The Air We Share: Seven-Month Mixed Method Study of Thailand's Motorcycle Rideshare Driver and Air Pollution

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Abstract

Addressing the gap between gig work autonomy and environmental health agencies, this study investigates extreme PM2.5 exposure among motorcycle rideshare drivers in urban Thailand. These workers face high risks due to prolonged open-air work with extensive working hours, often rendering standard health advice impractical. Using a mixed-methods approach combining seven months of longitudinal personal PM2.5 data and qualitative interviews, we captured detailed exposure patterns and explored lived experiences, health perceptions, coping strategies, and systemic barriers. We find drivers are consistently exposed to PM2.5 exceeding guidelines, with limited agency to mitigate these risks due to economic necessity and structural constraints. Our research underscores the critical need for interventions targeting exposure reduction and worker empowerment, balancing health protection with income stability for this vulnerable population.

CCS Concepts

• **Human-centered computing → Empirical studies in ubiquitous and mobile computing**; *Empirical studies in collaborative and social computing*; • **Applied computing → Health informatics**; • **Hardware →** *Sensor applications and deployments.*

Keywords

air pollution, air quality sensing, gig economy, environmental justice, urban health, empirical studies

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1 Introduction

Motorcycle rideshare drivers in Thailand, often low-income, face prolonged outdoor work in dense, polluted urban areas [17]. This vulnerability is amplified by high motorcycle usage (87% of households in 2014 [14]) and poor air quality [1]. A key hazard is PM2.5, fine particulate matter linked to severe health risks, including respiratory and cardiovascular diseases and millions of premature deaths globally [21]. Prolonged exposure is associated with a 6-13% increase in heart disease mortality per 10 $\mu g/m^3$ of PM2.5.

Standard public health advice for high PM2.5 (e.g., stay indoors and avoid busy roads) [5] is often impractical for these workers. Financial pressures and platform dynamics limit their agency to prioritize health over income, creating a gap between known risks and self-protection capabilities [17].

Understanding the specific, individual experiences of PM2.5 exposure and the barriers preventing workers from prioritizing their health is crucial. This study aims to bridge this gap by focusing on the lived experiences of at-risk workers (including but not limited to rideshare drivers) in urban Thailand. To better understand this intersection, we ask:

> **How can integrating personal air pollution exposure data with the lived experiences of rideshare drivers help surface structural barriers, coping strategies, and health-income trade-offs and inform more equitable interventions that support worker agency and well-being?"**

We employ a methodology combining longitudinal personal sensing with qualitative interviews to capture both the quantitative patterns and the qualitative nuances of exposure and agency over seven months. By deploying personal sensors, we gather detailed, real-time data on individual PM2.5 exposure across varying conditions. This quantitative data is complemented by in-depth qualitative interviews exploring personal narratives, health perceptions, and coping strategies. We will present data illustrating that workers frequently experience exposure exceeding WHO guidelines [20], highlighting the urgency of this issue.

Key contributions include:

(1) Fine-grained, longitudinal individual PM2.5 exposure monitoring.
(2) Integration of sensor data with qualitative insights into lived experiences and perceptions relative to health guidelines.
(3) Identifying challenges, coping strategies, and agency constraints through worker narratives.
(4) Exploring potential solutions considering health-income trade-offs. This research aims to inform interventions enhancing worker agency and well-being.

2 Related Work

We review prior work on air pollution exposure, socio-economic disparities, and impacts on motorcycle rideshare workers.

2.1 Rideshare Workers and Their Agency to Prioritize Health

Motorcycle taxi drivers face high exposure to air pollution daily but are often excluded from formal occupational safety regulations due to self-employment or contract status [16]. Tieanklin et al. [17] found that Thai motorcycle rideshare drivers often prioritize income over health despite pollution awareness. While gig work offers flexibility, financial/social pressures and ride assignment opacity limit their agency to avoid pollution [7, 10]. Therefore, understanding their activity patterns is key to identifying their mitigation strategies. By incorporating hyperlocal data with real-time air quality monitoring sensors and their locations, we offer a granular understanding of the environmental challenges faced by these gig workers, enhancing public health perspectives.

2.2 Understanding Risk Through Personal Data

Environmental health risks are unevenly distributed, with informal and low-income workers often facing higher exposure and fewer protections. While personal informatics systems have been developed to support health and self-awareness through data tracking [9], these systems largely focus on white-collar users with stable routines [8]. For informal workers like rideshare drivers - whose labor is mobile, physically demanding, and shaped by economic precarity - the role of personal data in shaping awareness and behavior remains underexplored [16].

