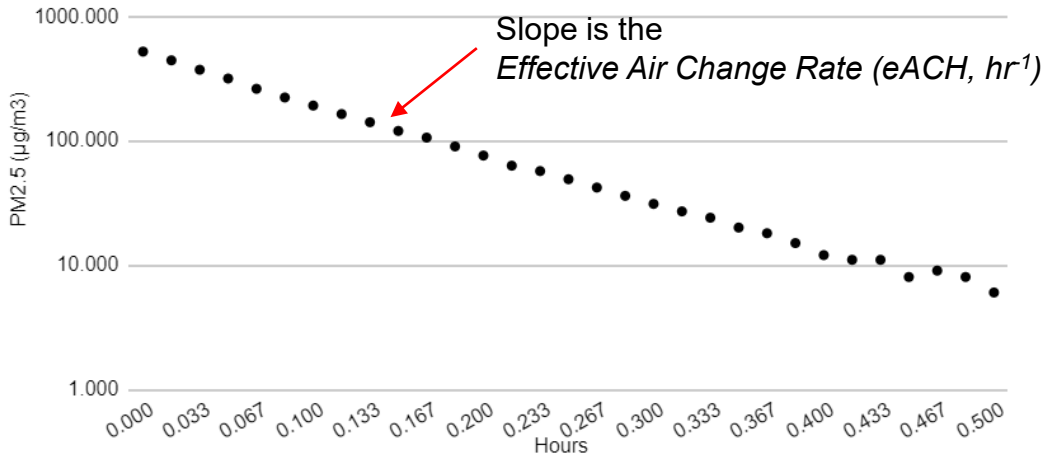
Figure 2.

Personal Exposure

Real-Time Personal Exposure Data Reporting:
https://www.sjeqdenver.com/airsensordashboard



DIY Air Cleaner Intervention



	1-MERV13 Filter, 20x20x1" (shroud)	1-MERV13 Filter, 20x20x2" (shroud)	1-MERV13 Filter, 20x20x4" (shroud)	1-MERV13 Filter, 20x20x4" (no shroud)	2-MERV13 Filters, 20x20x2" (shroud)	4-MERV13 Filters, 20x20x2" (shroud)
CADR ($PM_{2.5}$) [ft^3/min]	108 😩	127 😐	127 😐	149 🙂	230 😄	415 😄
Ease of Build	Medium 🙂	Medium 🙂	Medium 🙂	Easiest 😁	Hardest 😩	Hard 😐
Size	Small 😁	Small 😁	Small 😁	Small 😁	Medium 🙂	Large 😩
Initial (Annual) Cost ($)	$59 ($20) 😁	$65 ($32) 😄	$72 ($46) 🙂	$72 ($46) 🙂	$81 ($64) 😐	$113 ($184) 😩
CADR/Initial Cost [ft^3/min-$]	1.8 😐	2.0 🙂	1.8 😐	2.1 🙂	2.8 😄	3.7 😄
CADR/Annual Cost [ft^3/min-$]	5.4 😁	4.0 😄	2.8 😐	3.2 🙂	3.6 😄	2.3 😩

Atmotube Interviews

Participants: 30 of 50 Atmotube users in Cohorts 1 and 2, 22 of which were involved in both cohorts

Interview Design: Seminstructured interview guide developed asking about:

- Motivation to carry the sensor
- How they used/interpreted data
- What they expected to learn vs. what they actually learned
- Feelings regarding their personal environment before and after using the sensor
- Whether they changed their behaviors, environments, or routines after using the sensor
- Difficulties encountered using the sensor
- Feedback about participating in a community science project using a sensor

Atmotube Interviews

Air Quality Sensors Build Pollution Exposure Awareness:

- Rationales for joining study included seeking a baseline understanding of exposure, being a community scientist, or being a health-concerned activist
- Participants wanted to use the Atmotube to measure contamination and get real-time data to know just how bad the air was, conduct community science, and investigate a pollution-related health concern
- 71% of participants said the main benefit of carrying the sensor was building awareness about air pollution exposure in relation to health
- Participants found value in sensor due to increased consciousness about invisible sources of air pollution

Air Quality Sensors Validate/Invalidate Residents' Sensory Experiences

- Participants were able to access and understand sensor data from the Atmotube app regardless of scientific literacy
- Color-coded air quality visuals in the app helped participants without prior air quality knowledge understand their data
- 50% of participants used the app's "air quality score" to frame their understanding of air pollution exposure

Atmotube Interviews

Community Science Experimentation:

- Participants conducted two types of self-directed experiments with their sensors:
  - General exploratory experiments that revealed unexpected sources of poor air quality
  - Experiments performed with the intent of validating specific concerns

  Example: An Elyria-Swansea resident first explored the conditions in their backyard greenhouse, noting a rise in temperature. Then they started to notice that when they smoked marijuana inside, their air quality significantly degraded. This was a surprise to the resident, as they thought marijuana smoke was safer than tobacco smoke.

