Evaluating PFAS Exposure From Fluorinated Waxes Among US Snow Sport Participants

NEWMOA PFAS Webinar Series
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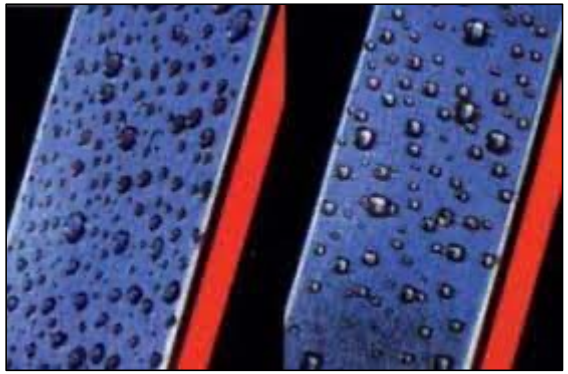
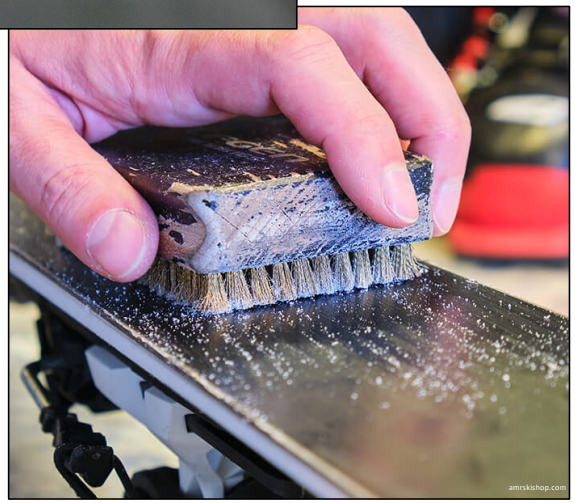
The Need for Speed

https://www.si.com/olympics/2019/12/11/mikaela-shiffrin-historic-2019-season-dominance