Nguyen et al. [13] show that low socio-economic status workers in Bangkok are disproportionately affected by air pollution and often lack access to accurate or usable information. This limits their ability to understand their own exposure or to take informed, protective action. In this study, we seek to address that gap by supporting drivers in making sense of their own exposure data, helping connect them with their personalized working conditions, and revealing how they cope with risk under constrained conditions. By integrating hyperlocal sensor data with interviews, we surface not only exposure patterns but also the decisions, adaptations, and structural limitations that shape how drivers respond. This work contributes to understanding how environmental health risk is experienced and navigated in the context of informal labor.

3 Methodology

This study combined real-time sensor deployment for hyperlocal air pollution monitoring with qualitative interviews capturing participant experiences and perceptions. University of Washington Institutional Review Board (IRB) approval was obtained.

3.1 Participants Recruitment

Ten adult motorcycle rideshare drivers (five each from Bangkok/Chiang Mai) were recruited to capture diverse driving behaviors and exposure patterns. Inclusion criteria were regular passenger transport and driving ≥5 hours/day; passengers-dropoff drivers were preferred. Participant income details are in Table 1.

Table 1: Participant income sources (Rideshare: app-based; Legacy: station-based) and self-estimated daily average (THB). DriverID prefix indicates location (BKK: Bangkok, CMI: Chiang Mai).

DriverID	Source of Income	Avg. Income/ Day (THB)
BKK1	Rideshare, Legacy	2250
BKK2	Legacy	800
BKK3	Rideshare, Legacy	1300
BKK4	Rideshare, Legacy	1350
BKK5	Rideshare	1800
CMI1	Rideshare	700
CMI2	Rideshare	700
CMI3	Rideshare	600
CMI4	Small Business Owner, Rideshare	500
CMI5	Rideshare	900

In Bangkok, participants were initially recruited through a widely used motorcycle ride-hailing application. Drivers were approached during rides, with an author (a native Thai speaker) explaining the study objectives and eligibility criteria. Due to last-minute participant dropouts, the research team recruited an additional motorcycle rideshare driver from the legacy rideshare system, where drivers wait for passengers at designated stations.

In Chiang Mai, where the rideshare driver population is smaller, recruitment was conducted through an unofficial rideshare driver association. While recruitment was facilitated by the organization, all participants were required/preferred to meet our study criteria stated above.

On-boarding Process. Interested drivers received study details (purpose, procedures, data handling) and provided informed consent. Participants were required to sign an informed consent form before participating in the study. Participants were trained on accessing/interpreting their real-time data via a map visualization [2]. We clarified non-affiliation with rideshare platforms and informed participants of their right to withdraw or request data deletion anytime without penalty.

Compensation. Participants were compensated 4,000 Baht per month for their participation, with payments distributed twice monthly during check-ins by transferring into their bank account.

3.2 Real-Time Sensor Deployment and Calibration

To collect real-time air pollution data, we deployed 10 portable low-cost air quality sensors developed by our research team [12].

Sensor Deployment and Support. Sensors were mounted on helmets of 10 motorcycle rideshare drivers (5 Chiang Mai, 5 Bangkok) near the breathing zone, powered by 2 portable batteries during their 6-17 hour workdays. Drivers manually operated sensors and used a LINE group (a popular messaging app in Thailand) for communication and troubleshooting assistance, prompted by automated malfunction notifications. They could view real-time collective data via a web application featuring a map visualization tool [2] displaying color-coded pollution levels; training was provided. Deployment spanned November 2023 to mid-May 2024, covering Thailand's peak pollution season (Jan-Apr) and diverse seasonal conditions to capture varied PM2.5 exposure.

Bi-Weekly Check-Ins. Biweekly check-ins facilitated participant feedback, shared data summaries (local street-level pollution), equipment checks, and re-calibration.

3.3 Qualitative Interview

Qualitative exit interviews with all participants explored their experiences, routines, and perceptions of air pollution (pre/post study). Conducted by a native Thai author, the 45-60 minute semi-structured interviews used open-ended questions.

Interview Coding. We analyzed qualitative data using thematic analysis [4], collaboratively developing a codebook via inductive and deductive approaches [11, 15]. Interviews, transcribed in Thai, were iteratively coded for recurring themes. Two researchers independently coded a subset of transcripts for inter-coder reliability and resolved discrepancies through discussion. Key themes included changes in driver awareness of air pollution, behavior changes during high PM2.5 periods, and participants' engagement in the project. We then applied axial coding using the codebook to explore theme interrelationships [18].

