Impact of Hurricane Maria on prenatal environmental exposures in Puerto Rico

SRP Risk e-learning Webinar – Climate Change and Health

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SCHOOL OF PUBLIC HEALTH
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PROTECT

Puerto Rico Testsite for Exploring Contamination Threats

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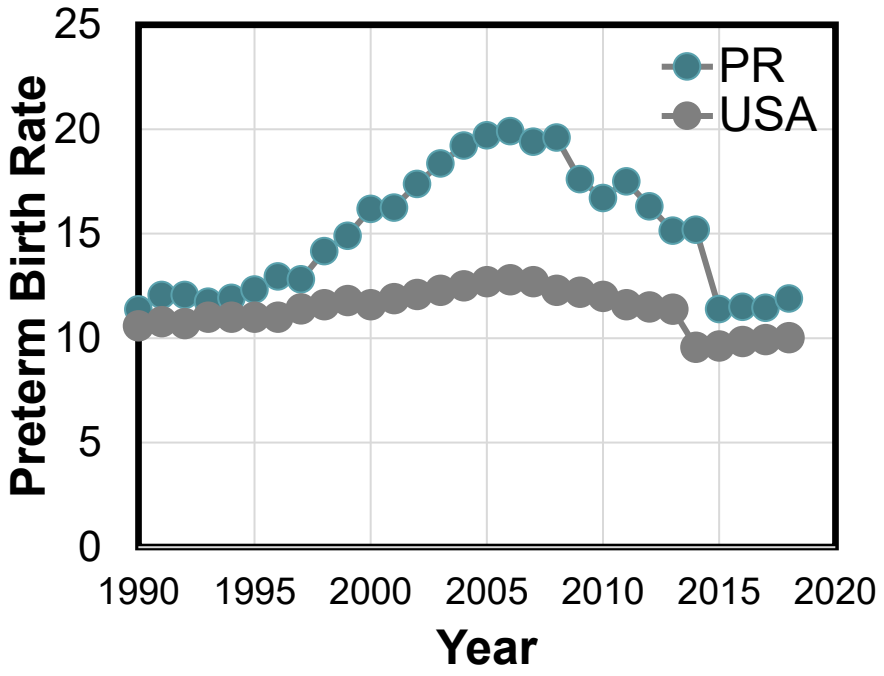
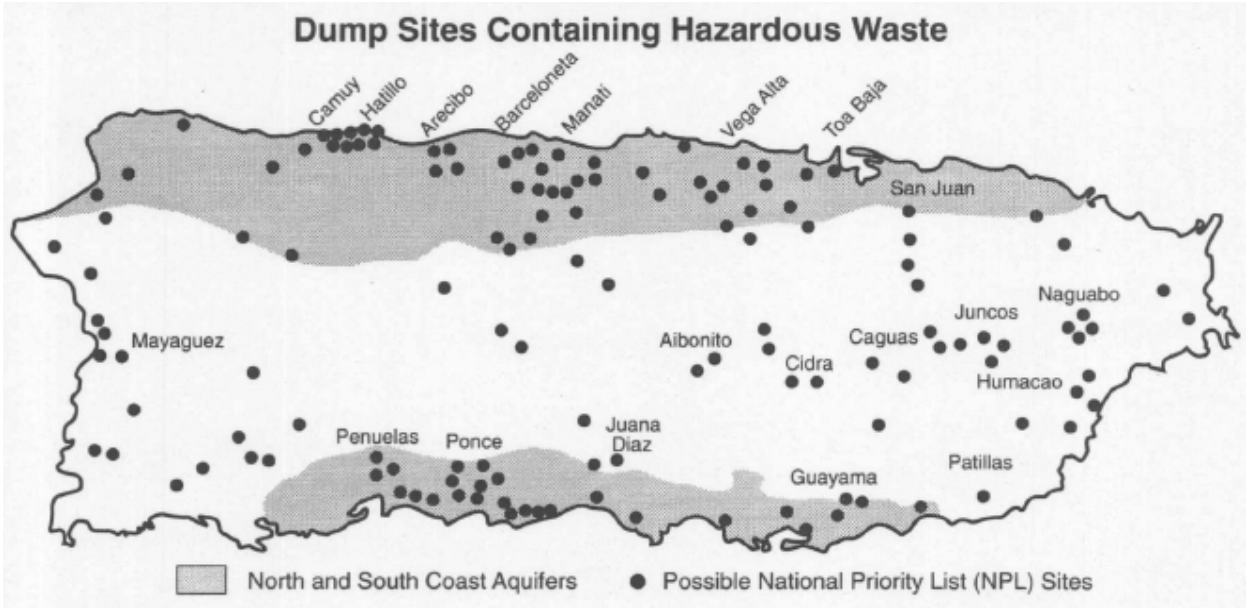
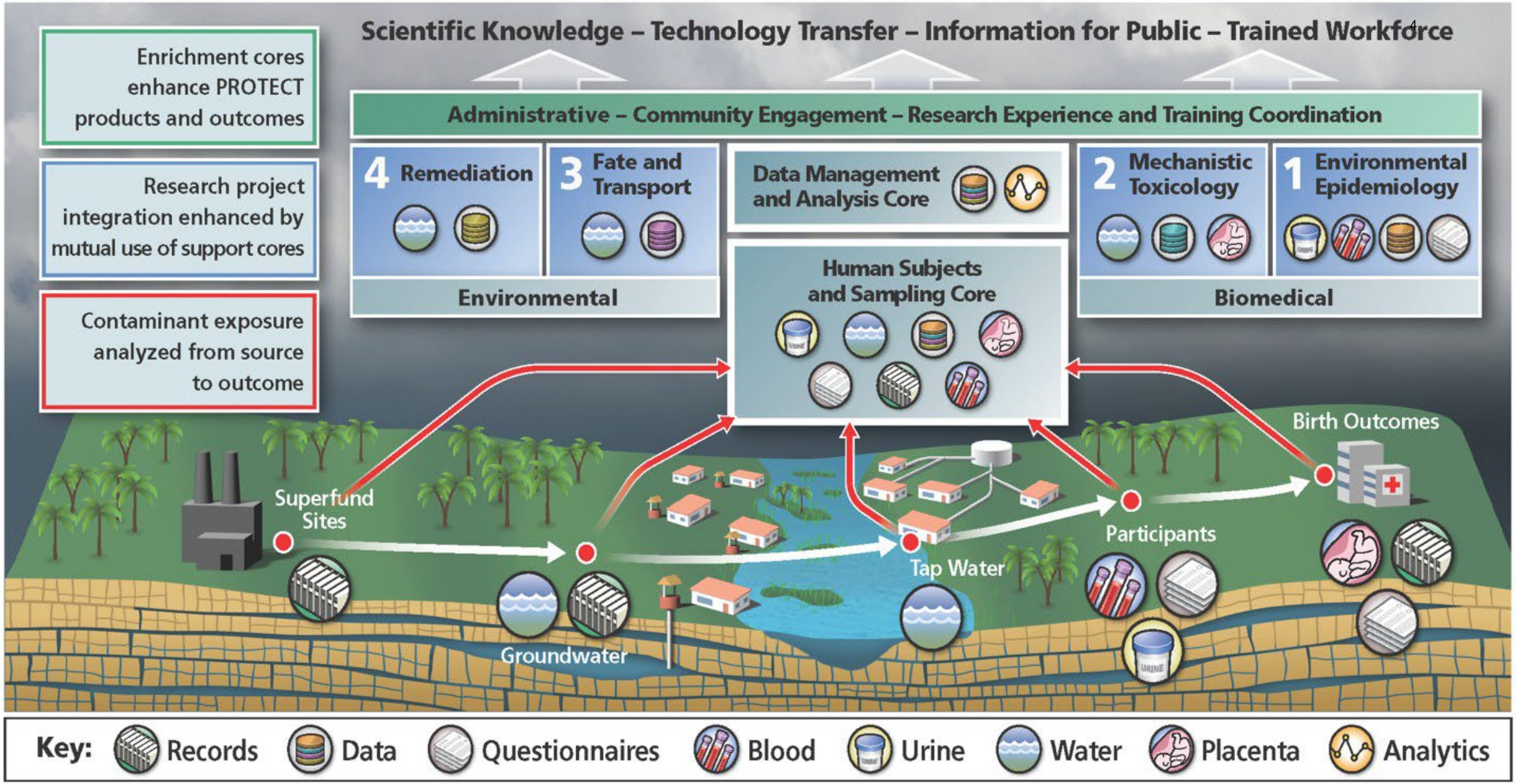
PROTECT in Puerto Rico

