Air Pollution Exposure During School Commutes

Mary Wolfe, Noreen McDonald, Sarav Arunachalam, & Alejandro Valencia

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

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School Siting & Children's Health

- Smart growth advocates encourage "walkable" school locations
  - Justification: greater potential for active travel

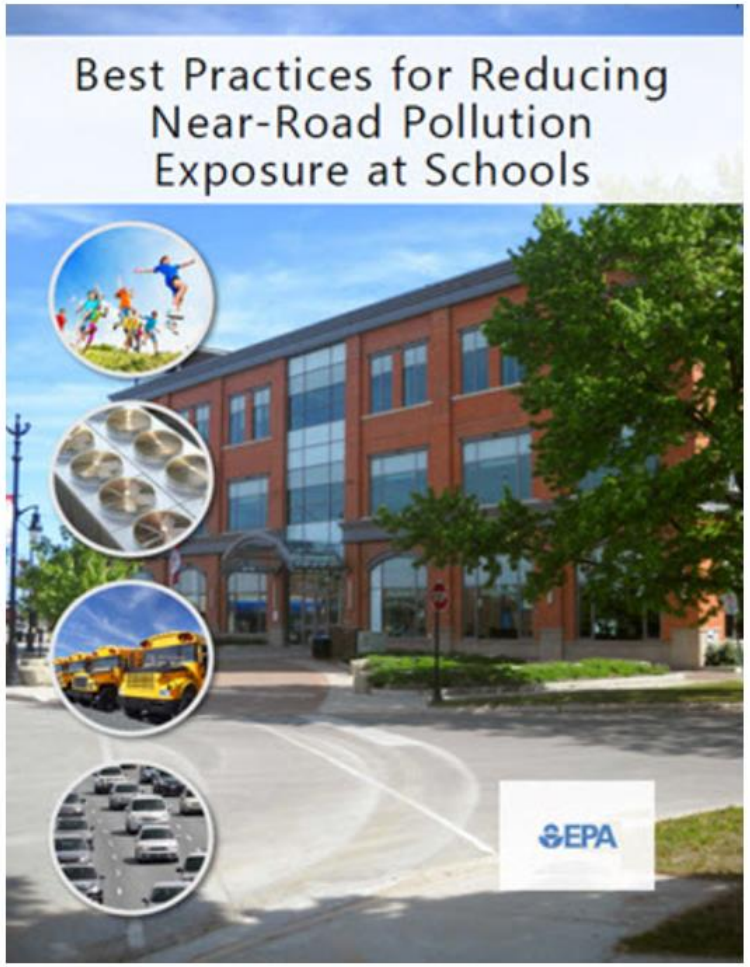
- Yet, health professionals want to minimize exposure
  - Justification: air quality risks to children's health, e.g. stunted lung development (Gauderman et al. 2007), worsening asthma (Delfino et al. 2015), and increased risk of cancer (World Health Organization 2012)

(Recent) Attention to the Issue

- Investigation by the Center for Public Integrity and The Center for Investigative Reporting (Feb. 2017)
  - about 1/11 U.S. public schools lies within 500 ft. of major road
- Joint investigation by the Guardian and Greenpeace in England & Wales (April 2017)
- First National Clean Air Day

Regulation

- Since 2003, CA regulates school siting based on air quality concerns
  - Recent update (April) to Land Use Handbook
- U.S. EPA does not have the statutory authority to control school siting decisions directly
  - voluntary school siting guidelines & best practices (EPA, 2011; EPA, 2015)



EPA, 2015

Research Problem

How can we understand the health impacts of regulations on locating schools near high-volume roads?

1. How does near-road air pollution exposure vary based on school location and commute mode?
2. How does exposure vary with potential interventions like improved HVAC, clean busses, and anti-idling policies?

Our Approach

- Simulate two school attendance scenarios
- Quantitatively compare traffic-related air pollution exposure for each

Live in **high-traffic** area

live in **high-traffic** area

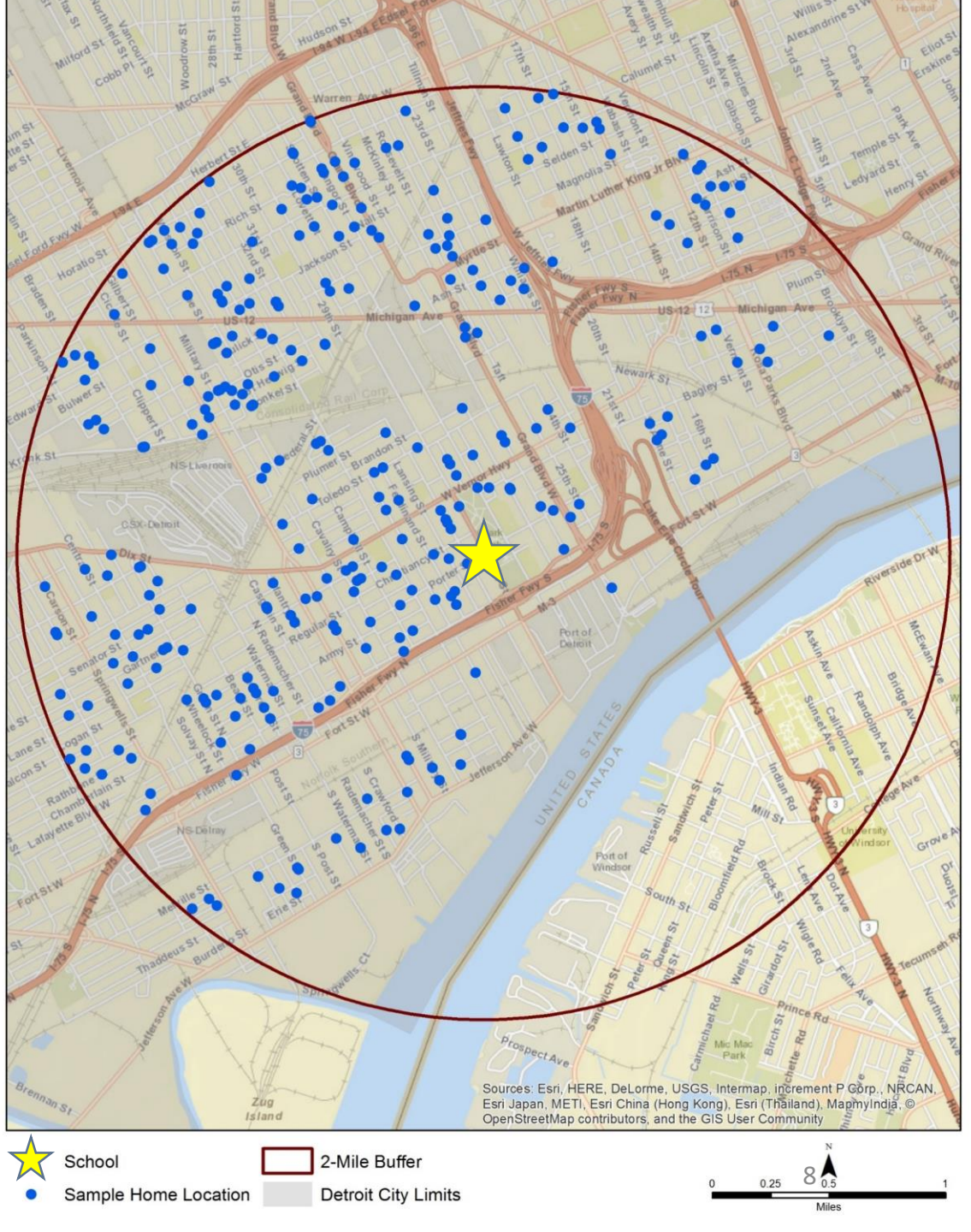
Attend local school in **high-traffic** area

Attend distant school in **low-traffic** area


102
Distant School
10
24
39
96
75
375
85
Local School
12
94
75
N
US HWY
interstate
Major roadways
Detroit, Michigan
0 1.5 3 6
Kilometers

Sample

- Synthetic sample using residential parcel data (City of Detroit)
- 300 children who live ≤ 2 mi from the "urban" school
- Excluded children whose shortest walking path to school was > 2 mi
- n=179