4 Overview of Collected Data

Air Quality Data From Sensors. Over the seven-month period (November 2023 to mid-May 2024), we collected data from ten motorcycle rideshare drivers in Bangkok and Chiang Mai, covering peak and non-peak pollution seasons. Each driver wore a helmet-mounted low-cost PM2.5 sensor, calibrated against stationary PCD air quality towers in Chiang Mai and Bangkok.

In total, we captured over 50 million data points on street-level pollution in approximately 163.49 km^2 driven in Bangkok and 97.21 km^2 in downtown Chiang Mai. Drivers drive approximately 6-10 hours per day, with consistent sensor functionality powered by portable power banks.

Sensor Data Cleaning and Validating. Prior the deployment, each PM2.5 sensor was field-tested by co-locating it with a reference air quality station operated by Thailand's Pollution Control Department (PCD) in Bangkok. Over five days, three low-cost sensors showed strong alignment with hourly PM2.5 readings from the PCD station, with Pearson correlation coefficients consistently above 0.81, indicating high reliability.

After collecting the data, we removed the PM2.5 readings above the detection limit (500 $\mu g/m^3$). Some drivers also received replacement sensors due to hardware issues; we reconciled device changes by mapping data streams to the correct participant timelines.

Exit Interviews. We conducted qualitative exit interviews with all participants to supplement the sensor data. These interviews focused on understanding drivers' experiences with sensor-equipped helmets, their daily driving patterns, and any changes in awareness or behavior regarding air pollution. The author, a native Thai speaker, conducted the 60-90 minute interviews, using a semi-structured approach with open-ended questions.

5 Results

This section analyzes the collective behaviors of motorcycle taxi drivers using helmet-mounted sensor data (air quality, location, movement) to understand how individual PM2.5 exposure varies across time periods and locations, and how drivers subsequently respond based on these observed exposure patterns.

5.1 PM2.5's Temporal Patterns

Analyzing daily average PM2.5 exposure (Figure 1) reveals relatively consistent levels in Bangkok (BKK), peaking moderately from December to mid-February, while Chiang Mai (CMI) shows pronounced seasonality with extreme peaks from March to early April (consistent with agricultural burning periods [3, 6, 22]). Within each city, drivers experience similar daily trends. Hourly averages (Figure 2) show daily cycles peaking during morning (BKK: 7 AM, CMI: 8 AM) and evening rush hours, with an afternoon dip, although late night/early morning data shows higher variance. Notably, BKK's PM2.5 measurements show a consistent trend throughout the year, reinforcing traffic as the primary air pollution source. In contrast, CMI's dominant seasonal variation indicates agricultural burning as the primary driver. Thus, PM2.5 sources differ substantially between cities (BKK: traffic, CMI: agricultural burning), implying the need for location-specific mitigation strategies.

