How Occupants Interpret Indoor Air Quality Sensor Data
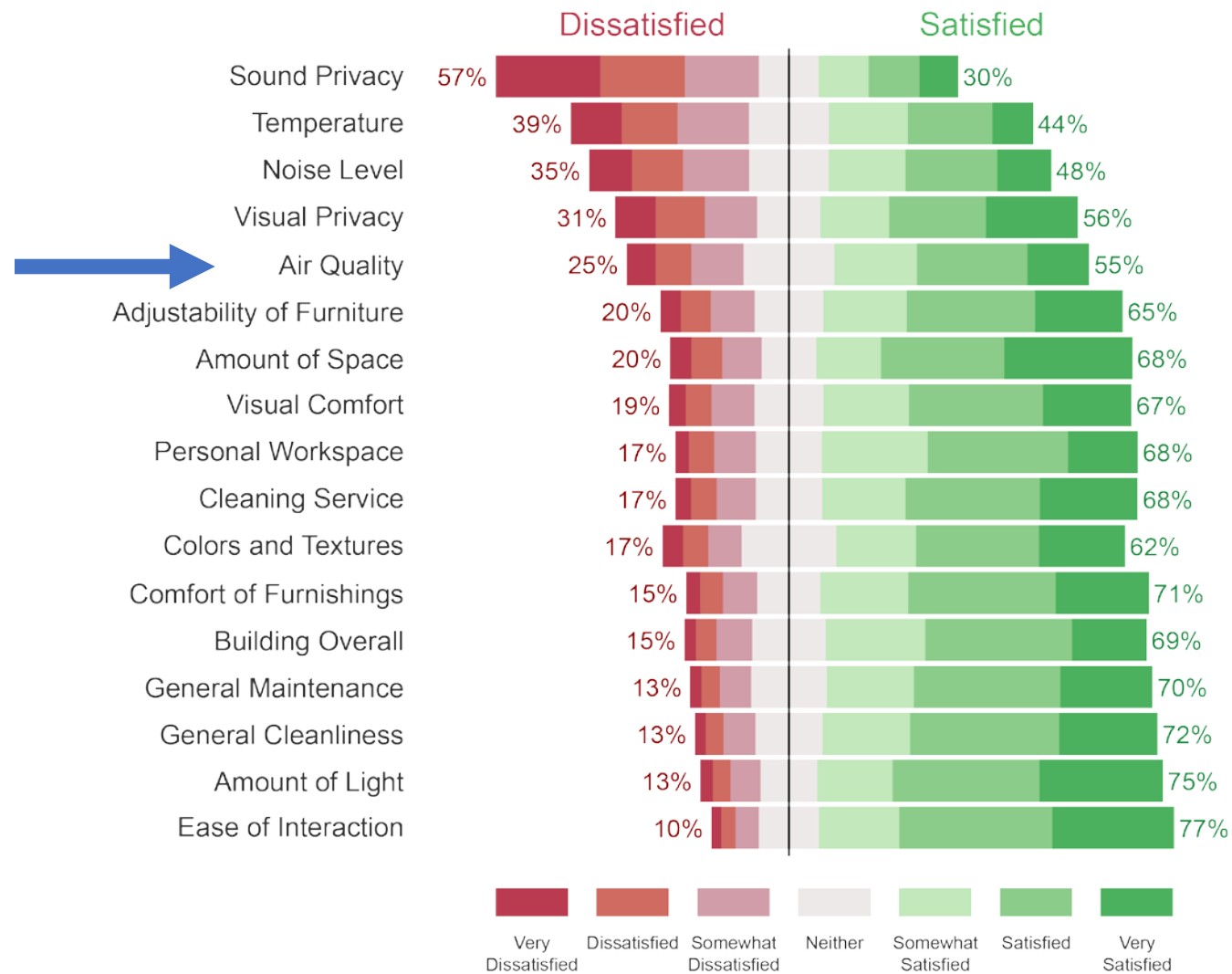
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