Air Quality Sensors Support Decision Making/Behavioral Change

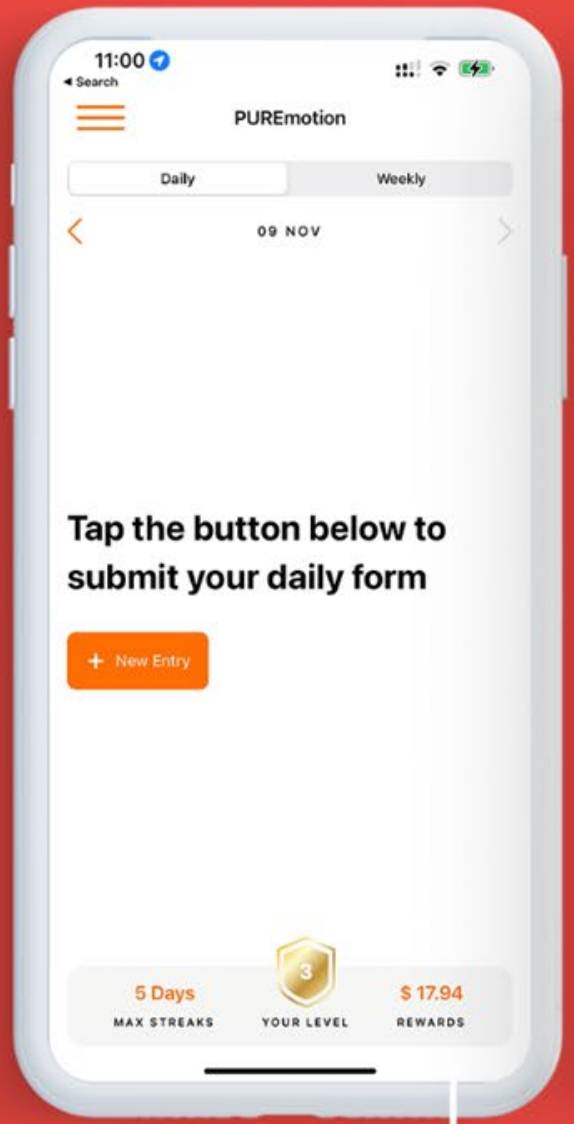
- 50% of participants adopted exposure mitigation behaviors when identifying poor air quality with the sensors, and were often able to identify sources of poor air quality (e.g., cleaning products, smoking)
- Behavior changes included: running humidifiers/air cleaners, running the house fan, cleaning ducts, replacing HVAC filters, closing windows, installing better windows
- 40% of participants adopted protective behaviors, such as going outside when outdoor air was better than indoor air, traveled to locations in neighborhood with lower air pollution

Atmotube Interviews

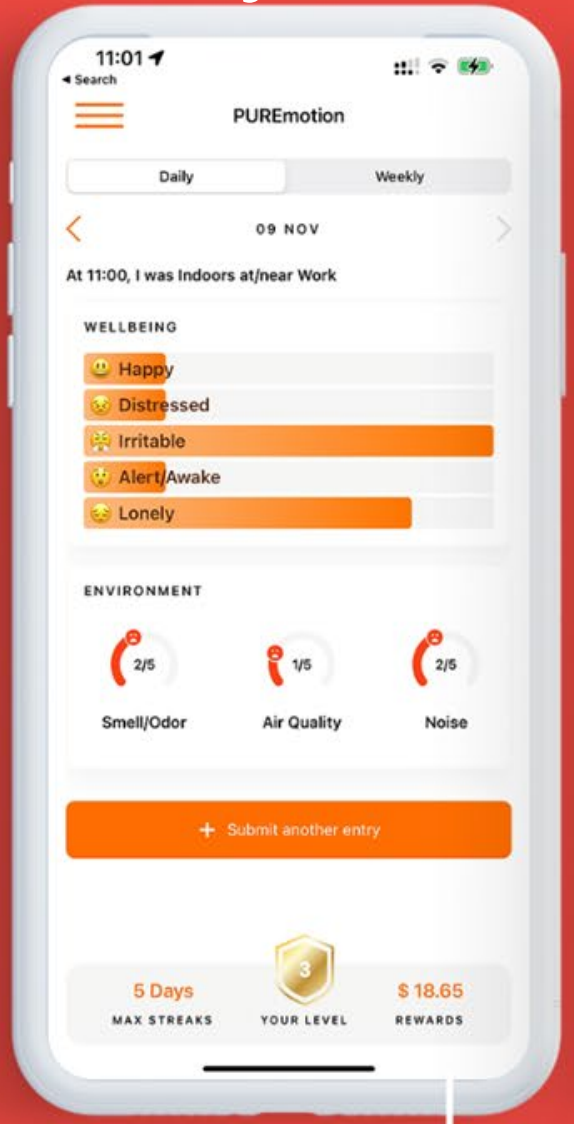
Air Quality Sensor Limitations:

- 14/38 residents did not report behavior changes, reasons included measuring good air quality, feeling powerless to change the situation
- 6/38 residents expressed not knowing what to do to improve air quality
- Four residents reported that they wanted what the sensor alone could not provide, specific guidance on next steps to improve air quality
- Knowledge of air quality gained using a personal sensor was valuable for the individual, but this potentially narrows the scope of residents' environmental action in the community

