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2019 Cambridge Particle Meeting

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Field investigations for evaluating air pollution exposure of in-pram babies compared to adults in roadside environment

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Motivation

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- UK UNICEF Analysis (UNICEF 2017)

6.5 million people die annually due to poor air quality

- Air pollution greatest risk to human health in UK
- 4th greatest threat to public health after cancer, heart disease and obesity

- Young children at highest risk.
- 17 million babies living in severely affected areas (air pollution exceeding international limits by 6 times)

- UK UNICEF Analysis (UNICEF 2018)

- 1 in 3 babies growing in UK with unsafe levels of particulate matter – nearly 270,000 babies under the age of 1 in the UK

- 1.6 million under-fives are growing in UK with unsafe levels of particulate matter – one third of all 0-5 year olds in the UK

Background (1)

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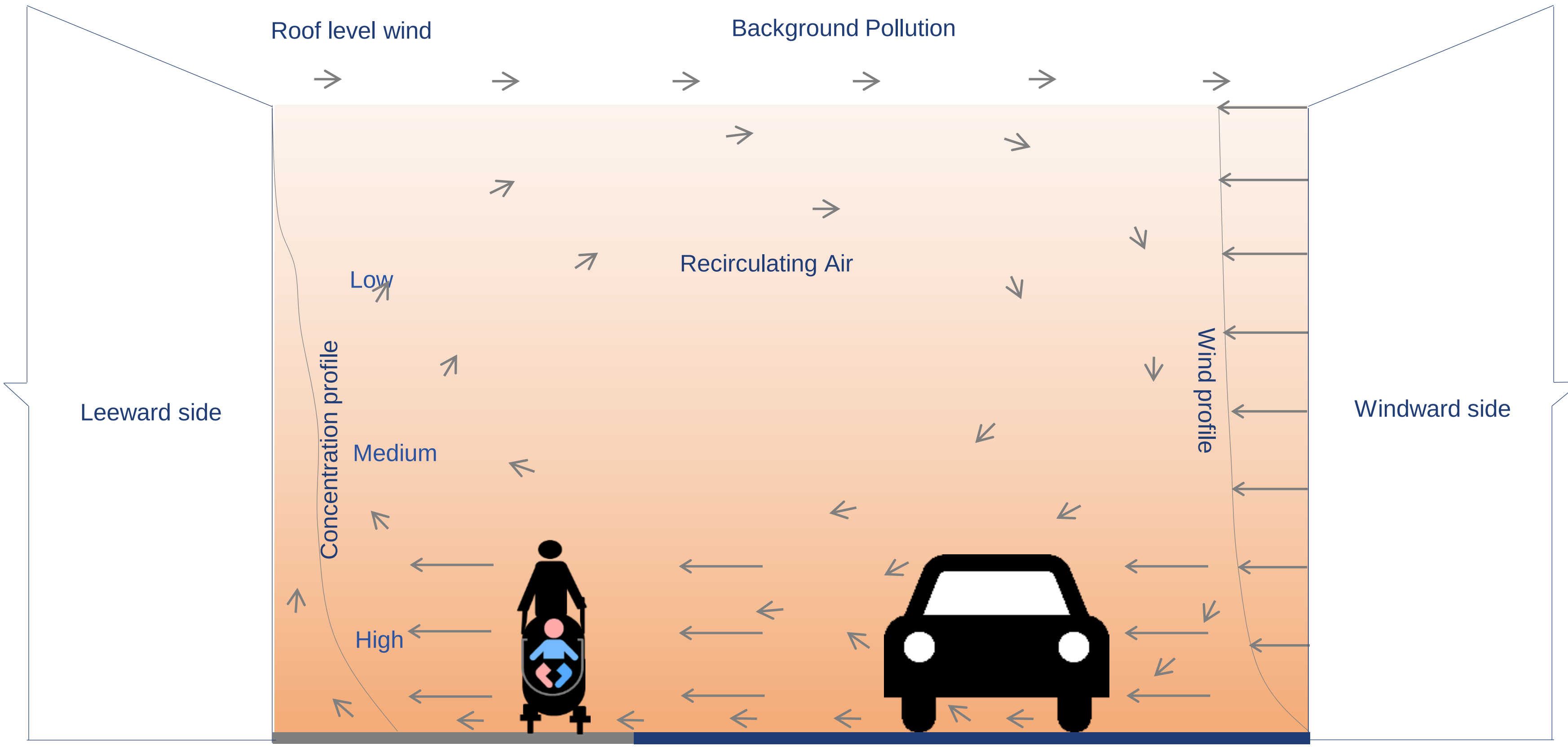
- How in-pram babies are exposed to air Pollution in roadside environments ?



Source : Sharma, A., & Kumar, P. (2018). A review of factors surrounding the air pollution exposure to in-pram babies and mitigation strategies. *Environment international*, *120*, 262-278.

Background (2)

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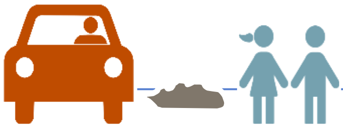
- Health effects of traffic-related air pollution ($PM_{2.5}$, PM_{10} and NO_x) on young children -



Young children are more vulnerable to the health effects of traffic-related air pollution (TRAP) such as particulate matter ≤10 µm (PM_{10}), ≤2.5 µm ($PM_{2.5}$) and oxides of nitrogen (NO_x)[1]

Positive correlations are reported between measured levels of TRAP exposure (e.g., $PM_{2.5}$, PM_{10} and No_x) and asthma development in young children[4]

- Long-term exposure of Black Carbon reduces cognitive function among young children.

- Negative characteristics of UFPs[2] impacting public health -

  - Greater surface area
  - Unique chemical composition
  - Higher pulmonary deposition efficiency
  - Ability to penetrate the body, circulation system and cardiovascular system
  - Pulmonary inflammation
  - Deposit in secondary organs including brain tissue
  - Causes asthma, allergies and respiratory diseases in children

- Children more vulnerable to higher breathing rates and dose intake[3]

[1]Bates, 1995, Giles et al., 2011; Harrison and Yin, 2000; Heal et al., 2012, Janssen et al., 2012; Lim et al., 2013, Morgan et al., 1997, Sydbom et al., 2001; Watt et al., 1995, World Health Organization, 2005, WorldHealthOrganization, 2011;
[2]Sioutas et al., 2005, Kumar et al., 2010, Branco et al., 2014, Donaldson et al., 2005; [3]Buonanno et al., 2013, Burtscher and Schüepp, 2012; [4]Iskandar et al.,2011, Khreis et al., 2017, WorldHealthOrganization, 2011; [5]Suglia et al., 2007

Aims and Objectives

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The overall goal of this project is to critically assess the comparative exposure levels of in-pram babies and to develop a conceptual framework with recommendations for mitigation of in-pram babies

Classification of baby prams

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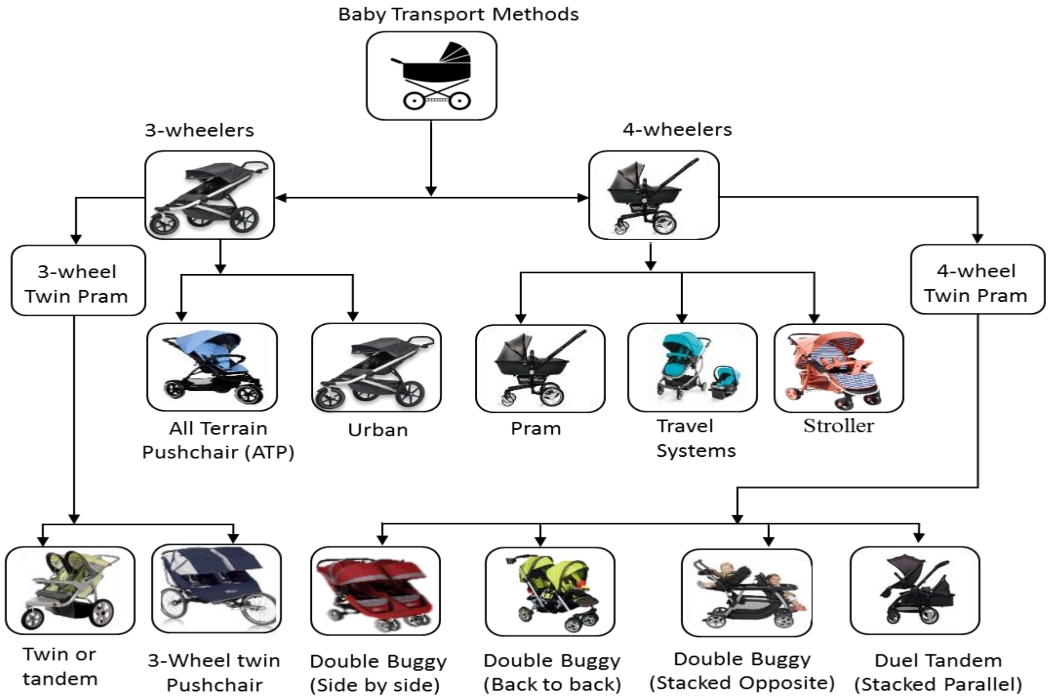
- Travel systems can be divided based on two important criteria :
  (i) number of wheels (3-wheelers, and 4-wheelers) and
  (ii) seating capacity (one baby versus two babies).



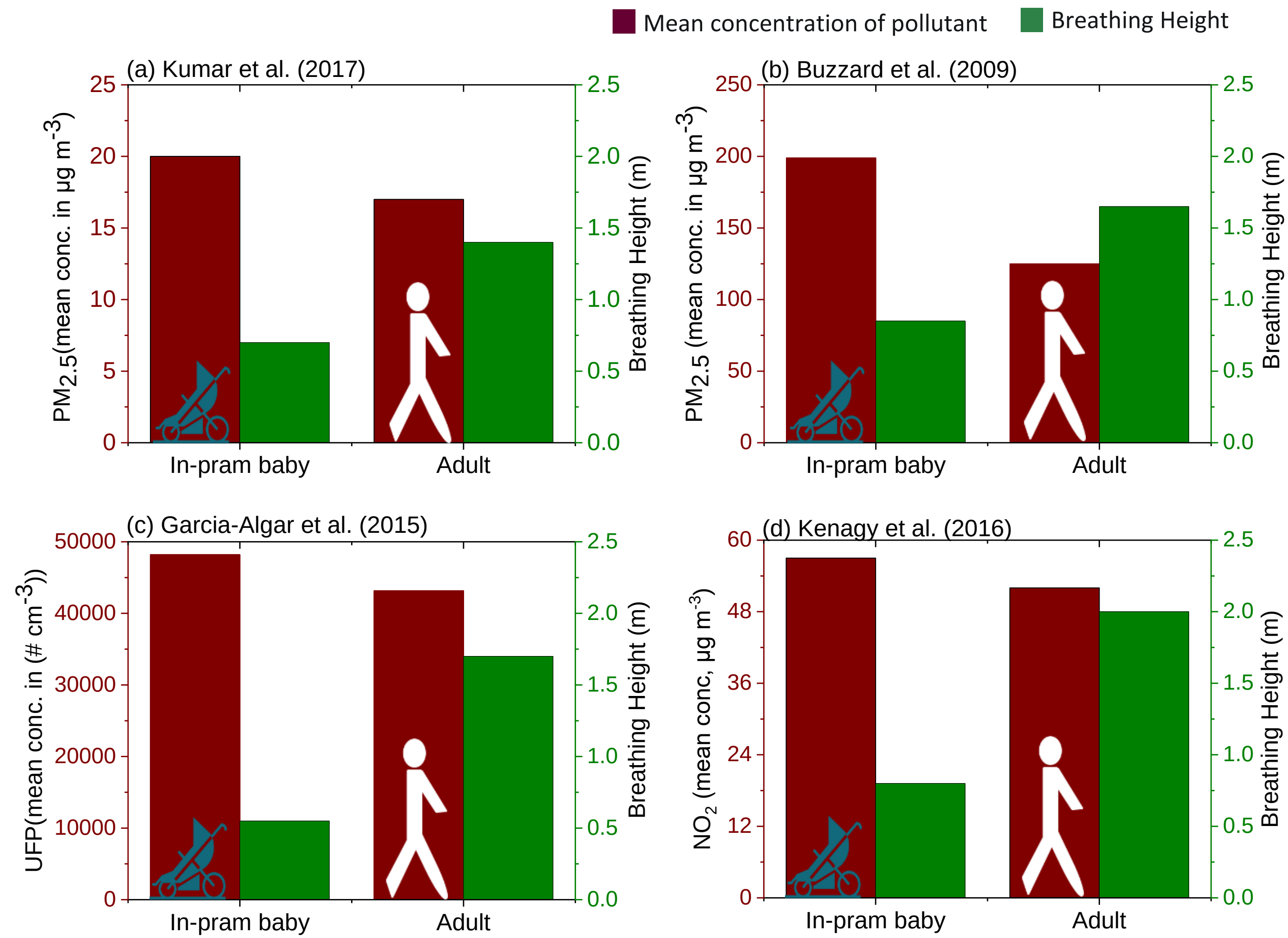
- Pram widths 0.56 ~ 0.82 m
- Top handle height ~ 1.25 m
- Breathing height 0.55 ~ 0.85 m

Source : Sharma, A., & Kumar, P. (2018). A review of factors surrounding the air pollution exposure to in-pram babies and mitigation strategies. *Environment international*, *120*, 262-278.