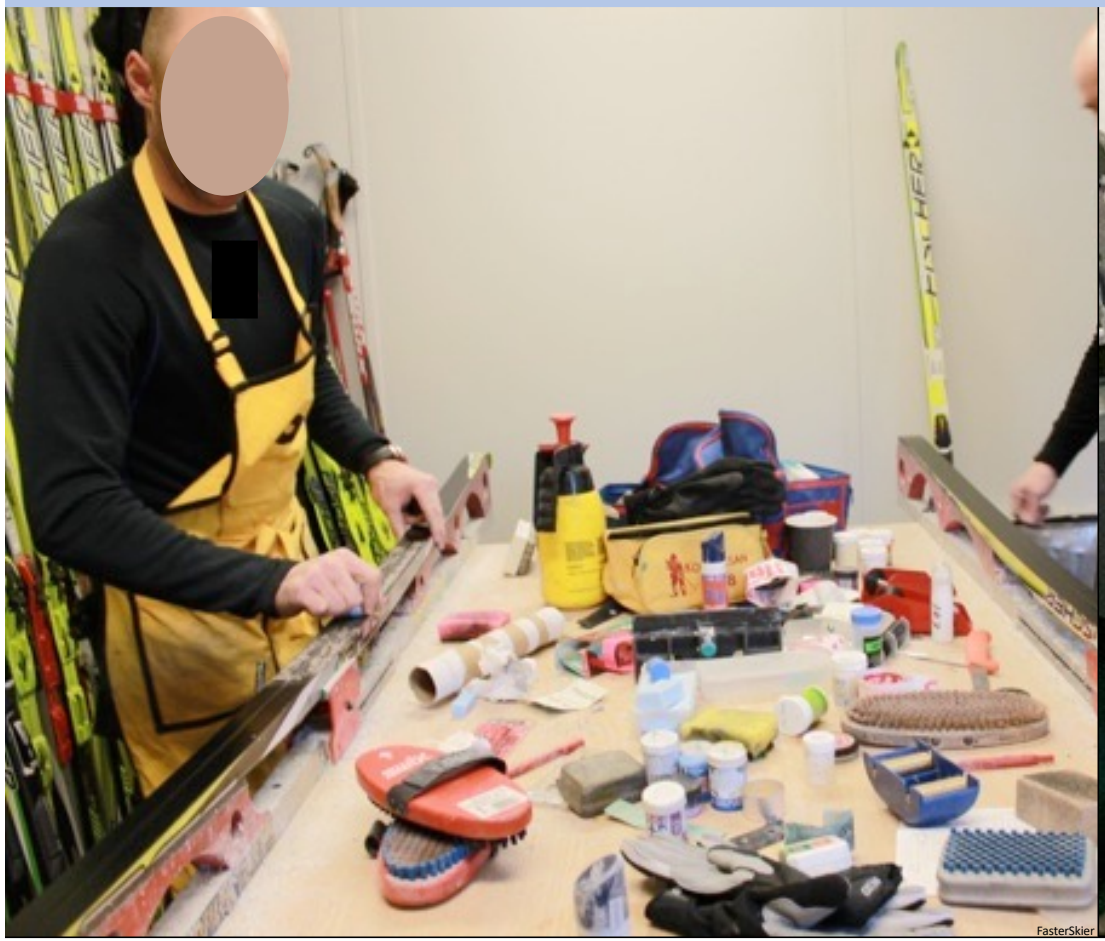

https://www.outsideonline.com/outdoor-gear/snow-sports-gear/how-buy-cross-country-skis/