- High rate of preterm birth
- >200 hazardous waste sites, 18 Superfund Sites
- High poverty rate

PROTECT
Puerto Rico Testsite for Exploring Contamination Threats






Scientific Knowledge – Technology Transfer – Information for Public – Trained Workforce
Enrichment cores enhance PROTECT products and outcomes
Research project integration enhanced by mutual use of support cores
Contaminant exposure analyzed from source to outcome
Administrative – Community Engagement – Research Experience and Training Coordination
4 Remediation
3 Fate and Transport
Environmental
Data Management and Analysis Core
Human Subjects and Sampling Core
2 Mechanistic Toxicology
1 Environmental Epidemiology
Biomedical
Superfund Sites
Groundwater
Tap Water
Participants
Birth Outcomes
URINE
Key:
Records
Data
Questionnaires
Blood
Urine
Water
Placenta
Analytics

PROTECT Birth Cohort

Goal: Investigate environmental, demographic, and lifestyle factors related to exposure and preterm birth risk.

Women are recruited into PROTECT at their first prenatal visit to participating clinics at less than 16 weeks gestation.

Inclusion Criteria:

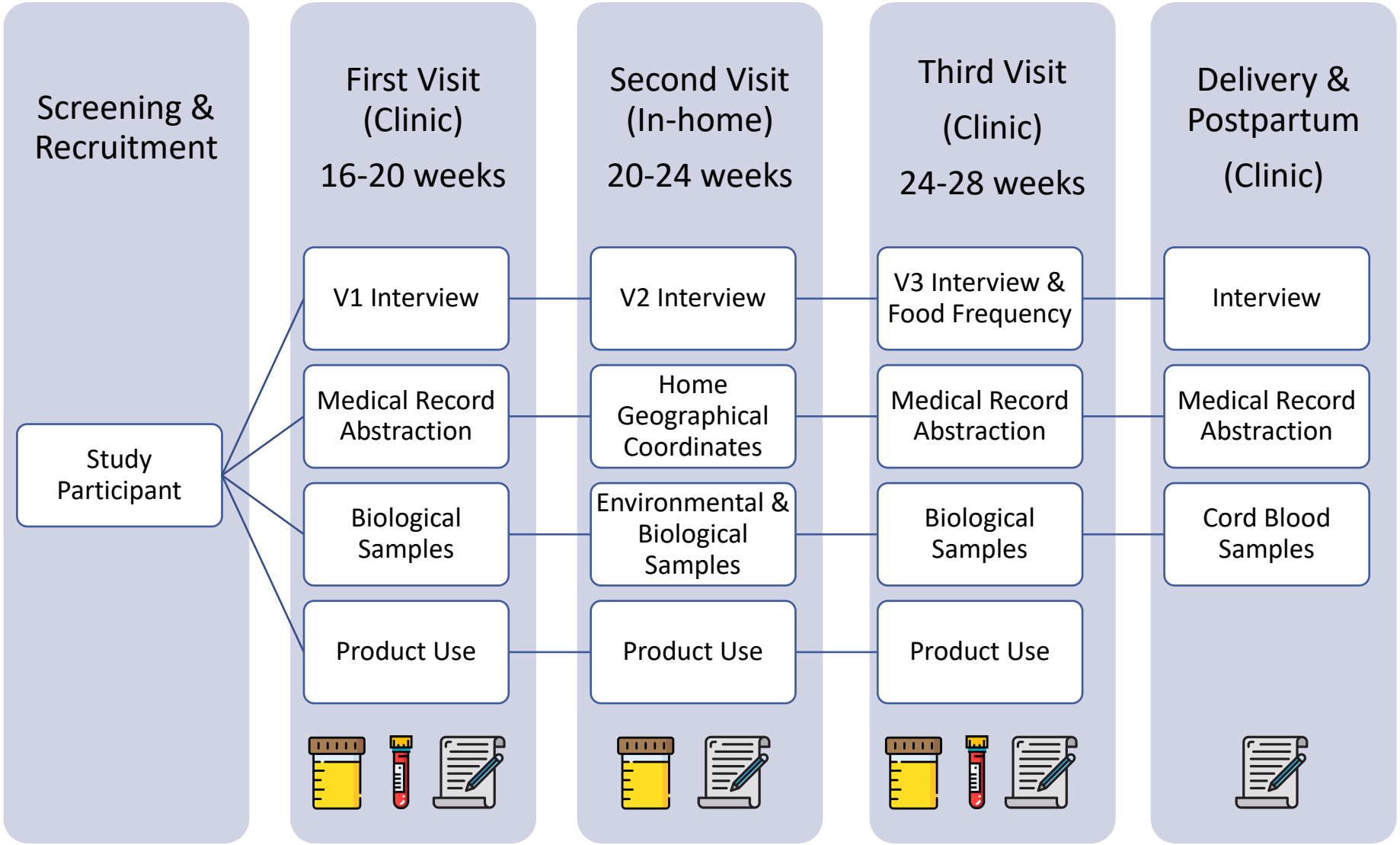
- residing in the Northern karst region
- 18 - 40 years of age

Exclusions:

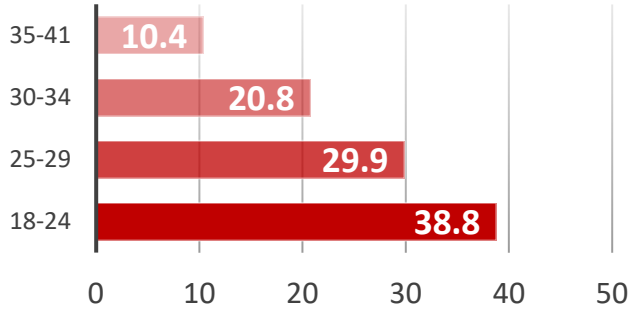
- gestational or medical complications (e.g., preexisting diabetes, hypertension, multiple gestations)
- use of oral contraceptives within three months
- pregnancy stemming from assisted reproductive technologies