Exposure levels of in-pram babies

- In-pram baby exposure concentrations are affected by –

- Concentration decay with height
- Proximity with the roadways
- Location of the vehicle tailpipe close to the passenger side
- Duration of exposure measurement



Source : Sharma, A., & Kumar, P. (2018). A review of factors surrounding the air pollution exposure to in-pram babies and mitigation strategies. *Environment international*, *120*, 262-278.

Flow around baby prams

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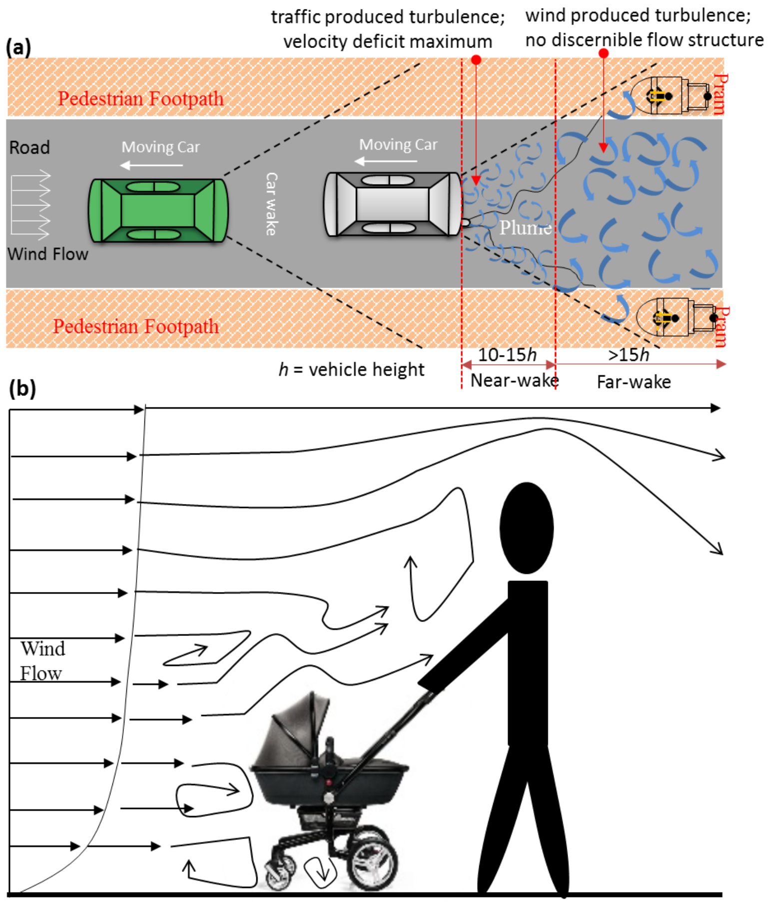

Source : Sharma, A., & Kumar, P. (2018). A review of factors surrounding the air pollution exposure to in-pram babies and mitigation strategies. *Environment international*, *120*, 262-278.

Experimental Design:
Route Map and in-pram measurements

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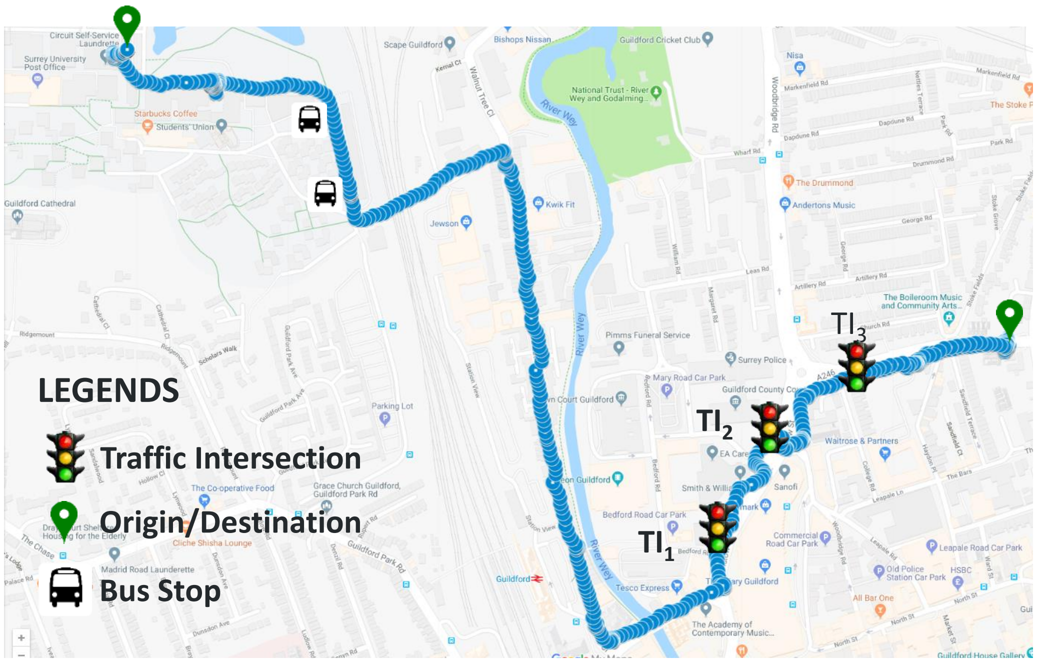
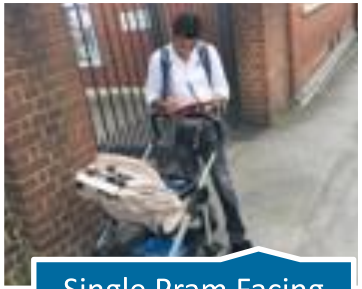
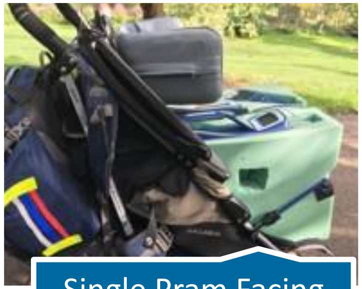



Single Pram Facing Roadside


Single Pram Facing Roadside


Double Pram Facing Roadside

Methodology: Instrumentation

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- Measurements performed for 2 different heights –
  - In-pram baby breathing height (i.e., 0.7m) and;
  - Adult breathing height (i.e.,1.7m)

Instrument (Model)	Pollutant Measured	Sampling Frequency/Resolution
GRIMM Aerosol Spectrometer (EDM 107, GRIMM Technologies Inc.)	Particles (size range 0.25-32 μm)	6 seconds
P-Trak Ultrafine Particle Counter (Model 8525, TSI Inc., USA)	Particles (size range 0.02 to 0.1 μm)	6 seconds
Q-trak (Model 7575, TSI Inc., USA)	Carbon Monoxide (CO)	10 seconds
Microaeth (Model MA 200 and Model AE51)	Black Carbon (BC)	10 seconds
JEOL SEM equipped with EDS (Model JSM-7100F, Japan)	SEM and EDS Analysis	Spatial resolution (depending on the sample) of 1.2 nm at 30 kV and 3.0 nm at 1 kV

Summary of datasets

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Scenarios	Measurement types	Measurement time	# of Single runs completed	Time (mins)	Distance Covered (kms)
SP_1 ($SP_{FP\text{-}WC}$)	Single Pram (facing parent-without cover)	AM PM	6 4	375.34 262.63	12.6 8.4
SP_2 ($SP_{FP\text{-}C}$)	Single Pram (facing parent-with cover)	AM PM	6 4	341.81 239.65	12.6 8.4
SP_3 ($SP_{NF\text{-}WC}$)	Single Pram (non-facing parent - without cover)	AM PM	6 8	352.48 459.85	12.6 16.8
SP_4 ($SP_{NF\text{-}C}$)	Single Pram (non-facing parent - with cover)	AM PM	4 4	191.68 245.08	8.4 8.4
SP_5 ($SP_{NF\text{-}BB}$)	Single Pram (non-facing parent - without cover – Clean Air Device)	AM PM	8 8	477.75 448.35	16.8 16.8
SP_6 ($SP_{NF\text{-}C\text{-}BB}$)	Single Pram (non-facing parent with cover - Clean Air Device)	AM PM	- 4	- 236.68	- 8.4
DP_7 ($DP_{SP\text{-}WC}$)	Double Pram (stacked parallel -without cover)	AM PM	8 6	428.64 341.37	16.8 12.6
DP_8 ($DP_{SP\text{-}C}$)	Double Pram (stacked parallel – with cover)	AM PM	5 8	286.43 422.06	10.5 16.8
Total			89 single runs	2705 mins (45 hours)	km

Note* AM=Morning; PM=afternoon; *Measurement period*: 29 days (6 August 2018 to 4th December 2018) for 5 days per week

Results : Concentration Profile on route

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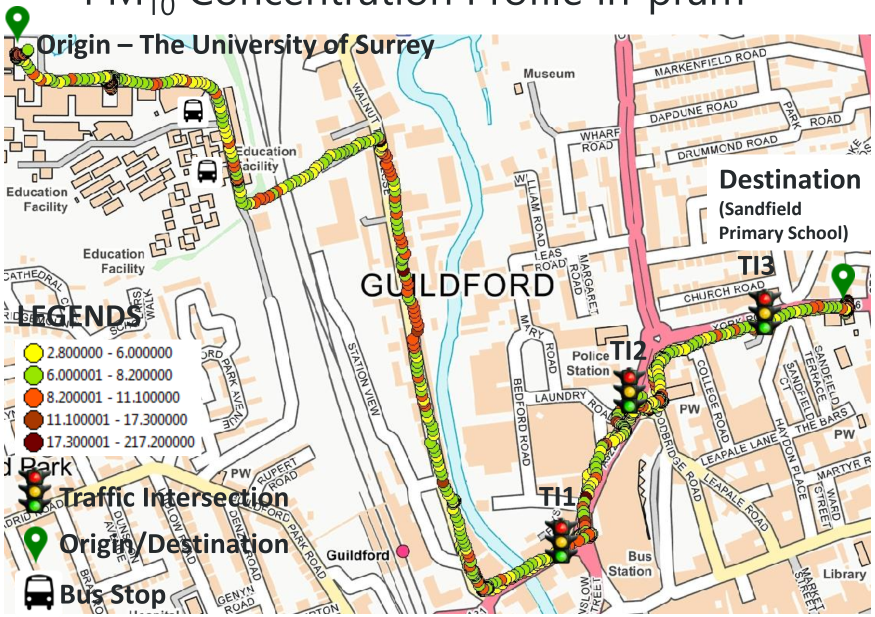
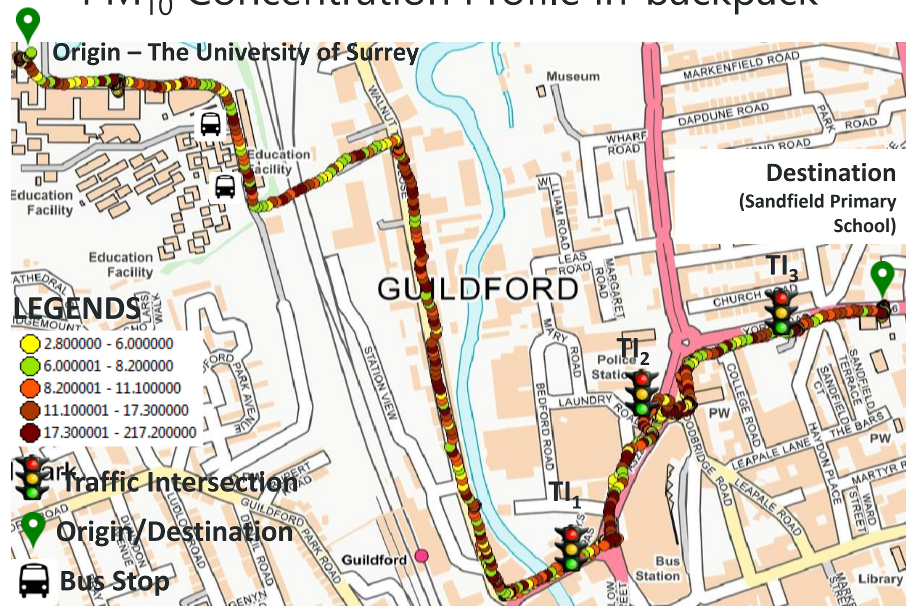
PM$_{10}$ Concentration Profile in-pram