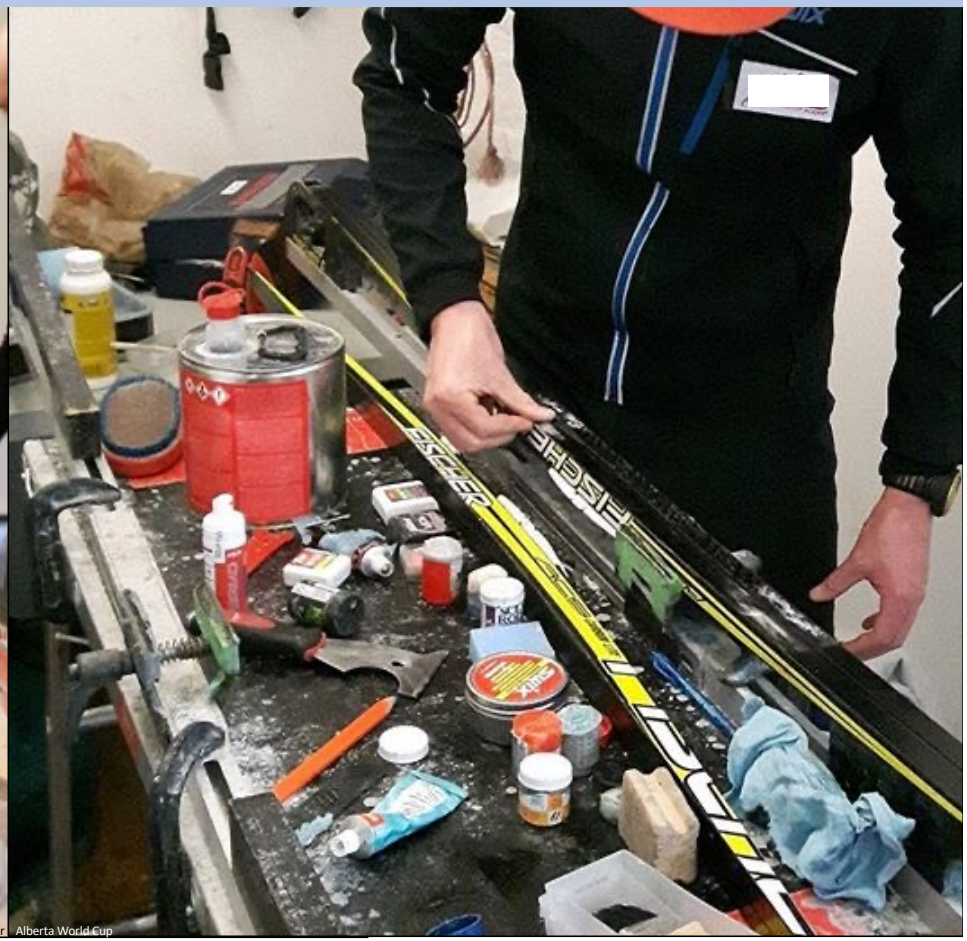
Ski & Snowboard Waxing



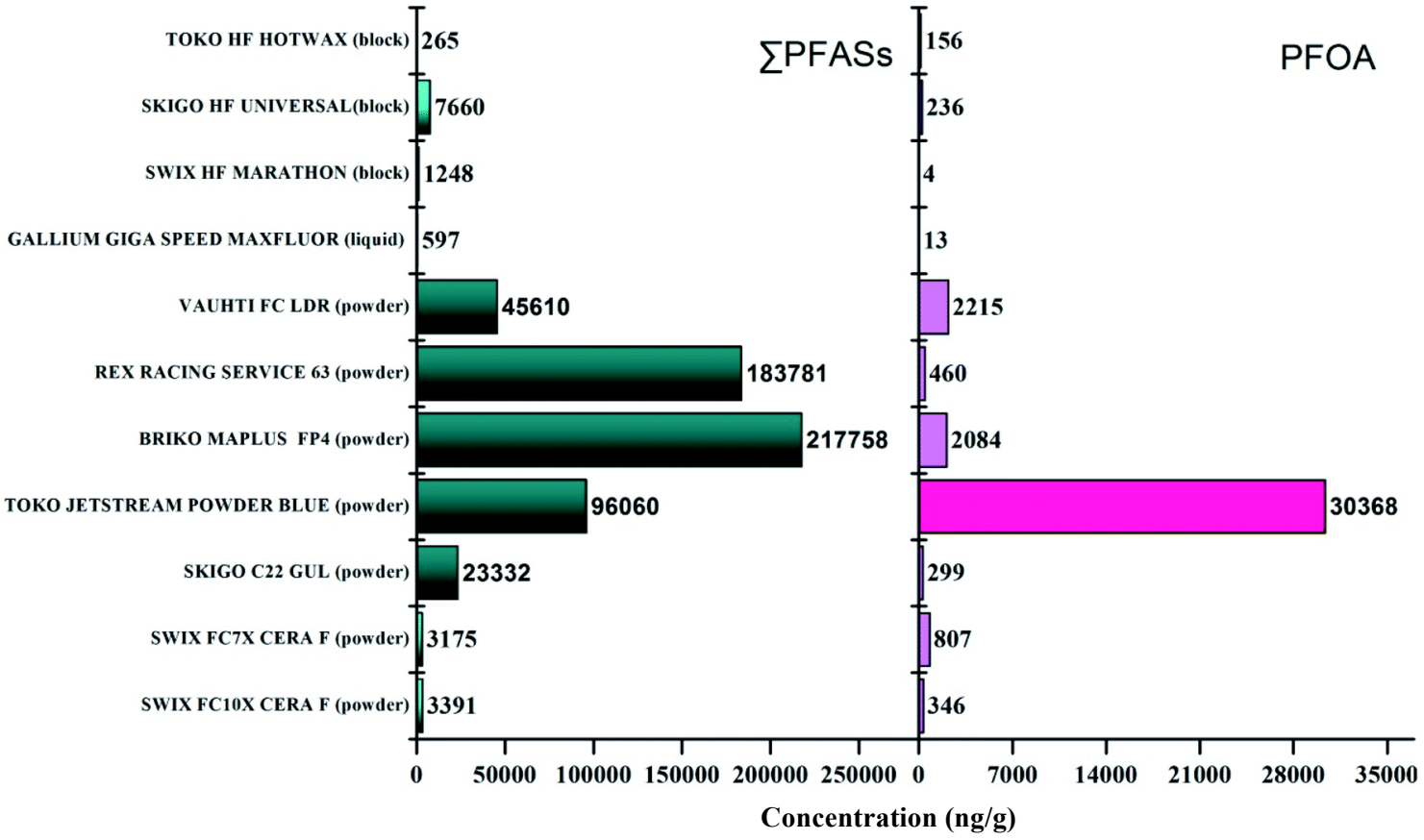


Inside A Waxroom





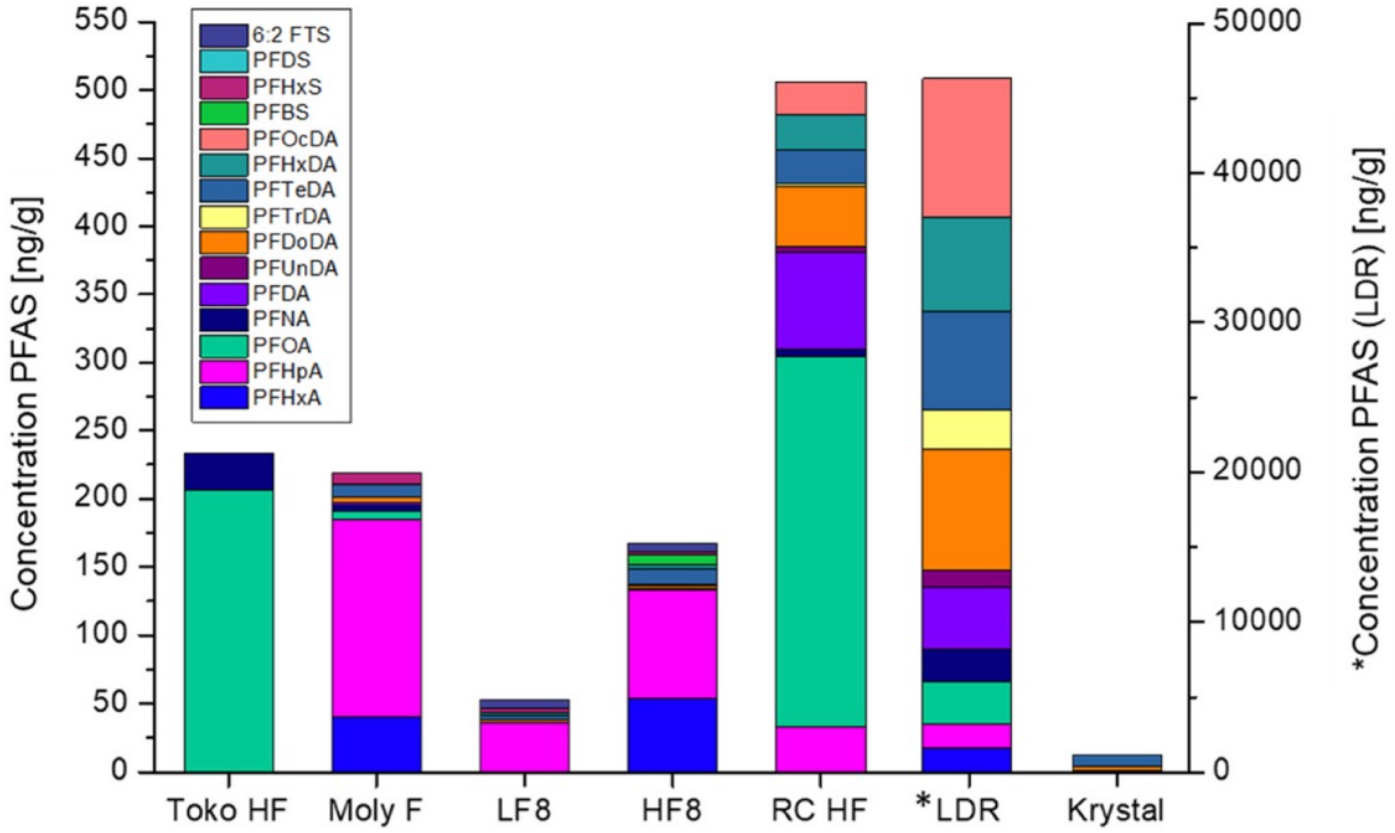
PFAS in Ski Waxes (1)



- Waxes purchased in Norway (2019), analyzed for 26 PFAS
- Profile dominated by PFCAs
- Highest PFAS in powdered waxes

