Use of Low-cost Sensors to Empower Nail Salon Workers to Reduce Exposures

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Goals

- Discuss regulations implemented by NYS to control exposure and the scope of the problem

- Review commercially available low-cost MOS to quantify TVOCs concentrations

- Describe the validation procedure and preliminary results

- Summarize the results of interventions to reduce exposure

Scope of the Problem

- Large contingent of nail salon workers in the tristate area
- Workplace exposures are well understood and characterized
- Ventilation controls are effective and are mandated by NYS
- Still, exposures are high due to lack of compliance with regulations
- Could low-cost sensors incorporated within nail salons reduce workers exposure?

Nail Industry in NYC

- NYC approximately 2,000 nail salons
  - 800 salons located in Manhattan alone

- NYC metropolitan area has the highest number of nail salon workers in the US with 23,000
  - Underestimated

- Significant source of business revenue and employment for Korean, Chinese, Vietnamese, and Nepalese immigrants
  - Limited English language skills and employment options

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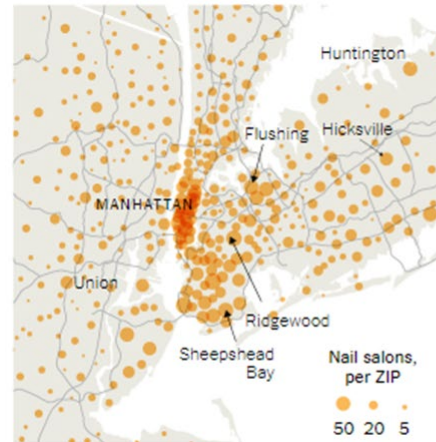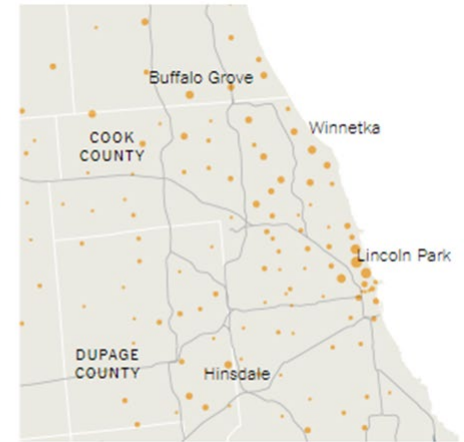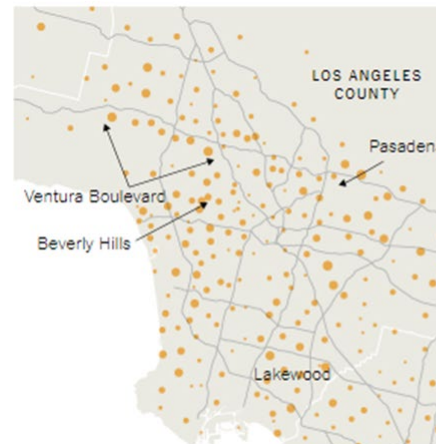
Workplace Profile

- Median annual salary:
  - Workers on average earn $31,200.
  - 10% of workers earn $29,990 or less.
  - 10% of workers earn $42,880 or more.
- Studies have found most exposures are below occupational exposure limits
  - Formaldehyde
- Mixture
  - Additive or synergistic health effects
- Health and safety may by either ignored or unknown by management

Mixture Exposure in Nail Salons

- Chemicals commonly found in nail salon products include carcinogens (formaldehyde), endocrine disruptors (phthalates), teratogens (toluene), sensitizers (methacrylate), and respiratory irritants (acetone, acetonitrile, and isopropyl acetate)

- Dust

- Secondary formation of ultrafine particles

- Ergonomic issues

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Health Effects from Nail Salon Work