Puremotion Surveys

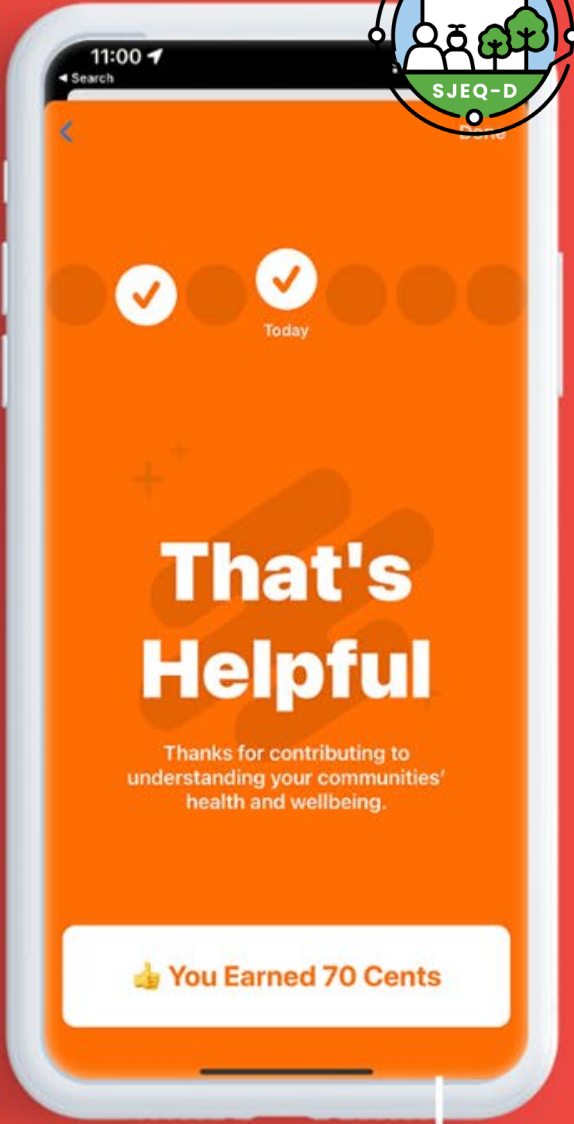


Data Collection



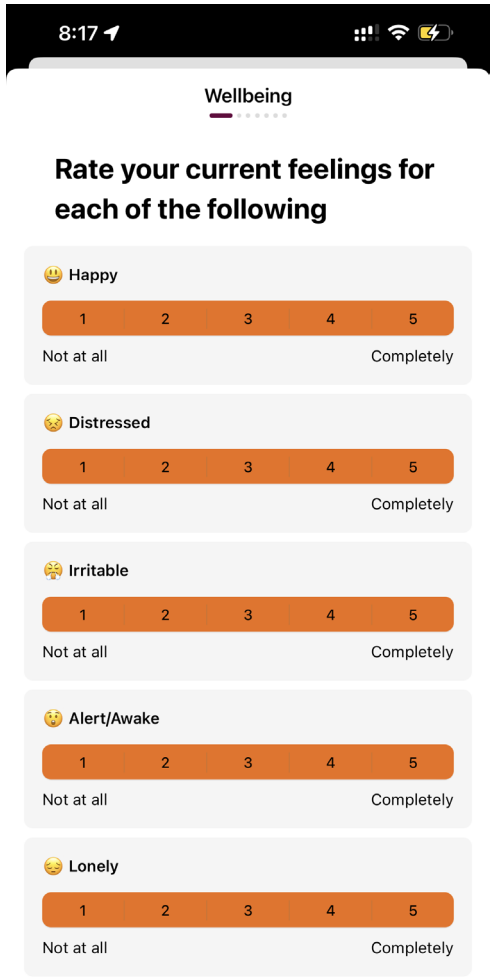
Daily Data

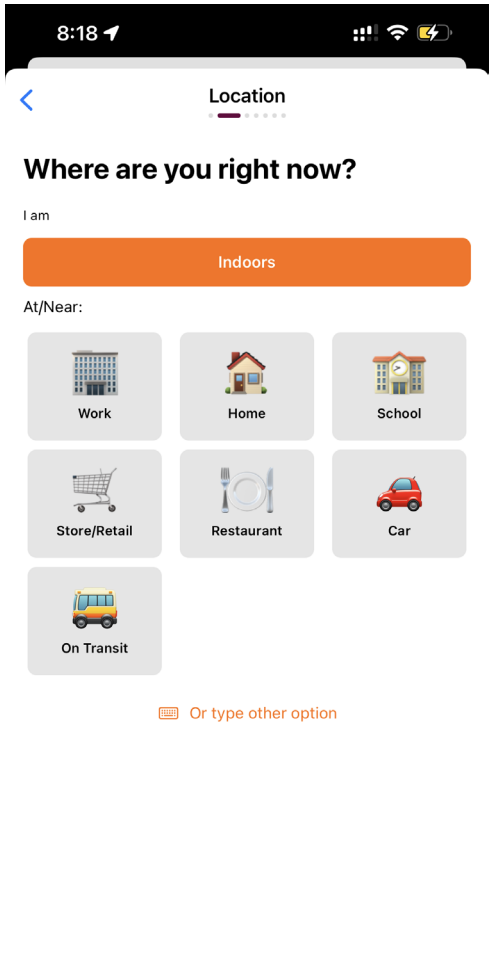
Weekly Data

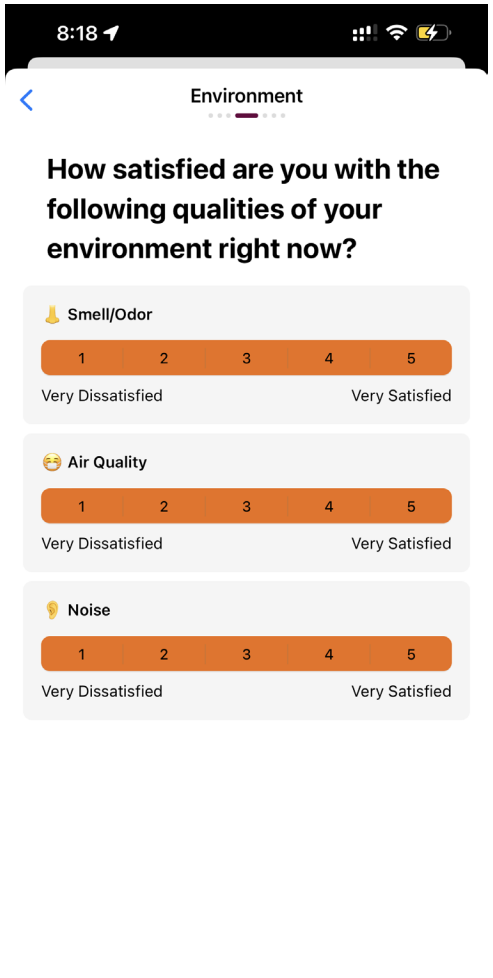


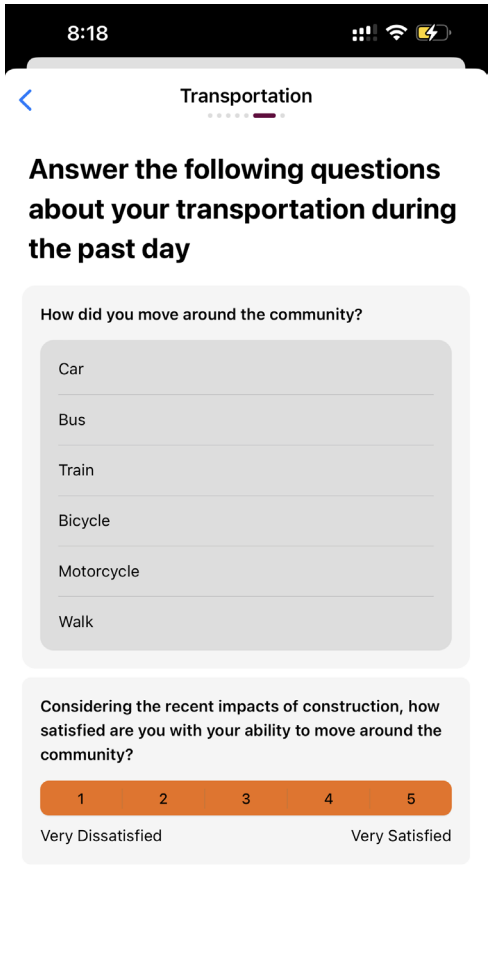
Data Streaks

Puremotion Surveys









Puremotion Surveys

cohort Place	1(%)	2(%)
Home Indoors	71.66	65.79
Work Indoors	8.23	10.06
Home Outdoors	3.24	9.33
Work Outdoors	1.39	2.23
Car Indoors	1.90	1.29
Walk/Bike Outdoors	1.39	1.46
Busy Road/Traffic Outdoors	1.54	1.29
Walk/bike Outdoors	0.51	1.33
Restaurant Indoors	1.39	0.60
Store/Retail Indoors	1.03	0.64

Table 4: Places of entries submission

Hours spent Outside	Cohort 1(%)	Cohort 2(%)
0-1 hours	63.94	40.27
2-3 hours	26.24	39.08