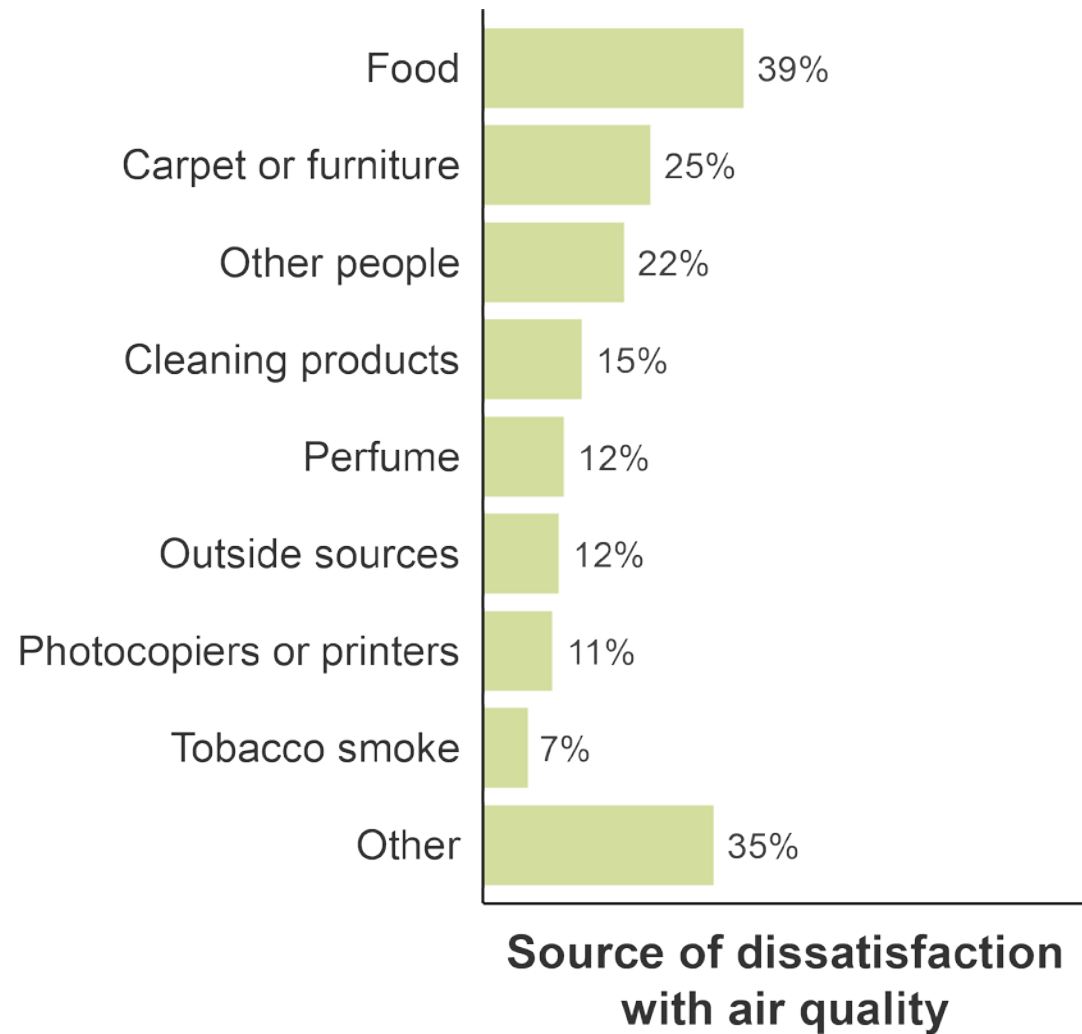
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Occupant perceptions of IAQ