- **Respiratory issues**
  - Asthma and other respiratory illnesses such as coughing, wheezing, difficulty breathing or shortness of breath
- **Skin disorders**
  - Allergic contact dermatitis
- **Other health issues**
  - Liver disease, reproductive loss, and cancer can be caused by chemicals in products like glues, polishes, and removers.
- **Musculoskeletal disorders**
  - Repetitive movements and awkward postures
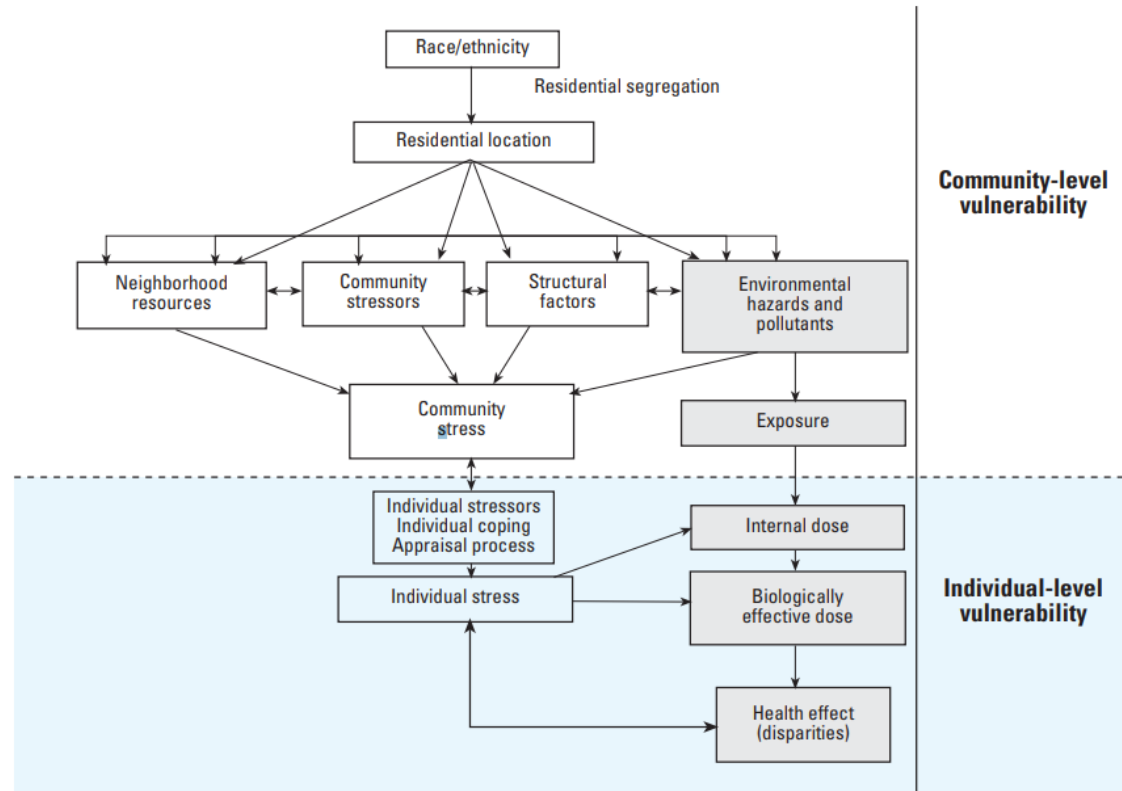
Gee, Gilbert C., and Devon C. Payne-Sturges. "Environmental health disparities: a framework integrating psychosocial and environmental concepts." *Environmental health perspectives* 112.17 (2004): 1645-1653.

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New York Times Investigative Reports

The Price of Nice Nails

Manicurists are routinely underpaid and exploited, and endure ethnic bias and other abuse, The New York Times has found.

By SARAH MASLIN NIR   MAY 7, 2015

한국어 읽기 | 点击查看本文中文版 | Leer en español

The women begin to arrive just before 8 a.m., every day and without fail, until there are thickets of young Asian and Hispanic women on nearly every street corner along the main roads of Flushing, Queens.

As if on cue, cavalcades of battered Ford Econoline vans grumble to the curbs, and the women jump in. It is the start of another workday for legions of New York City's manicurists, who are hurtled to nail salons across three states. They will not return until late at night, after working 10- to 12-hour shifts, hunched over fingers and toes.

On a morning last May, Jing Ren, a 20-year-old who had recently arrived from China, stood among them for the first time, headed to a job at a salon in a Long Island strip mall. Her hair neat and glasses perpetually askew, she clutched her lunch and a packet of nail tools that manicurists must bring from job to job.

