

Tobacco Smoke Pollution on Outdoor Patios

Documenting Sources of PM_{2.5} Using Wearable Imaging Technology

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Background

- The impact of tobacco smoke on air quality in outdoor settings is well documented
- Particulate matter (PM_{2.5}) concentration is an established proxy for tobacco smoke but is not specific to tobacco smoke
- It is challenging to discretely observe and document outdoor smoking events on the patio of a public restaurant, café or bar

Objectives

- Test the feasibility of using wearable imaging technology to discretely collect observational data in outdoor and adjacent indoor hospitality environments
- Pair observational data with environmental data to understand how observed sources of PM_{2.5} impact air quality

Methods

- Two teams of researchers visited a convenience sample of 21 outdoor hospitality environments in Atlanta, GA, USA
- Inclusion criteria for venues included a smoke-free indoor space, with smoking-permitted patio space, and table service on the patio
- Observations were conducted October 30 to November 2, 2014 between the hours of 12pm and 9pm
- Data were collected for approximately 40 minutes per venue during lunch, dinner, and night time
- One researcher per team wore Pivothead™ glasses with a built-in camera that took pictures every 30 seconds
- A second researcher measured PM_{2.5} concentrations on patios and adjacent indoor and outdoor areas using a Sidepak AM510
- Researchers noted if any patrons or staff commented on their wearable technology

Analysis

- PM_{2.5} concentrations were plotted for time spent on the patio, in the adjacent indoor hospitality space, as well as an outdoor space nearby to measure background/ambient levels (generally on a sidewalk near the venue studied)
- The sequential photos taken every 30 seconds during the visit to each venue were downloaded from the device; the content of the digital images were then assessed and classified as having visible PM_{2.5} source – including burning tobacco – or not
- Time series air quality measures were then paired with the digital images and average concentrations were calculated for the time periods with elevated PM_{2.5} concentrations (peaks); researchers used the content of the digital images to help understand the source of PM_{2.5} measured

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Results

- We observed tobacco smoking at 15 venues
- Data from 11 venues (73%) successfully paired PM_{2.5} readings with photos of concurrent smoking events
- Wearable technology was discrete: throughout the collection period, researchers did not receive any comments or feedback from staff or patrons
- Challenges with the glasses included:
 - Capturing exact start and stop times for smoking events due to poor sightlines
 - Capturing multiple concurrent smoking events in different areas of the patio