PM$_{10}$ Concentration Profile in-backpack



Time-series plot of $PM_{2.5}$ concentration

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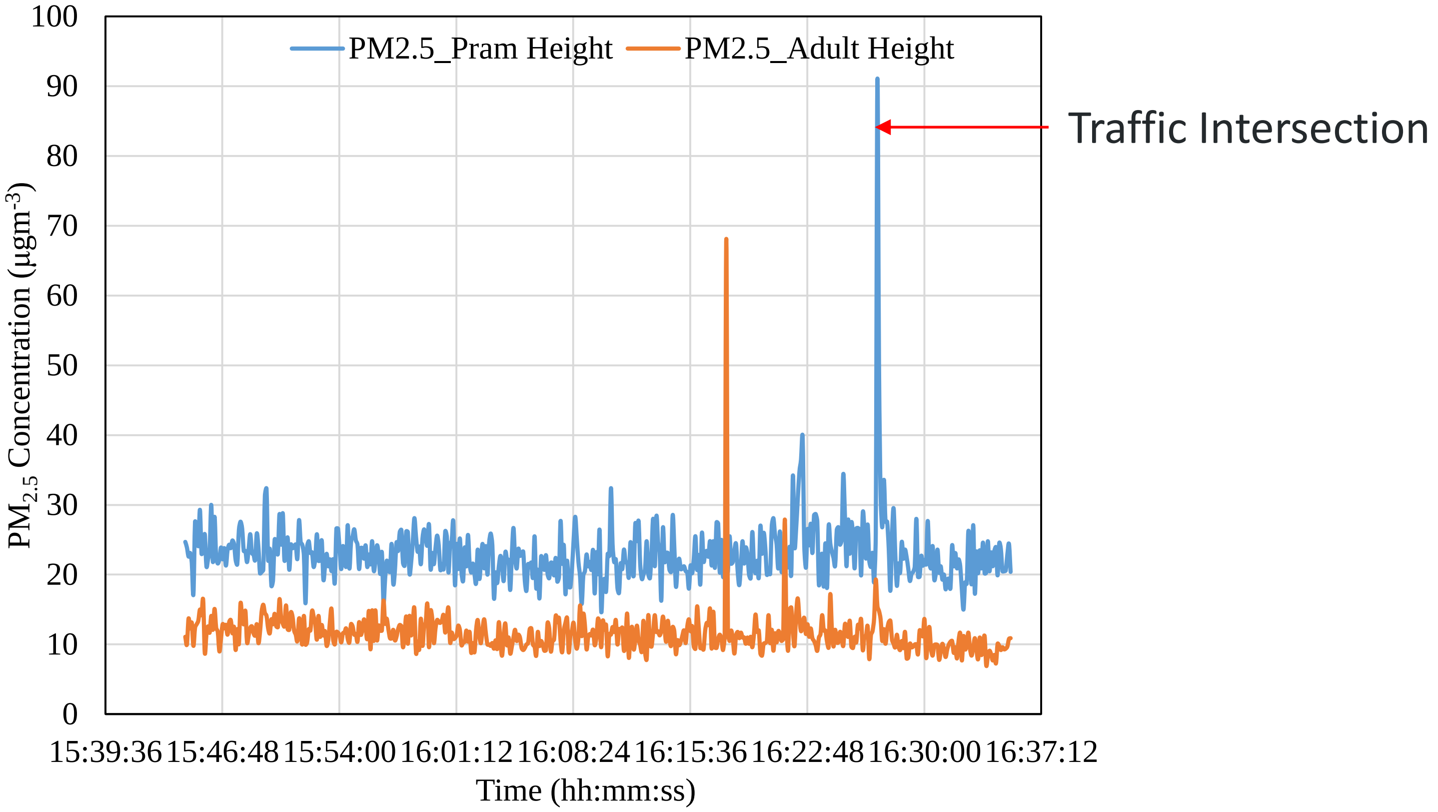

Results

Bar-charts : PM_x exposure at adult versus in-pram heights

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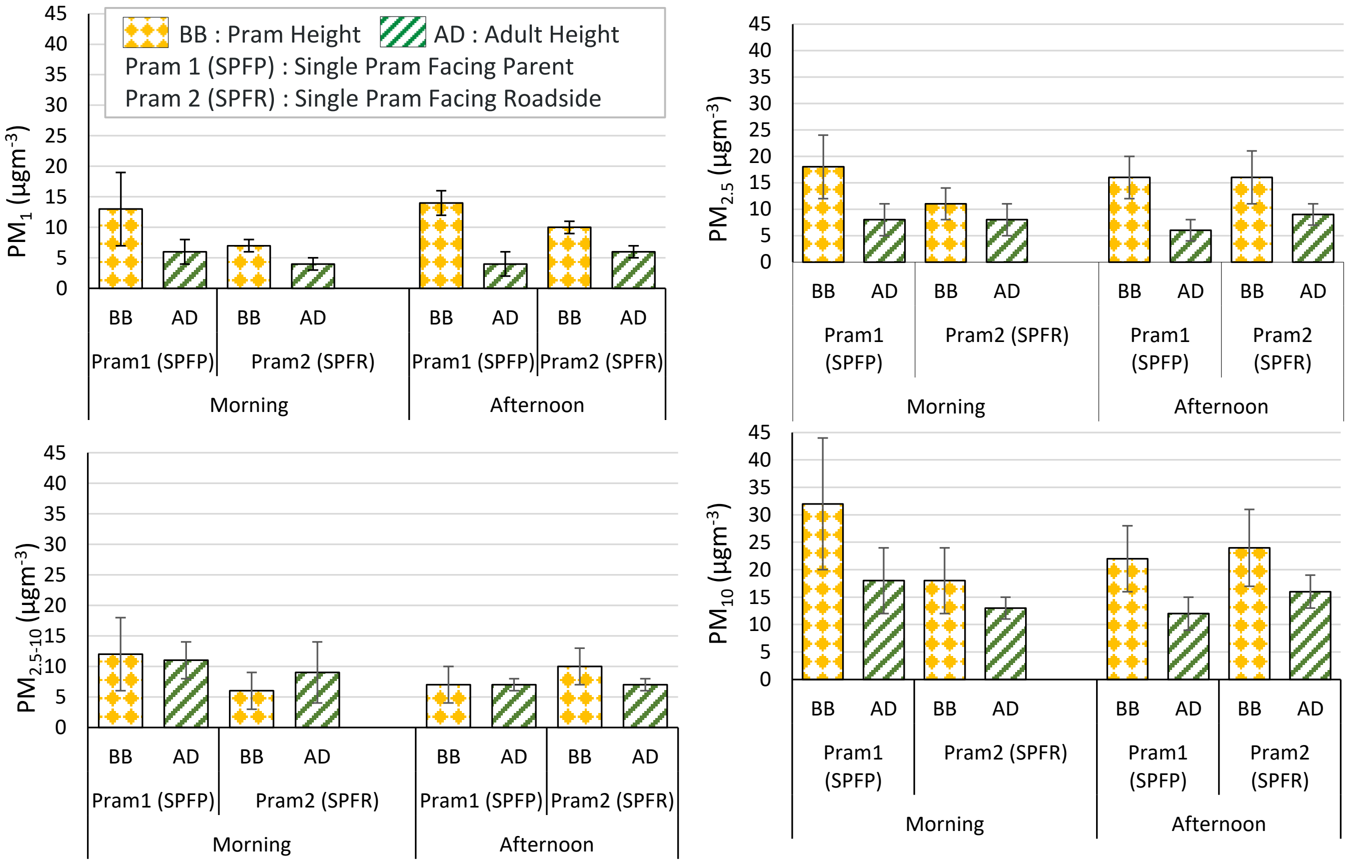

Bar-charts : PNC exposure at adult versus in-pram heights

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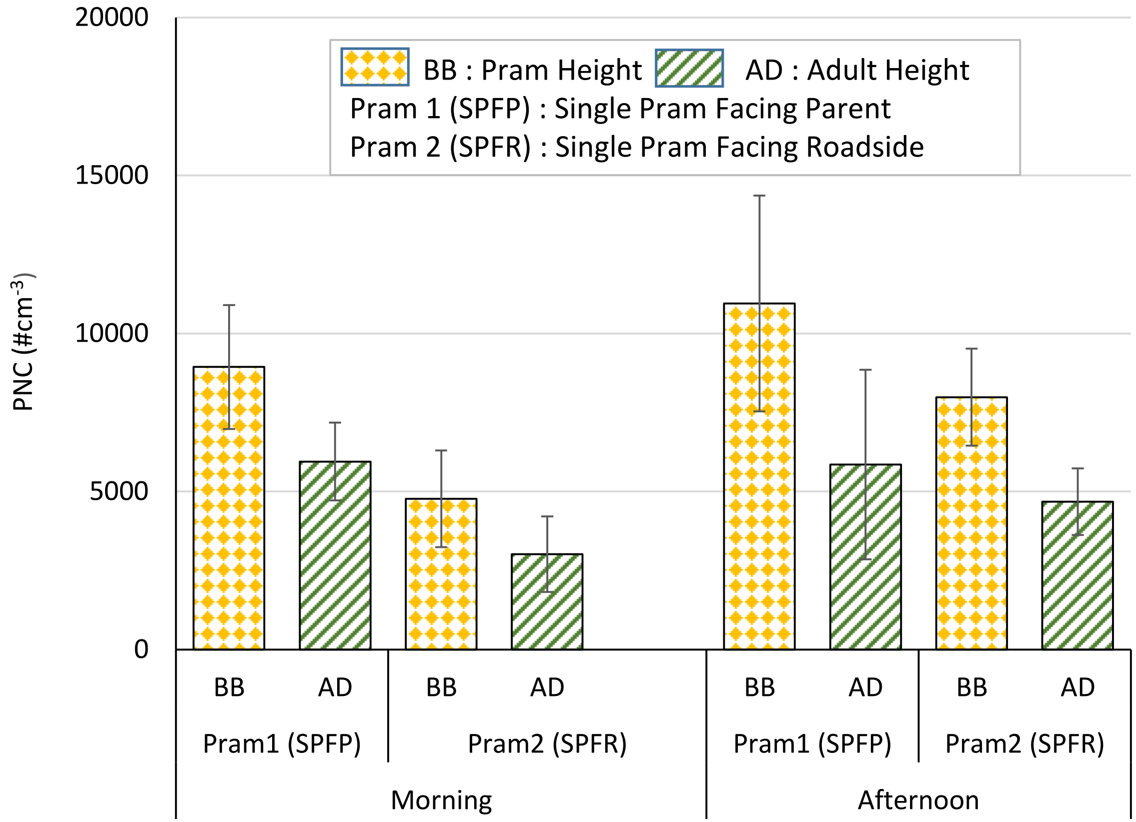

Summary and Conclusions

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Literature Review

- Babies exposure to traffic emissions damages frontal lobe, cognitive thinking and brain development.
- Classification of baby prams revealed first 1m above the road level (height of vehicle tailpipe) is critical for exposure assessment of in-pram babies, e.g., in-pram babies breathing vary height between 0.55 m and 0.85 m above the ground level and they could receive up to ~60% higher exposure than adults.
- Factors such as meteorological conditions (e.g., wind speed and direction), the built-up features along the roadside and traffic volume crucially affect the dilution, dispersion and exposure of pollutants in-prams.
- Passive control strategies (e.g., facemask and roadside green barriers) are effective in mitigating exposure concentrations of in-pram babies.

Data Analysis

- Fine particle concentration exposures are substantially higher at pram height compared to adult height and pram height exposures exceeds adult height by as much as 44%. However, BC and coarse particle showed mixed trends.
- Concentration exposures vary with type of prams, such as, single pram facing parent and facing roadside and also with different sitting heights in double pram viz., bottom seat versus top seat.
- Finally, for mitigation approach, pram covers are effective at mitigating concentration exposures of both fine particles and PNCs while might have reverse effect on coarse particle and BC concentration exposures.

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- Thanks to our research sponsors…

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- GCARE team
- University of Surrey's Department of Civil & Environment Engineering team

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Thank you ....