UNVARNISHED

Articles in this series are examining the working conditions and potential health risks endured by nail salon workers.
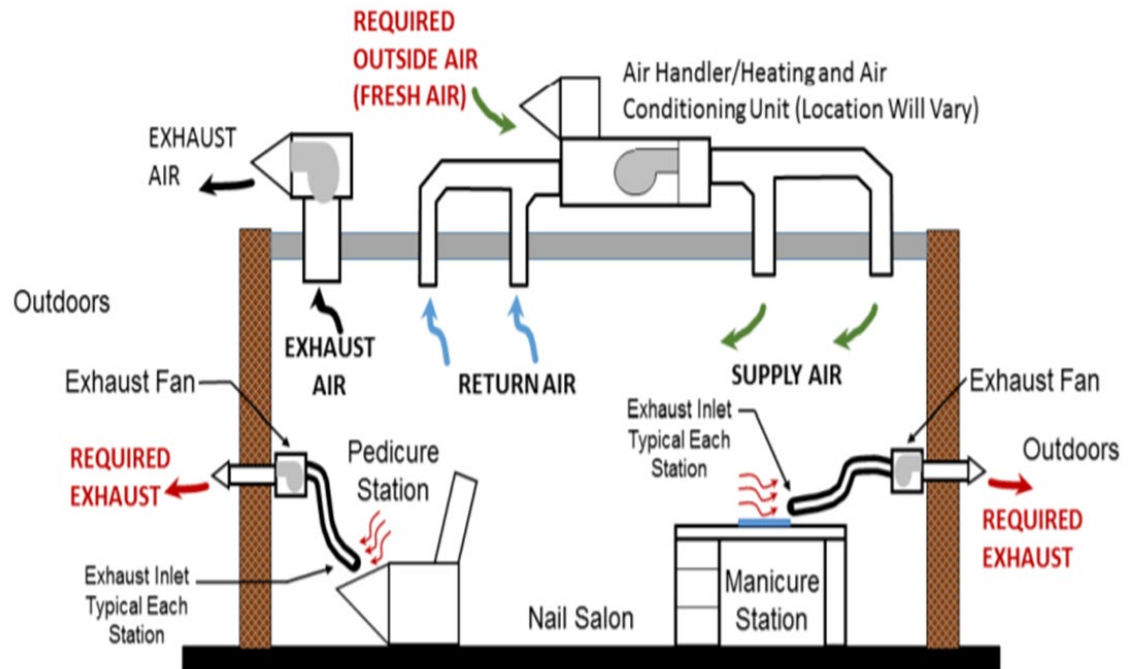
PART 1

Tucked in her pocket was $100 in carefully folded bills for another expense: the fee the salon owner charges each new employee for her job. The deal was the same as it is for beginning manicurists in

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NYS Ventilation Requirements

1. Install mechanical general ventilation → 20 cubic feet per minute (cfm)/per person (pp) of outdoor air plus 0.12 cfm of fresh air per 1000 ft^2 of space

2. Install LEVs → exhausted directly outside → 12 in from the "source" with an airflow of at least 50 cfm

REQUIRED OUTSIDE AIR (FRESH AIR)

Air Handler/Heating and Air Conditioning Unit (Location Will Vary)

EXHAUST AIR

Outdoors

EXHAUST AIR

RETURN AIR

SUPPLY AIR

Exhaust Fan

Exhaust Inlet Typical Each Station

Exhaust Fan

Outdoors

REQUIRED EXHAUST

Pedicure Station

REQUIRED EXHAUST

Exhaust Inlet Typical Each Station

Nail Salon

Manicure Station

2020 Study

- 12 nail salons recruited from June – August 2018
  - 300 salons approached
- Concentrations measured over the three days
  - Thursday
  - Friday
  - Saturday
- Measured individual chemicals in air
  - Methyl methacrylate (MMA)
  - Toluene
  - Ethyl acetate
- Measured CO_2 and TVOCs

Original Article

Occupational Exposure and Ventilation Assessment in New York City Nail Salons

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Abstract

In 2015, New York State enacted new ventilation regulations to protect employees and clients from exposure to chemicals used in nail salons. This study measured common air pollutants found in nail salons and assessed compliance with ventilation requirements. Area sampling was conducted in 12 nail salons located in New York City for three consecutive days (Thursday, Friday, and Saturday) to measure total volatile organic compounds (TVOCs), methyl methacrylate, toluene, and ethyl acetate concentrations and estimate ventilation rates. Salon characteristics were determined through a walkthrough inspection and survey administered to the manager. The average daily concentration of carbon dioxide and TVOCs across all salons was 1070 ppm [standard deviation (SD) = 440 ppm] and 29 ppm (SD = 25 ppm), respectively. Chemical-specific air sampling showed low to non-detectable levels of the three measured chemicals. Seventy-five percent of the nail salons did not meet general

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Exposure Reduction from GEV

Variable	N	Average Customers	Volume (ft³)	TVOC (ppm)	Outdoor Airflow (CFM/person)
Compliant	3	85	11000	16	37
Windows Open	2	54	6600	12	175
Non-complaint	7	38	7400	39	14

General Conclusions

- Salons are not prepared for the new regulations
  - 25% met the GEV requirements
  - None met LEV requirements

- Most managers do not understand their ventilation systems
  - Many were unsure if exhaust was ducted outside, or air was recirculated

- Need tools to visualize exposure

Study Goals

- Ventilation works! How do we get salons to comply with the regulations?