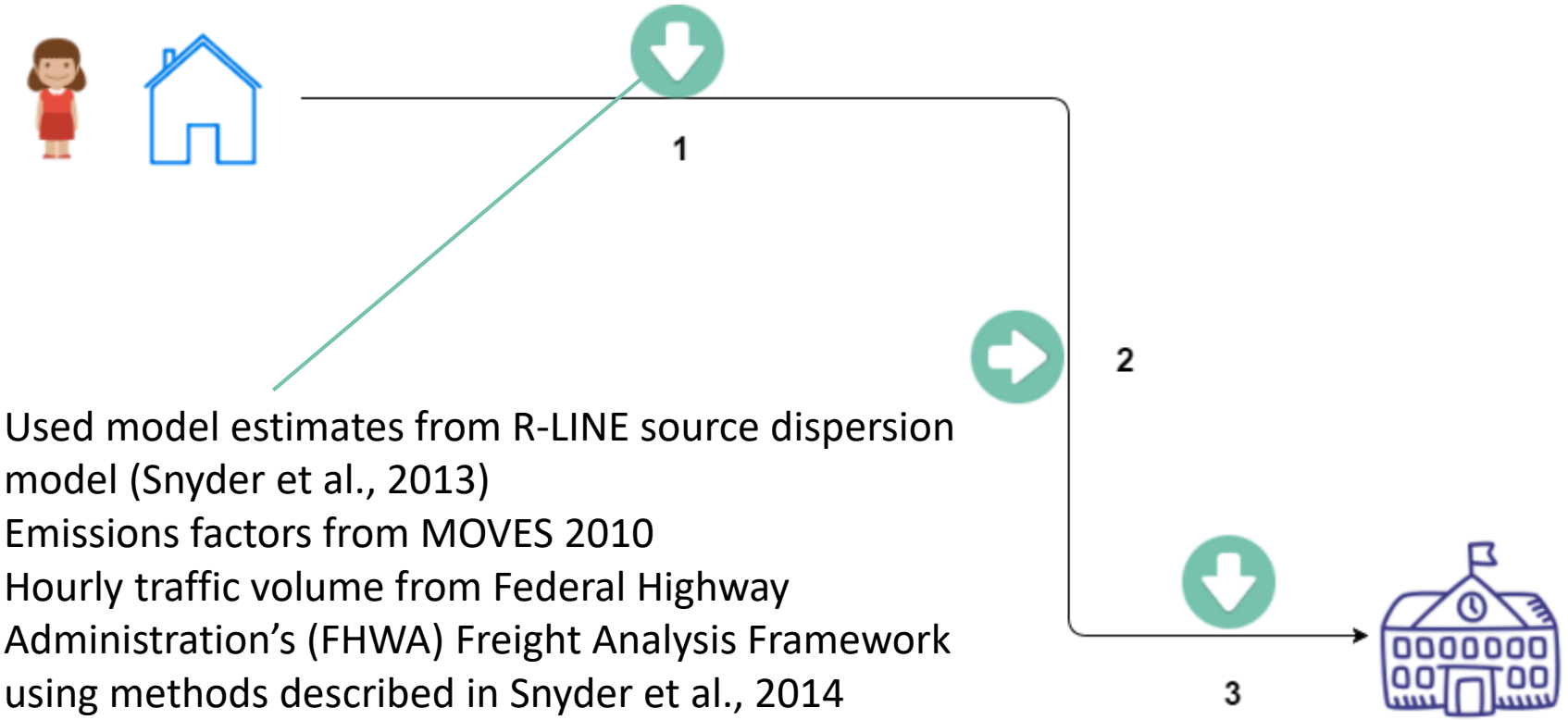


Exposure Estimation

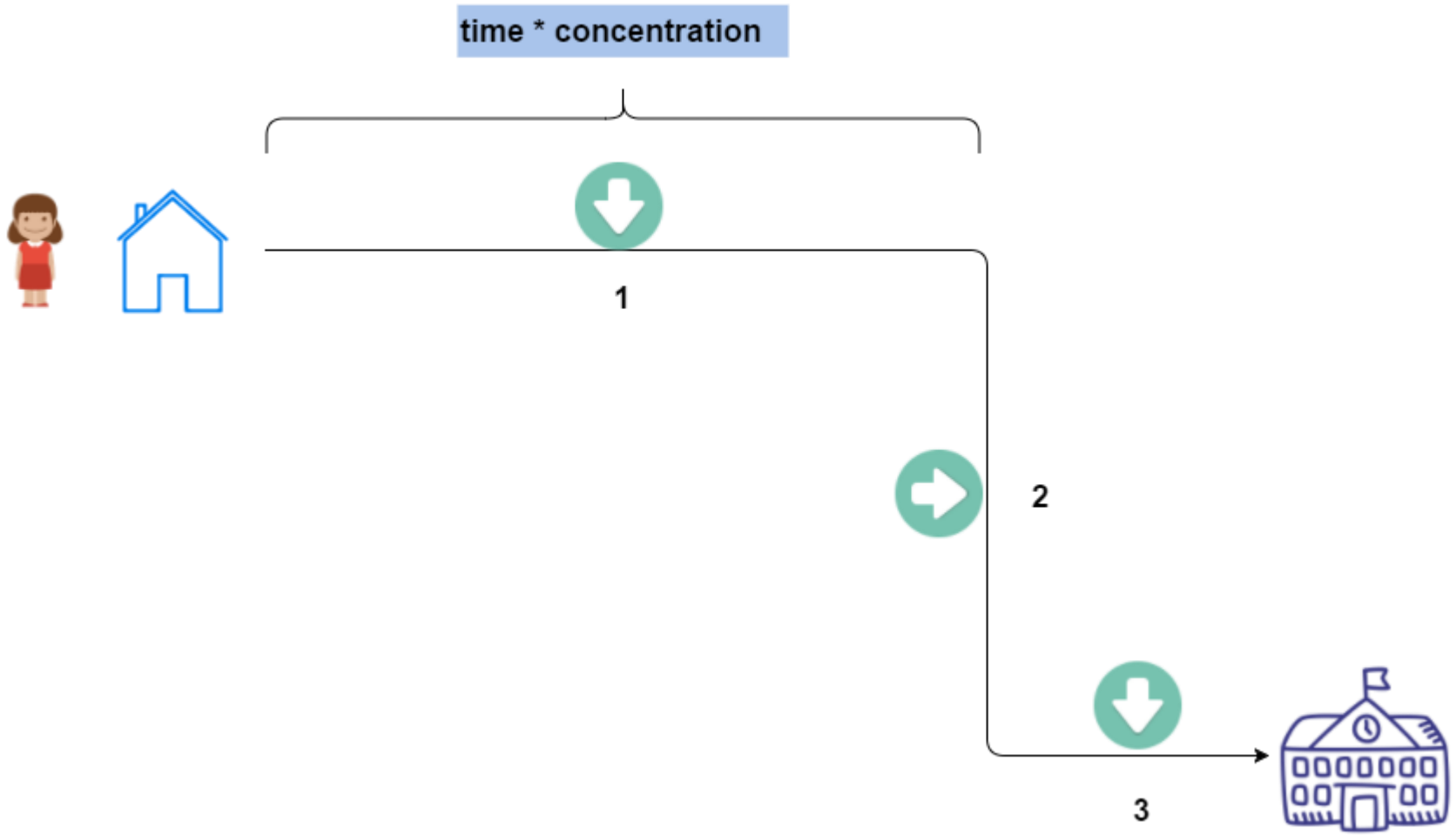
1. Generated home-to-school commuting routes

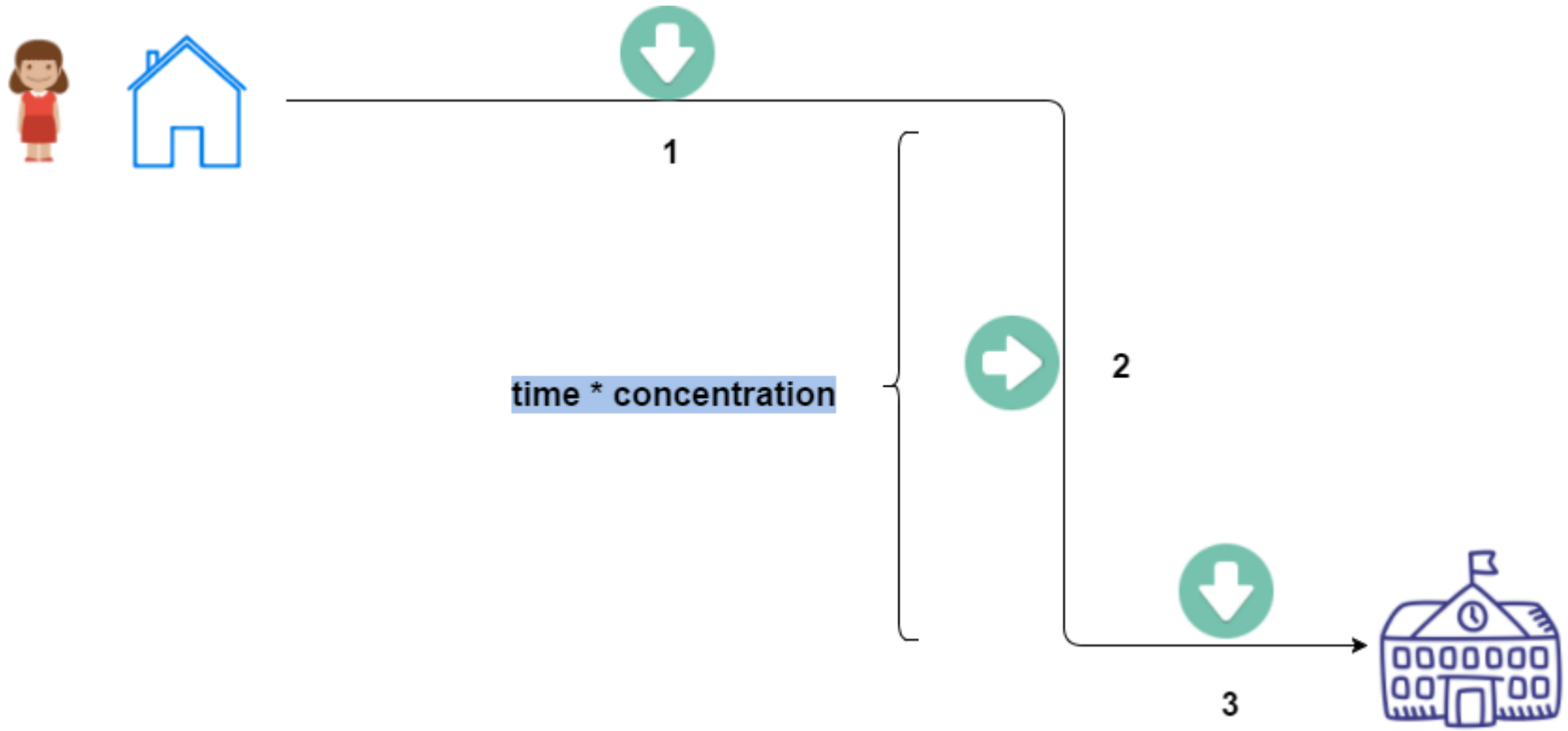
2. Estimated time-averaged daily exposures for the school day (7a-4p) for six pollutants