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International Media Coverage of Project *MAPE* (*Mitigating Air Pollution Exposure of In-pram Babies*)

BBC

UK Daily Mail

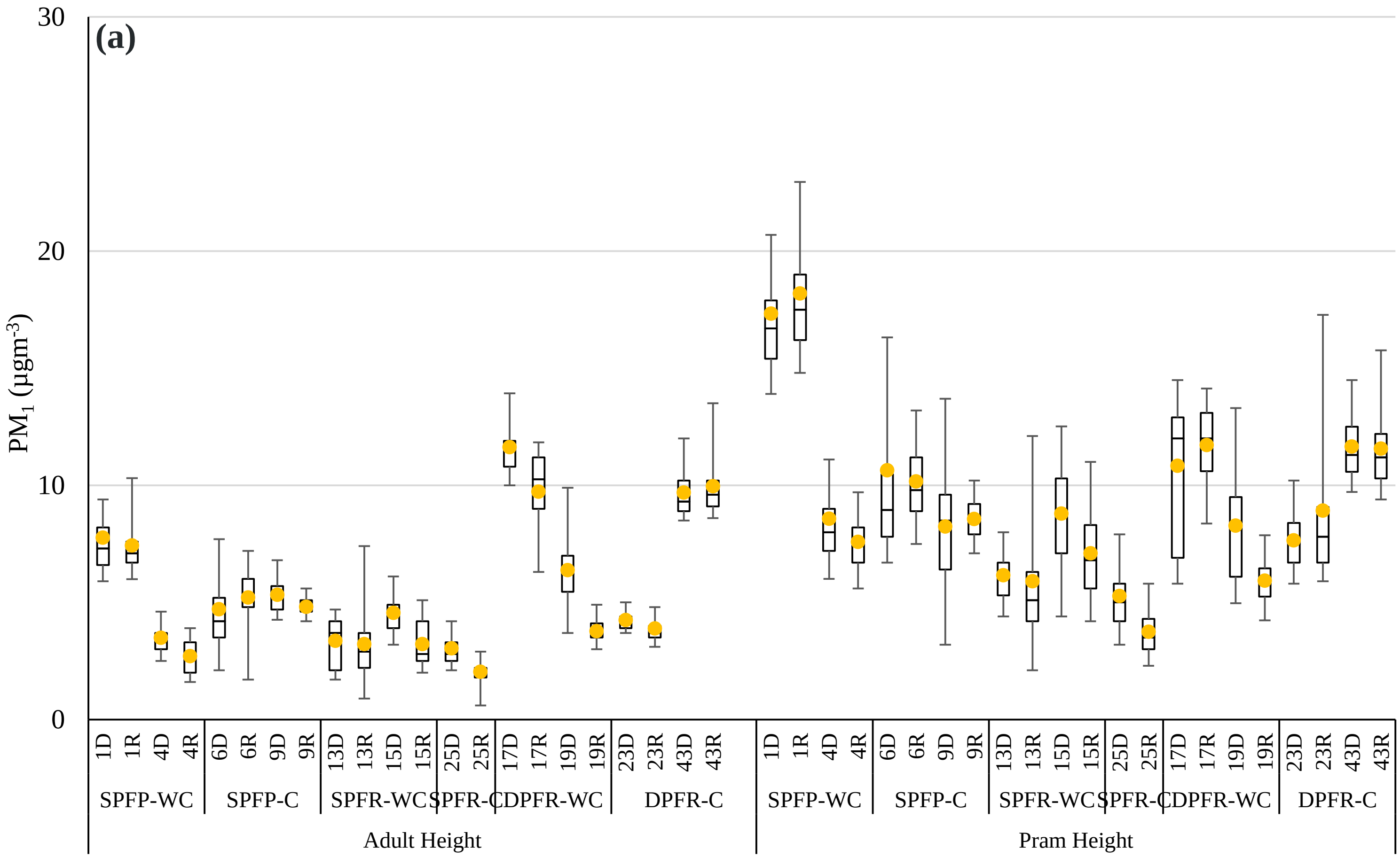
Telegraph

Huff Post

Further information about MAPE project, visit:
https://gtr.ukri.org/projects?ref=studentship-1948919

visit: surrey.ac.uk/gcare

Run-wise boxplots – Adult vs. Pram Height Morning PM_1



Run-wise boxplots – Adult vs. Pram Height Morning $PM_{2.5}$

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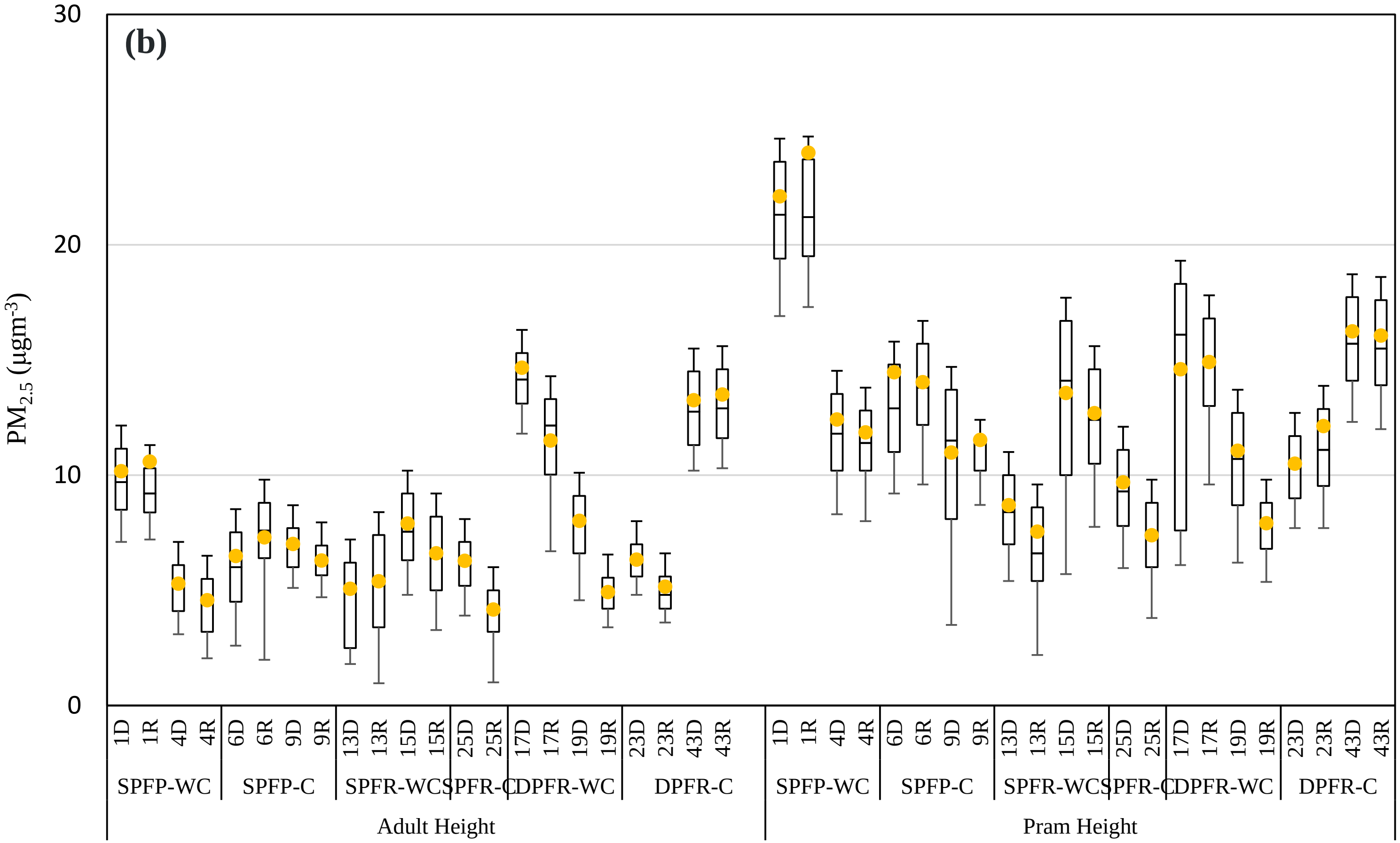

Run-wise boxplots – Adult vs. Pram Height Morning $PM_{2.5-10}$

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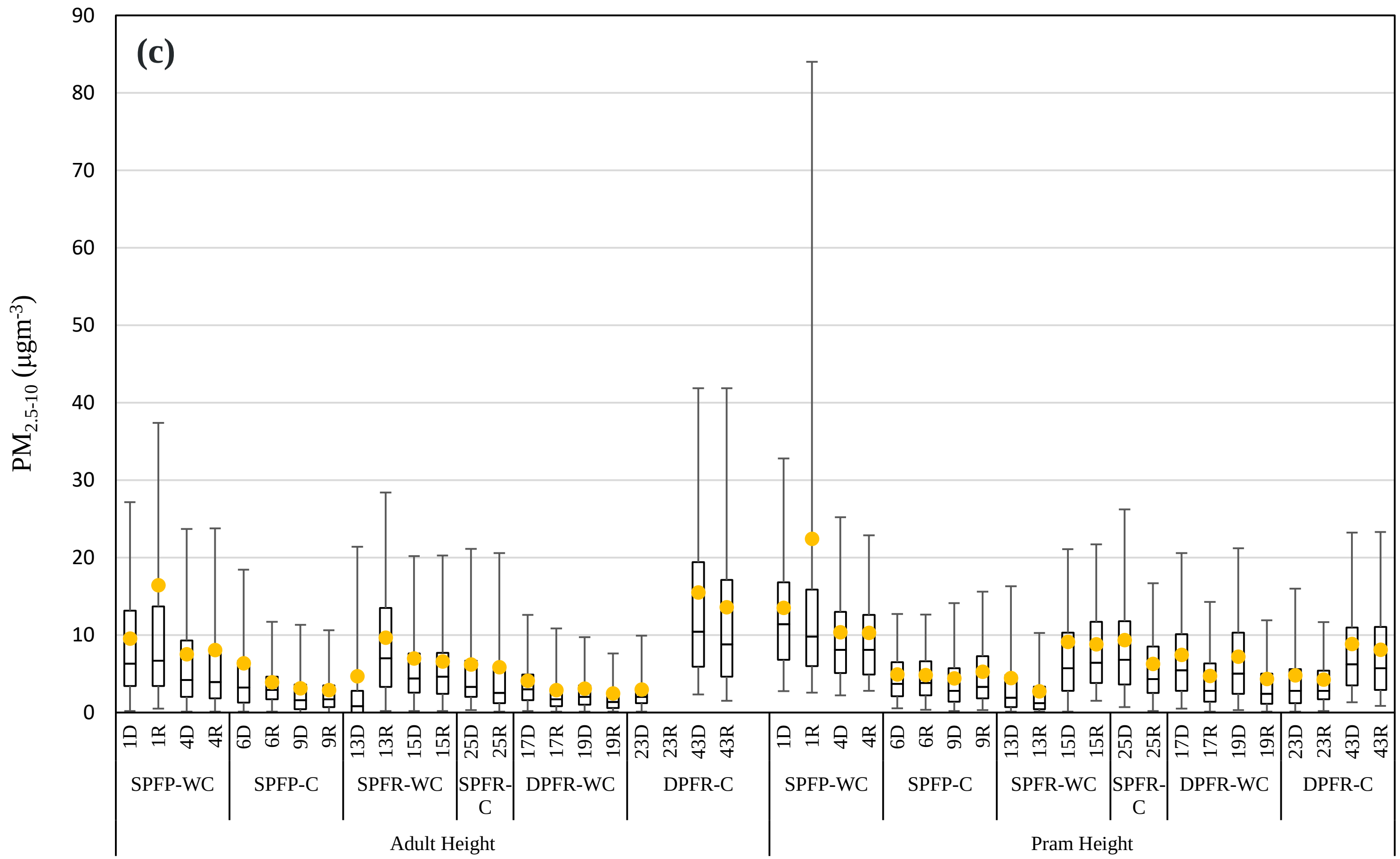

Run-wise boxplots – Adult vs. Pram Height Morning PM_{10}

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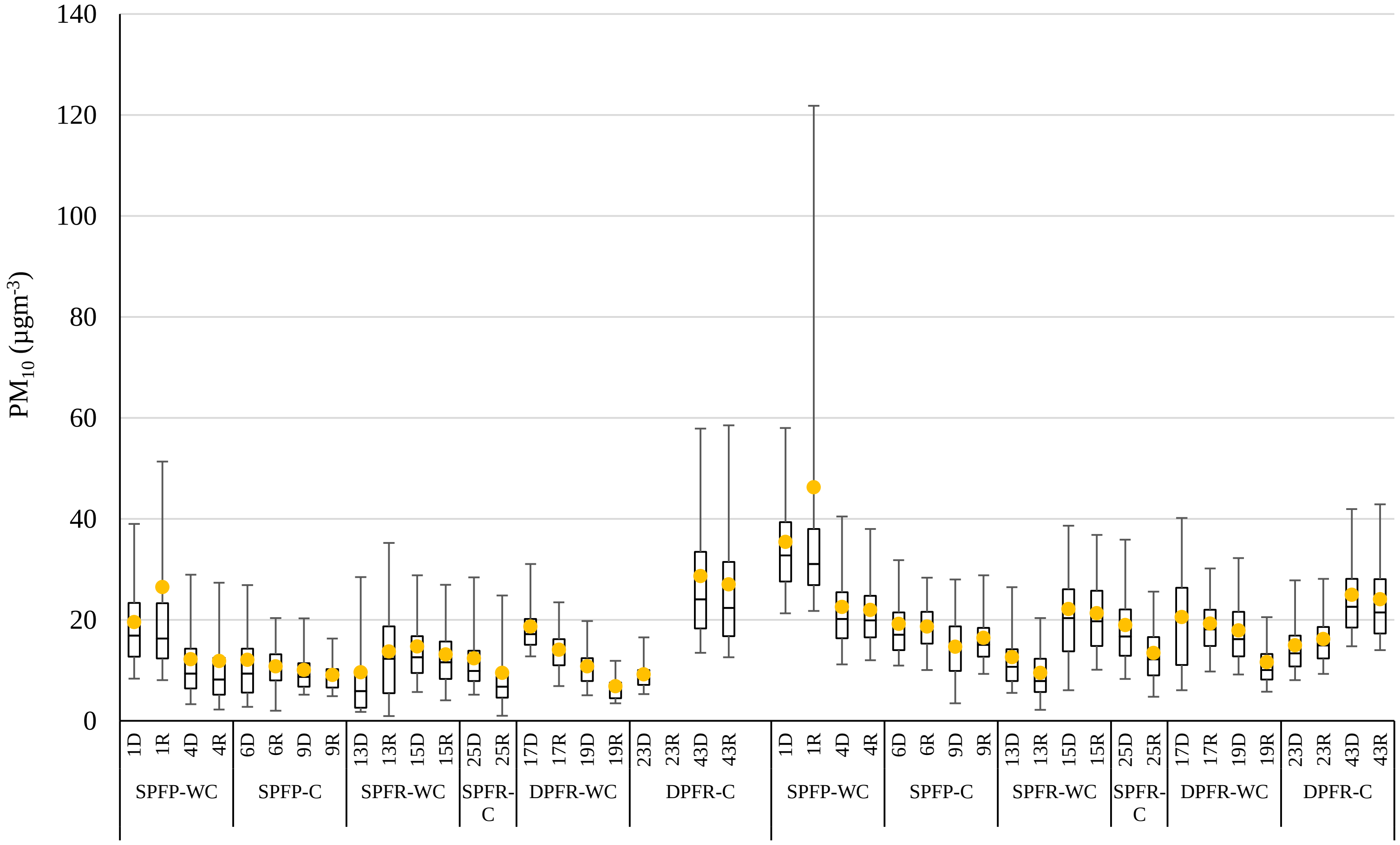