1. Test the validity of low-cost sensor to measure TVOCs in nail salons in NYC

2. Develop intervention strategies to reduce exposure to TVOCs

3. Determine the feasibility of the sensors and overall reduction in exposure from the intervention

Research Partnership

- Adhikaar is a women-led community and workers' center that provides direct services to the Nepali-speaking community

- Members earn less than $20,000 annually and suffer from chronic health problems

- Recruited 7 nail salons for this study
  - 4 complied w/ NYS law
  - 2 complied with LEV
  - 1 had no ventilation system

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Baseline Data Collection
- Collocate low-cost sensors with validated instruments inside nail salon
- Measure VOC concentrations for 7 consecutive days

Intervention
- Create individual report on daily exposure within salon
- Work with salon to develop plan to monitor exposure using low-cost sensor and reduce using existing controls

Follow-Up Data Collection
- Collocate low-cost sensors with validated instruments inside nail salon
- Measure VOC concentrations for 7 consecutive days
- Report back results on exposure reduction to salon

Validation Analysis
- Compare 5-minute average concentrations reported by low-cost sensors to those reported by validated instruments (correlations, mean absolute difference)
- Monitor changes in sensor accuracy over time

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# Workplace Sensors

- Features required:
  - Datalogging capabilities
  - Under $1000 with data tools
  - > 10 ppm
  - Threshold with warning ability

	Price	Sensor Type	Detectable Range (ppm)
Awair Omni	$399	Metal oxide	0.02 – 38.82
Kaiterra Sensedge	$700	Metal oxide	0 – 60
uHoo Smart Air Monitor	$299	Metal oxide	0 – 60
Airthings View Plus	$299	Metal oxide	0 - 10
Atmotube	$189	Metal oxide	0 – 60
Atmocube	$349	Metal oxide	0 – 60

Low-cost vs. High-cost Sensors
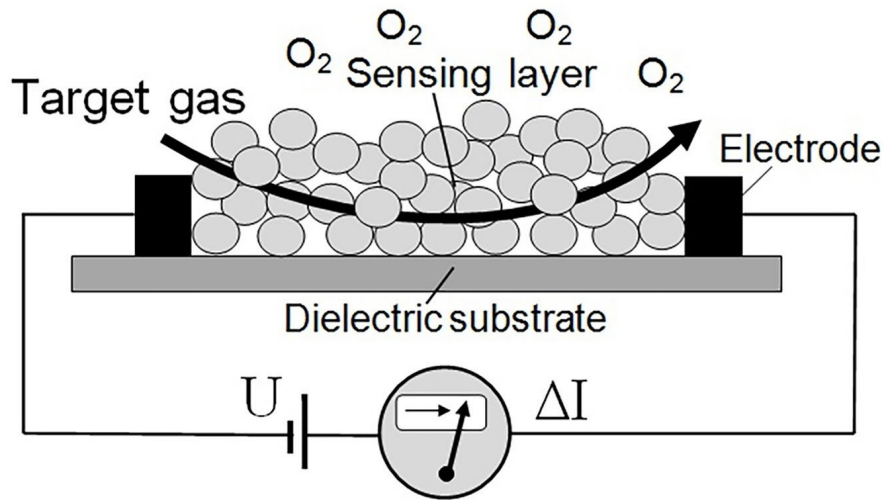
- Low-cost
  - Less than $100
  - Uses MOS
  - No calibration
  - Temp and humidity are interferents

- High-cost
  - $8-10K + calibrant+ UV lamp
  - Calibration
  - Humidity can affect readings