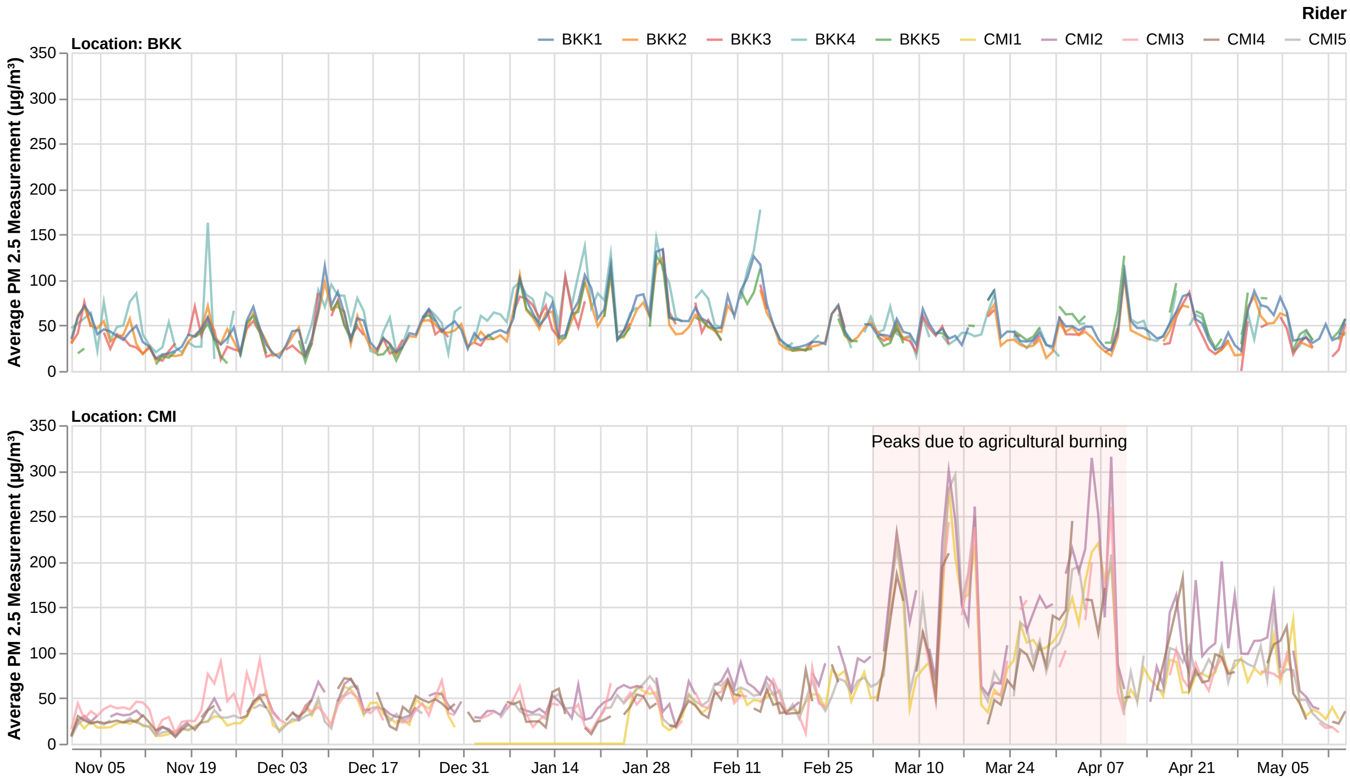


Figure 1: Daily PM 2.5 exposure measured from the helmet-mounted sensors for Bangkok and Chiang Mai drivers. Vertical grid lines represent Sundays.