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Perceived sources of poor IAQ

Food — 39%
Carpet or furniture — 25%
Other people — 22%
Cleaning products — 15%
Perfume — 12%
Outside sources — 12%
Photocopiers or printers — 11%
Tobacco smoke — 7%
Other — 35%

Source of dissatisfaction with air quality

Parkinson et al, in prep.

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Perceiving air

Thermal and air quality perceptions are connected, but often IAQ and "freshness of air" is conflated with: temperature, air speed, and humidity.

(Fang et al., 1998, 2004; Melikov, Kaczmarczyk, 2012; Schiavon, 2017; Zhang et al, 2011)

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Complicated to detect, but big impact.

Communicating IAQ

- Few IAQ devices on the market for the average user

- Most of what we know about air quality communication is for outdoor air quality

- Little is known about

  - The average person's knowledge of IAQ.

  - How people engage with IAQ information.

  - What motivates behavior change to improve IAQ.
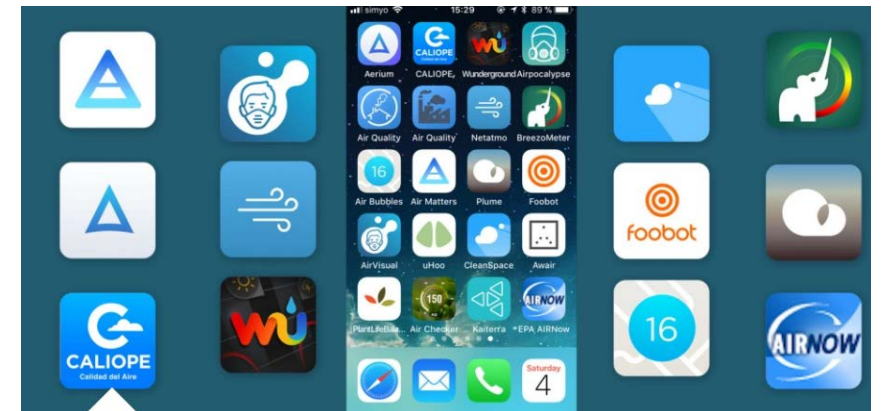
Various IAQ applications and home sensors on the market

Testing IAQ communication

Study objectives

- Identify what type of information occupants prefer and use to accurately and easily interpret indoor air quality (IAQ).

Approach

- Identify common environmental quality data visualizations.

- Generate and test different types of data visualizations.

- Evaluate visualizations in online survey.
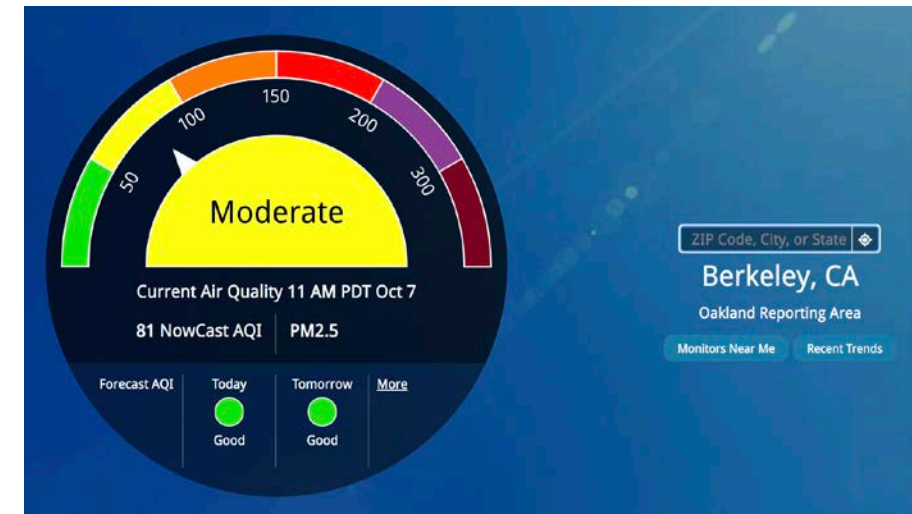

www.airnow.gov

Methods

Data visualizations

- 3 visualization types: Numeric, Scale, Health.
- Scenario same across all 3 visualizations.
  - Depicts high PM 2.5 and elevated CO2
  - Presented in random order.

Survey

- 248 participants
- Participant background (including respiratory health, personality, living conditions)
- Likes/dislikes, preference, ease of interpretation, perception of IAQ, whether or not action is needed.
- Basic knowledge of pollutants.
- Experience with products that influence IAQ.