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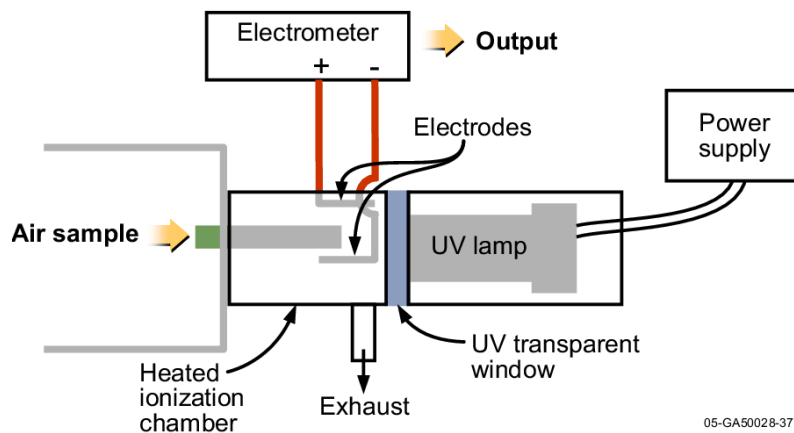
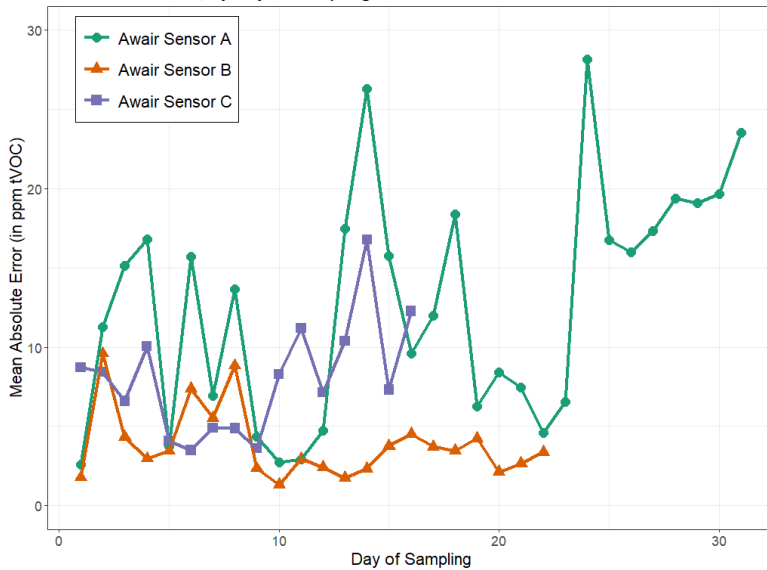# Sensor Accuracy – Awair Omni and Kaiterra Sensedge

Detectable Range (ppm)	Correlation (R_s) with Reference Sensors	Mean Absolute Error (MAE)	Total 5-min Samples Logged	Number of Salons Tested
0.02 – 38.82	0.63	9.02 ppm	17,159	6

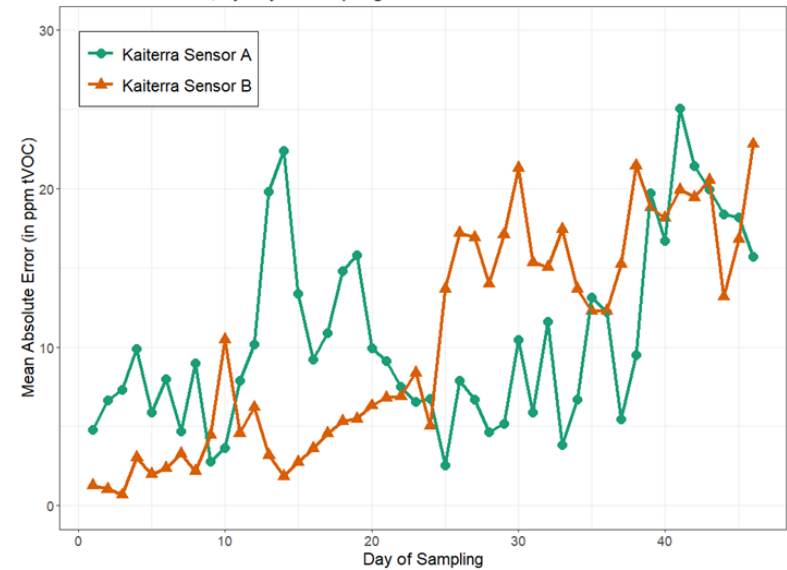| Detectable Range (ppm)	Correlation (R_s) with Reference Sensors	Mean Absolute Error (MAE)	Total 5-min Samples Logged	Number of Salons Tested
0 - 60	0.64	10.8 ppm	22,653	9