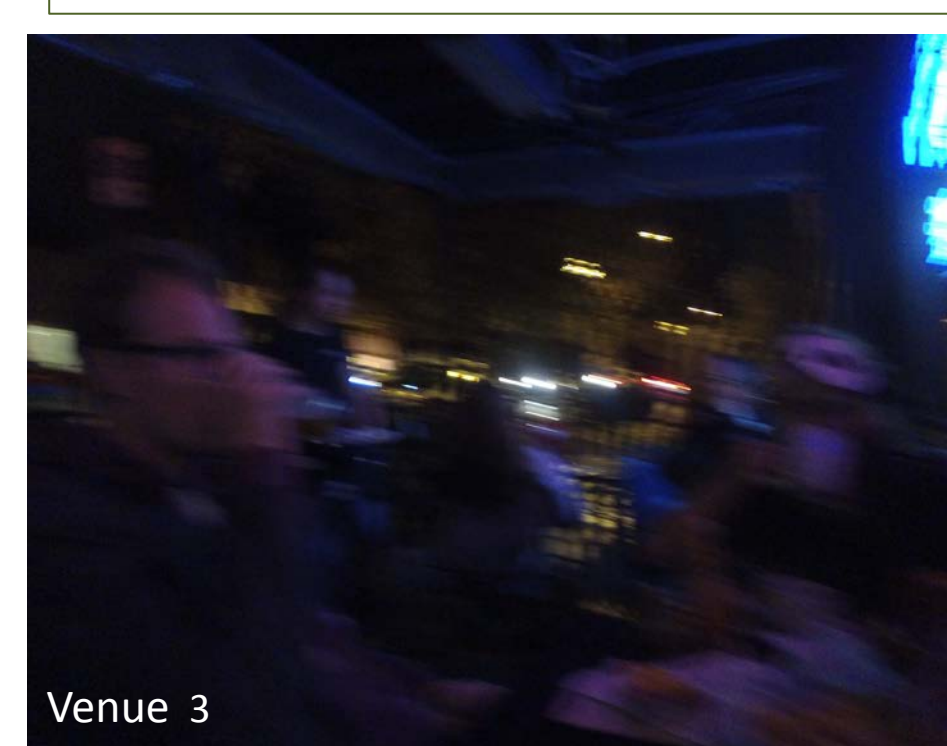


Figure 1. Pivothead™ wearable technology

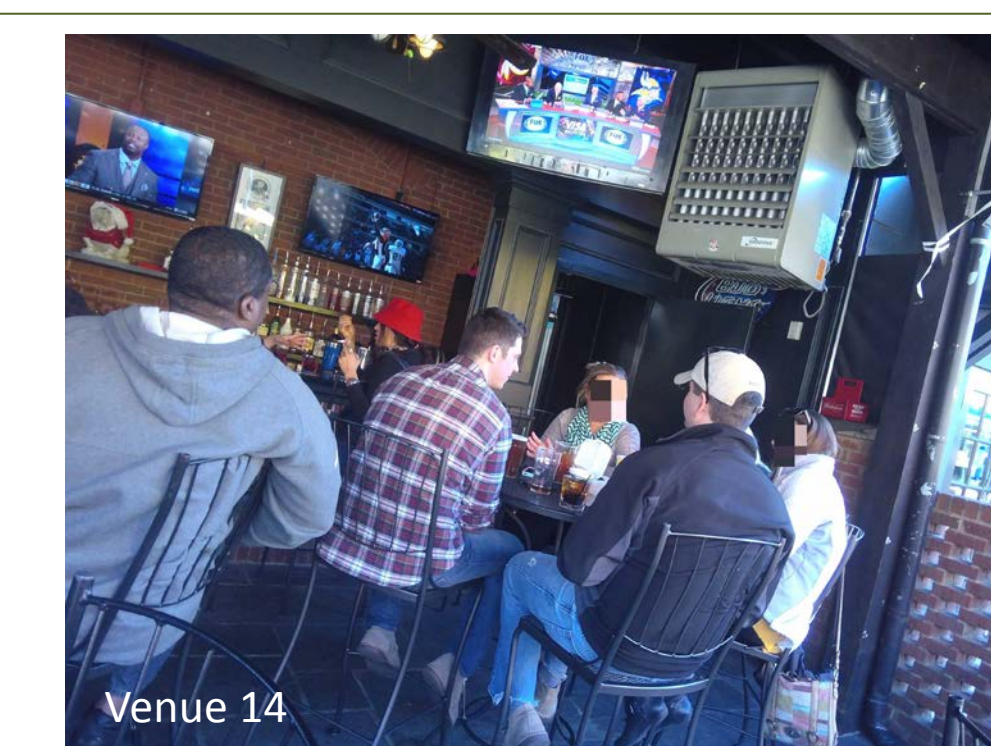
Table 1. Characteristics, air quality, and number of events at venues with smoking

Venue ID	Type of Venue	Sampling Duration (minutes)	PM _{2.5} Events Observed on Patio		Patio Environment PM _{2.5} concentrations (µg/m³)		Ambient Environment PM _{2.5} concentrations (µg/m³)	
			Total	Paired with ≥1 Image	Average	Maximum	Indoor Average	Outdoor Average
1	Bar	54	1	no	1	75	0	0
2	Bar	35	1	yes	8	59	7	11
3	Bar	41	2	yes	22	486	32	6
4	Restaurant	43	1	no	2	40	4	1
5	Bar	36	2	yes	10	152	8	7
6	Bar	41	2	yes	15	547	8	4
7	Coffee shop	40	4	yes	4	49	3	4
8	Bar	33	1	no	7	50	24	6
9	Bar	51	2	yes	3	85	2	2
10	Bar	43	2	yes	38	200	7	3
11	Restaurant	41	1	yes	14	1283	3	2
12	Bar	42	7	yes	14	478	9	11
13	Restaurant	40	3	yes	4	184	9	3
14	Bar	49	1	yes	6	266	5	5
15	Bar	52	2	no	5	381	3	3