Status	Total Number
Screened	2,935
Eligible	2,560
Recruited	2374 (92.7%)
Pregnancies Completed	1,988
Live Births	1,890
Other Pregnancy Outcomes	98 (4.9%)
Pregnancy in Progress	94
Withdrawals	292 (12.3%)

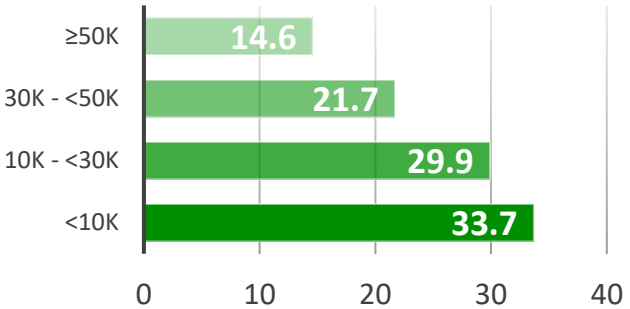
PROTECT Cohort Study Design



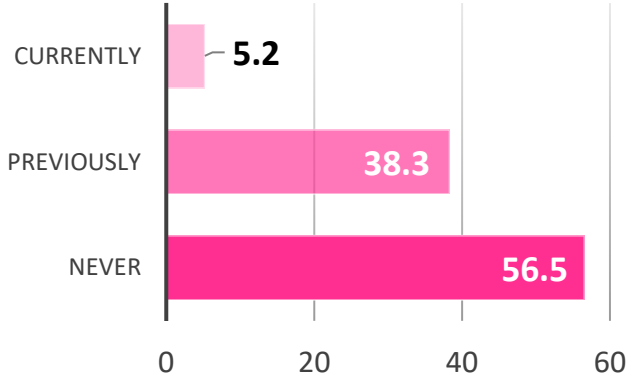
PROTECT Cohort Characteristics



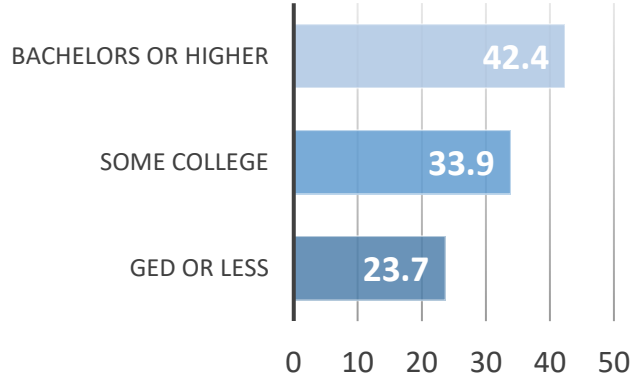
Income



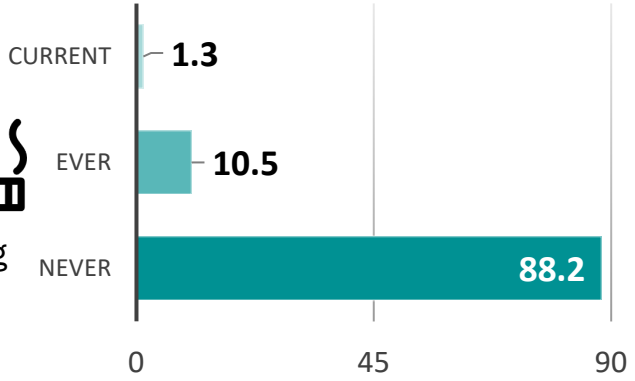
Alcohol Use



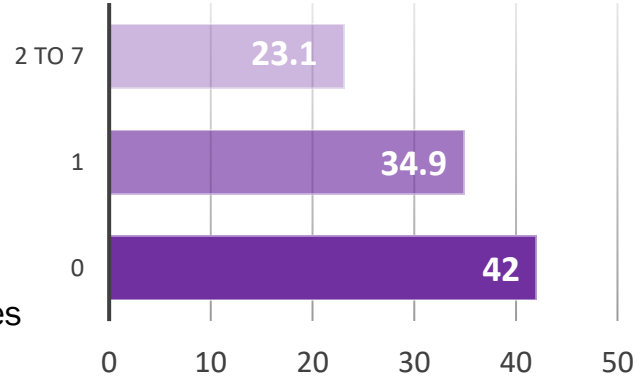
Education



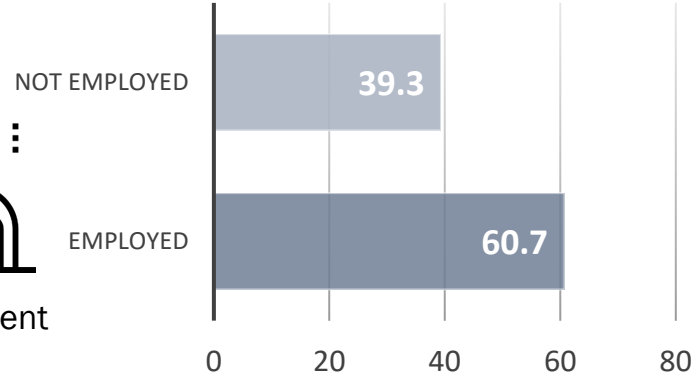
Smoking



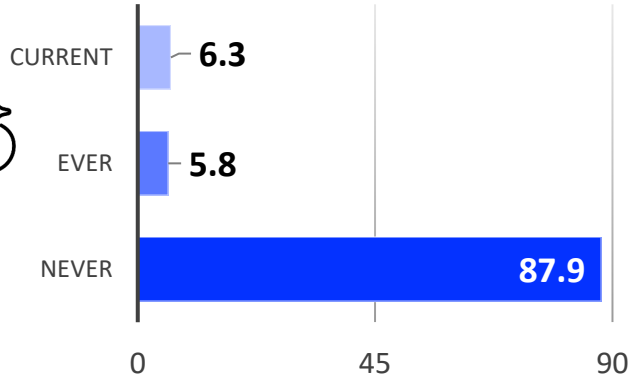
Previous pregnancies



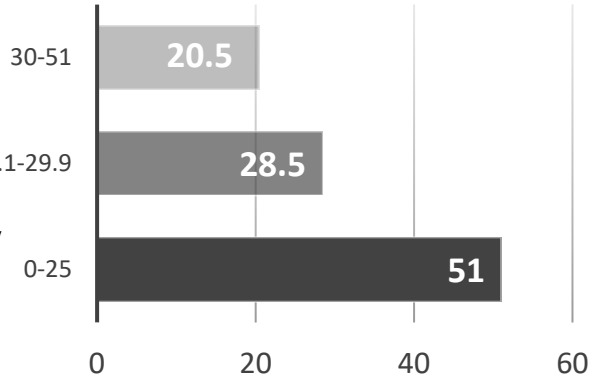
Employment



ETS



Pre-pregnancy BMI



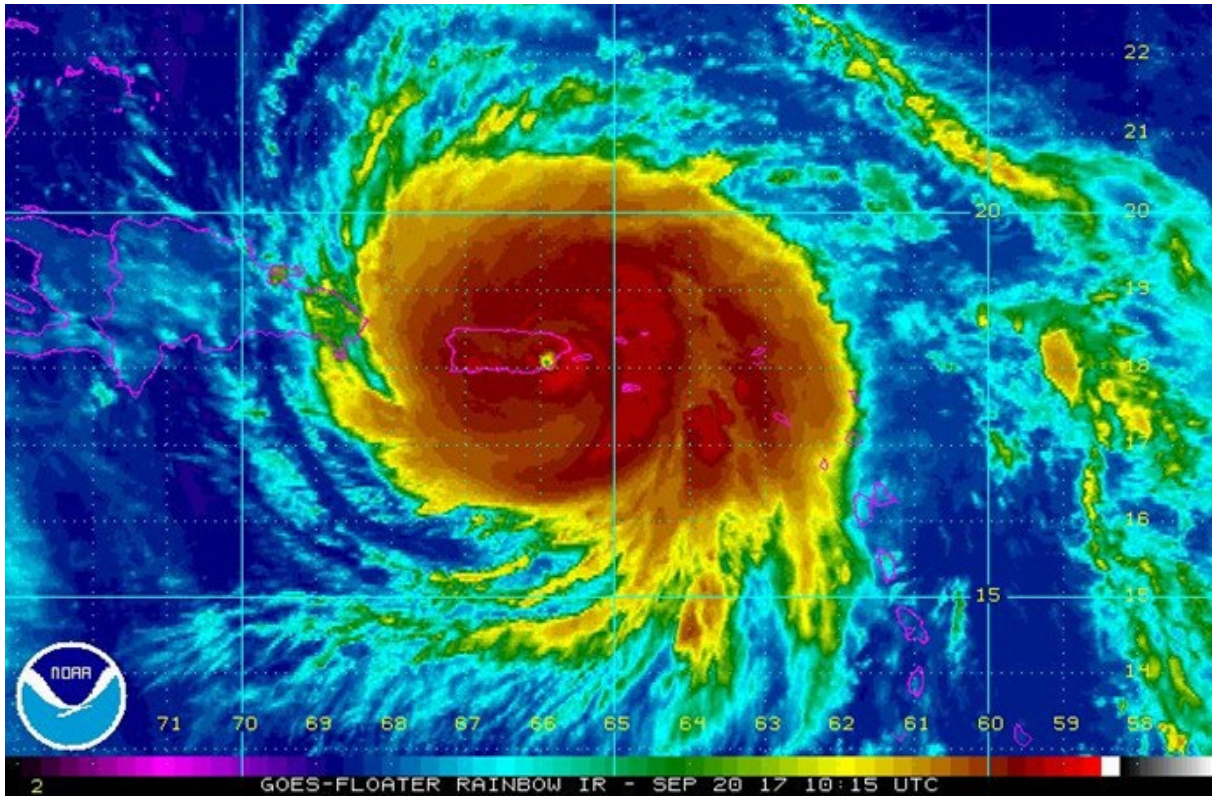
Hurricane Maria in Puerto Rico – September 2017

Hurricane Maria struck Puerto Rico as the most powerful hurricane to hit the island in over 80 years

Collapse of the electric grid, water systems, telecommunications, roads, and many homes destroyed

All of Puerto Rico lost electricity and cell phone service, and half of the population lost water service

Estimated cost over $100 billion in damage and resulted in over 3000 deaths



Puerto Rico after Hurricane Maria – September 2017






Path of Hurricane Maria and PROTECT Study Sites

1: Manatí Medical Center and PROTECT Clinic, 2: Ciales FQHC, 3: Morovis FQHC, 4: Camuy FQHC, 5: Arecibo Pavia Hospital