4-6 hours	5.73	13.13
More than 6 hours	4.09	7.52

Table 5: Number of hours spent outside

Note: Scale transformed to -1 to 1

Cohort	Happy	Distressed	Irritable	Alert/Awake	Lonely
1	0.627	-0.681	-0.732	0.398	-0.666
2	0.627	-0.633	-0.679	0.335	-0.723

Table 3: Average feelings levels

Satisfaction (/5) cohort	Air Quality	Noise	Smell/Order
1	0.301	0.337	0.336
2	0.161	0.135	0.242

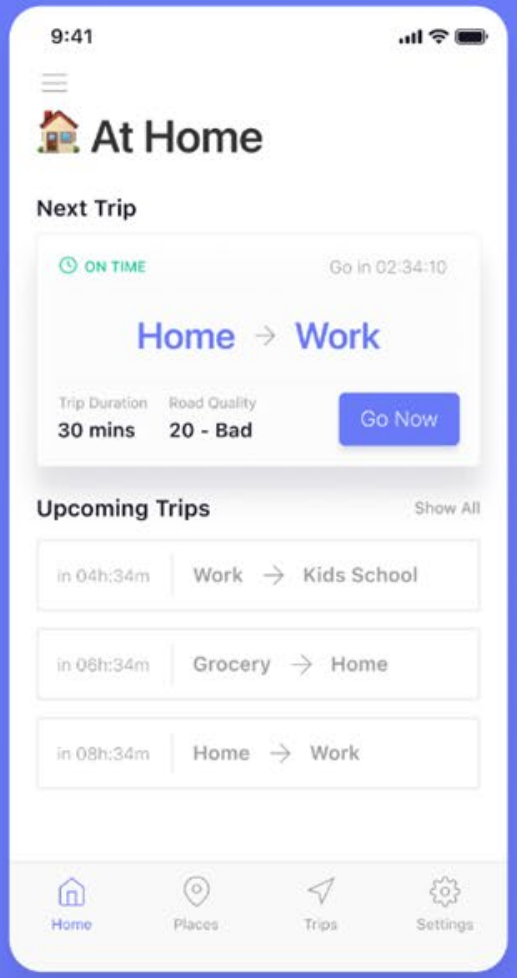
Table 6: Satisfaction with environmental qualities

cohort	1		2	
	count	(%)	count	2 (%)
Smell/Odor	558	27.31	760	19.41
Dustiness	401	19.63	803	20.51
Allergies	330	16.15	836	21.35
Temperature	309	15.12	554	14.15
Mustiness	209	10.23	350	8.94
Smokiness	135	6.61	319	8.15
Visibility	101	4.94	294	7.51
Total Reports	2043		3916	