Figure 2. Challenges of using wearable technology

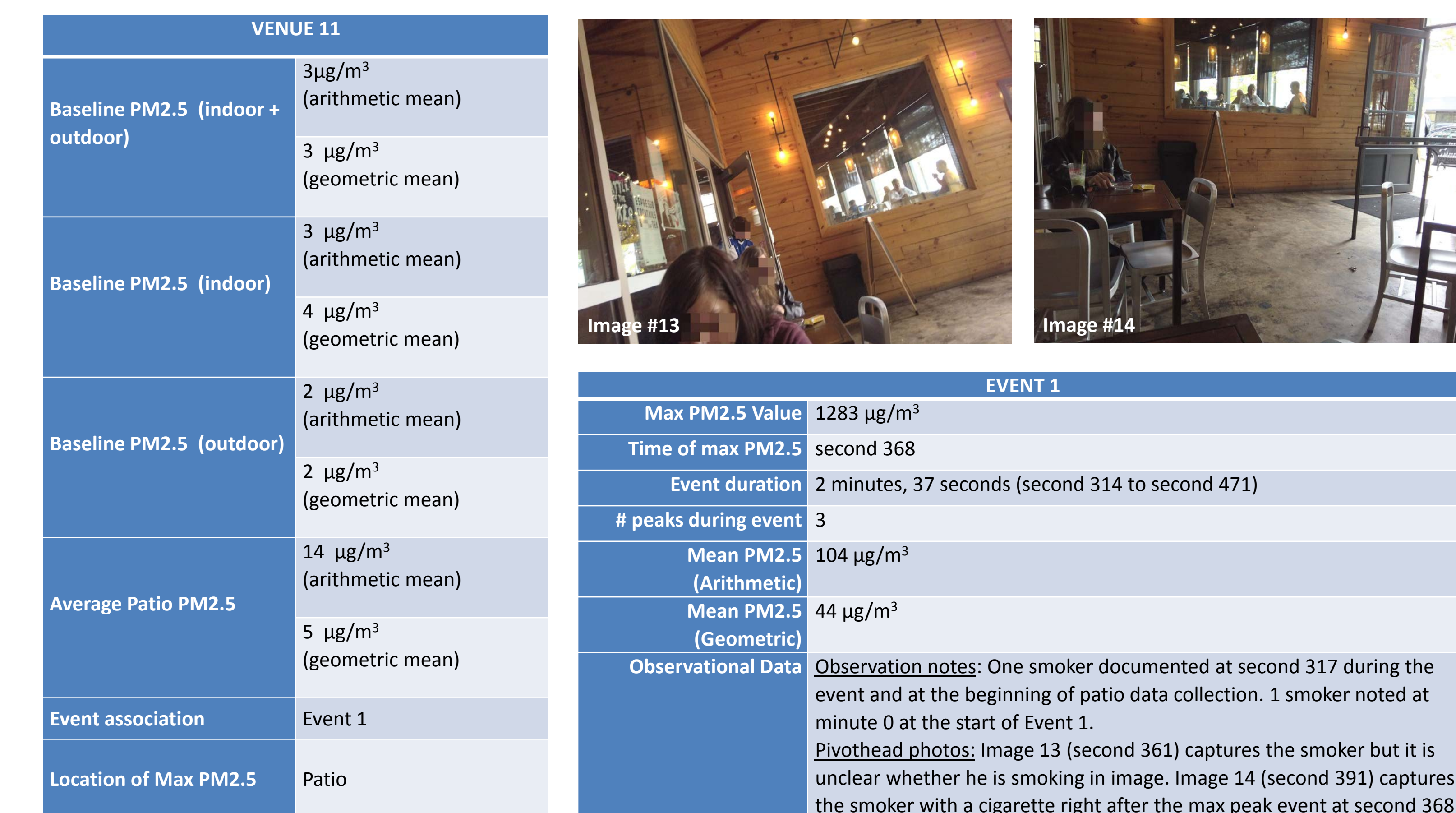


Researchers documented tobacco smoking in observation notes, but the image quality was too low to validate pairing with PM_{2.5} data.



High quality image captured tobacco smoking, but the PM_{2.5} data did not pair. Researchers had to rely on recorded observation notes.

Figure 3. Venue highlights, event identification, and data pairing between observation and PM_{2.5} concentrations



Conclusions

- Wearable technology was useful for recording tobacco smoking events on outdoor patios without drawing any undue attention to researchers
- Photos supported pairing of observational data with environmental data to understand how tobacco smoke pollution impacted air quality
- Additional written notes are recommended to augment daily recorded observations and to further validate data, particularly when photo quality is low
- Future research would benefit from wearable technology with capacity to take photos second-by-second for a minimum of 30 minutes at a time