PROTECT SRP Center : After Hurricane Maria

- Ensured the safety and welfare of team members, study participants, community health center partners, and members of the surrounding communities.
- Distributed water filtration systems, diapers, baby food, baby wipes, mosquito nets and repellent, hand sanitizer

Natural Disasters and Health

Previous Research on Hurricane Exposure

Hurricanes Andrew, Katrina, and Sandy

- Hurricane exposure was associated with long-term physical and psychological health consequences
- Pregnant women who experienced a hurricane were at higher risk of preterm birth, low birth weight, and other adverse birth outcomes

Hurricane Maria in Puerto Rico

- Geographic isolation
- Prolonged recovery

Frequency and intensity of storms are increasing

(https://www.gfdl.noaa.gov/global-warming-and-hurricanes/)

PROTECT: Environmental Exposures after Hurricane Maria

PROTECT had 176 participants pregnant during or within 5 months after Hurricane Maria.

- Flooding and damage potentially exacerbated already present groundwater contamination. Impact on drinking water?
- Use of diesel-powered generators lead to increased polycyclic aromatic hydrocarbon (PAHs) exposure?
- Increased intake of processed, packaged foods and bottled water lead to higher phthalate exposure?
- Effects of increased stress or trauma?

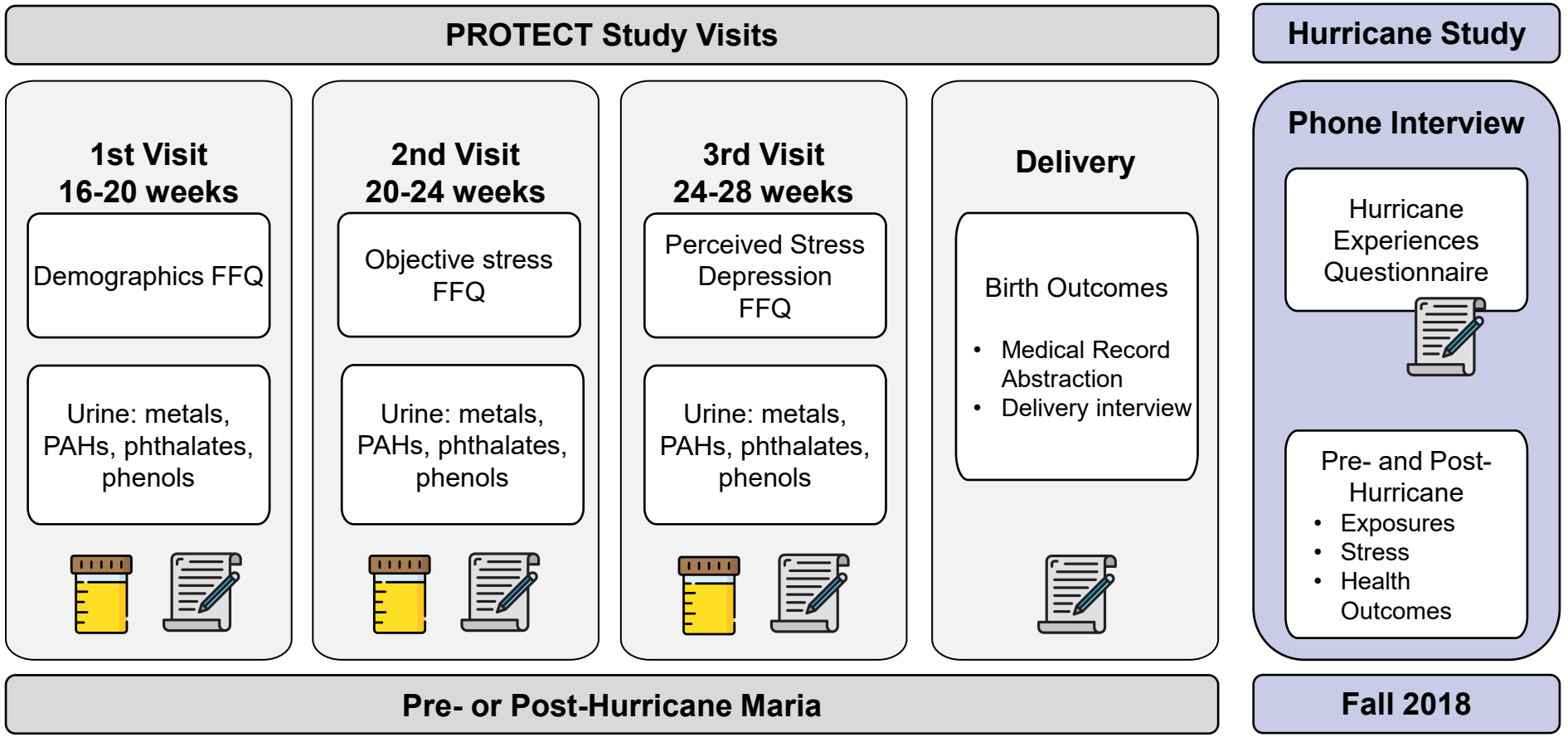
PROTECT "Hurricane Study"