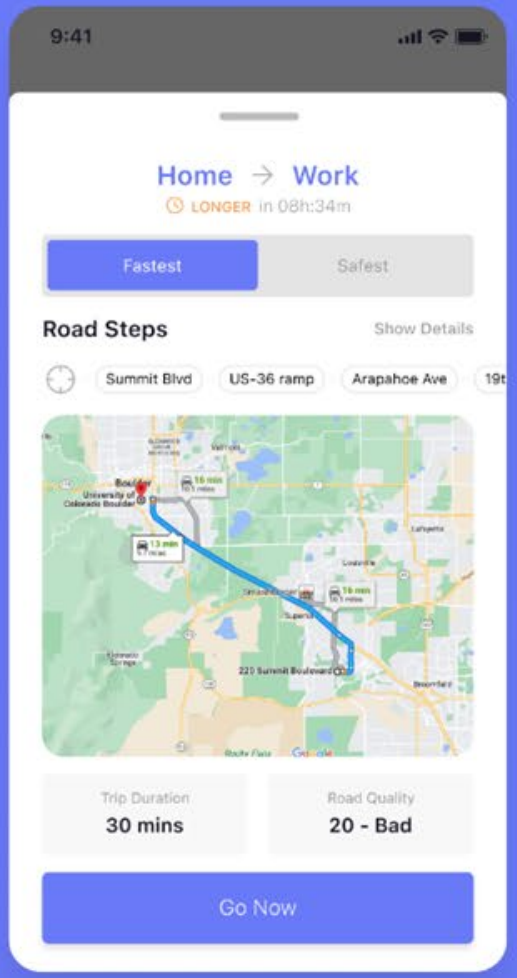
Table 7: Air Quality Complaints

Purenav Trip Planner

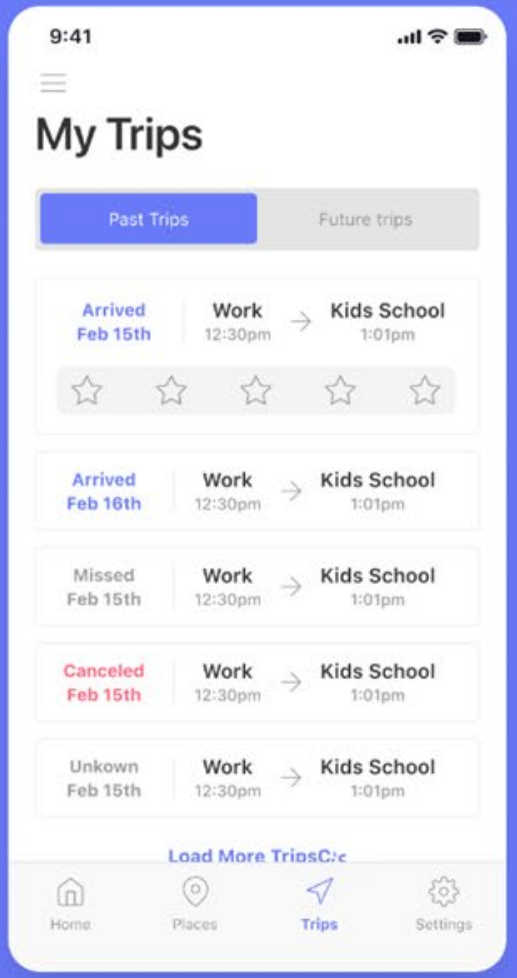
Home



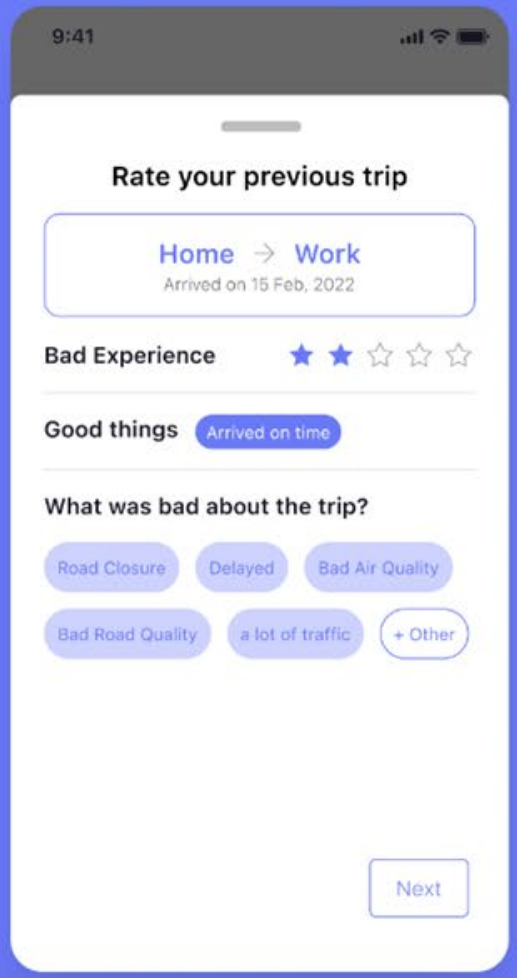
Trip Preview



Past Trips

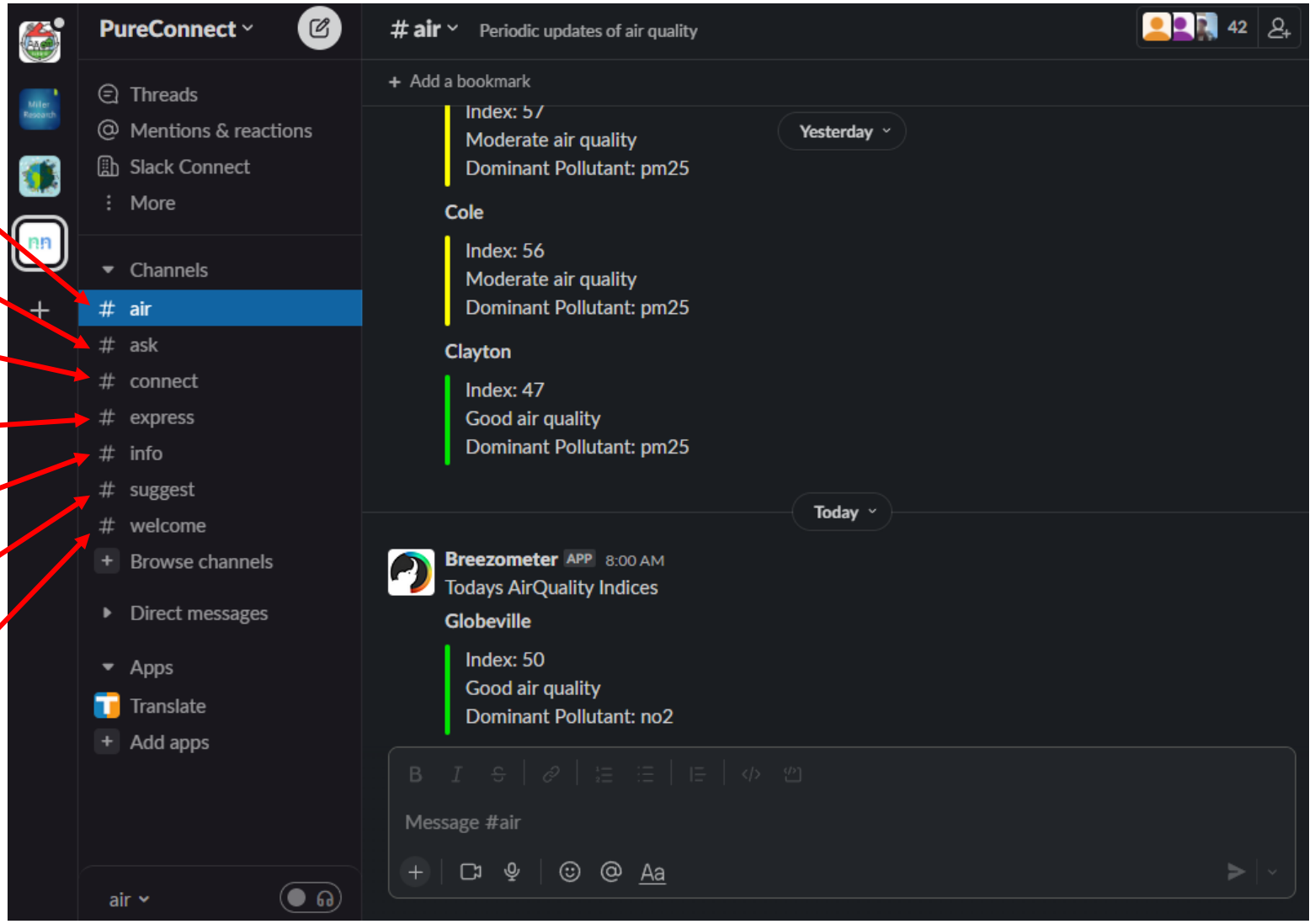


Rate a trip



Pureconnect

- Daily neighborhood air pollution data
- Ask research team questions and chatbot
- General discussion between participants
- Express concerns related to construction
- Daily road status information for region
- Suggestions for mitigating issues
- PureConnect introduction and channel information

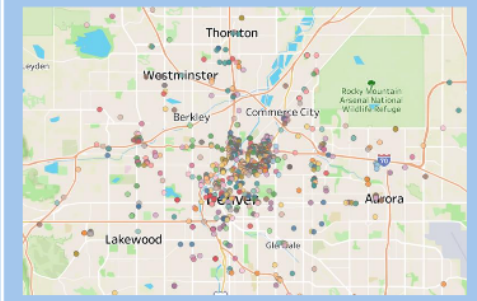


Community Reporting

SJEQ-D Study Summary for Cohorts 1 & 2

The Social Justice and Environmental Quality – Denver (SJEQ-D) study is working to improve indoor air quality in the Denver communities of Globeville, Elyria-Swansea, Cole, and Clayton.

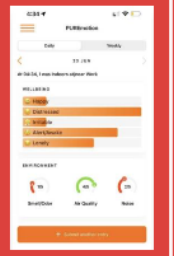
Thank you to the **88 community scientists** from Cohort 1 in winter 2022 and the **97 participants** from Cohort 2 in summer 2022!



Residents have been submitting answers about daily activities and health/wellbeing through PUREmotion, a smartphone app. This map shows where users have been submitting their entries, which helps our research team understand air quality both in the neighborhoods of study as well as in comparison to other parts of the Denver Metro area.

Participants have submitted around **2,000 entries per cohort** in PUREmotion! From that data, we have learned that:

- Participants from Cohort 1 on average rated smell odor as 2.45 out of 5, air quality as 2.37 out of 5, and noise as 2.45 out of 5
- Participants from Cohort 2 on average rated smell odor as 2.31 out of 5, air quality as 2.19 out of 5, and noise as 2.17 out of 5
- Car is the most popular transportation choice, followed by walking
- Dustiness was the top reported air quality concern