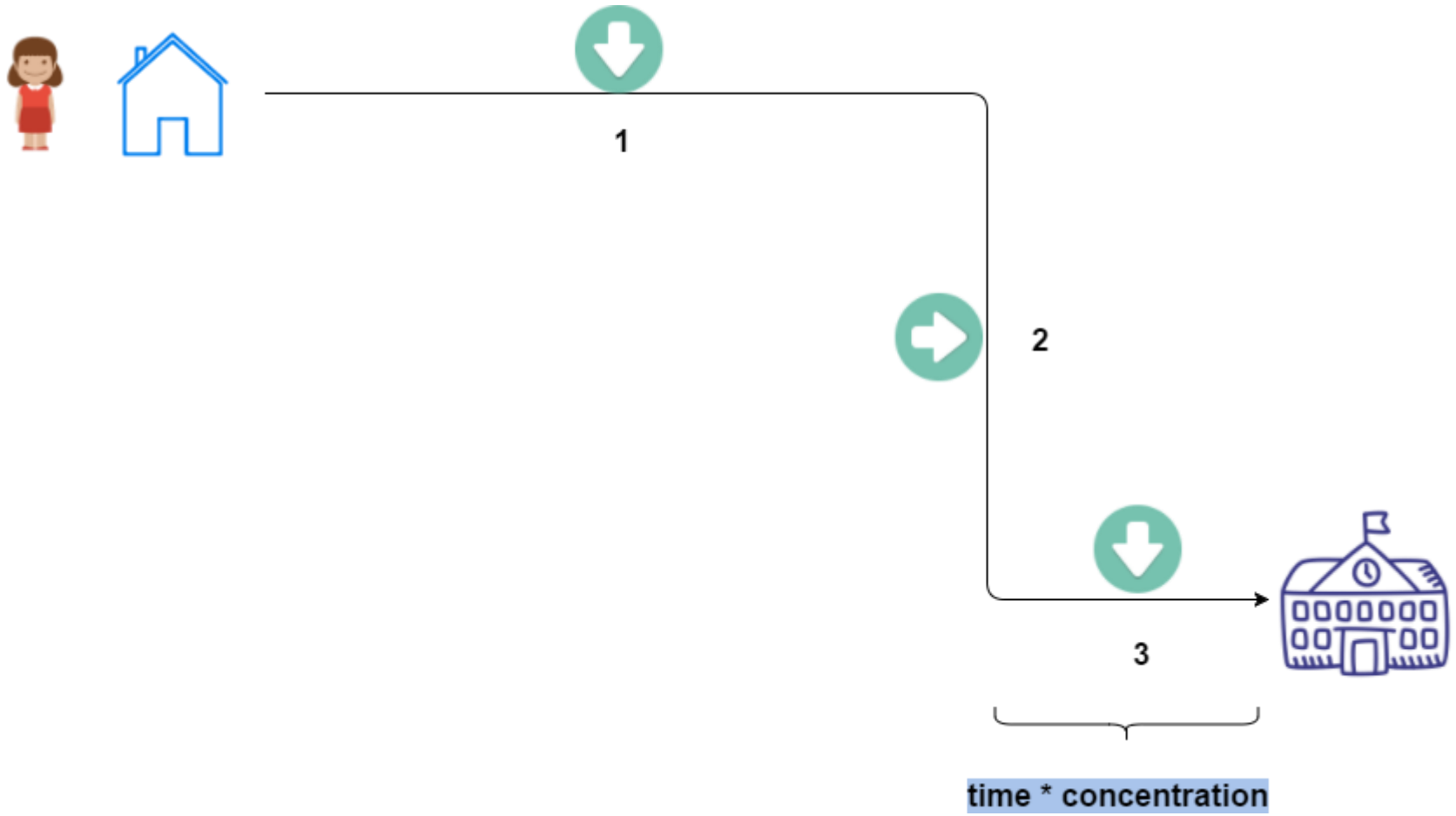
3. Adjusted infiltration factors (multiplicative) to model effects of three possible policy interventions:
   - clean bus, HVAC, anti-idling