Fang et al. (2020) *Environmental Science: Processes & Impacts*

PFAS in Ski Waxes (2)



- Waxes purchased in Sweden (pre-2020) and Austria (2022), analyzed for 24 PFAS
- Consistent with previous studies

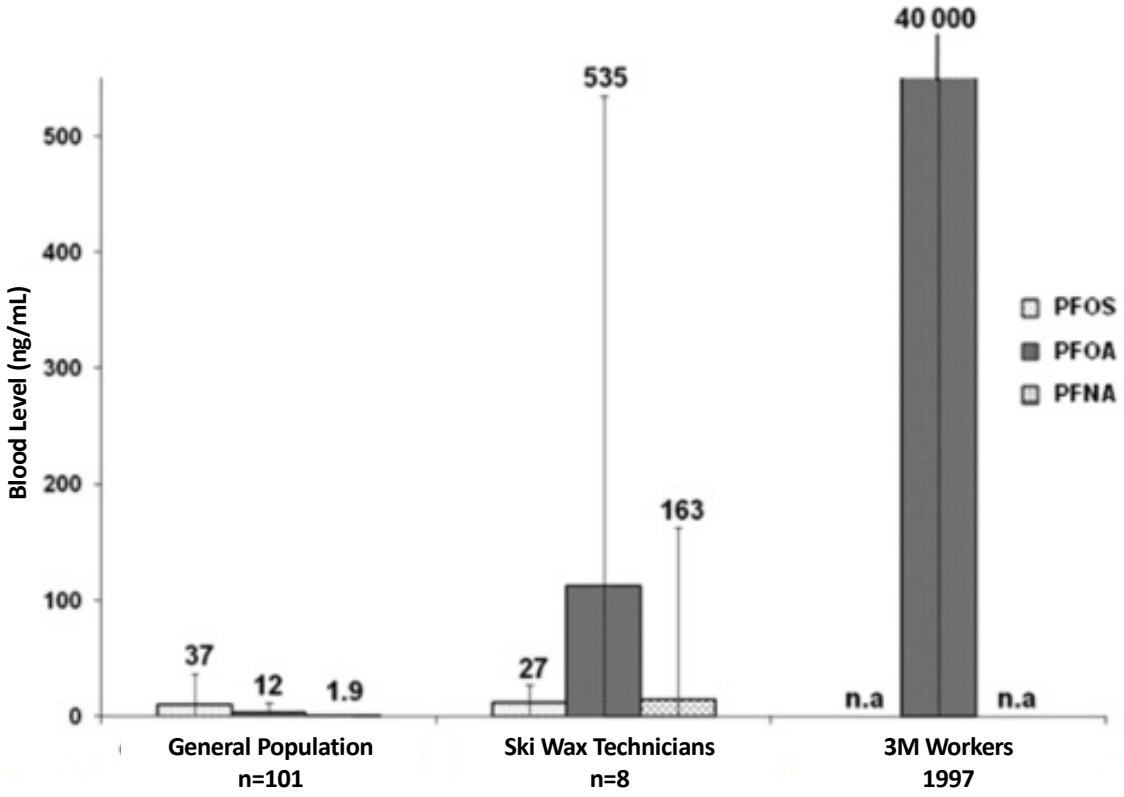
Gonzalez de Vega et al. (2024) *Analytica Chimica Acta*

PFAS Release to the Environment from Wax

- PFAS detected in environmental media around ski venues (Grønnestad et al., 2019; Carlson & Tupper, 2020; Wang et al., 2021)
- Concentrations in snow highest at start (Carlson & Tupper, 2020)
- Dominated by carboxylic acids (Grønnestad et al., 2019; Carlson & Tupper, 2020; Wang et al., 2021)
- PFAS bioaccumulate in wildlife near ski race venues (Grønnestad et al., 2019)