- Users reported more allergy symptoms during summer than winter



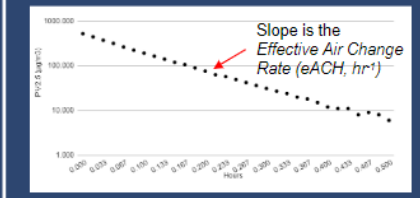
Cohort/Emotion	Cohort 1	Cohort 2
Happy	2.89	2.86
Irritable	0.85	0.91
Distressed	0.96	1.01
Alert/Awake	2.52	2.49
Lonely	0.84	0.76

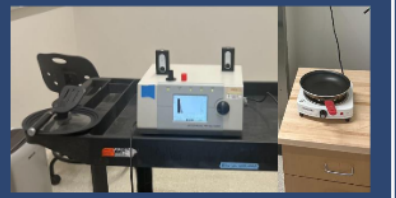
Emotional Index

The table on the left represents the average answer to each emotion reported within the PUREmotion app for each cohort (on a scale where **0** is not at all and **5** is completely). Looking at this information about emotions across different cohorts alongside the reported experiences of construction disruption will help us analyze whether there are any impacts on wellbeing.

DIY Air Cleaner Design for North Denver Communities

The Social Justice and Environmental Quality – Denver (SJEQ-D) study is working to improve indoor air quality in the Colorado communities of Globeville, Elyria-Swansea, Cole, and Clayton. Do-it-yourself (DIY) solutions using box fans and furnace filters taped together are a low-cost option for effective air cleaning. We studied DIY air cleaner designs to optimize air cleaning capacity, reduce cost, and minimize build time and physical size.





The clean air delivery rate (CADR), or the volume of clean air produced per minute by an air cleaner, was measured to assess the effectiveness of different designs. The figure above on the right shows the testing facility.

To measure the CADR, we first estimated the effective air changes per hour (eACH) of particulate matter removal provided by each air cleaner in a test room at the University of Colorado Boulder. We filled a test room with cooking pollution from frying a hamburger in canola oil. We measured how fast each air cleaner design reduced $PM_{2.5}$ concentrations using two Atmotube Pros and calculated the eACH from the slope of the removal curve (see figure above).