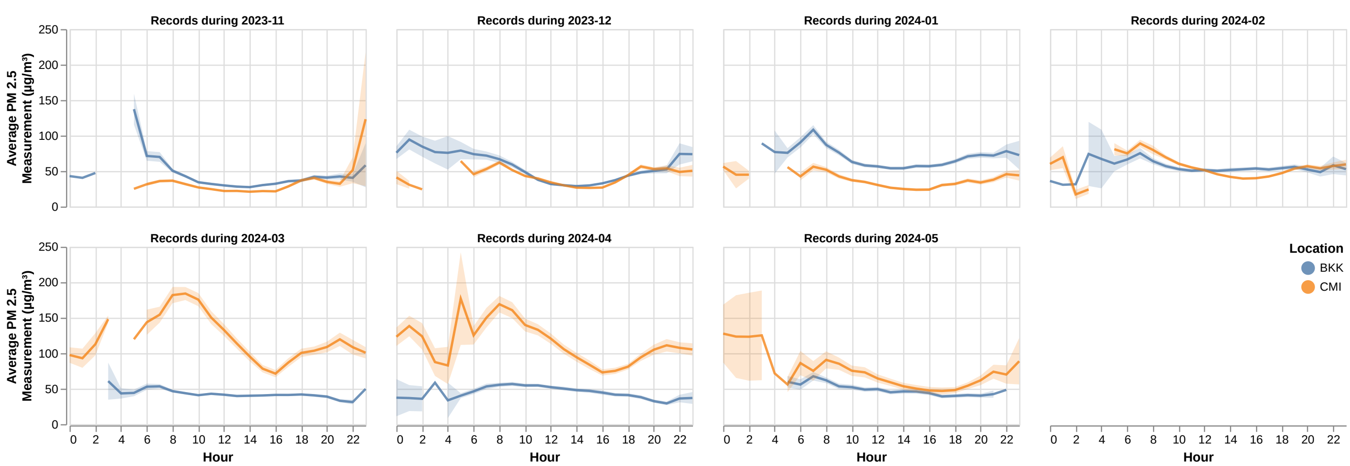


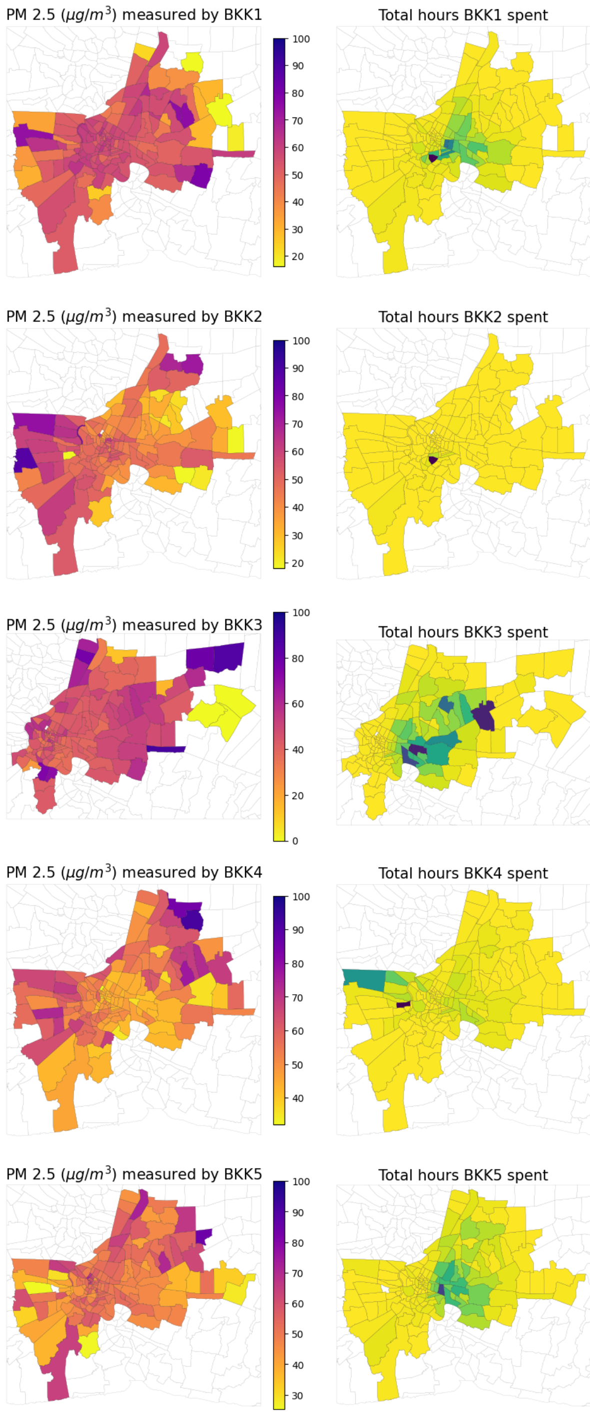
Figure 2: Mean and standard deviations of air pollution measurement in each hour of the day throughout the study period. Each subplot represents each month in the study.

5.2 PM2.5's Spatial Patterns

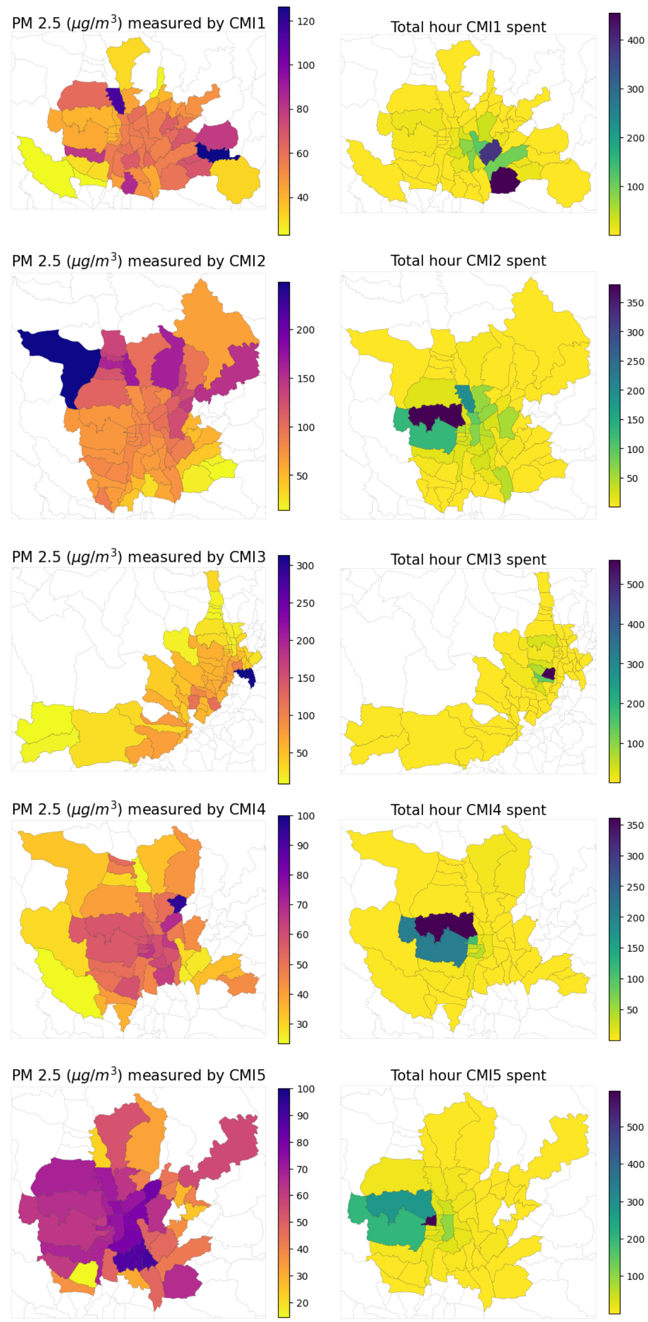
Spatial analysis (Figure 3) reveals that PM2.5 distribution is uneven across subdistricts and individual drivers, with drivers experiencing different exposure levels even in similar areas. Furthermore, each driver tends to operate primarily within specific locations. Consequently, effective PM2.5 exposure mitigation strategies must consider these individual spatial work patterns.