POLLUTANT	FORMULA
PARTICULATE MATTER	PM2.5
CARBON DIOXIDE	CO_2
TOTAL VOLATILE ORGANIC COMPOUNDS	TVOC
OZONE	O_3
NITROGEN DIOXIDE	NO_2
SULPHUR DIOXIDE	SO_2
CARBON MONOXIDE	CO

TOTAL VOLATILE ORGANIC COMPOUNDS (TVOC)
OZONE (O3)
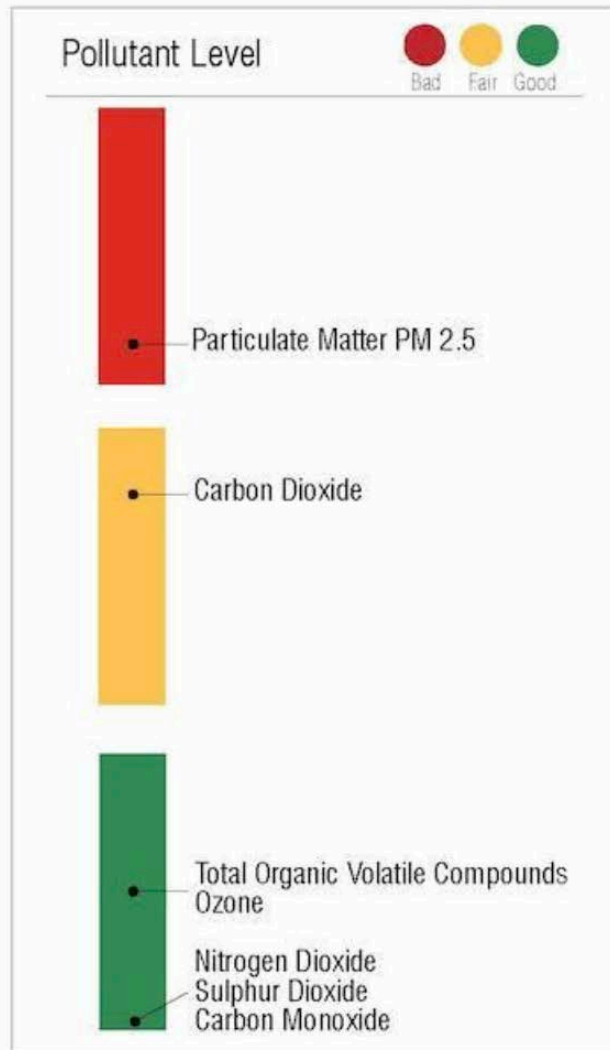NITROGEN DIOXIDE (NO2)
SULPHUR DIOXIDE (SO2)
CARBON MONOXIDE (CO)

SEDENTARY   PHYSICAL EXERTION
ACTIVITY
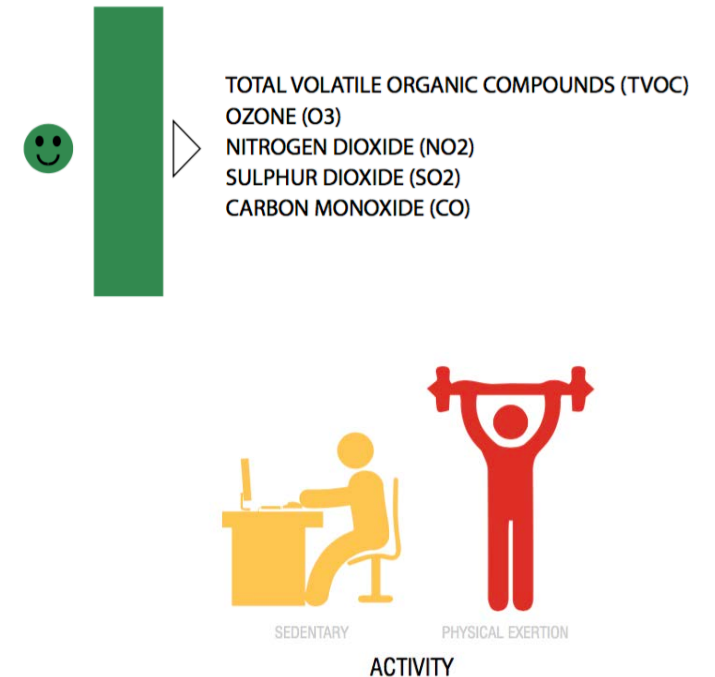
"Numeric" visualization of hypothetical IAQ scenario