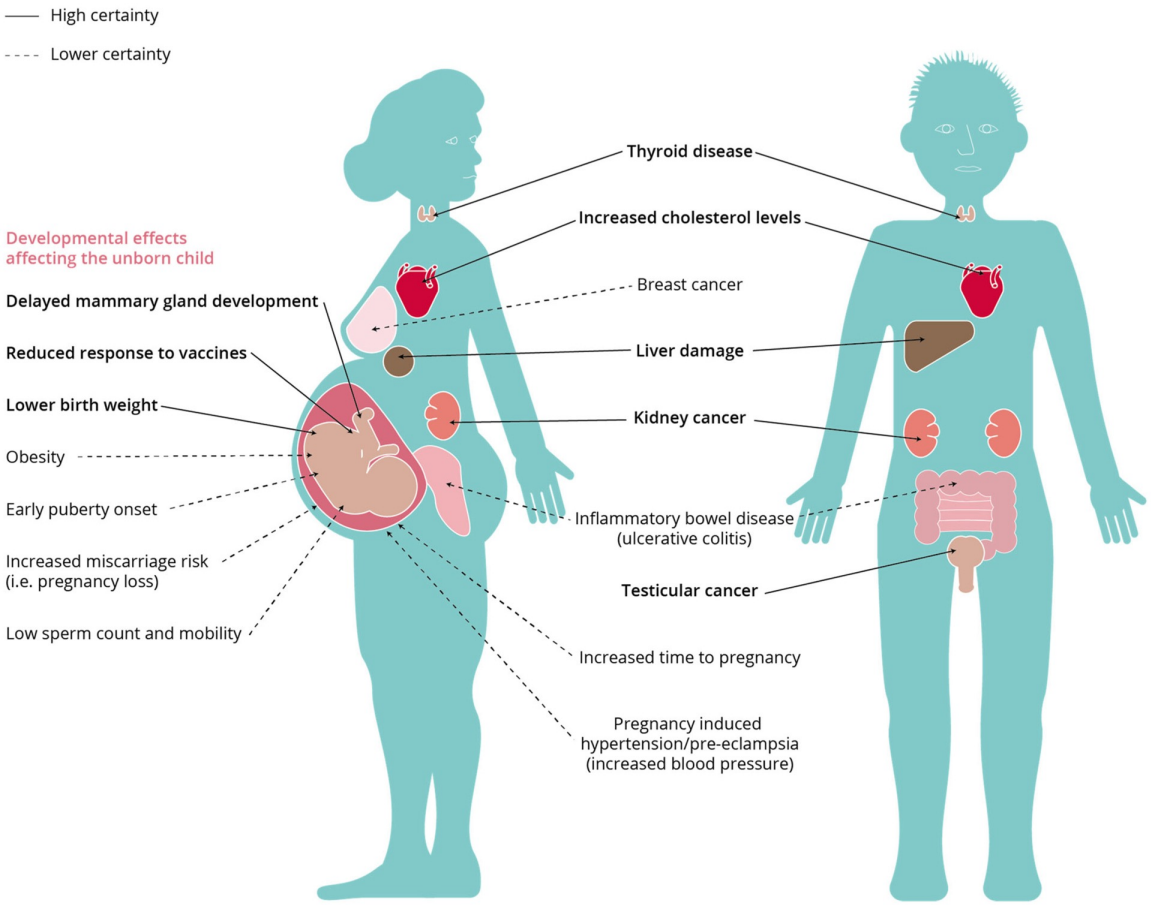
Human Exposure to PFAS from Wax

- Limited evaluation of occupational PFAS exposure from ski wax (e.g., Nilsson et al., 2010 and 2013; Freberg et al., 2010 and 2013)
- Documented high exposures, acute health effects
- Wax professionals' blood PFAS concentrations within range of 3M workers