5.3 Driver Responses to Air Pollution Exposure

This section explores how drivers responded to the observed air pollution patterns, combining quantitative findings with qualitative



(a) Measurement collected in Bangkok.



(b) Measurement collected in Chiang Mai.

Figure 3: The left column of each sub-figure shows the average PM2.5 level throughout the study period measured in each subdistrict. The right column of each sub-figure shows the amount of time in hours that each driver spent in each subdistrict throughout the study.

insights from interviews and driver archetypes ("Income-Driven" and "Health-Conscious"). While quantitative analysis reveals complex exposure patterns varying temporally (Figure 1, Figure 2) and spatially (Figure 3) across individuals and cities, driver responses show limited adaptation, dictated primarily by economic needs and the perceived unavoidability of pollution.

5.3.1 Prioritizing Income Amidst Pervasive Pollution. Our analysis reveals no correlation between drivers' daily work hours and concurrent average PM2.5 levels (Figure 4), indicating a lack of temporal work adjustments in response to pollution fluctuations. This aligns with qualitative interviews where drivers frequently expressed perceiving pollution exposure as an unavoidable occupational hazard rather than a modifiable risk. Many prioritized immediate income over avoiding polluted times, echoing sentiments like,

> "I just go where the application tells me to go, ..., the (air) pollution is everywhere anyway." (BKK1)

> "When I see that the area gets smoggier, I often thought about driving out to the suburban area. But that means I'll have to drive an empty car out." (BKK5) 5

This "Income-Driven" approach was common. Driver BKK1 (46, Male), targeting 2,000-2,500 baht daily through long hours (4 AM-9 PM), exemplified this. Despite experiencing symptoms like runny noses and eye irritation and becoming aware of pollution levels via our map visualization after joining the study, his driving patterns remained unchanged. He explained his reliance on masks and persistence:

> "I can feel my body gets weaker (the more I drive); I always wear masks. ... If Google Maps tells us to go, I go. Wherever it is, I just have to push through." (BKK1)

He further emphasized the lack of choice dictated by the platform and financial needs:

> "I will not be able to be selective about routes; I go wherever the application assigns me to go, no matter of how far or how polluted the area may be." (BKK1)

The dominant narrative remains that immediate economic needs override pollution avoidance strategies concerning work timing.

5.3.2 Limited Mitigation. While prioritizing income was dominant, some drivers, exemplified by the "Health-Conscious" driver BKK3, attempted mitigation strategies within existing constraints. BKK3 (54, Female) actively incorporated heightened air pollution awareness into driving decisions after using the sensor helmet and map visualization. She observed pollution spikes when riding behind buses,

> "When I follow big buses, the graph just shoots up immediately." (BKK3)

and gained insight into hazardous AQI levels (80-100 $\mu g/m^3$) even on seemingly clear days. This awareness prompted actions like avoiding main roads for side streets, despite potentially longer distances,

> "Main roads have more dusts (air pollutants), it's better to go through small alleys." (BKK3)

and selectively accepting rides or disabling auto-matching nearby to reduce prolonged exposure, particularly when heading home.