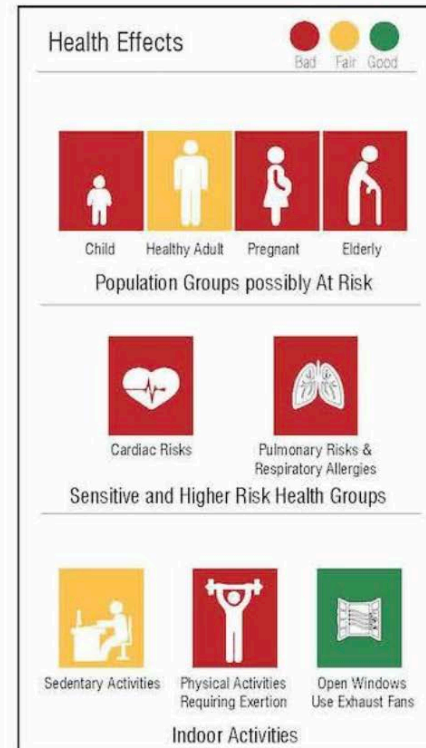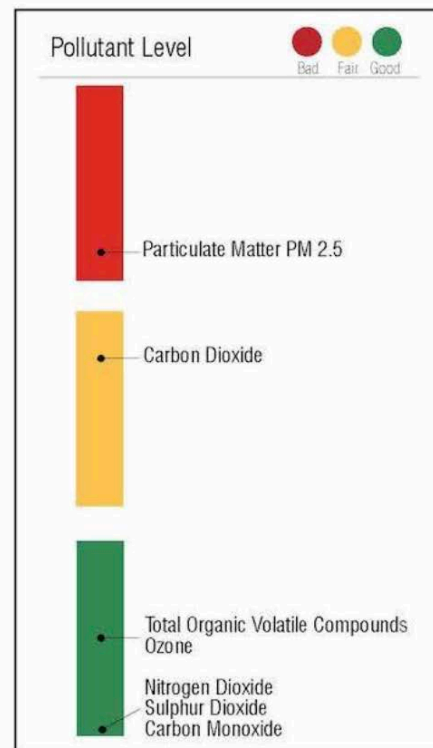| Pollutant	Formula	Value	Level of Health Concern
Particulate Matter	PM2.5	45 μg/m3	Bad
Carbon Dioxide	CO_2	800 ppm	Fair
Total Volatile Organic Compounds	TVOC	0.5 ppm	Good
Ozone	O_3	0.03 ppm	Good
Nitrogen Dioxide	NO_2	0 ppm	Good
Sulphur Dioxide	SO_2	0 ppm	Good
Carbon Monoxide	CO	0 ppm	Good

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"Health" visualization of hypothetical IAQ scenario
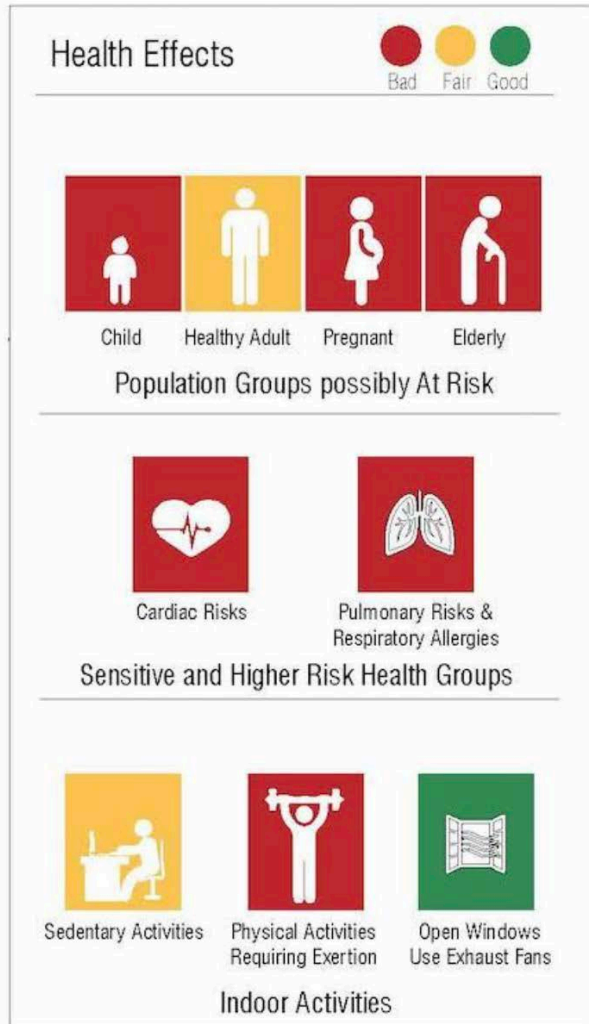
Visualizations of hypothetical IAQ scenario