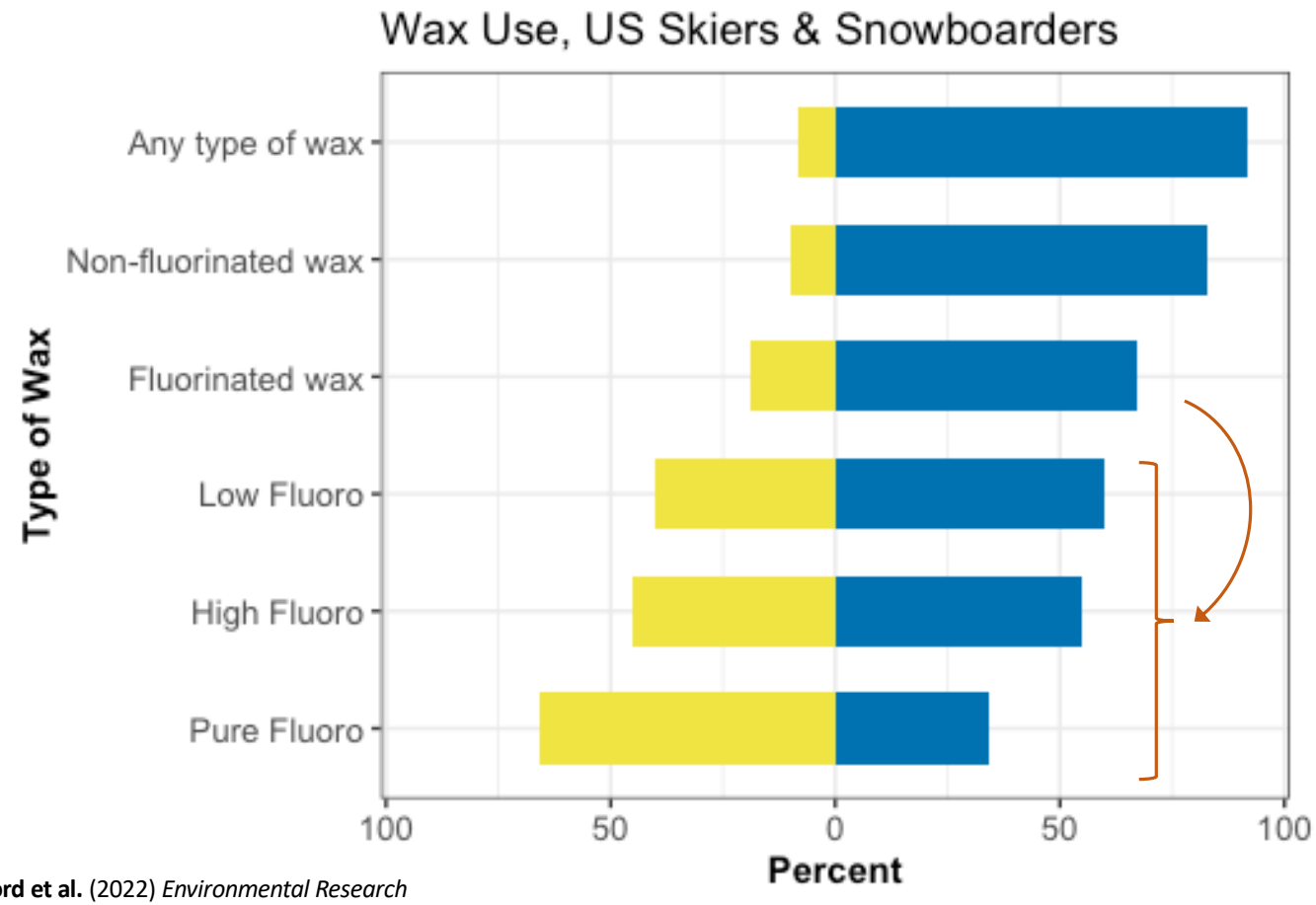
Nilsson et al. (2010) *Environmental Science & Technology*