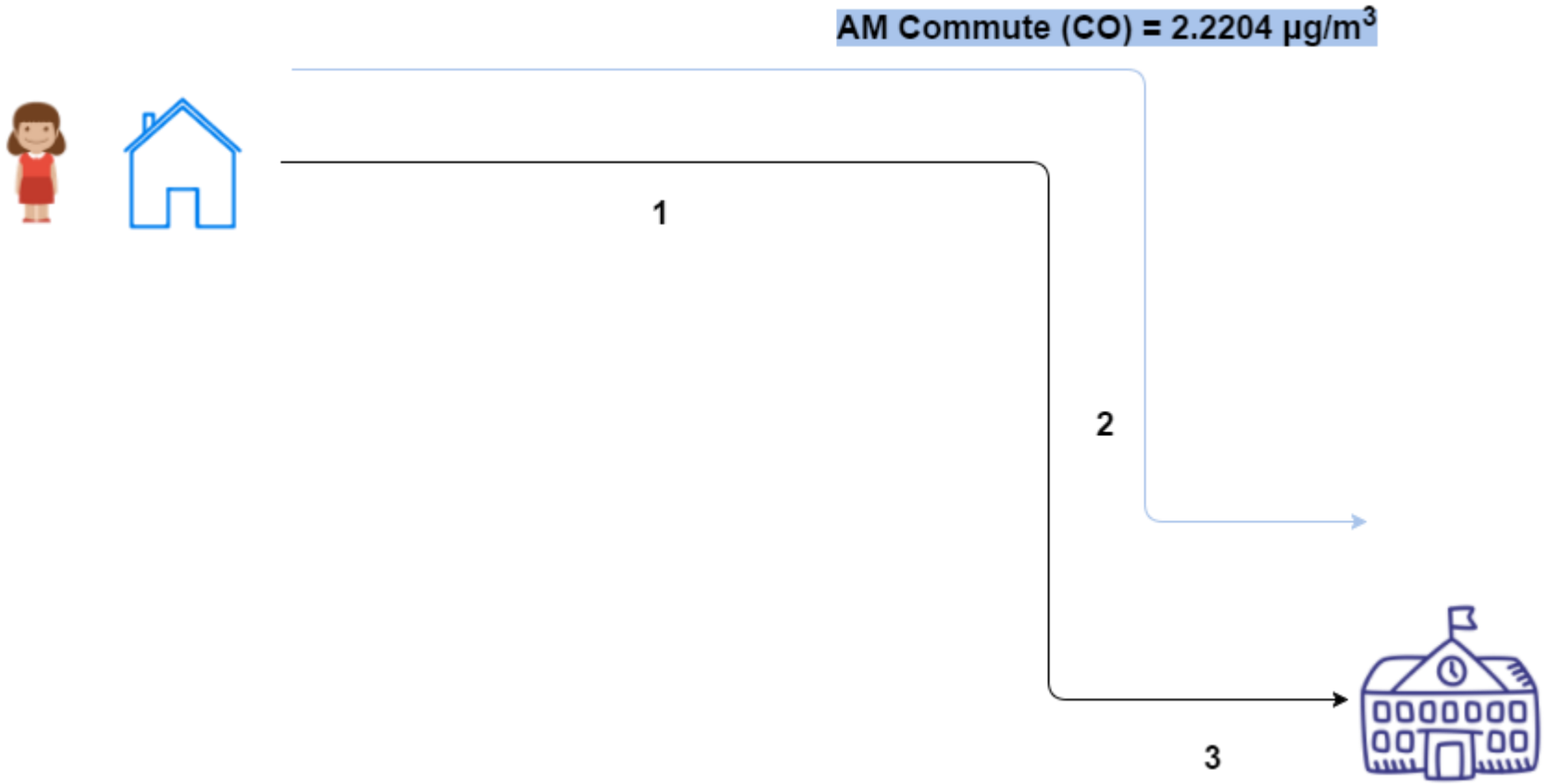


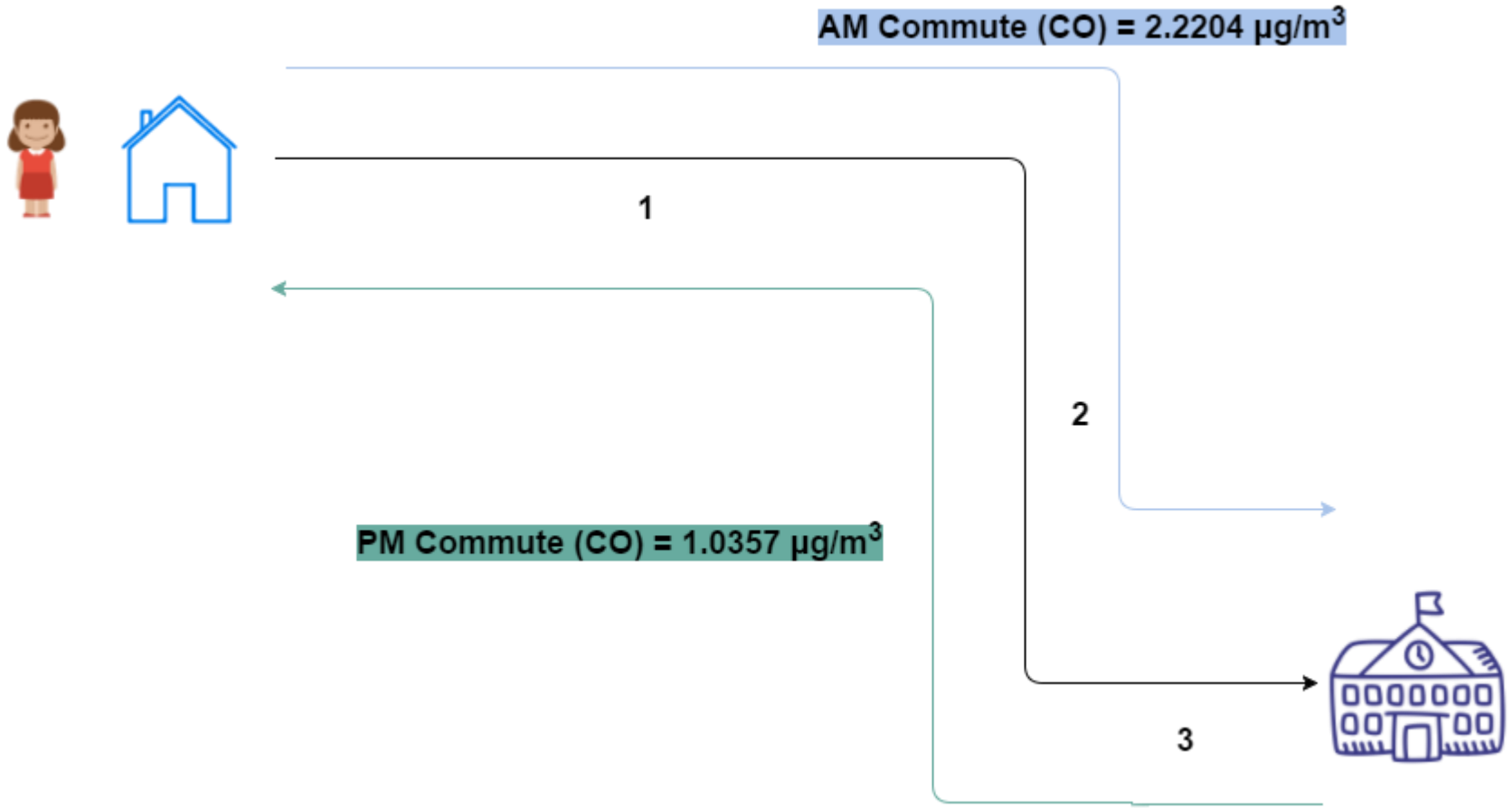
- Used model estimates from R-LINE source dispersion model (Snyder et al., 2013)
- Emissions factors from MOVES 2010
- Hourly traffic volume from Federal Highway Administration's (FHWA) Freight Analysis Framework
- using methods described in Snyder et al., 2014


time * concentration
1
2
3


1
time * concentration
2
3


1
2
3
time * concentration


AM Commute (CO) = 2.2204 µg/m3
1
2
3


AM Commute (CO) = 2.2204 µg/m3
1
2
PM Commute (CO) = 1.0357 µg/m3
3

AM Commute (CO) = 2.2204 µg/m^3

PM Commute (CO) = 1.0357 µg/m^3

unload (CO) = 6.5531 µg/m^3

day (CO) = 28.122 µg/m^3

load (CO) = 2.939 µg/m^3

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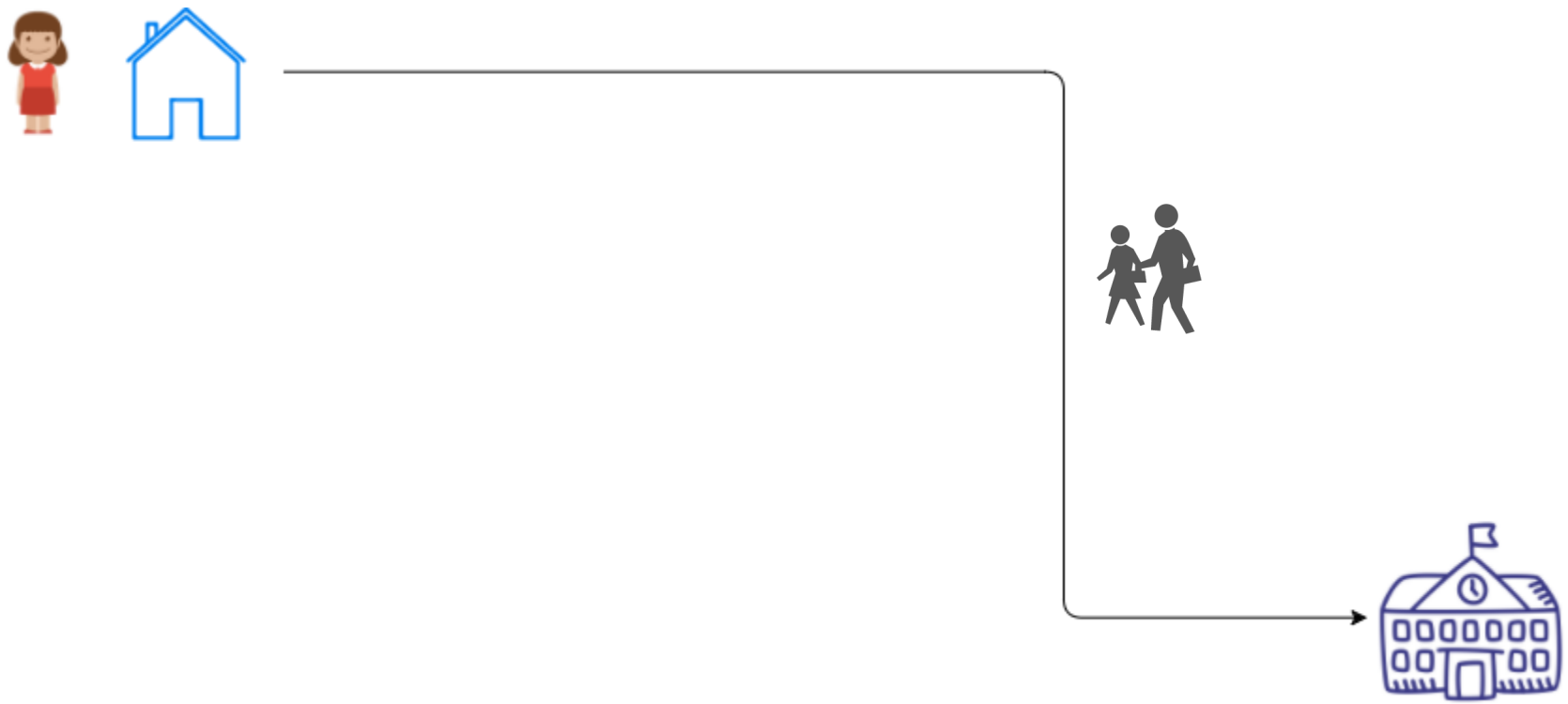
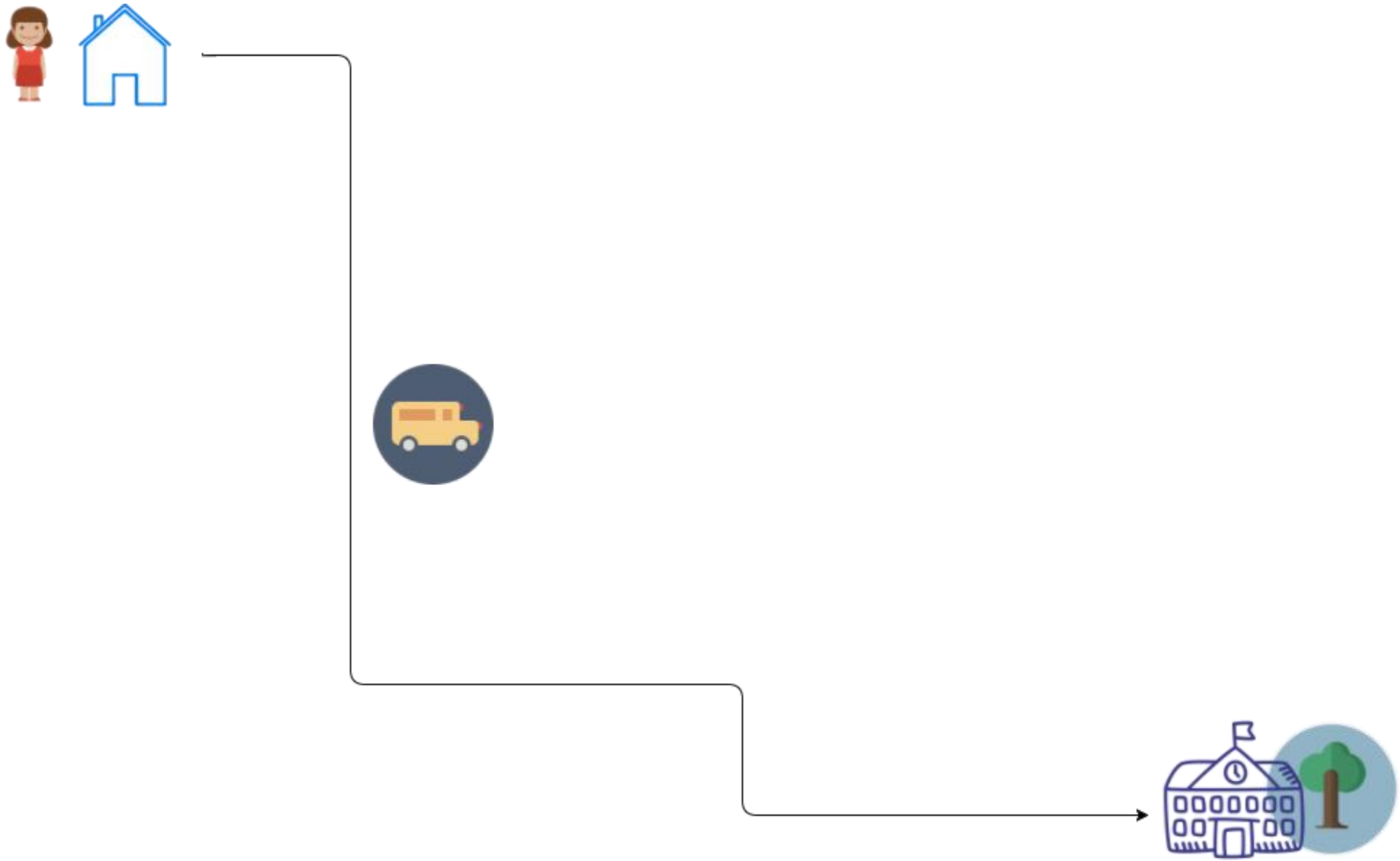
load (CO) = 2.939 µg/m^3