Pollutant	Formula	Value	Level of Health Concern
Particulate Matter	PM2.5	45 μg/m3	Bad
Carbon Dioxide	CO_2	800 ppm	Fair
Total Volatile Organic Compounds	TVOC	0.5 ppm	Good
Ozone	O_3	0.03 ppm	Good
Nitrogen Dioxide	NO_2	0 ppm	Good
Sulphur Dioxide	SO_2	0 ppm	Good
Carbon Monoxide	CO	0 ppm	Good

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Perceptions of the visualizations

- Participants prefer the Health Action visual
  - Binomial test: preferred by 56% (p_0 = 33% ; p < .001)

- However, participants believed all 3 were easy to interpret.
  - 65%, 53%, 62% found easy to interpret for Numeric, Scale, and Health Action respectively

- Likely not the ability to interpret the information given, but rather the actual *content* that drives preference.

Preferred Visualization?
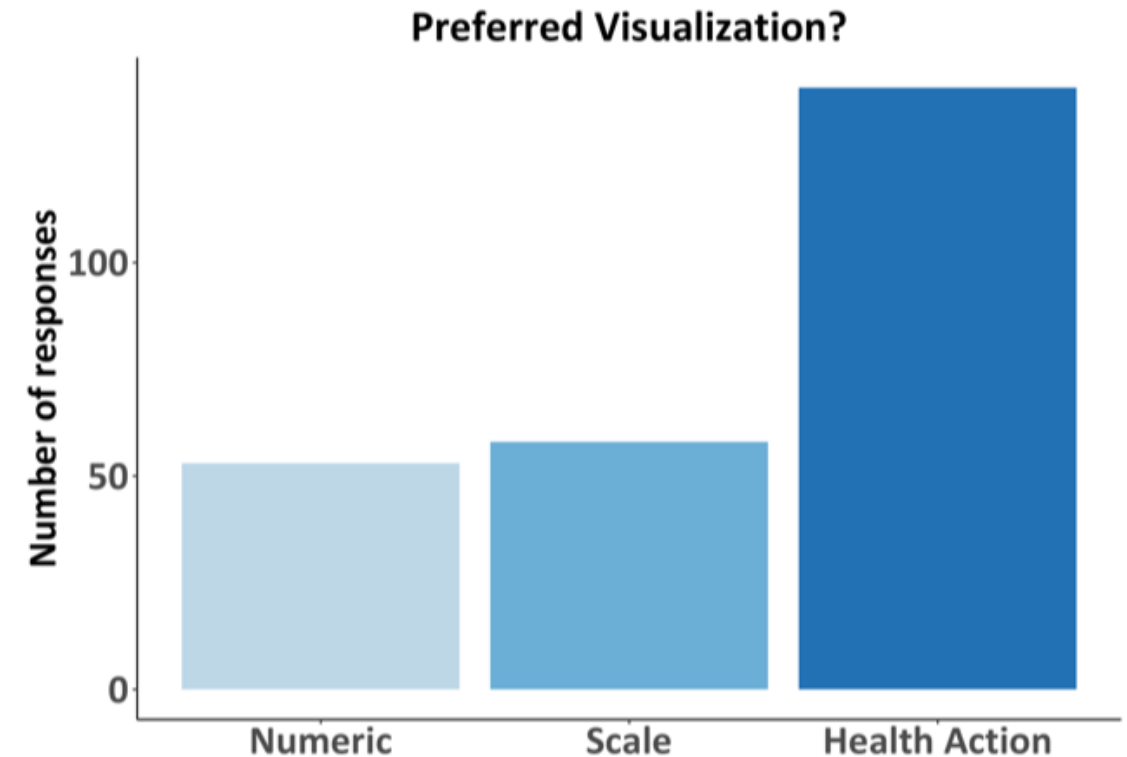
What do occupants <u>like</u> in a visualization?

- Easy to understand and interpret.

"it doesn't require a lot of scientific knowledge to understand"

- Provides visual/graphic information.

"The images help a lot, it is easier to get an idea of the air quality at the first glance"

- Provides actionable information.