# Sensor Accuracy – Awair Omni and Kaiterra Sensedge

Mean absolute error of low-cost sensor tVOC concentrations comparing to validated sensors, by quartile of tVOC concentration
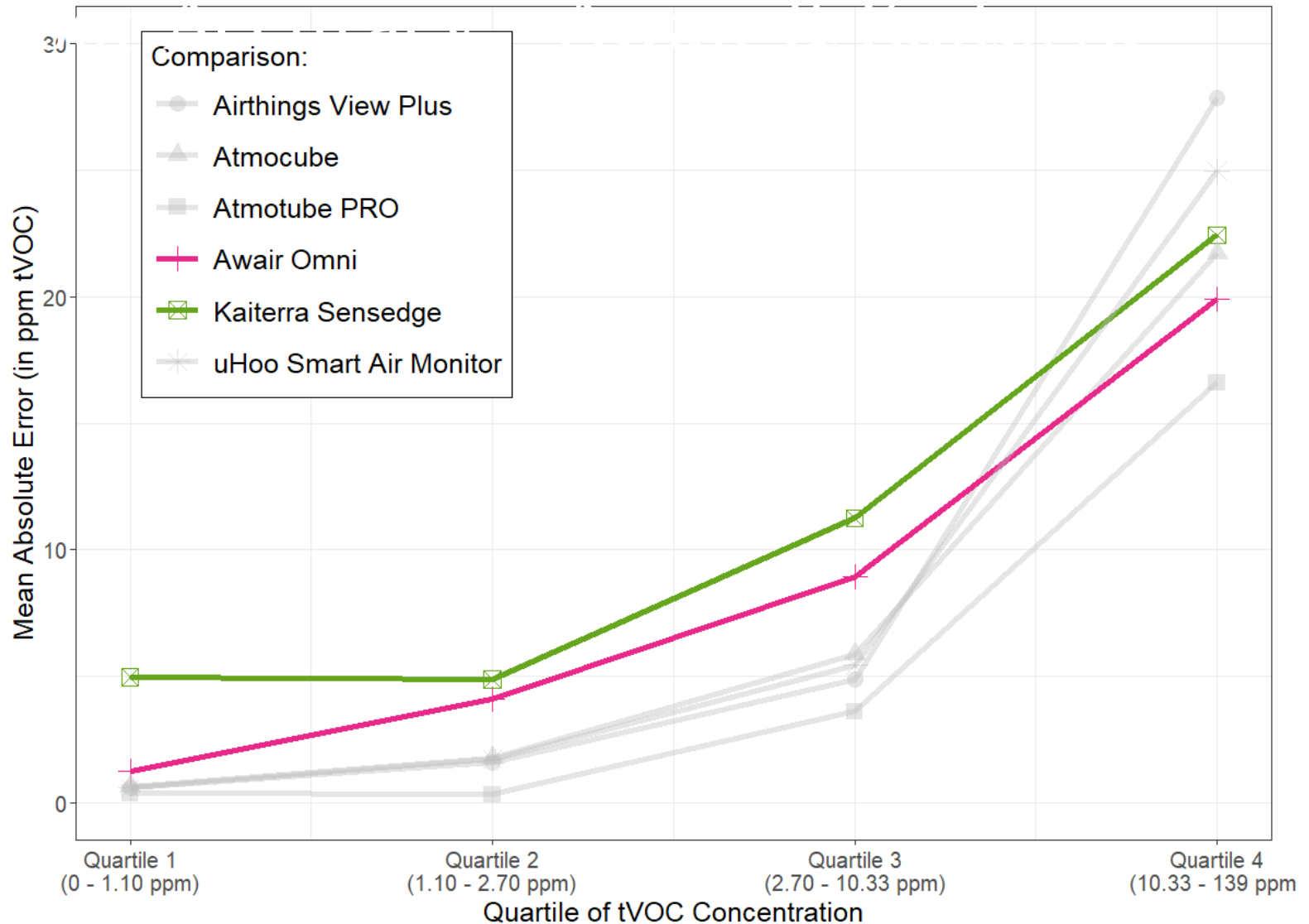
Sensor Accuracy – uHoo & Airthings

|	Detectable Range (ppm)	Correlation (R_s) with Reference Sensors	Mean Absolute Error (MAE)	Total 5-min Samples Logged	Number of Salons Tested
uHoo Smart Air Monitor	0 - 60	0.70	11.1	7,780	3
Airthings View Plus	0 - 10	0.55	13.1	4,610	2