PM Commute (CO) = 1.0357 µg/m^3

time-weighted exposure = 40.870 µg/m^3





Policy Interventions:

Pollutants Modeled

- CO, NO_x, $PM_{2.5}$, EC, OC
- Benzene (mobile source air toxic)

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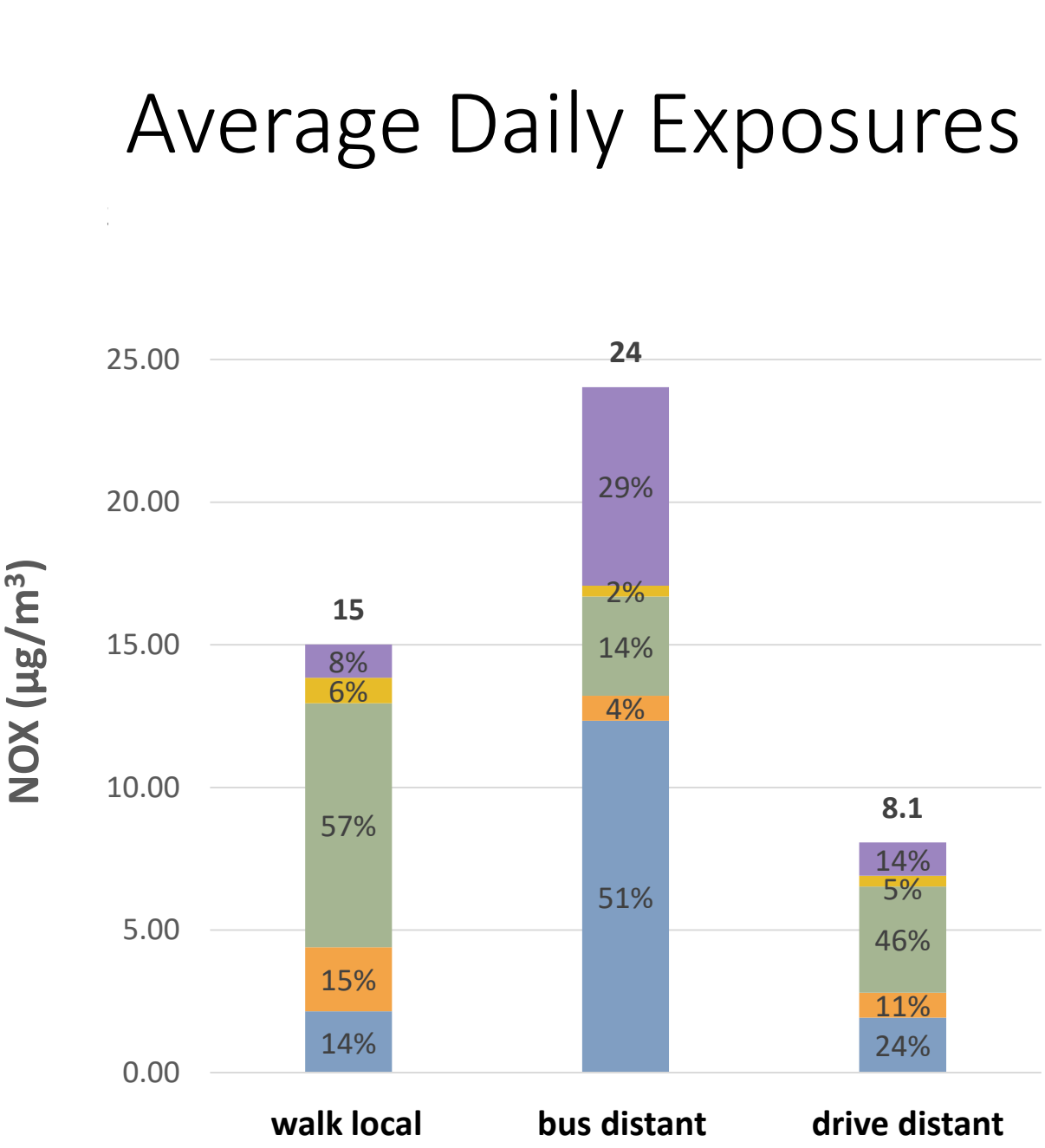
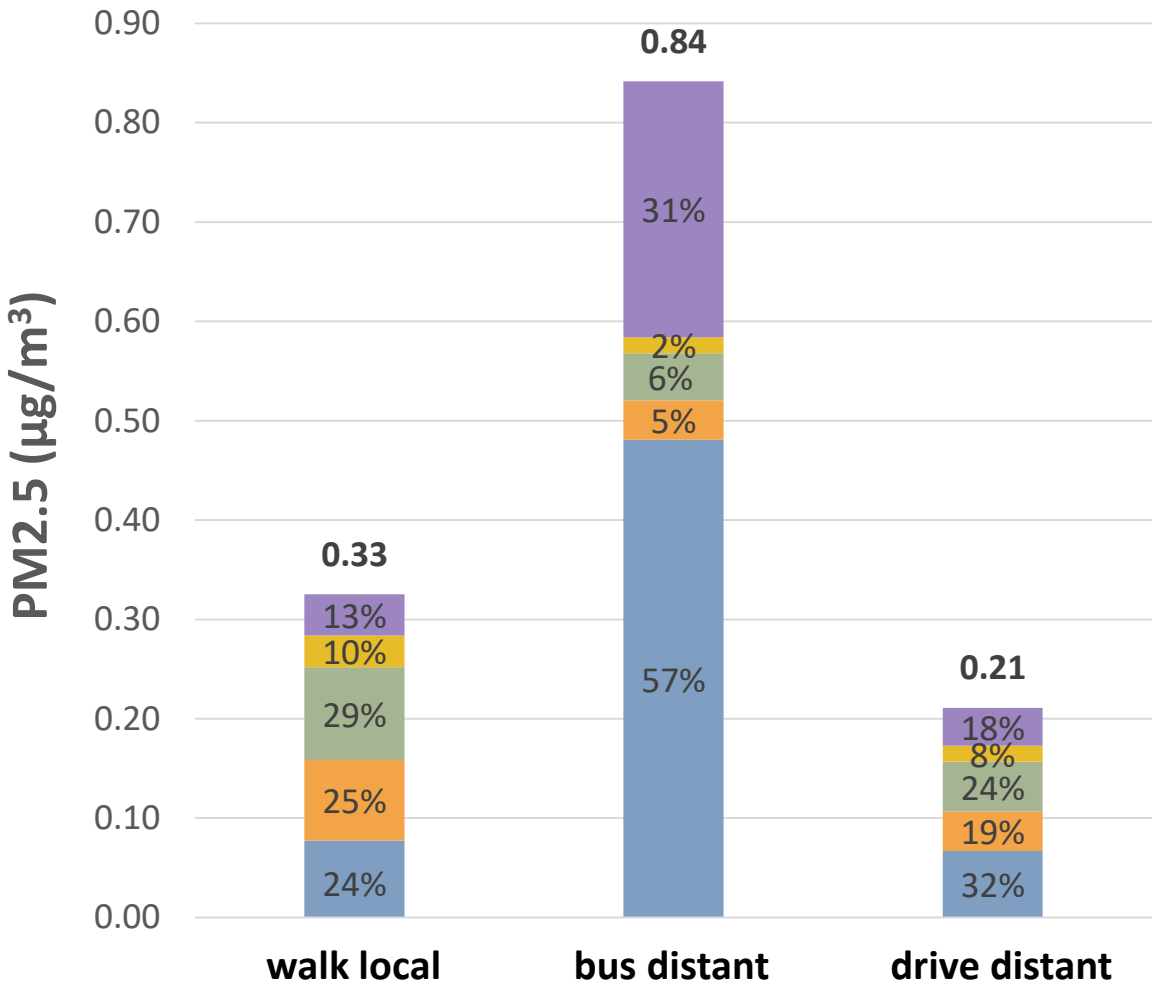
- CO, **NO_x**, **$PM_{2.5}$**, EC, OC
- Benzene (mobile source air toxic)