Run-wise boxplots – Adult vs. Pram Height Afternoon PM_1

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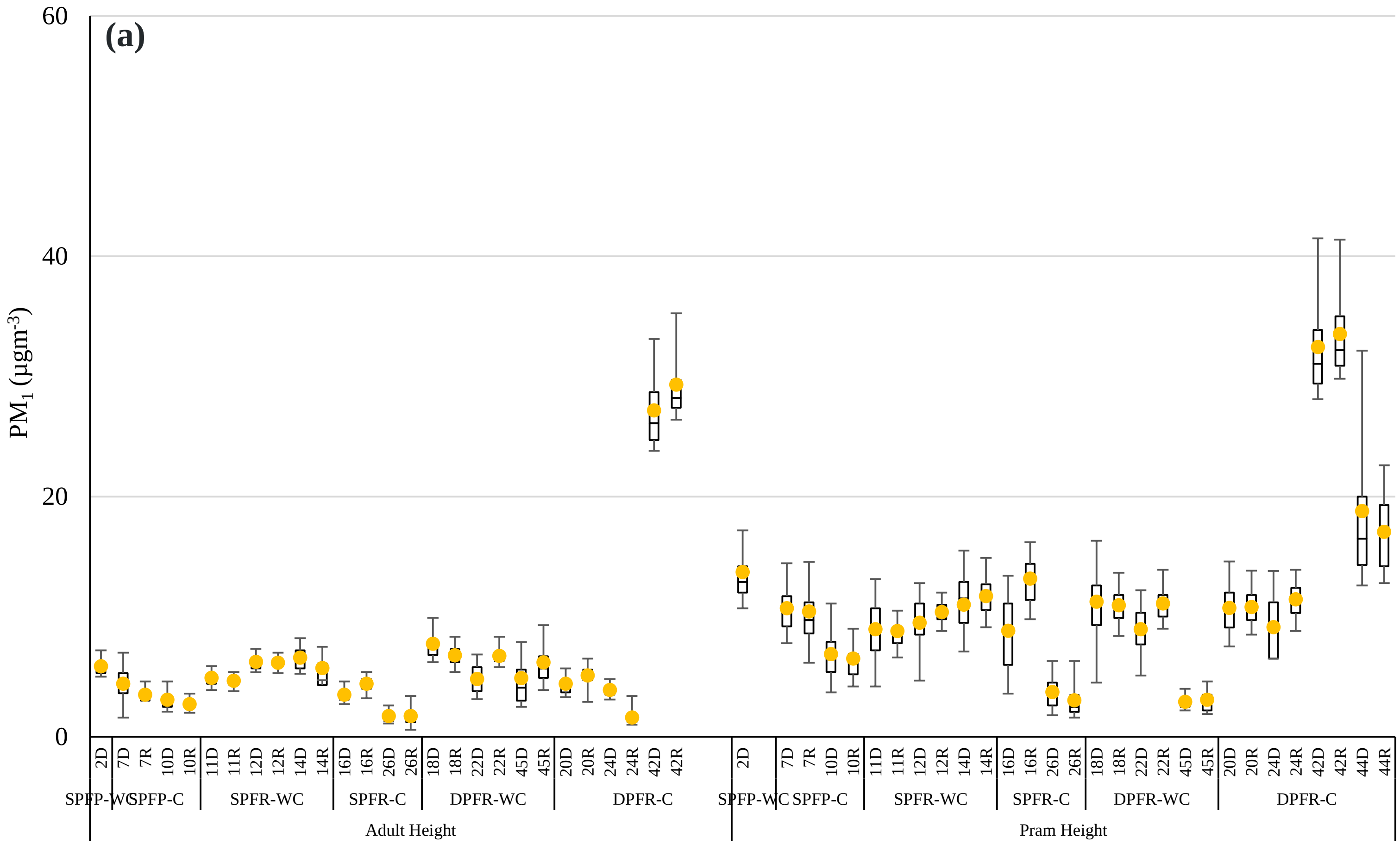

Run-wise boxplots – Adult vs. Pram Height Afternoon $PM_{2.5}$

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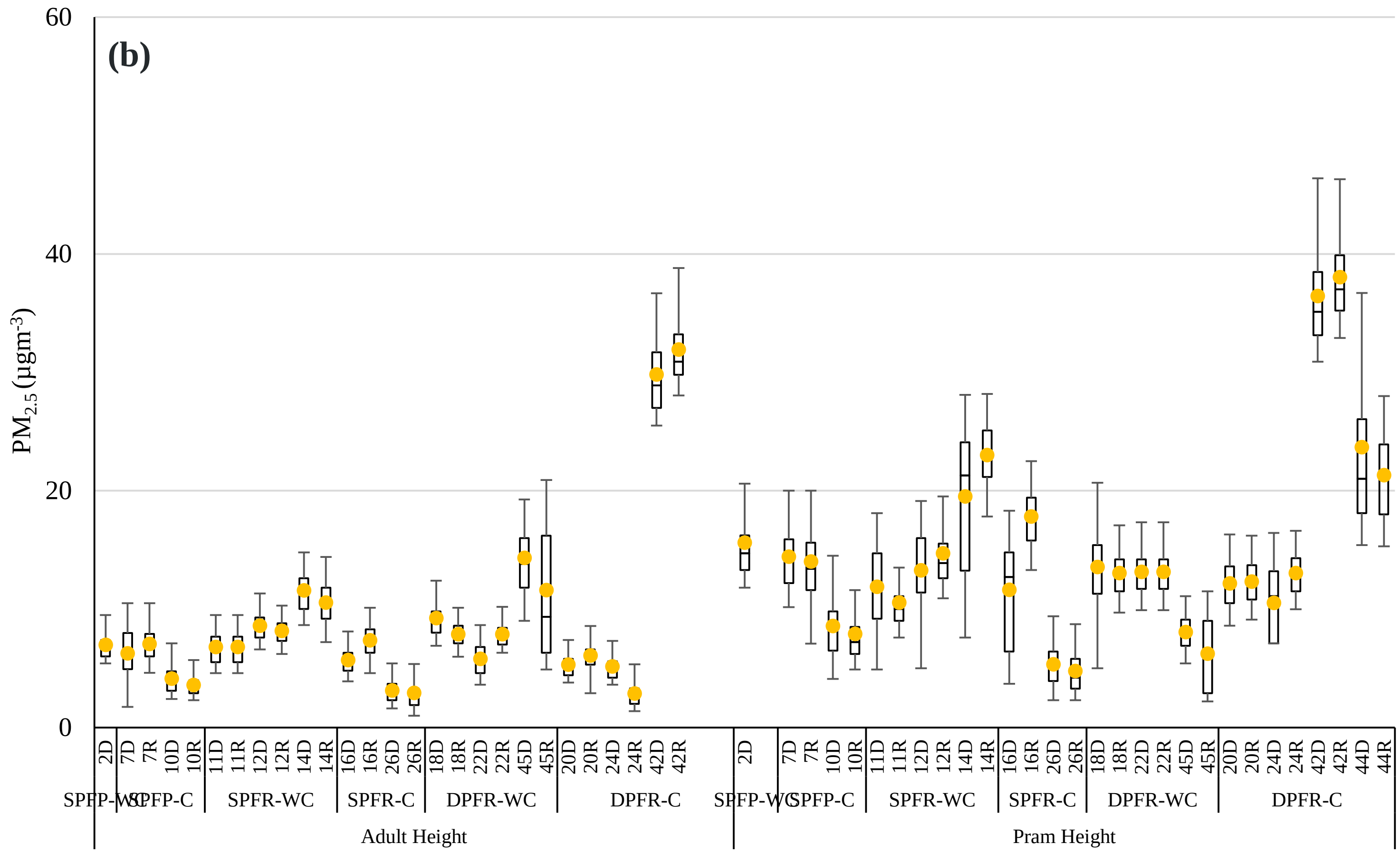

Run-wise boxplots – Adult vs. Pram Height Afternoon $PM_{2.5-10}$

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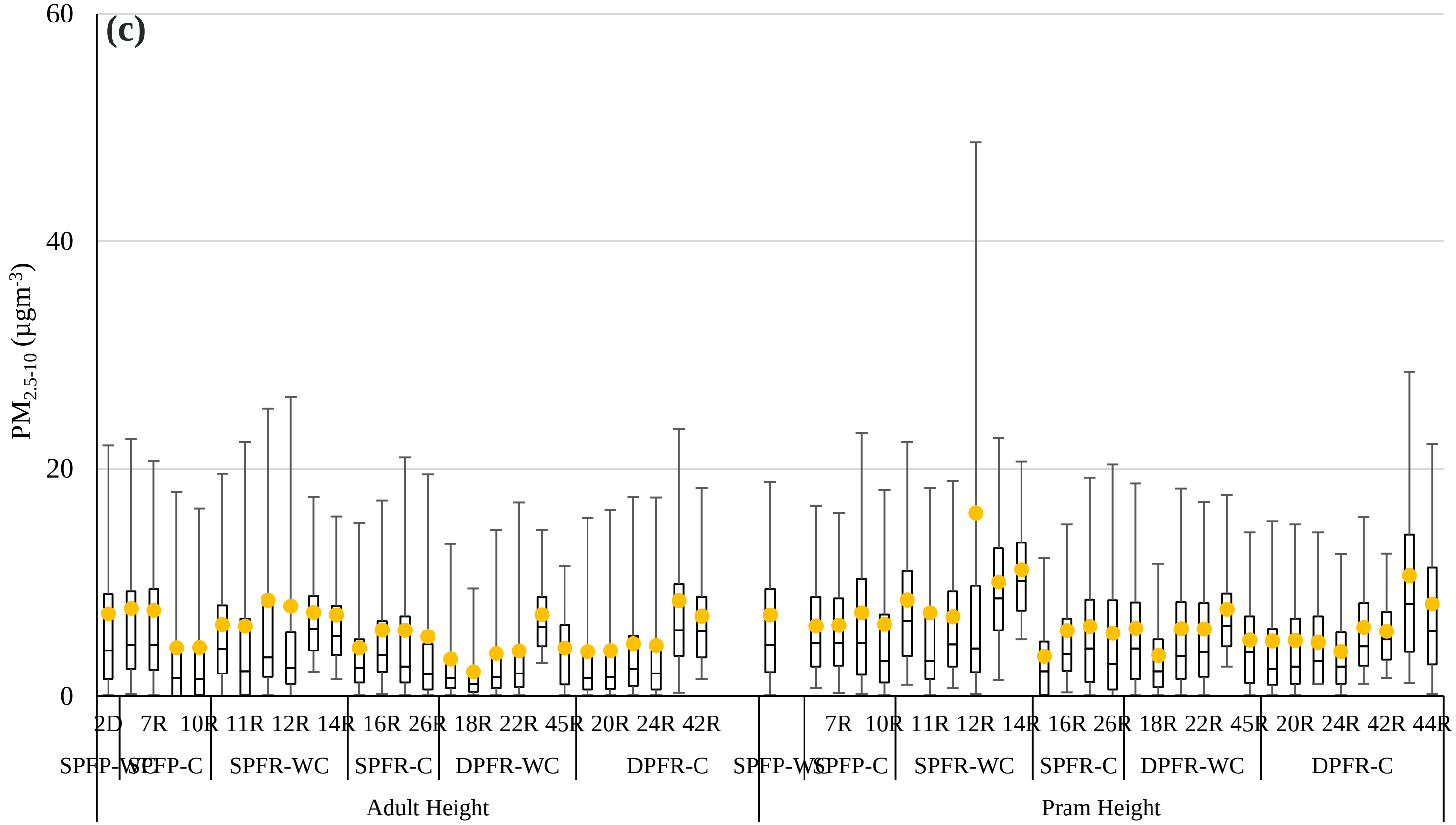