NIEHS R21:

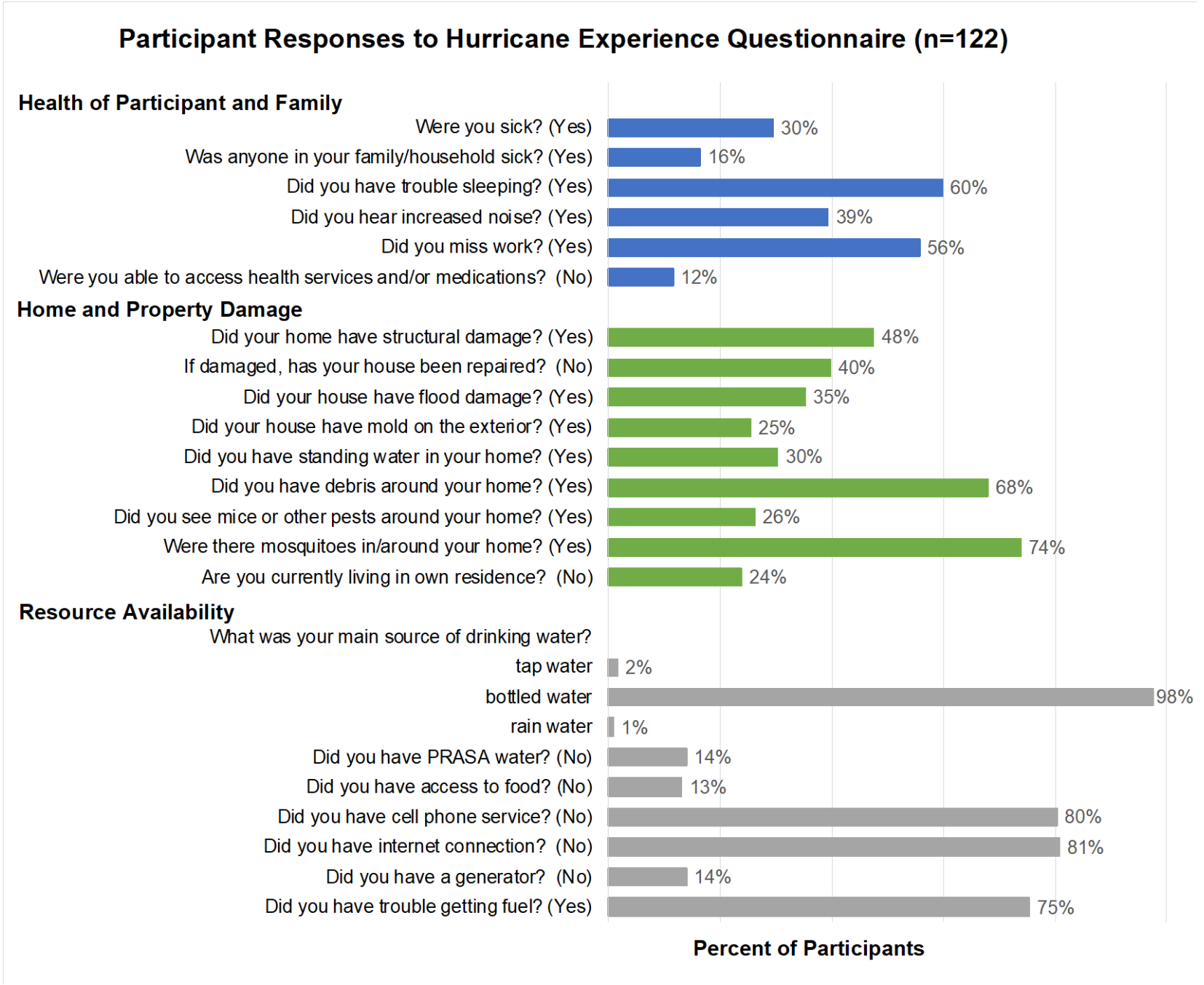
Investigate impact of Hurricane Maria on prenatal stress, environmental exposures, and birth outcomes within the PROTECT birth cohort

- Utilize urine samples collected pre- and post-Maria to assess changes in exposure to PAHs, metals, phthalates, and phenols.
- Phone-administered questionnaire on hurricane-related experiences to identify sources of exposure and stress. (Aug 2018-Feb 2019)

PROTECT and Hurricane Study: Design



Hurricane Experience Questionnaire (n=122)