However, despite finding the real-time, localized AQI data useful, financial needs prevailed:

> "We took this job for the money. We just have to live with it." (BKK3)

BKK3's experience illustrates the tension between health awareness and economic necessity. While information tools provide valuable insights, platform constraints significantly limit drivers' ability to act on this information without sacrificing income.

In this study, we do not observe a correlation between drivers' mitigation behaviors and their age or gender.

5.3.3 Increased Awareness and Community Engagement. Participation in the study and access to the map visualization significantly increased drivers' awareness and spurred public engagement. Most participants reported frequently checking the visualization, particularly on high-pollution days. This led to discussions about air quality with friends and passengers; for instance, CMI4 advised others on mask use, while BKK4 shared real-time data from the visualization with passengers during rides in poor conditions. The visualization thus served both as a personal reference tool and a catalyst for community awareness.

Driver CMI1 exemplified proactive community engagement. He monitored morning pollution levels and actively shared warnings in the Chiang Mai rideshare driver community (>5,000 members) when conditions were hazardous:

> "I often take a screenshot (of the map visualization) when the air pollution levels turn red (hazardous) and share it in the group, warning everyone to be extra careful since the pollution got worsen that day." (CMI1)

This demonstrates how access to real-time, localized data empowered drivers beyond personal monitoring. It fostered collective awareness and turned some participants, like CMI1, into informal educators and active contributors to environmental health knowledge sharing within their community, moving beyond passive data reception.

Overall, while access to air quality information increased awareness and even spurred community engagement, the demanding nature of gig work and the perceived ubiquity of pollution limit drivers' capacity to translate this awareness into significant behavioral changes, particularly regarding work schedules. Financial imperatives largely override health considerations, highlighting the

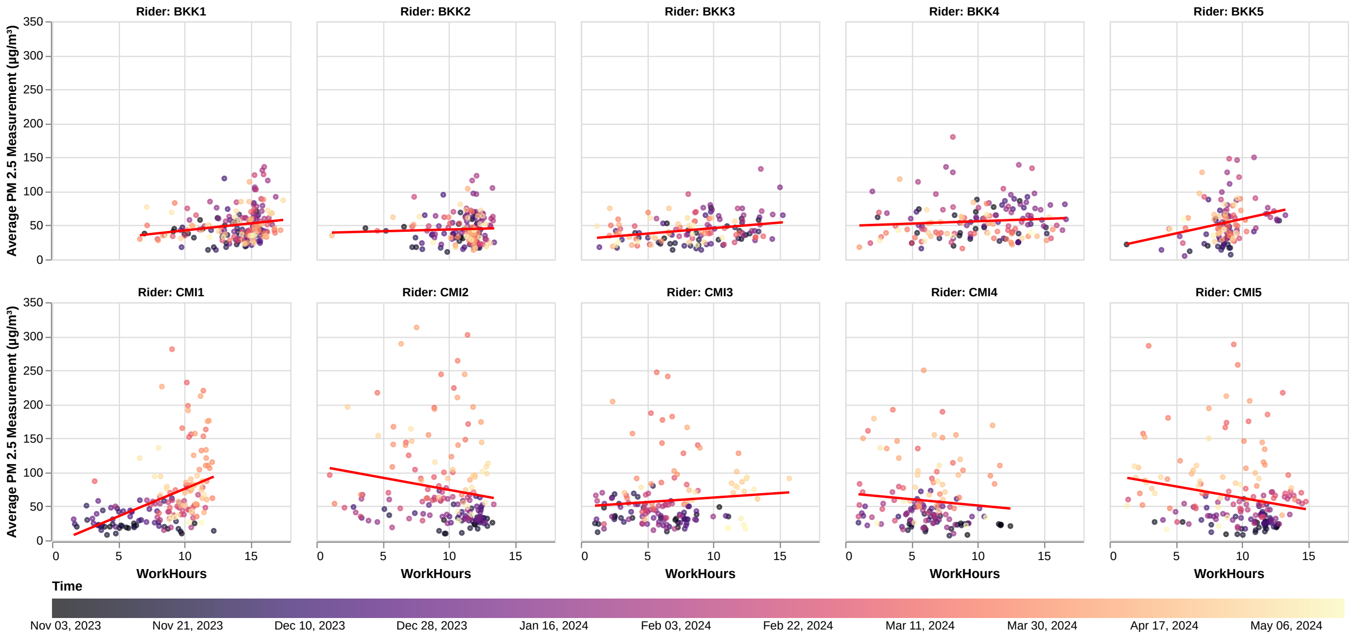


Figure 4: Correlation of daily work hours and air pollution measurement for each driver, averaged through each week, with regression lines.

need for systemic interventions beyond individual information provision to effectively reduce exposure, such as low-emission zones or integrating real-time AQ data into traffic management.