"I like that it has suggestions as to what I can and cannot do considering the current air conditions" "I like that it gives clear indications of who is at risk in the current situation as well as steps to take to improve the situation and things to avoid"

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What do occupants <u>dislike</u> in a visualization?

- Complexity: not clear, confusing, not intuitive, cannot understand.

"I'm still unclear as to what this image is telling me. it's too vague"

"confusing and might be hard for people without any knowledge on the subject to understand"

- Action items not included.

*"It's unclear whether I need to act upon the different levels"*

"Does not provide sufficient information for me to make a decision. I don't know what the number means and what I can do"

- Little to no information on cause and effect of pollutants.

"This isn't as helpful to me because it doesn't tell me WHY the health effects are bad for these groups....I would prefer to know what exactly is causing the air issues in my home so I can know whether just to open a window or to take more drastic measures"

Which image leads to occupant action?

- Regardless of the visualization type, **those who believe the IAQ to be poor**, are more likely to **also believe action needs to be taken.**

- However, people are more likely to believe **the air is bad and that the environment is unhealthy when viewing the Health Action visual.**
  - Friedman's test : X^2 (2, N= 594) = 71.8, p < .001) and X^2 (2, N= 753) = 50.8, p < .001)-- for IAQ and health of environment, respectively.

Perception of IAQ vs. need for intervention

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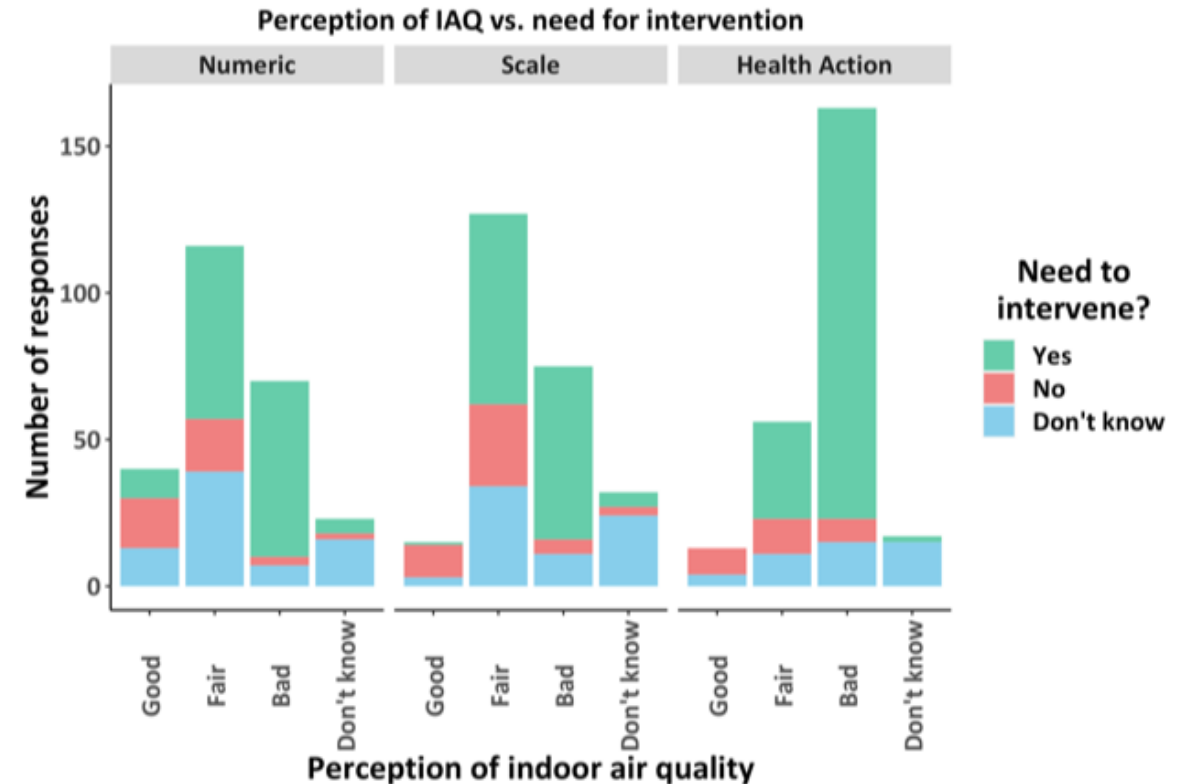
Guidelines for application

- Provide occupants with information depicting info relevant to their health and behavior, not just the air.