Run-wise boxplots – Adult vs. Pram Height Afternoon PM_{10}

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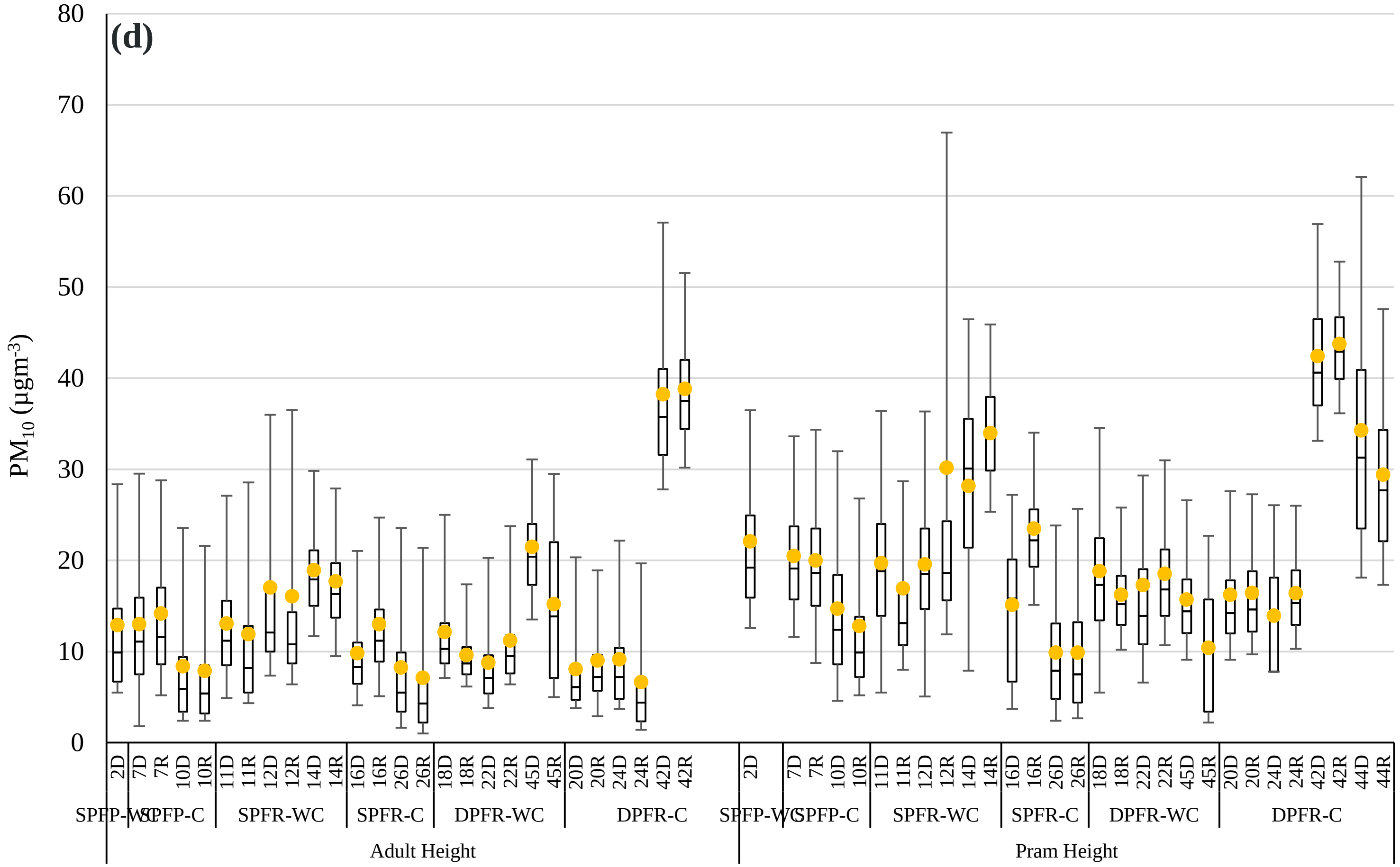

Boxplots for Morning PM_x runs in-pram

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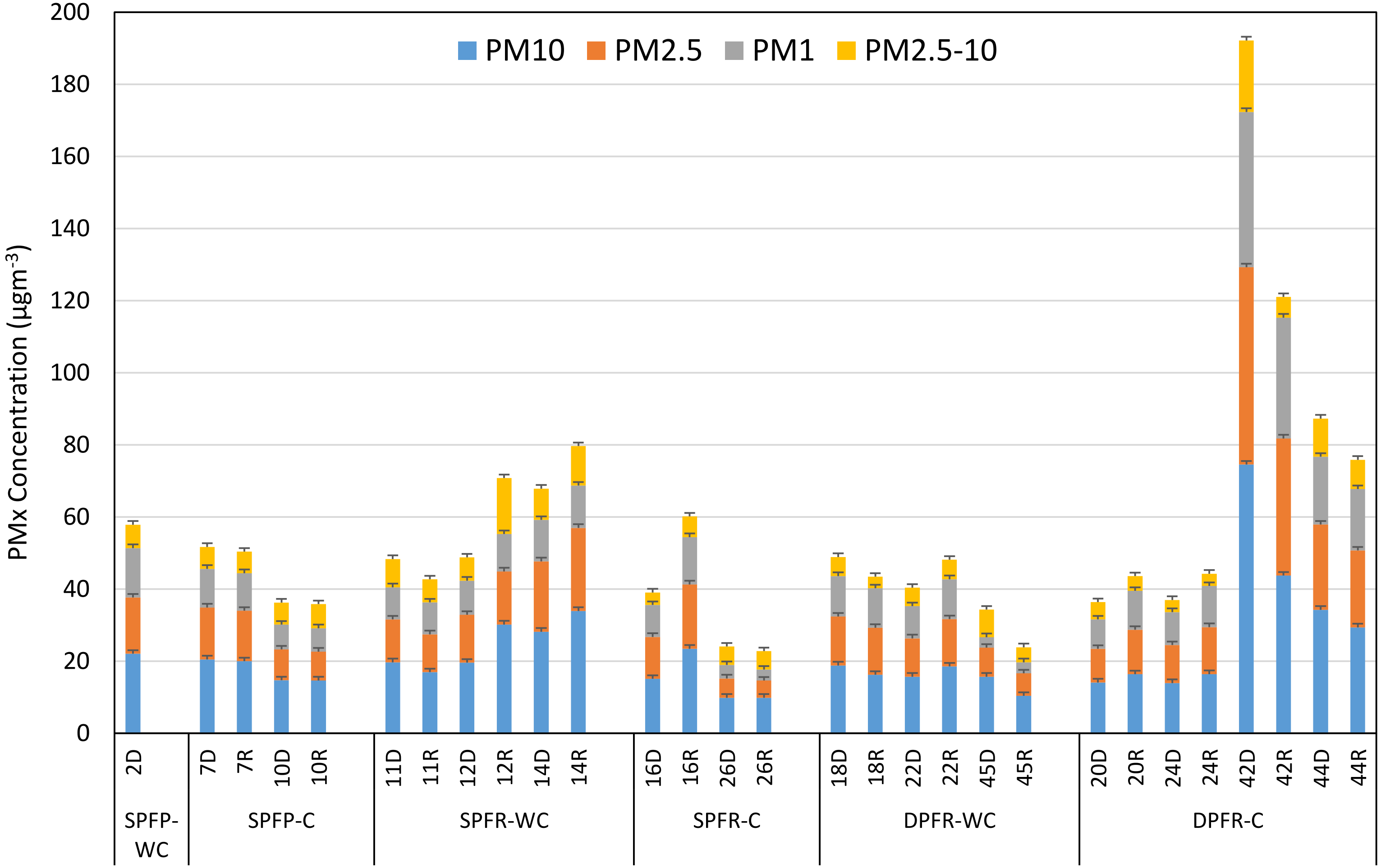

Boxplots for Afternoon PM_x runs in-pram

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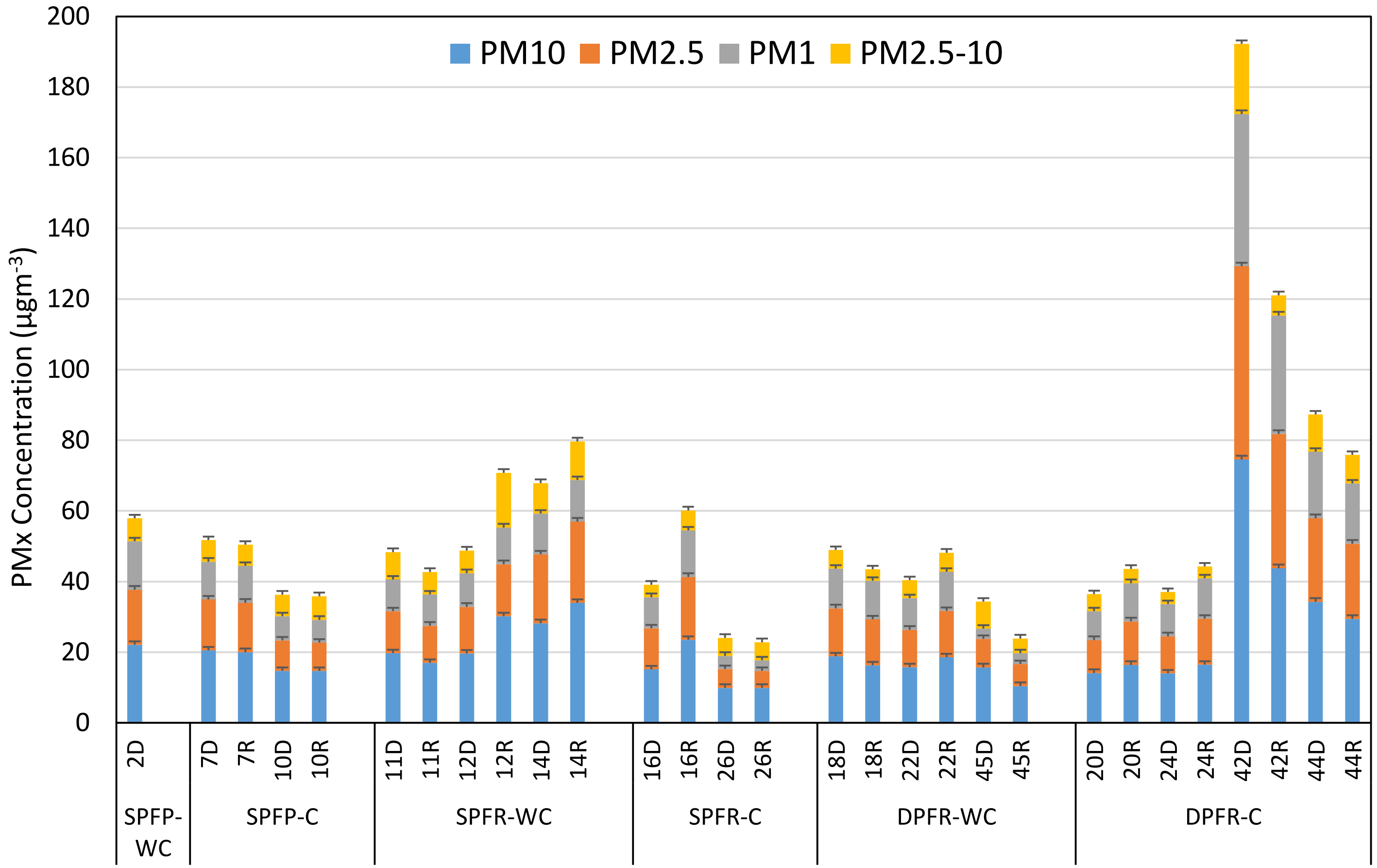
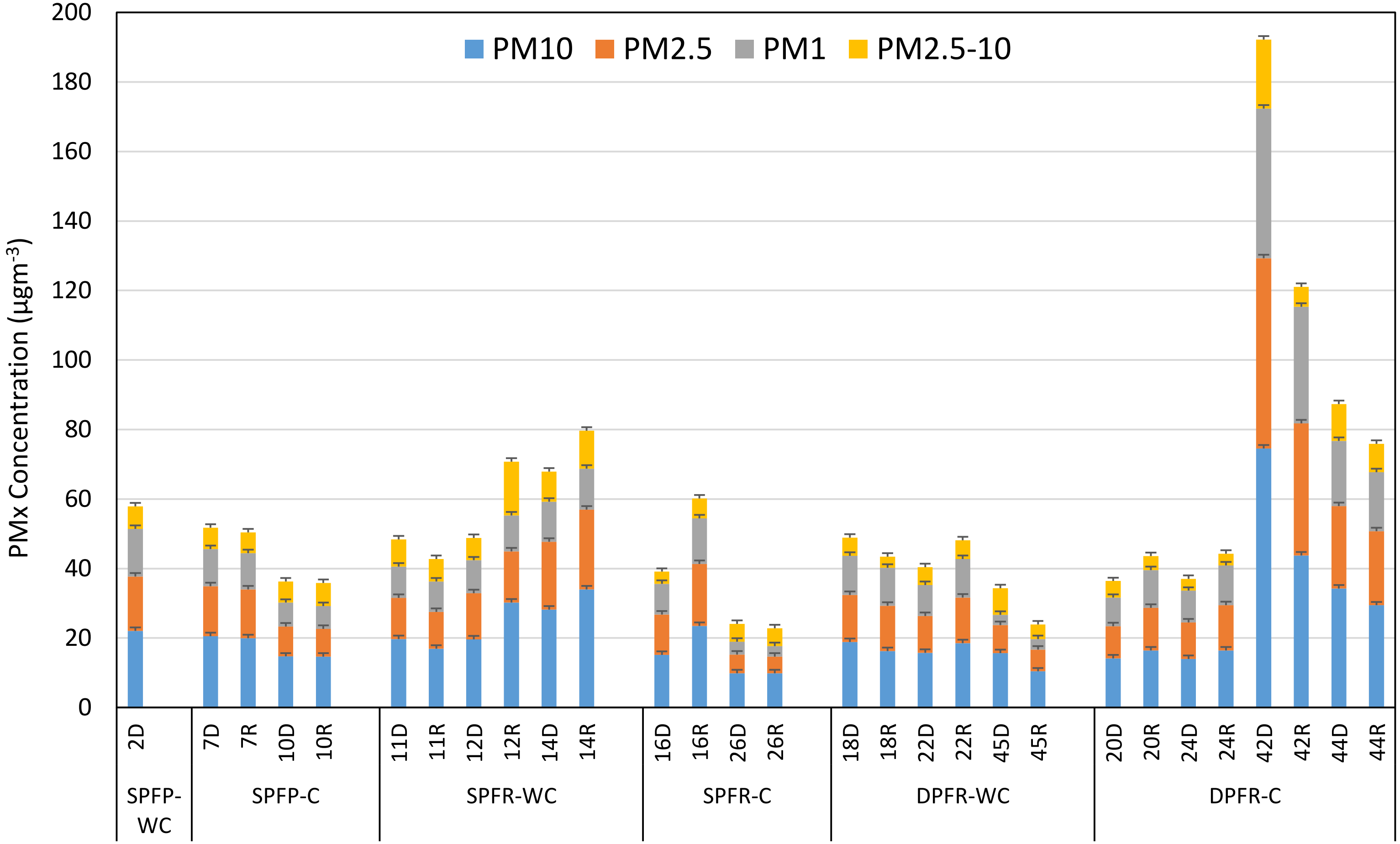