6 Discussion

This study combines sensor data and interviews to offer a multimodal perspective on Thai motorcycle rideshare drivers' experiences. A key goal was understanding this environment to identify interventions improving driver health and livelihoods. We discuss driver interest in real-time data, policy implications, infrastructure improvements, and platform-level incentives.

User Interest in Real-Time Data. Despite prior work [17] suggesting drivers prioritize revenue over technology-led behavioral change, participants valued real-time air quality data, feeling it empowered more informed decisions and increased awareness. Some drivers used this data to prepare for better protection, such as wearing masks on high-pollution days. However, many also stated they would continue working regardless of conditions, as income needs outweighed health concerns. Drivers suggested integrating air quality data via motorcycle dashboards, ride-share apps, interactive maps, or directly into motorcycles. Predictive algorithms could offer proactive warnings. While designing non-distracting interfaces is challenging, this area warrants future investigation.

Policy Interventions and Financial Support. Government interventions like targeted financial support (e.g., subsidies for protective equipment, healthcare benefits, compensation during severe pollution) could improve driver outcomes. Stricter emission controls and encouraging electric motorcycles offer long-term improvements. Drivers themselves did not propose specific policy solutions beyond requesting better compensation or basic protections, reflecting their limited agency in shaping broader environmental conditions. Ultimately, reducing driver exposure requires a multi-stakeholder approach involving government, platforms, passengers, and drivers, integrating technology and policy to balance stakeholder needs (platform profitability, driver health/income, user convenience).

Local and Collective Action. The differing primary PM2.5 sources were identified; consistent traffic emissions in Bangkok versus seasonal agricultural burning dominating in Chiang Mai. This fundamentally shapes the air pollution challenge across regions and underscores that effective mitigation strategies must be location-specific. For instance, government policies like Work-From-Home (WFH) campaigns (e.g., Bangkok's 2024 initiative contributed to an 8% traffic reduction [19]) directly target the traffic congestion identified as Bangkok's primary issue, particularly during peak rush hours indicated by daily cycles (Figure 2). Yet, these policies offer limited impact where sources differ (e.g., Chiangmai's burning season) and fail to resolve direct exposure for frontline workers like motorcycle taxi drivers who remain operational amidst pollution sources. Therefore, effective solutions need integrated approaches by complementing national policies with targeted, local actions against dominant sources (traffic/burning) plus direct support (e.g., PPE, technology) for those highly exposed, potentially scaled through tailored public-private partnerships and advocacy from local nonprofit organizations.

Passenger Awareness and Platform-Level Incentives. Rideshare platforms involve competing passenger and driver incentives. For example, passenger demand for food deliveries during high pollution increases driver exposure. Educating passengers about these risks could help. Platforms could offer off-peak discounts during high-pollution events, aligning incentives, though potentially reducing platform usage. Alternatively, external campaigns could discourage peak-pollution usage.

Study Limitations. Limitations include the sensor's battery life (8–10 hours), which may lead to data gaps during longer shifts. Although drivers did not find the sensors intrusive, long-term deployment would benefit from logistical support such as battery swap stations for the sensors' battery power. Our non-random sample intentionally focused on uniquely deep, longitudinal lived experiences rather than generating statistically generalizable health conclusions typical of epidemiological studies. Furthermore, sensors measured only a subset of pollutants, likely underestimating total exposure risks.

7 Conclusion

This study investigated the severe PM2.5 exposure faced by motorcycle rideshare drivers in urban Thailand, highlighting how economic constraints create significant barriers for this population to follow standard health advice, even when aware of the dangers. Building upon previously identified agency limitations, our seven-month mixed-methods study uniquely introduced a real-time air quality map visualization, observing that although drivers incorporated this data to adjust routes and schedules, income generation consistently superseded significant exposure mitigation actions.

Our contributions include fine-grained, individualized exposure data contextualized by lived experiences, revealing the complex interplay between health risks, economic pressures, and structural barriers. The findings underscore the urgent need for multi-faceted interventions involving technology (e.g., real-time data interfaces), policy (e.g., financial support, targeted regulations), and platform adjustments.

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