We then calculated CADR for each design: **CADR = Test Room Volume [1366 ft³] x eACH [hr⁻¹] / 60 [min/hr]).**

We tested six air cleaner designs with 20x20" MERV13 filters: a 4-filter cube, a 2-filter triangle, and 1-filter designs with filters of differing depths (4", 2", 1"). A fan shroud was used in some designs, intending to improve efficiency. In the table below we compare CADR, ease of build, size, and cost of our designs to determine the best one for North Denver communities. Initial costs include the price of the fan ($49) and filters, and annual costs include the price of changing the filters every 6 months.

	1-MERV13 Filter, 20x20x1" (shroud)	1-MERV13 Filter, 20x20x2" (shroud)	1-MERV13 Filter, 20x20x4" (shroud)	1-MERV13 Filter, 20x20x4" (no shroud)	2-MERV13 Filters, 20x20x2" (shroud)	4-MERV13 Filters, 20x20x2" (shroud)
CADR ($PM_{2.5}$) [ft³/min]	108	127	127	149	230	415
Ease of Build	Medium	Medium	Medium	Easiest	Hardest	Hard
Size	Small	Small	Small	Small	Medium	Large
Initial (Annual) Cost ($)	$59 ($20)	$65 ($32)	$72 ($46)	$72 ($46)	$81 ($64)	$113 ($184)
CADR/Initial Cost [ft³/min-$]	1.8	2.0	1.8	2.1	2.8	3.7
CADR/Annual Cost [ft³/min-$]	5.4	4.0	2.8	3.2	3.6	2.3

OPTIMAL AIR CLEANER DESIGN

We chose the **1-filter design using a 20x20x4" MERV13 filter and no fan shroud**. The 1-filter designs are less time consuming to build, take up less space in a room, and have lower initial and annual costs. Of the 1-filter designs, the 4" filter depth had the highest CADR. Activated carbon was added to the design to remove volatile organic compounds (VOC's) and ozone.
For comparison, a Coway Airmega AP-1512HH ($197) air cleaner provides a CADR of 233 ft³/min for smoke (1.2 ft³/min-$ CADR/initial cost) with $115/year of filter replacement costs (1.9 ft³/min-$ CADR/annual cost).

Odor Assessment Studies in North Denver

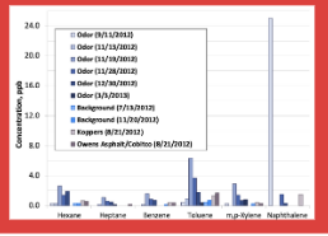
Local residents are key resources in identifying odors. Combining odor identification by residents with chemical monitoring can be useful in identifying odor sources and taking action. Our study goal was to combine these methods to **assess industrial odors in the northern part of the Denver** metropolitan area, which has many factories and two major highways mixed with residential areas. Many health complaints from north Denver residents related to **strong industrial odors have been recorded**, including suffering from burning eyes and throat, headaches, skin irritation, coughing and breathing difficulties.

Based on our work, a regional cooperation to reduce odor problems in North Denver was highly recommended. After completion of our first study in 2016, Dr. Shelly Miller participated in the advisory board to the Denver Department of Public Health and Environment (DDPHE) to develop an **updated odor ordinance**. Instead of relying on an inspector and a scentometer, **they now require specific industries to develop and submit an odor control plan**, including marijuana growers and pet food manufacturers. Also, **a facility must submit a plan if DDPHE has received five or more complaints** from individuals from separate households or businesses within a 30-day period.

Study 1: Tar odors: measuring contaminants and identifying sources

What we did: In response to complaints of a tar odor, we worked with Groundwork Denver on a study in the Globeville community in 2012-2015. Our work was funded by an EPA Environmental Justice Grant. Efforts to identify the odor and its potential sources included a door-to-door survey, meteorological correlations, and air quality sampling for volatile organic compounds (VOCs), sulfur gases, and polycyclic aromatic hydrocarbons (PAHs).

Odor, background, and industrial sample concentrations of compounds detected in air during Study 1.



What we learned: The area has industrial sources of harmful tar odors and we measured high levels of naphthalene, a carcinogen. The study recommended a more detailed investigation to explain the effects of odors in communities, to assess the relationship between odor exposure and well-being, and to understand the effect of odor mixtures.

Middle School Summer Camp Outreach

1: What is environmental injustice and how do you describe experiencing it in your community?

Day 1, Tuesday 8/2

1. Introduction to EJ
2. Mapping intro
3. Photo-journaling

2: What tools are available to measure and solve the problem of poor air quality?

Day 2, Wednesday 8/3

1. Introduction to air quality
2. Instrument demos
3. Build particle sensors

Day 3, Thursday 8/4

1. Introduction to IAQ
2. Build air cleaner
3. Air cleaner testing

3: How does science get communicated in a way that makes change happen?

Day 4, Friday 8/5

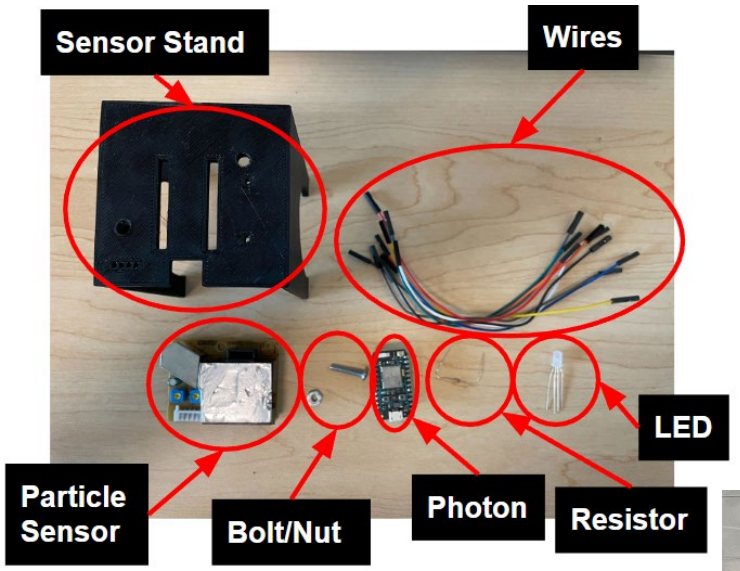
1. Intro to science communication and policy making
2. Air quality campaign prep
3. Open activities w/ sensors, air cleaners, etc.