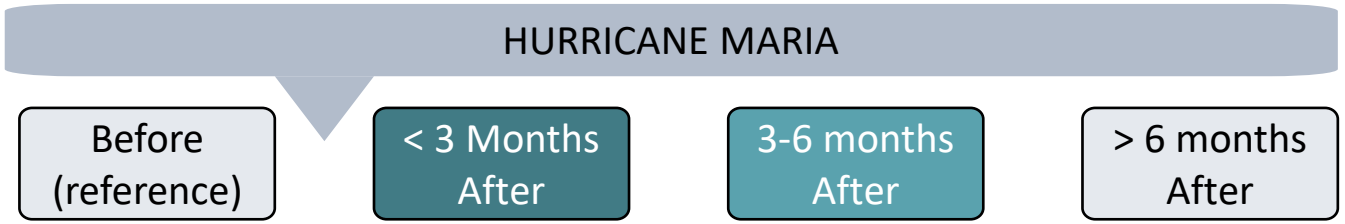


On average, respondents were without electricity for 108 days

Watkins et al. 2020. Population and Environment

Environmental Exposures: Pre vs. Post Maria

Statistical Methods

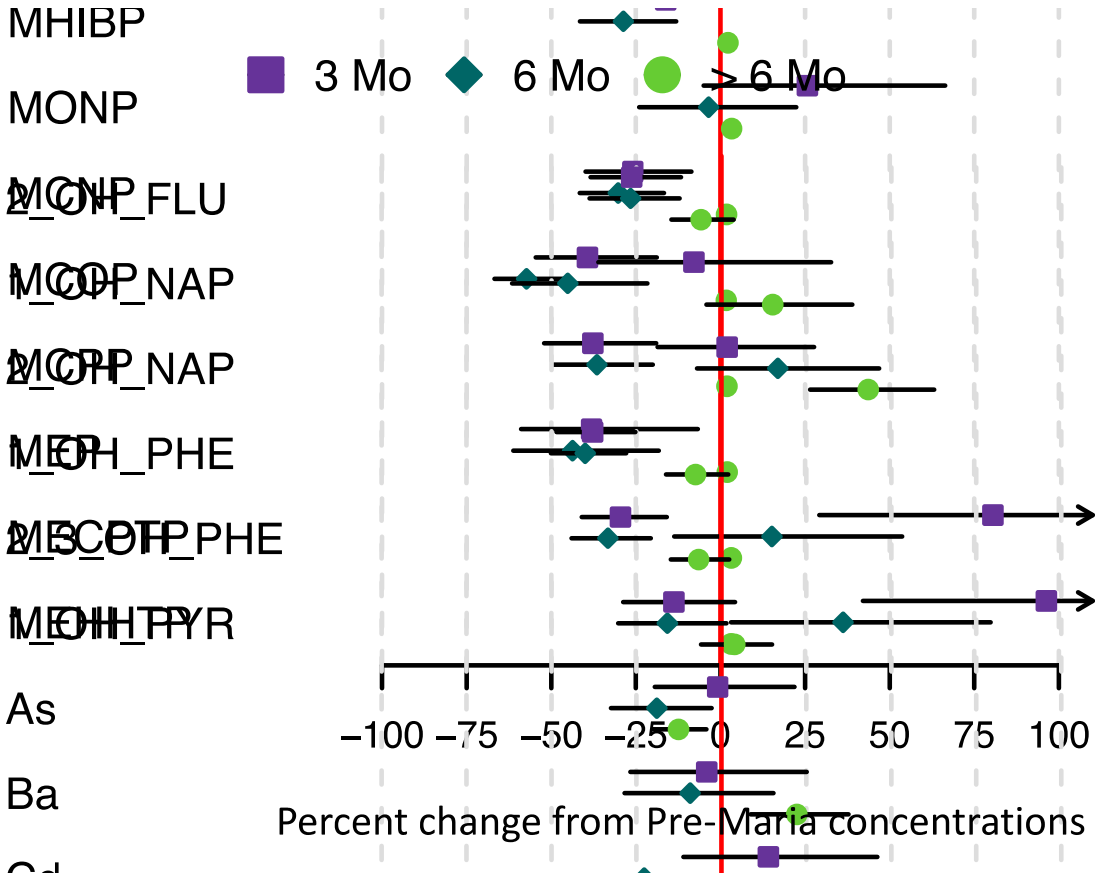


- "Hurricane Status" variable
- Urinary biomarkers of exposure
  - standardized using specific gravity
  - natural log-transformed
- Hurricane Status was entered into linear mixed effect models as predictor of exposure biomarker concentrations
  - Mixed model adjusts for within individual correlations over time
  - Model adjusted for maternal education and income
  - Effect estimates are presented as the percent change in geometric means
- Biomarkers detected in <50% of samples were examined as detect vs. non-detect using generalized linear mixed models with logit link function to determine Hurricane Status as predictor of biomarker detection

Sample Distribution

Number of Urine Samples Collected within each "Hurricane Status" Period with Biomarker Measurements				
	Before Maria	< 3 months After	3-6 months After	> 6 months After
PAHs	1750	66	88	460
Metals	1902	66	97	466
Phthalates	2620	67	110	941
Phenols	2584	21 + 4 = 25		640

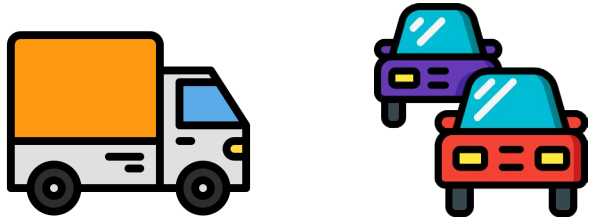
PAHs (ng/L)



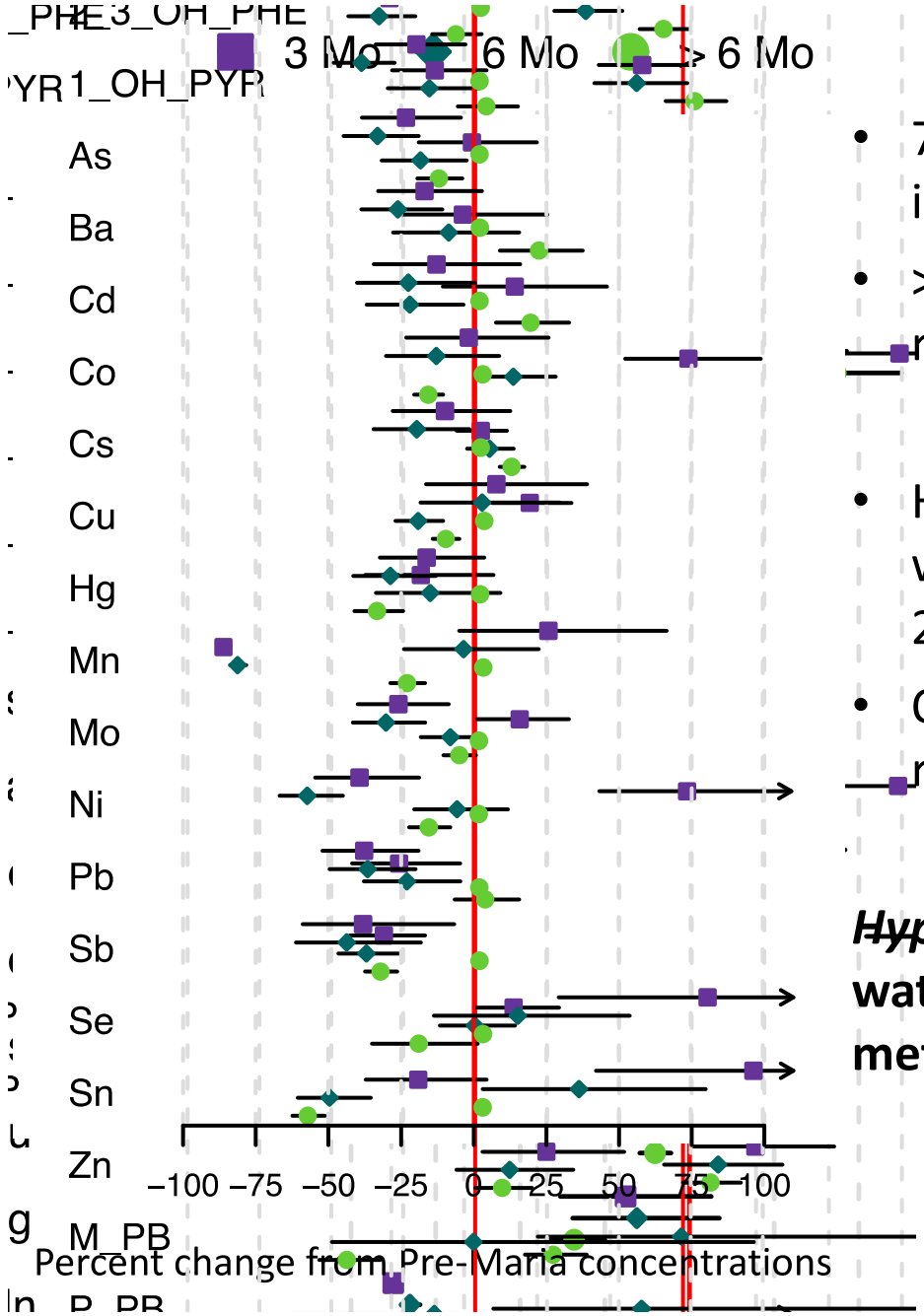
- Decrease of 15-45 % in most PAH concentrations in 3 and 6 months after Maria
- Exception was 2-hydroxynapthalene, which didn't decrease in the 6-month aftermath, but increased by 40%