Mean absolute error of low-cost sensor tVOC concentrations comparing to validated sensors, by quartile of tVOC concentration
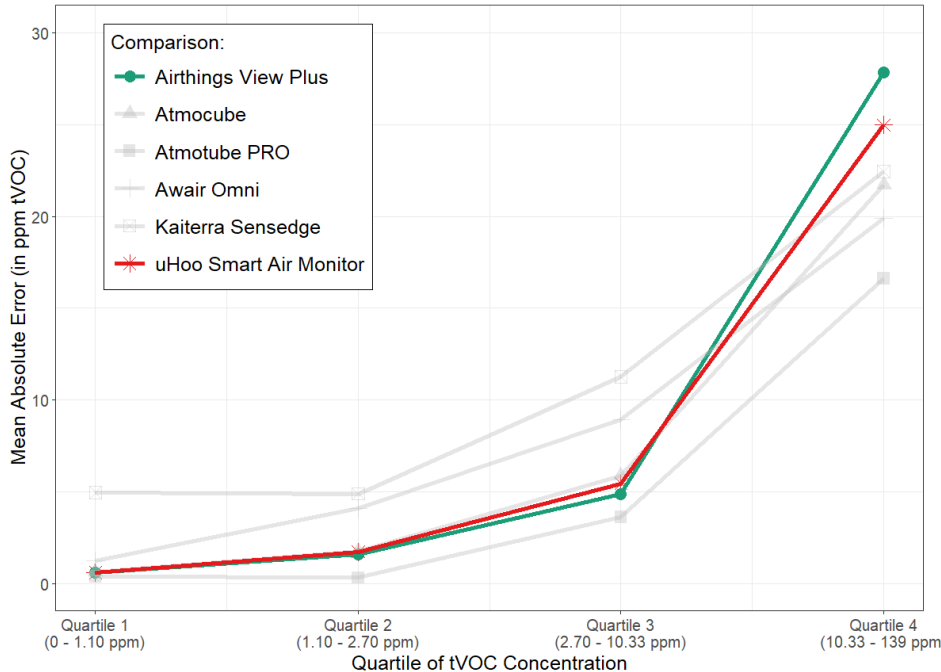
Sensor Accuracy – Atmotube & Atmocube

	Detectable Range (ppm)	Correlation (R_s) with Reference Sensors	Mean Absolute Error (MAE)	Total 5-min Samples Logged	Number of Salons Tested
Atmotube	0 - 60	0.98	8.0	469	1
Atmocube	0 - 60	0.90	9.7	3,910	2

Mean absolute error of low-cost sensor tVOC concentrations comparing to validated sensors, by quartile of tVOC concentration

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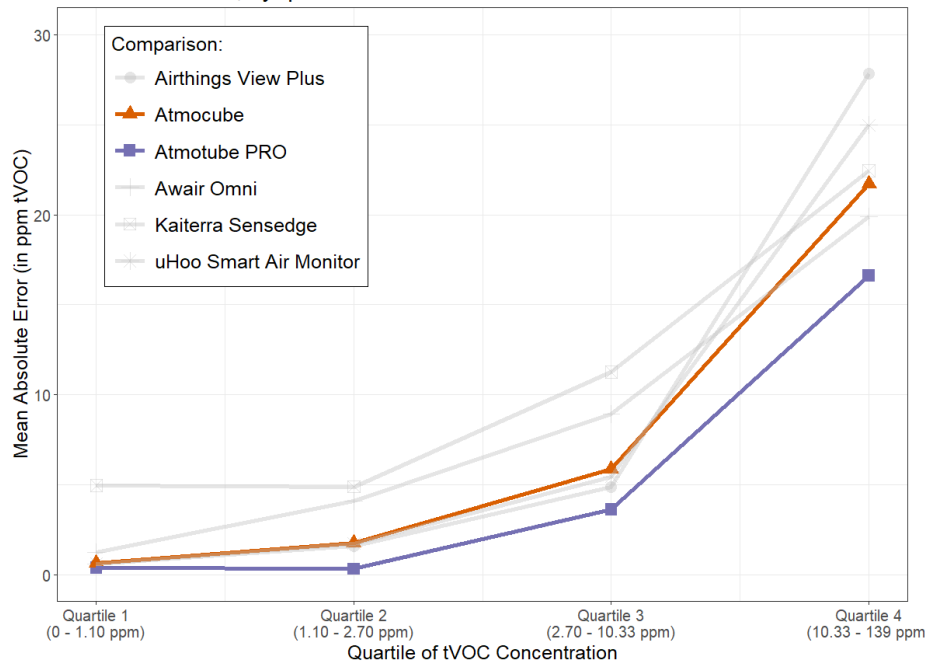
Workplace Intervention