Boxplots for Morning PM_x runs in-backpack



Boxplots for Afternoon PM_x runs in-backpack

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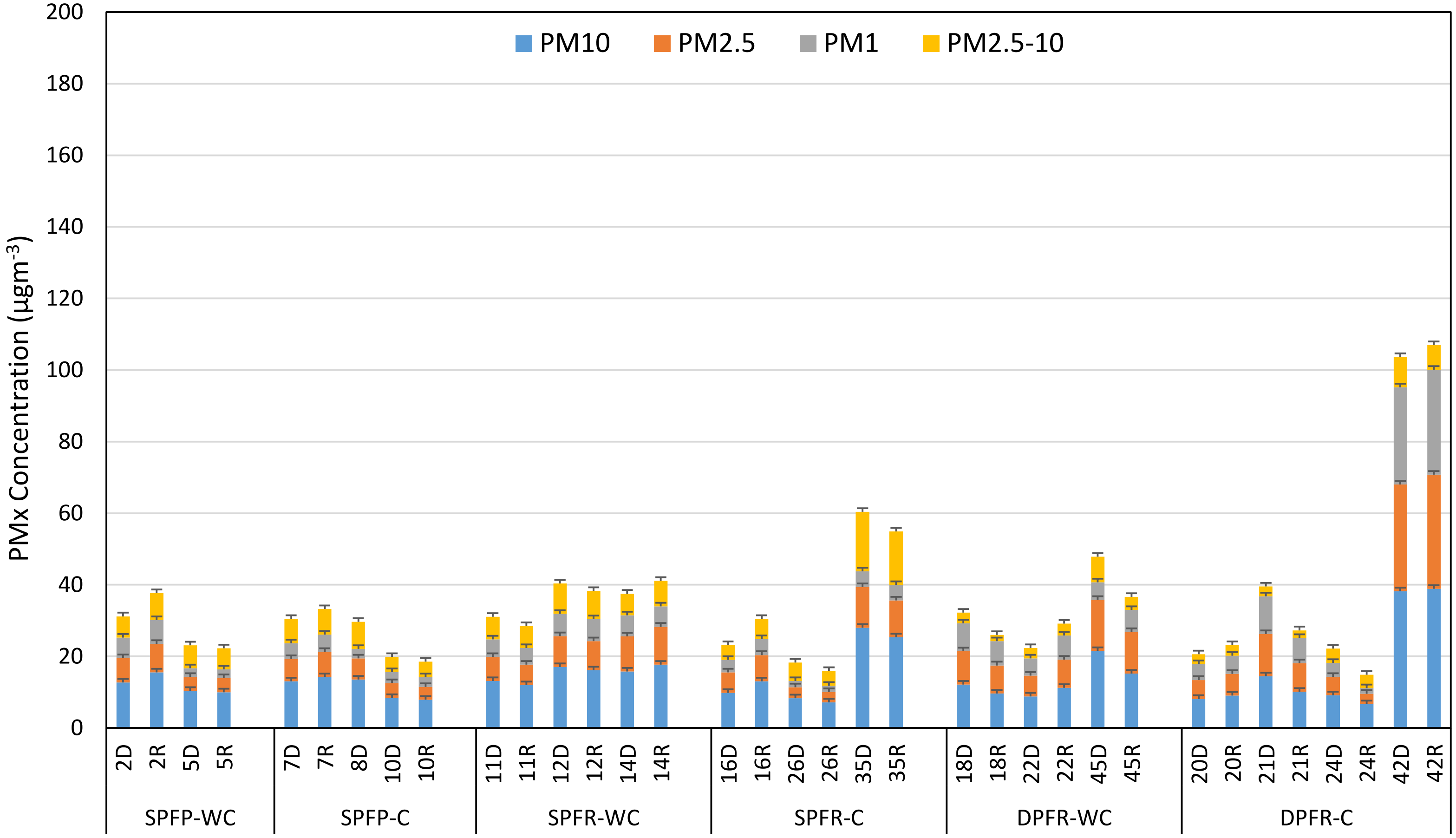
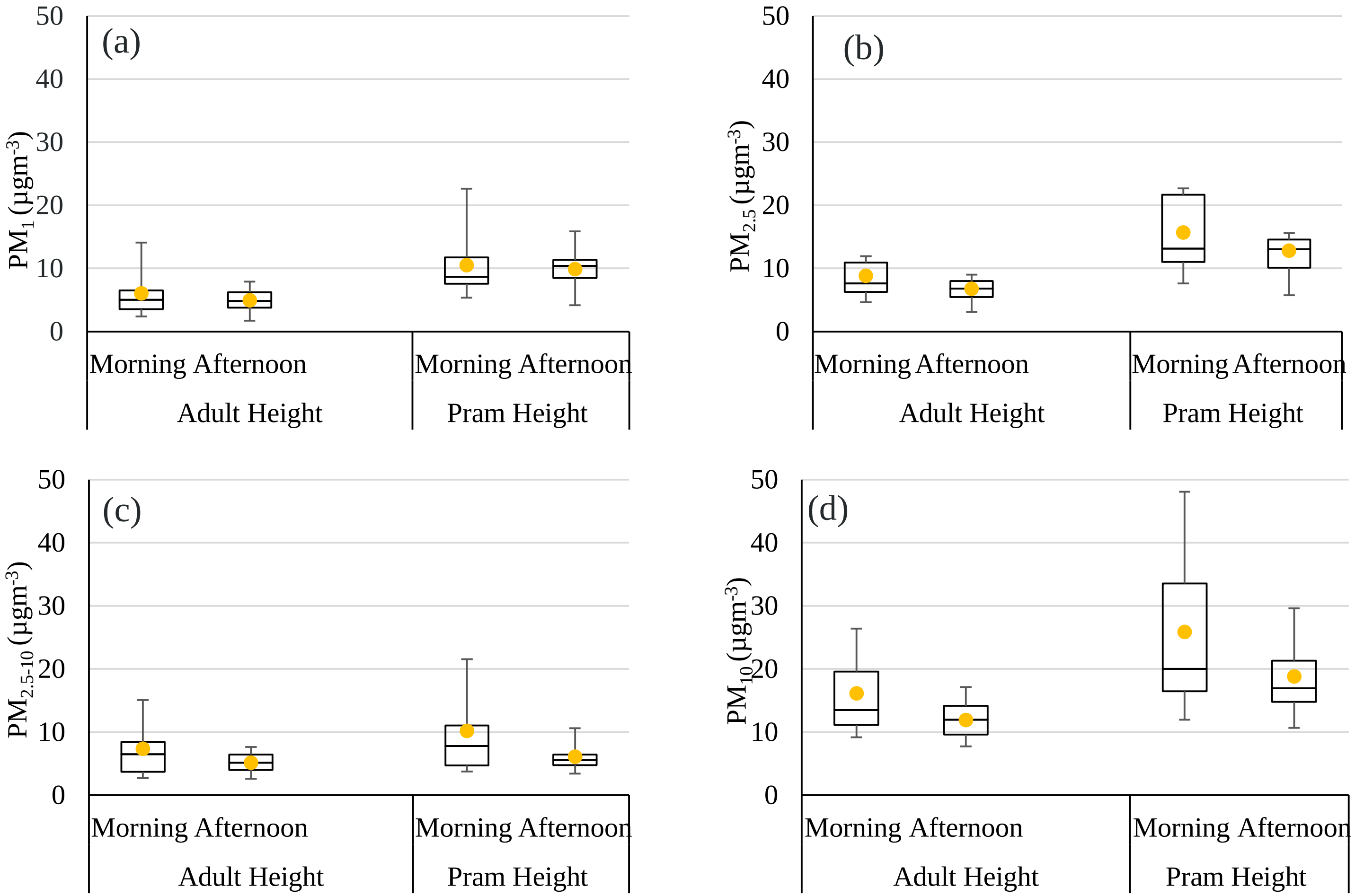
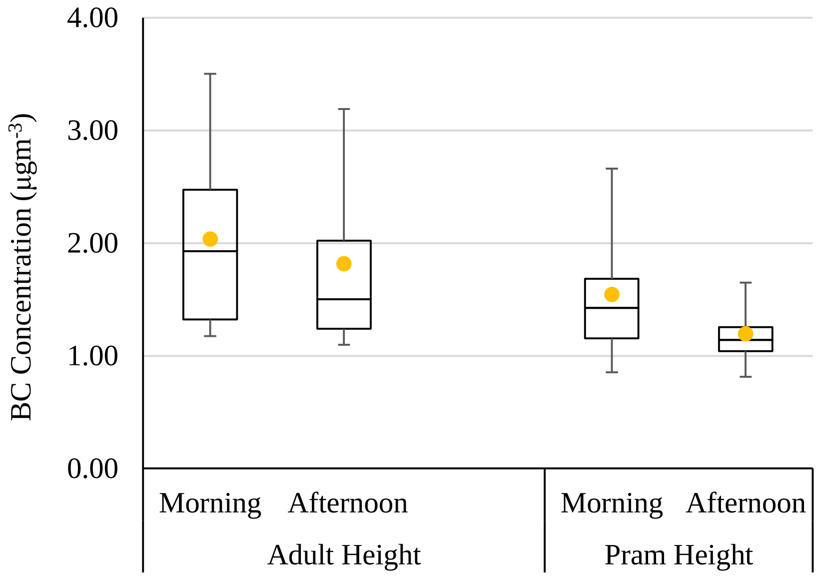


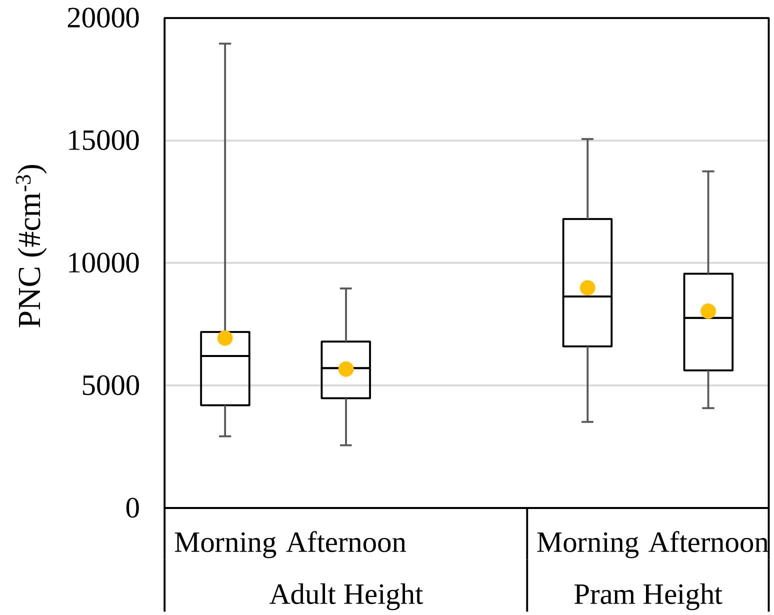
Boxplots for PM_x runs in-pram and backpack