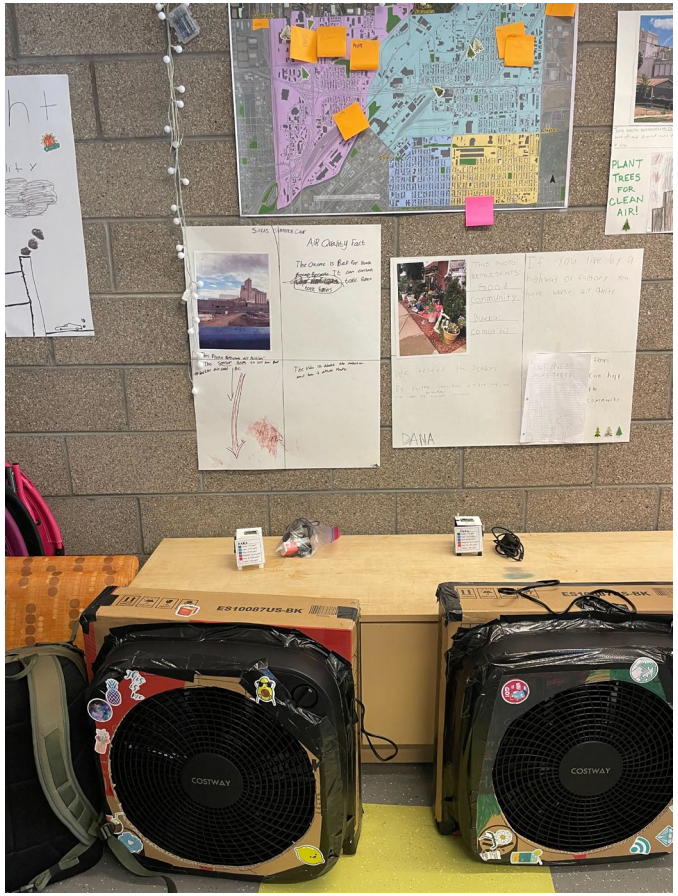
4: How does science get communicated in a way that makes change happen?

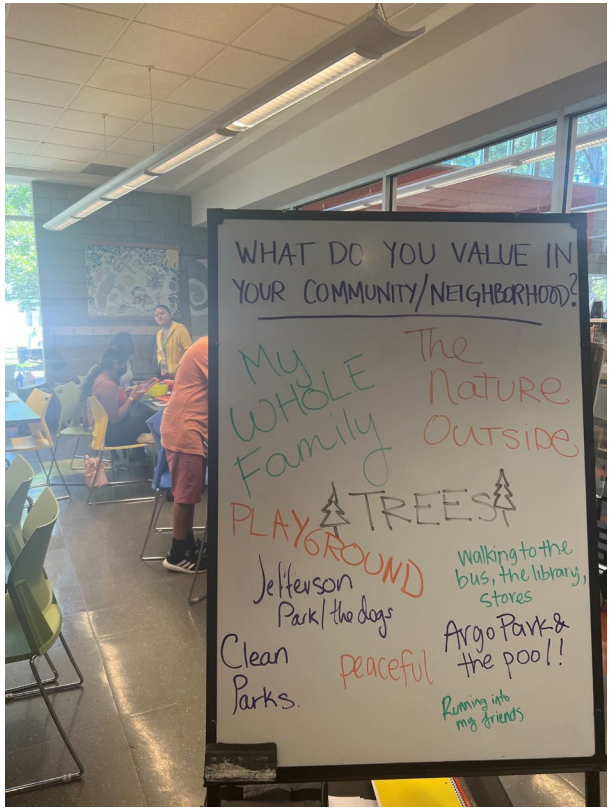
Day 5, Saturday 8/6

1. Museum-style presentations
2. Show off air cleaners & sensors
3. Communicate science to community

Middle School Summer Camp Outreach







Next Steps

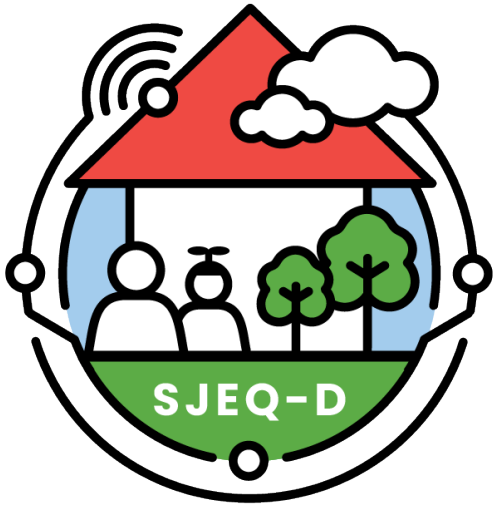
- Complete data collection, cohort 4 runs through the end of March
- Complete data processing and simple analysis
- Analyze intervention app use
- Process exposure data to microenvironments (home, work, etc.)
- Analyze air cleaner effectiveness
- Pursue linear modeling between surveys and exposure data
- Pursue spatial modeling of surveys and exposure data
- Share findings with the community and policy makers
- Run second summer camp in 2023

Thank you!

Questions?

University of Colorado Boulder

Denver
CU IN THE CITY



https://www.sjeqdenver.com/

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