Average Daily Exposures





Clean Bus Technology

Average Daily Exposure (µg/m³)			
	Standard Bus Distant	Clean Bus Distant	% change
Benzene	0.140	0.0622	-55.7%
CO	96	43	-55.8%
EC	0.38	0.14	-61.8%
NO_X	24	11	-56.2%
OC	0.31	0.12	-61.6%
$PM_{2.5}$	0.84	0.32	-61.4%

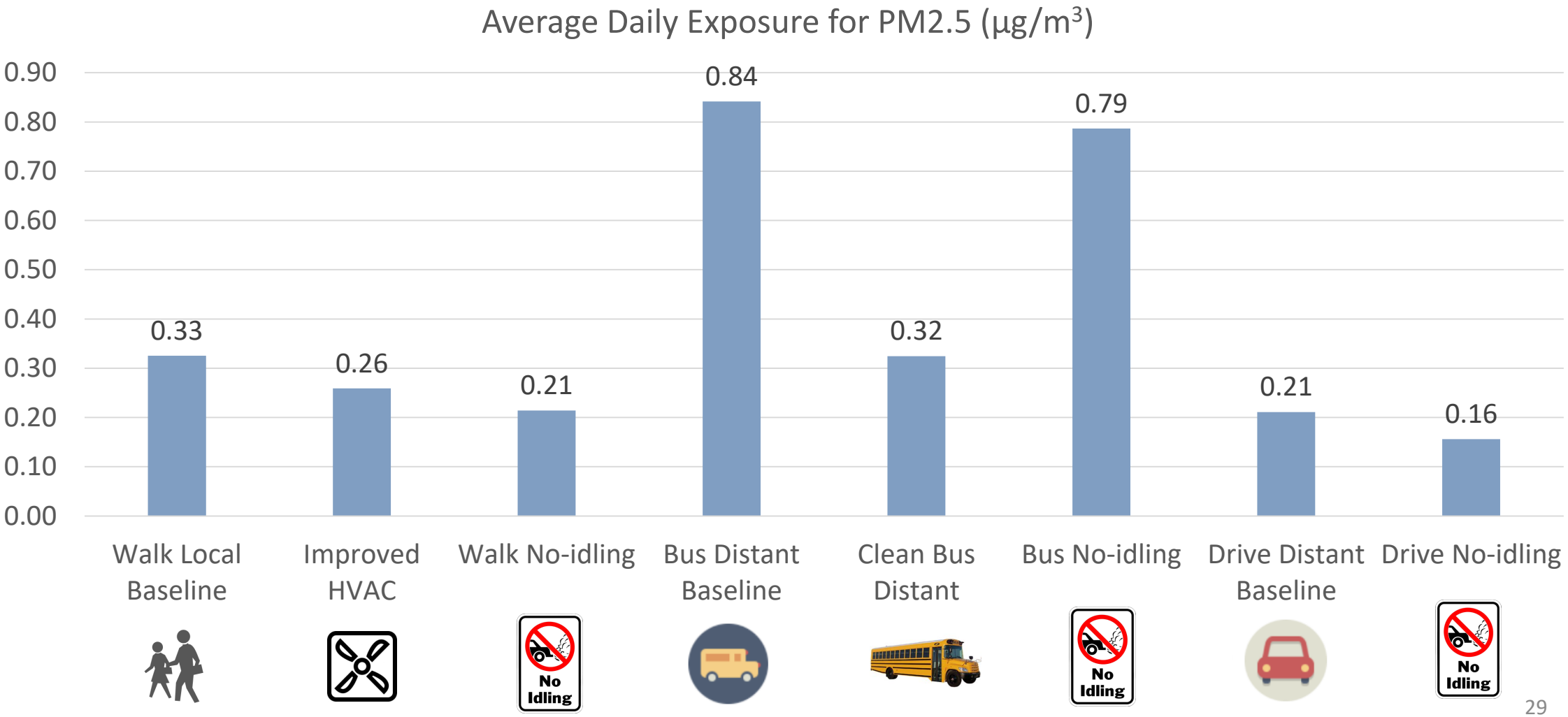
Improved HVAC

Average Daily Exposure (µg/m³)			
	Walk local Baseline	Walk local Improved HVAC*	% change
Benzene	0.0718	--	
CO	46	--	
EC	0.16	0.13	-20.2%
NO_X	15	--	
OC	0.11	0.085	-20.8%
$PM_{2.5}$	0.33	0.26	-20.4%