- After baseline measurements are collected, we follow-up with owner
  - Discuss tVOC results
  - Inspect salon and ventilation system
  - Devise a strategy to reduce exposure
 - Set up equipment again to resample salon

Interventions in Salons

Salon	Baseline TVOC (ppm)[1]	Intervention TVOC (ppm)[1]	% Change
1	37.5 (21.1)	20.2 (25.3)	-46.2%
2	5.2 (5.3)	1.5 (2.3)	-70.1%
3	36.8 (37.2)	11.1 (10.6)	-69.9%
4	21.9 (14.3)	15.0 (8.1)	-31.7%

[1] Mean (SD)

Other notes:

- Data filtered to salon open days/times only
- TVOC values are averaged over 5-min sampling intervals and across two reference instruments (Honeywell UltraRAE & TSI Q-Trak)
- TVOC concentrations are in ppm
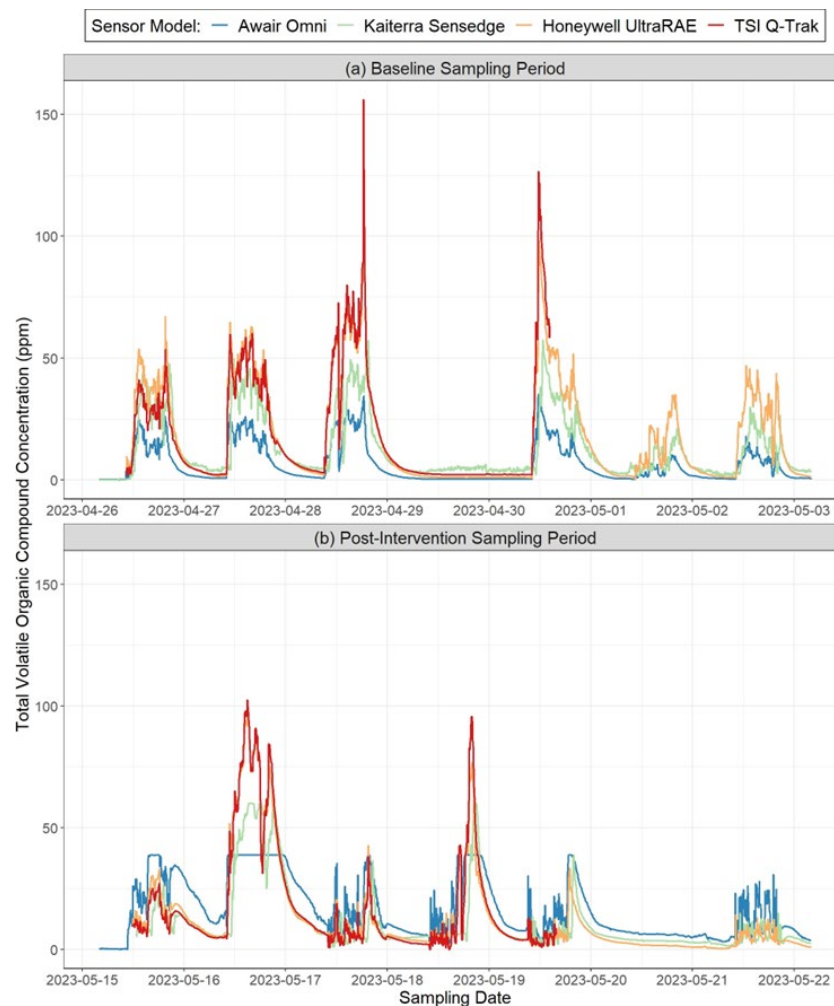
Conclusions

- Ventilation works! However, compliance with regulations will only come from investment from the State

- Low-cost sensors preform satisfactory, however there are barriers
  - Can measure changes in exposure
  - Onboarding can be challenging
  - No threshold
  - Accuracy varies by concentration
  - What happens when it malfunctions
  - Calibration

Other Work Conducted at the Center

- One new course created at CUNY SPH
  - **Advanced Exposure Assessment and Policy Applications**

- Dr. Homero Harari has been conducting multiple training sessions among Latinx day laborers with our partners at the Labor Institute

- Convened a conference at Mt. Sinai about emerging technologies in occupational health attended by academics and community members

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