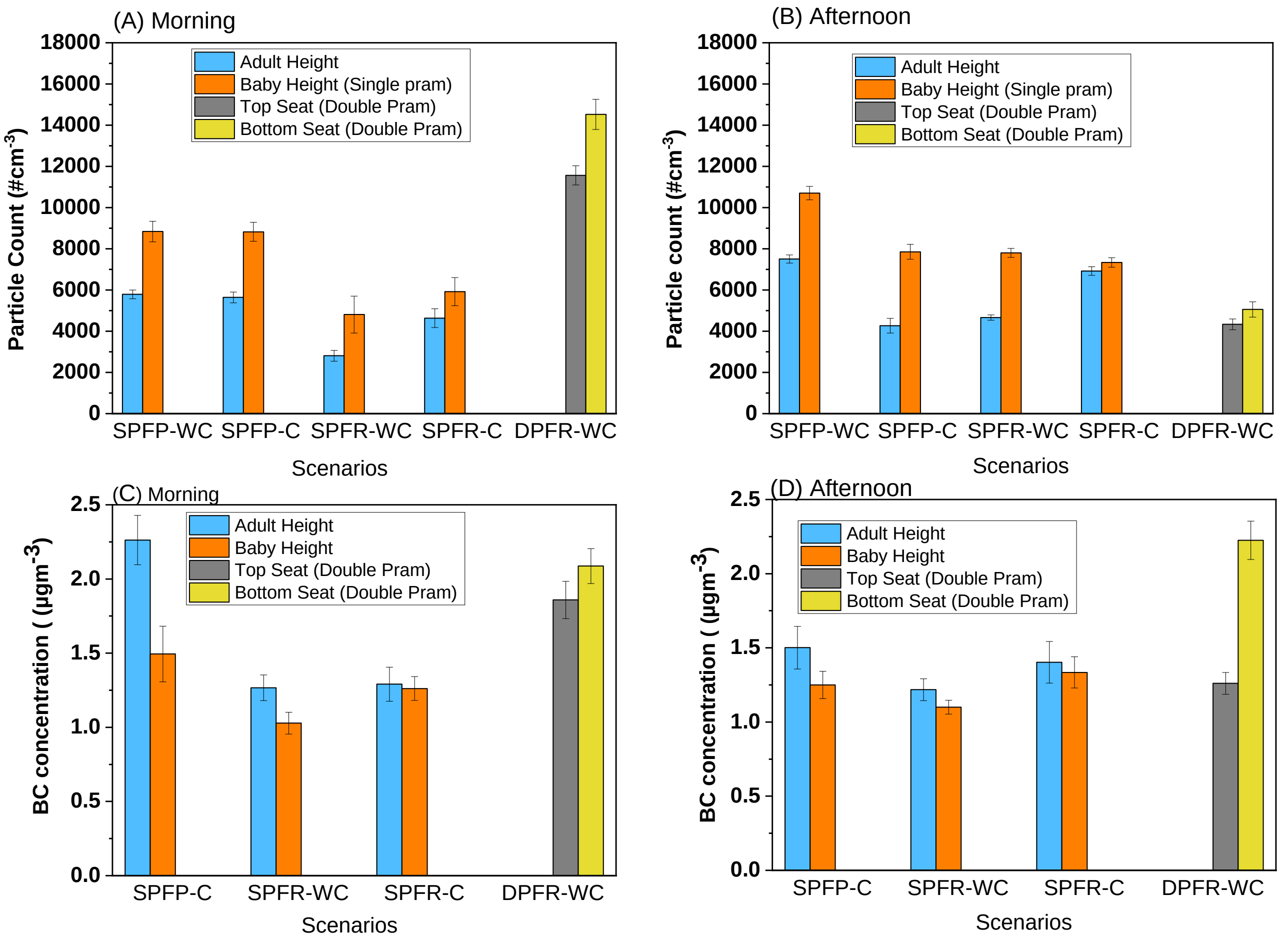
Results :

Boxplots for BC and PNC runs in-pram and backpack





Results : PNC and BC Scenario Analysis



Scenario	Description
$SP_{FP\text{-}WC}$	Single Pram (facing parent-without cover)
$SP_{FP\text{-}C}$	Single Pram (facing parent-with cover)
$SP_{FR\text{-}WC}$	Single Pram (facing roadside without cover)
$SP_{FR\text{-}C}$	Single Pram (facing roadside with cover)
$DP_{FR\text{-}WC}$	Double Pram (facing roadside-without cover)

Note* Correlation coefficient between new p-trak and old-ptrak is high (R^2 = 0.97)

Note* Correlation coefficient between new Microaeth (MA 200) and old-Microaeth (AE) is high (R^2 = 0.85)

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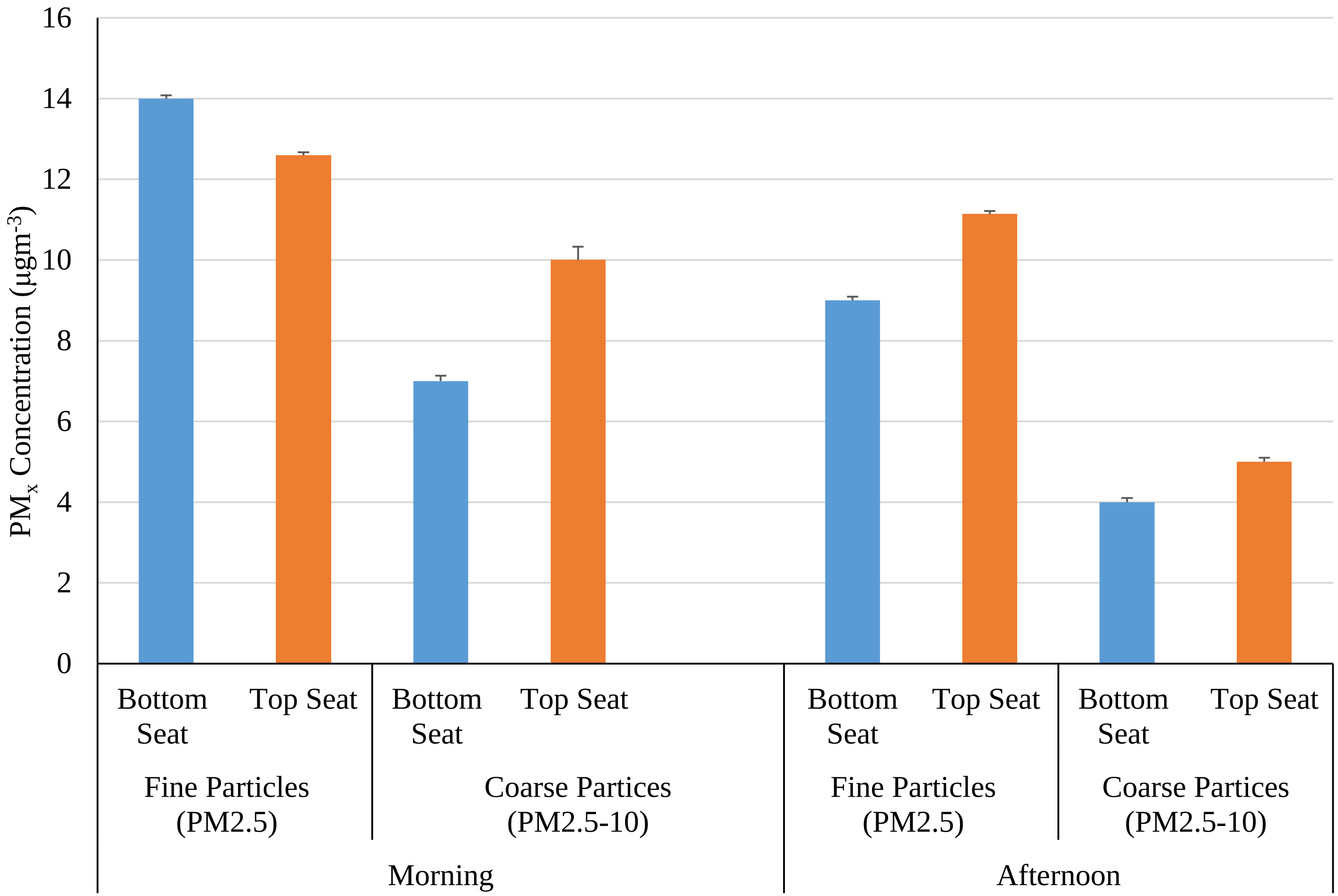
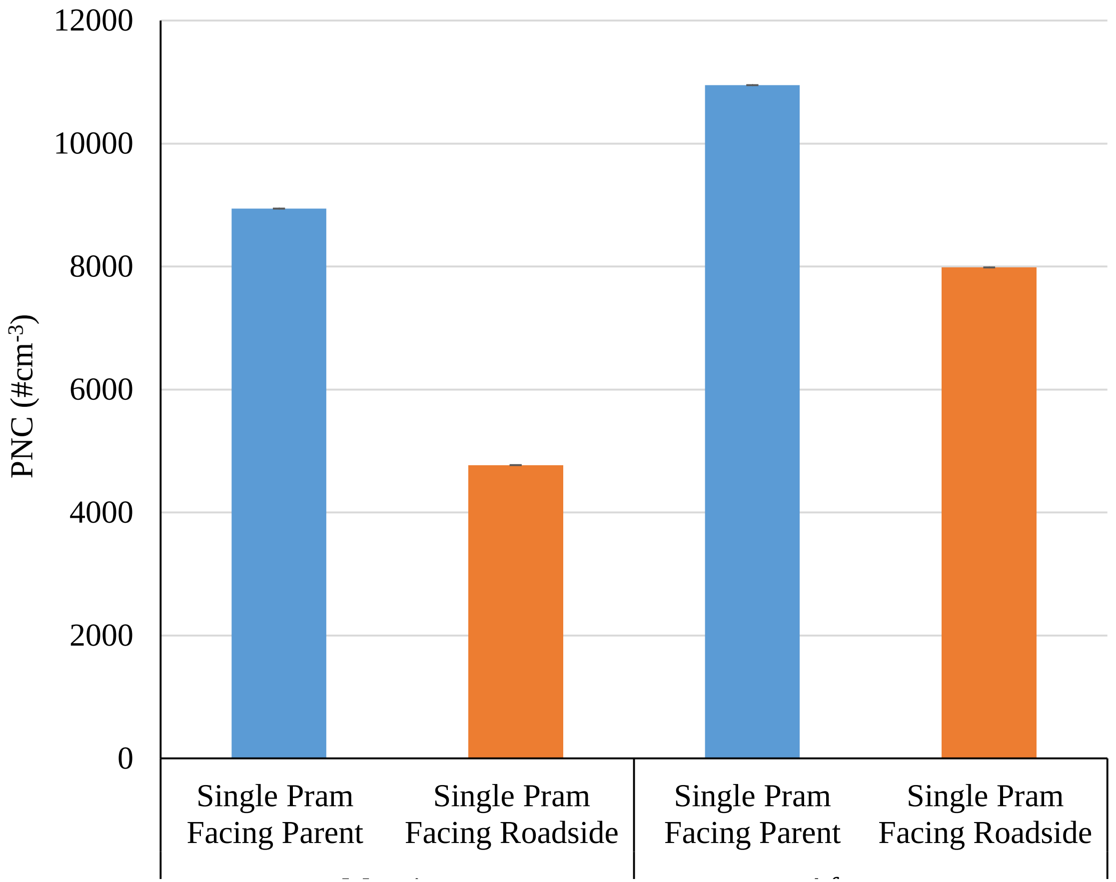


Scenario	Description
SP_{FP-WC}	Single Pram (facing parent-without cover)
SP_{FP-C}	Single Pram (facing parent-with cover)
SP_{FR-WC}	Single Pram (facing roadside without cover)
SP_{FR-C}	Single Pram (facing roadside with cover)
DP_{FR-WC}	Double Pram (facing roadside-without cover)

Results : PM_x in double pram top vs. bottom Seat



Scenario	Description
SP_{FP-WC}	Single Pram (facing parent-without cover)
SP_{FP-C}	Single Pram (facing parent-with cover)
SP_{FR-WC}	Single Pram (facing roadside without cover)
SP_{FR-C}	Single Pram (facing roadside with cover)
DP_{FR-WC}	Double Pram (facing roadside-without cover)