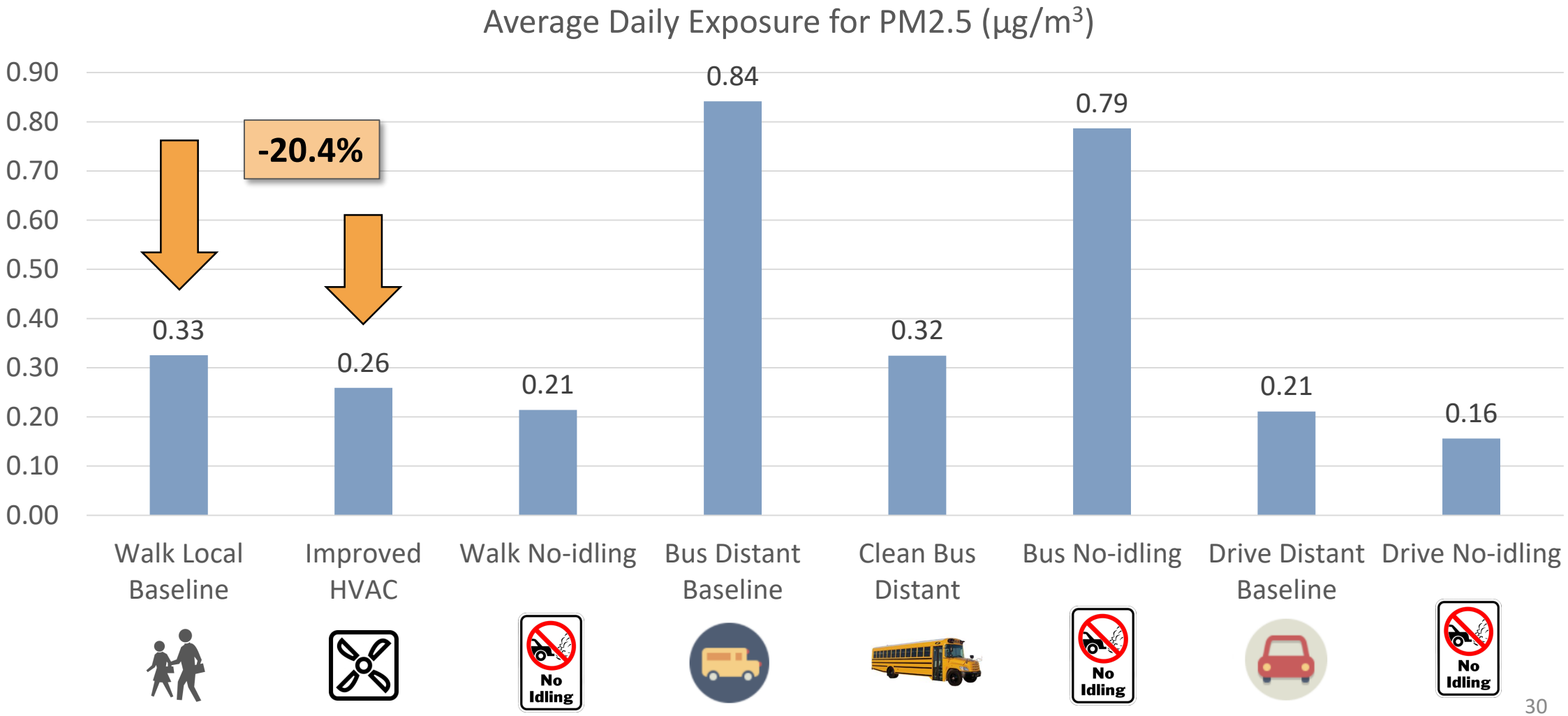
Anti-idling Policy

	% change for walk	% change for bus	% change for drive
Benzene	-19.4%	-5.0%	-7.1%
CO	-19.3%	-5.0%	-13.2%
EC	-34.2%	-6.2%	-25.5%
NO_X	-19.8%	-4.9%	-14.6%
OC	-34.2%	-6.4%	-25.6%
$PM_{2.5}$	-34.2%	-6.5%	-26.0%