- 86% of respondents had a generator
- 75% reported difficulty getting fuel

Hypothesis: **Decreased traffic led to lower PAH exposure**



Metals & Metalloids (ng/mL)

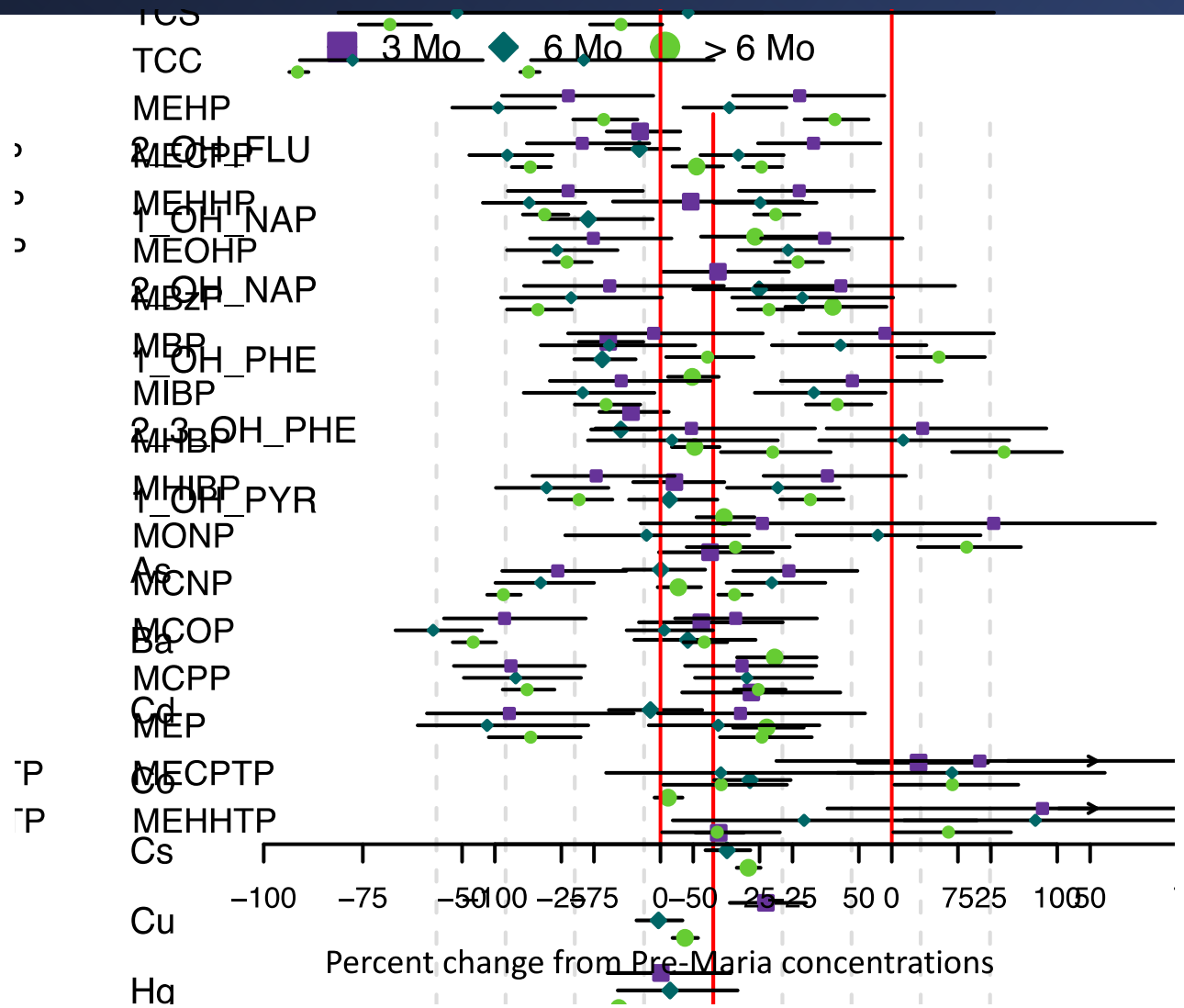


- 75% increase in Co, Ni, and 25% increase in Cu in 3 months
- >80% decrease in Mn, with slow return to pre-Maria levels

- Higher As, Mn, Ni, and Cu in tap water after Maria (Lin et al. 2020)
- Only 2% of respondents reported drinking tap water

Hypothesis: **Changes in drinking water sources led to changes in metal and metalloid exposure.**