- Provide steps to take to overcome poor IAQ in their space.

- Remember, occupants like clear, graphical, and actionable information.

- And they dislike confusing/non-intuitive visuals that lack action steps or cause and effect relationships.
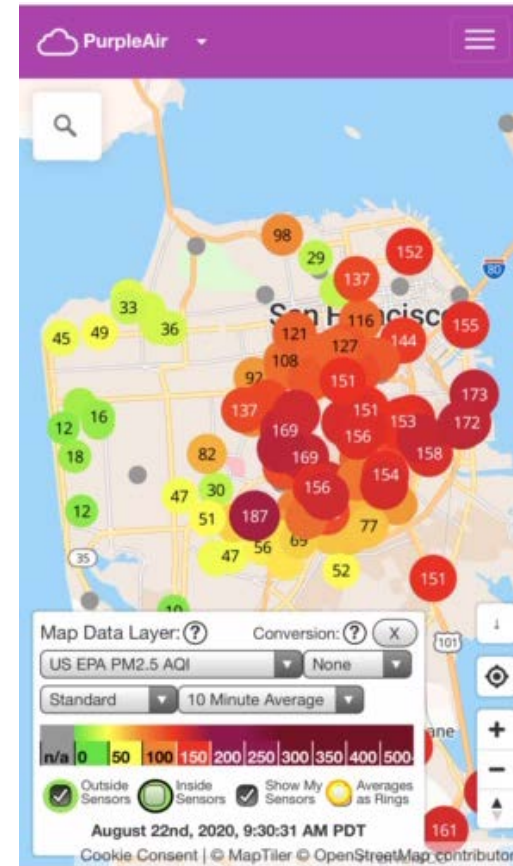

Screenshot from www.purpleair.com

Where do we go from here?

- **We have to keep working to understand the person.**
- Are there individual differences that impact data interpretation?
  - Personality, gender values, motivations, lifestyle
- Would these perceptions translate into actual occupant actions?
- What building <u>and/or</u> behavioral interventions could be implemented to nudge healthier behaviors?
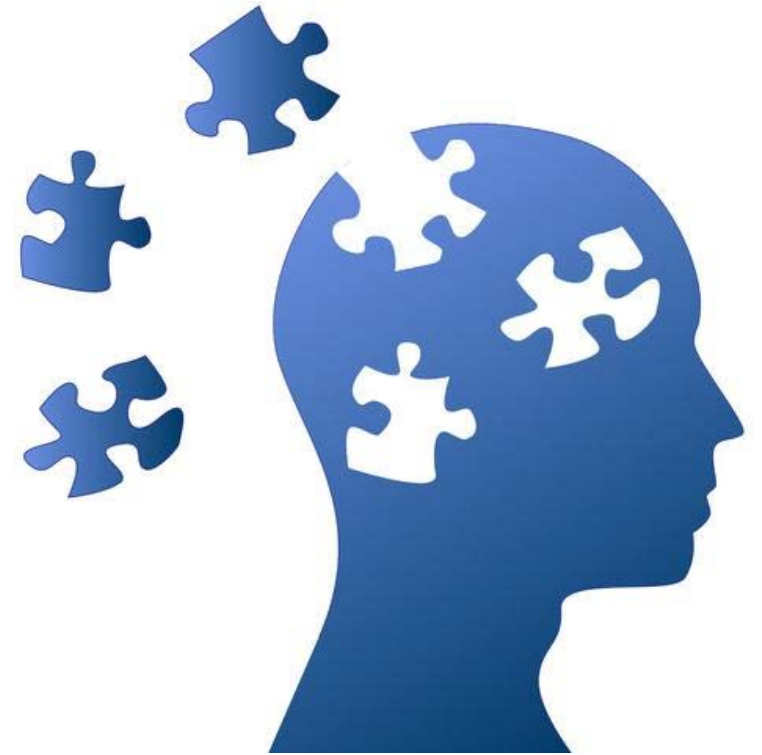
Building system automation is helpful, but occupant education and empowerment is paramount.

Thank you!!

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