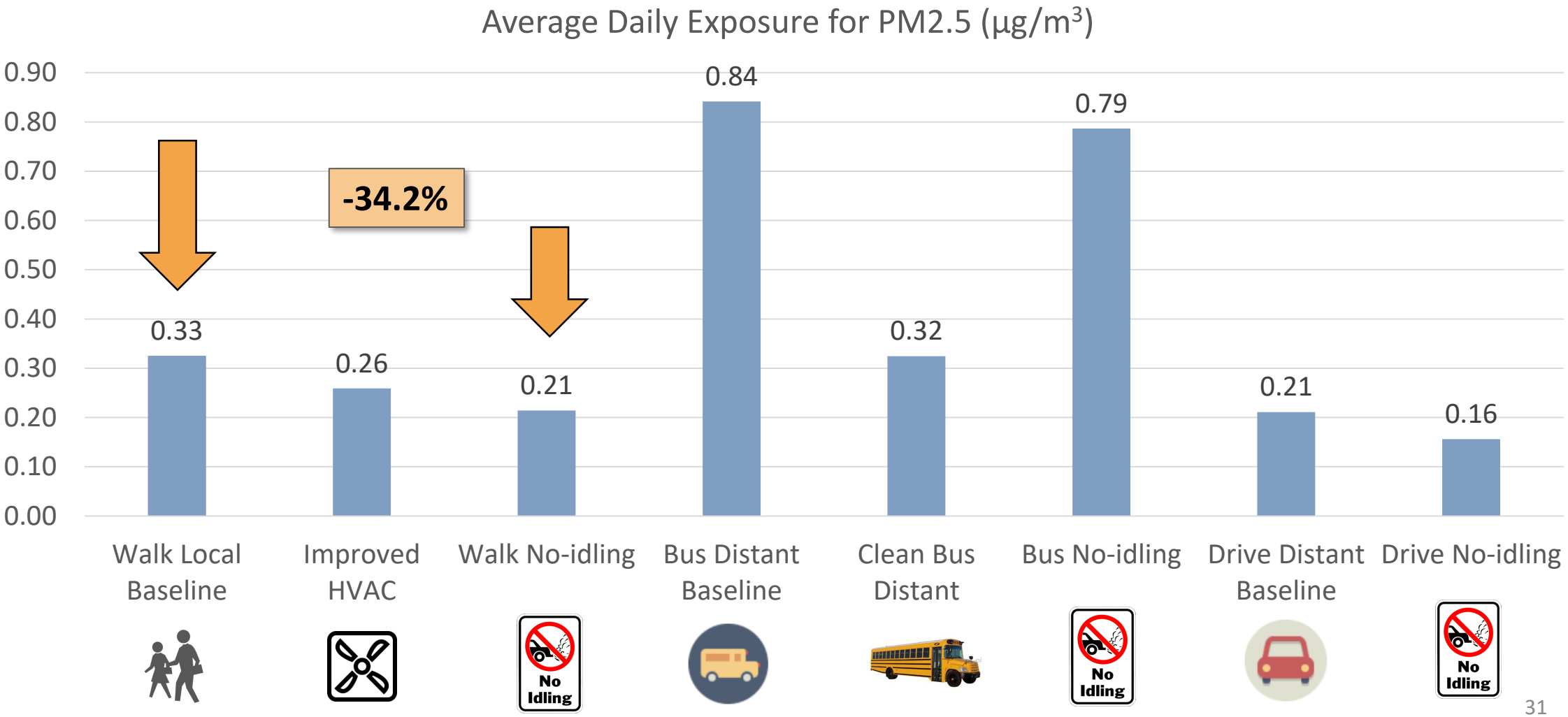
Comparing Policies



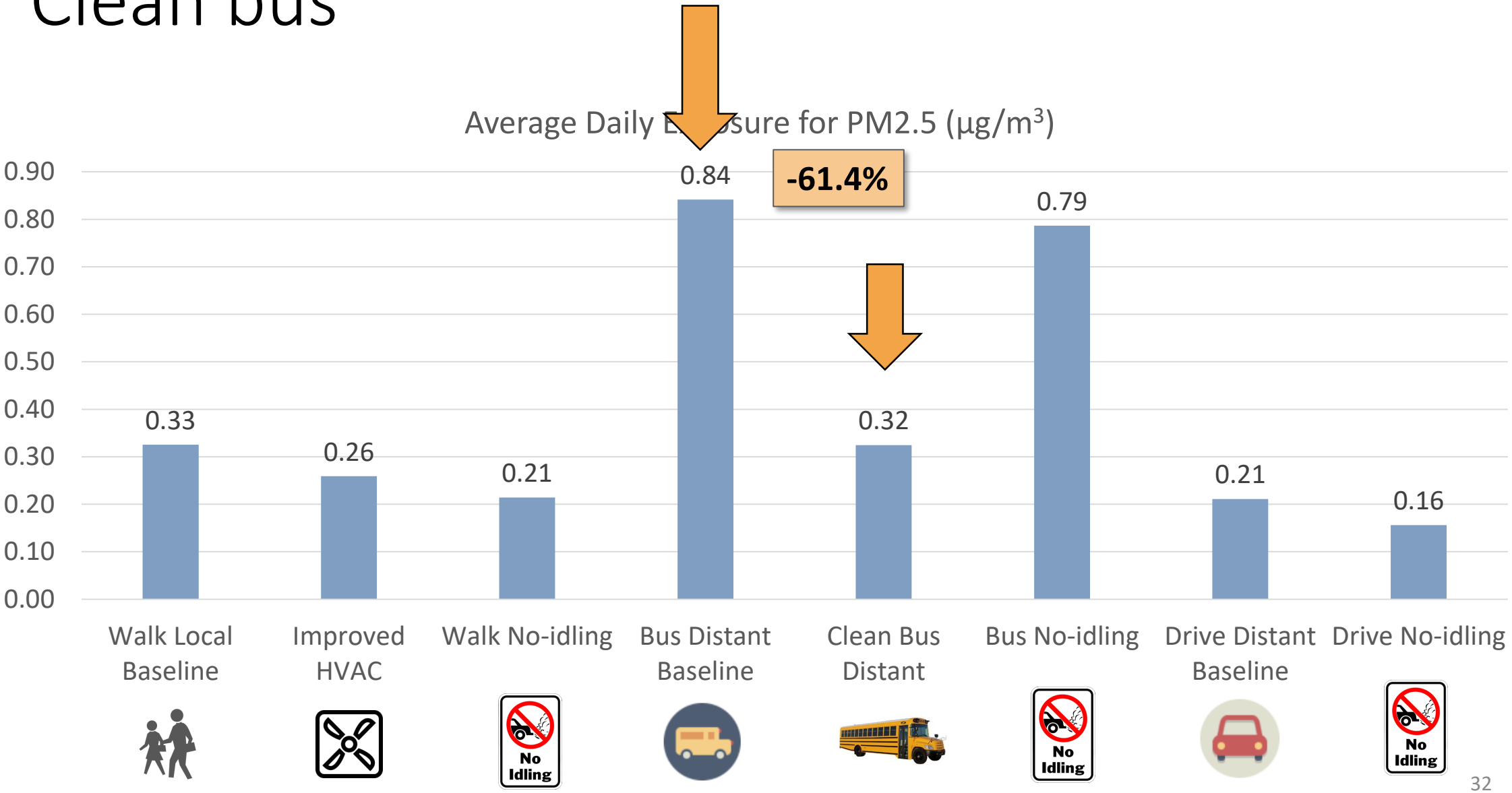
HVAC for Walkers



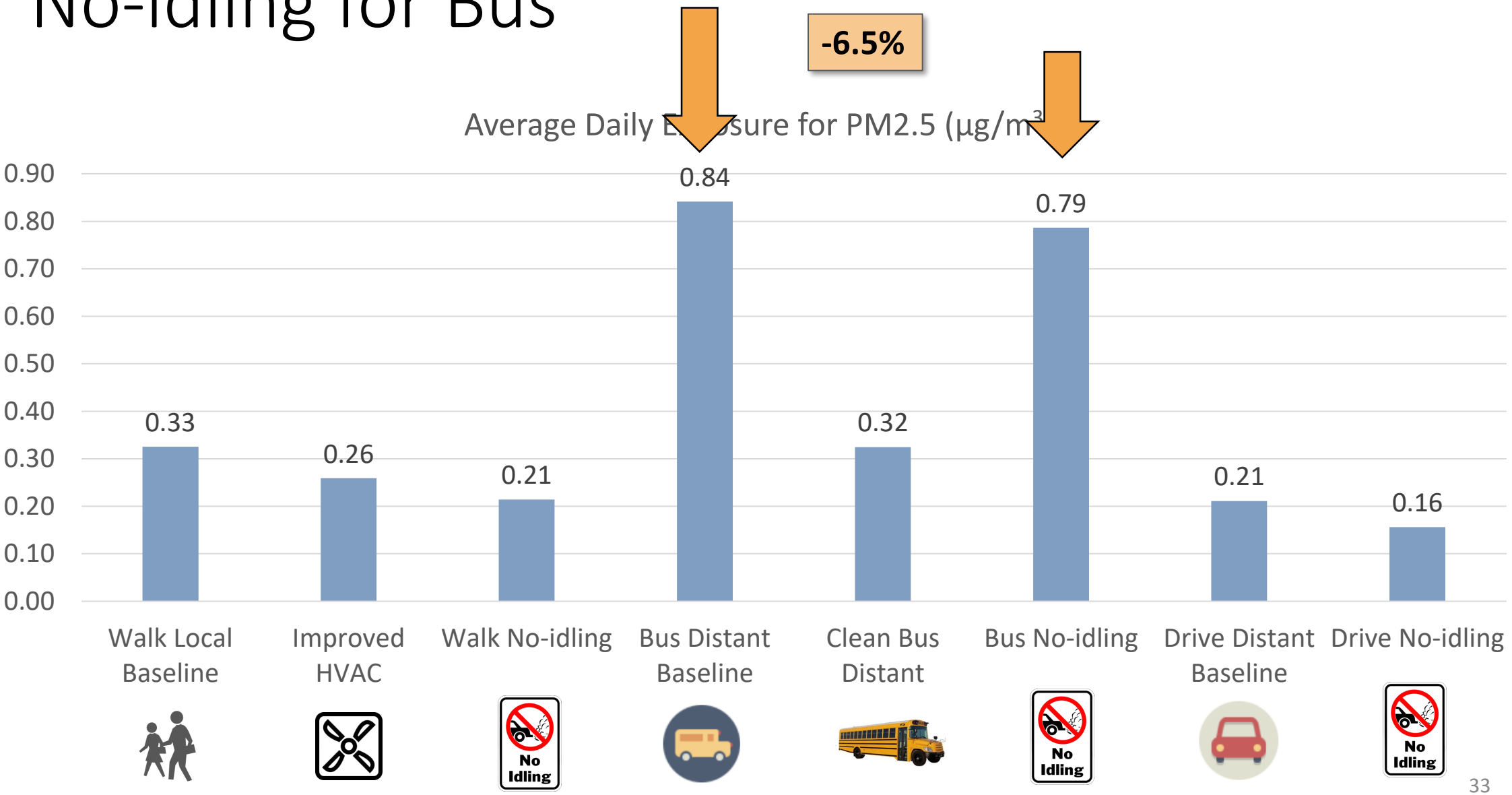
No-idling for Walkers



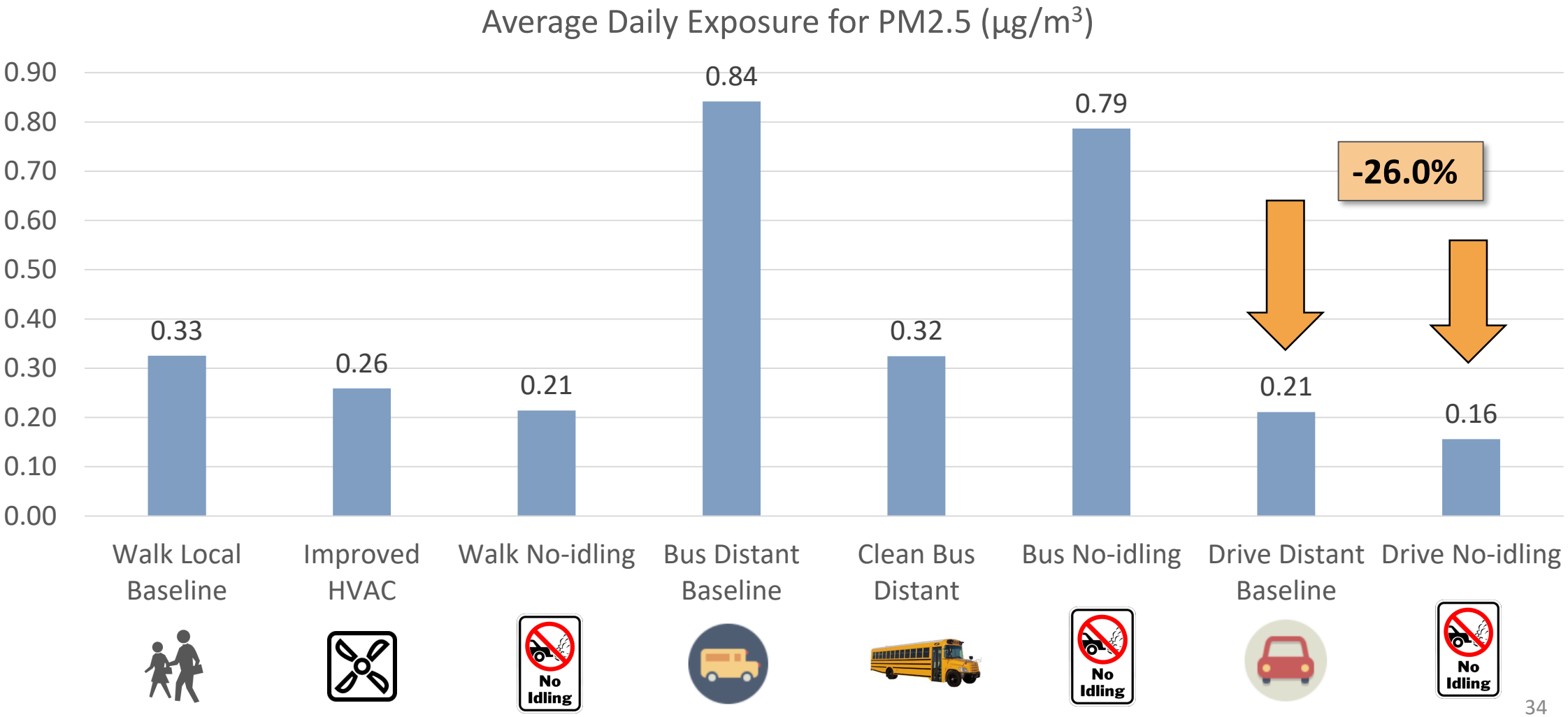
Clean bus


Average Daily Exposure for PM2.5 (µg/m³)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.33
0.26
0.21
0.84
0.32
0.79
0.21
0.16
-61.4%
Walk Local Baseline
Improved HVAC
Walk No-idling
Bus Distant Baseline
Clean Bus Distant
Bus No-idling
Drive Distant Baseline
Drive No-idling
No Idling
No Idling
No Idling

No-idling for Bus



No-idling for Drive



Discussion

- In our simulation, bussing children to better air quality environment saw no association with net reductions in daily exposure
  - bussing to distant school associated with daily exposures 2 to 3x higher than walking local
  - statistically significant across all 6 pollutants ($p<0.001$)

Policy Implications

- Educational needs ultimately drive school assignment, however, schools should address potential unintended health risks

- For walkers, greatest potential impacts in anti-idling policies; school design interventions

- For bussing children remotely, clean busses offer stark reductions in exposure

- Improved HVAC likely moderate reductions; most readily implementable approach

Mary Wolfe
Dept. of City & Regional Planning
mkwolfe@unc.edu

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