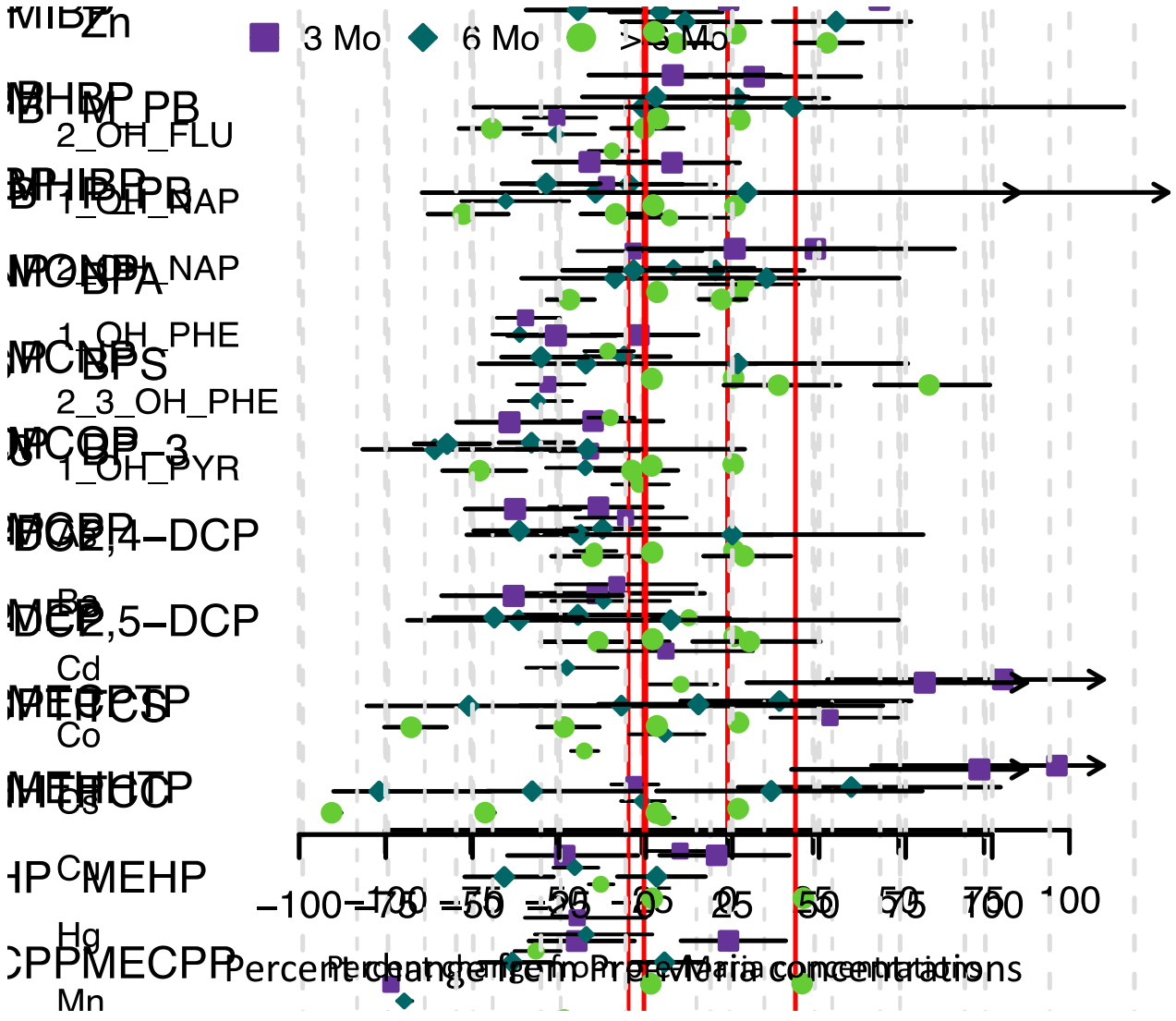
Phthalate Metabolites (ng/mL)



- Decreased concentrations of many phthalate metabolites
- Metabolites of terephthalate increased 80-100% in 3 months
- Some differences due to trends in phthalate use

Hypothesis: **Increased DEHTP exposure due to packaged and processed foods, plastic use**

Phenols & Parabens (ng/mL)



- 61% decrease in benzophenone-3 (UV-filter) after Maria
- 50-90% decrease in antimicrobials triclosan, triclocarban

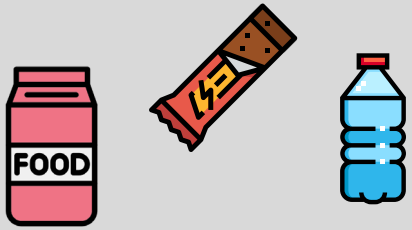
Hypothesis: **Differences in exposure due to trends in chemical use in products**

Change in % samples with detectable concentrations

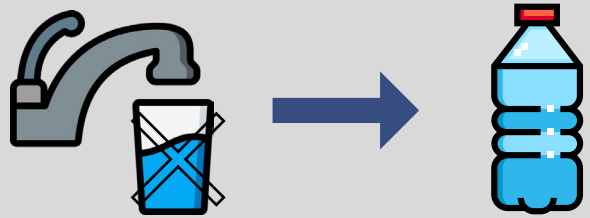
	PRE-MARIA (n=1750)	< 3 MONTHS (n=66)		3 to < 6 MONTHS (n=88)		> 6 MONTHS (n=460)	
	% > LOD	**% > LOD**	**p-value**	**% > LOD**	**p-value**	**% > LOD**	**p-value**
4-OH-PHE	66.7	40.9	0.004	31.8	<.0001	70.2	0.75
9-OH-PHE	46.6	31.8	0.07	22.7	0.001	47.4	0.86
	(n=1902)	(n=66)		(n=97)		(n=466)	
Chromium	19.2	21.2	0.62	2.1	0.005	7.5	<.0001
Beryllium	23.1	7.6	0.02	15.5	0.41	7.3	<.0001
Thallium	46.8	69.7	0.008	67	0.001	49.6	0.13
Uranium	36.2	9.1	0.0002	9.3	<.0001	9.7	<.0001
Tungsten	22.9	18.2	0.73	4.1	0.002	2.4	<.0001
	(n=2620)	(n=67)		(n=110)		(n=941)	
MHINCH	36.5	47.8	0.14	30.9	0.18	54.1	<.0001
MCOCH	21.1	32.8	0.05	12.7	0.20	27.7	0.002
MNP	29.6	26.9	0.71	27.3	0.11	27.3	0.22

Sources of exposure after Hurricane Maria

Higher levels of phthalate replacements used as plasticizers in food packaging & processing



Despite increased metal concentrations in tap water (Lin et al. 2020), changes in drinking water sources post-hurricane likely contributed to changes in metal exposure.



Widespread use of gas-powered generators post-hurricane did not result in higher PAH exposure.

Potential changes in diet and reduced traffic post-hurricane may have led to lower PAH exposure.

Challenges

Birth outcomes

- Few cases of preterm birth and other adverse birth outcomes
- Shift in participant demographics? selection bias?

Timing

Year	Withdrawal Count	Withdrawal %	Total recruited
2011	32	21%	153
2012	61	22%	274
2013	51	21%	246
2014	21	14%	155
2015	15	6%	263
2016	17	9%	199
2017	**12**	**7%**	**164**
2018	**22**	**7%**	**296**
2019	20	7%	300
2020	8	8%	105
2021	11	6%	170

Next Steps

Child Development

- Growth
- Neurodevelopment
- Hurricane Exposure Questionnaire n=175

Mental Health

- Perceived Stress, Depression Pre- and Post-Hurricane Maria
- Hurricane Related Traumatic Experiences (HURTE) scale (2019)
- Traumatic Exposure Severity Scale (TESS) (2019)

Conclusions

Hurricane-related changes in environmental contaminants, behavior, and diet can lead to changes in exposure with potential health consequences.

Aim to inform practices regarding specific vulnerabilities of pregnant women and young children during a disaster to mitigate the effect of future storms.

Thank you!

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