PFAS: Adverse Health Effects



Fenton et al. (2021) *Environmental Toxicology Chemistry*

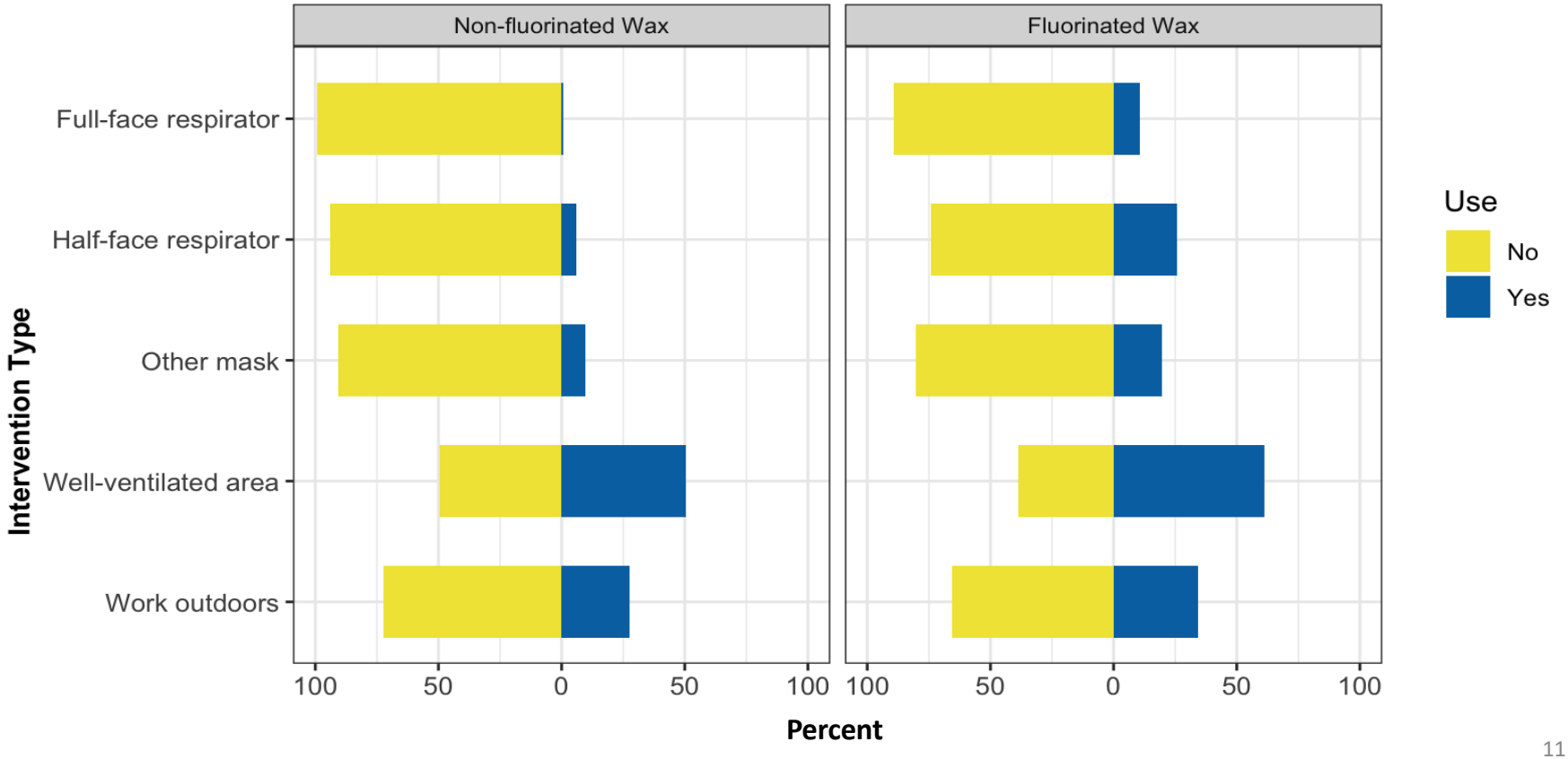
Wax Use Among US Skiers & Snowboarders



Key Finding: Most US skiers and snowboarders surveyed regularly apply fluorinated waxes.

Crawford et al. (2022) *Environmental Research*

Minimal Respiratory Exposure Intervention



Crawford et al. (2022) *Environmental Research*

Research Objectives

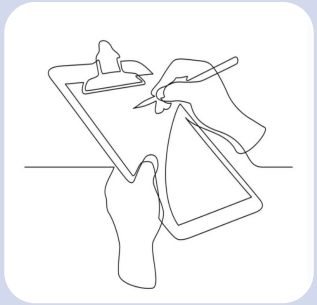
1. Quantify serum PFAS concentrations in active skiers in the US.

2. Evaluate associations between serum PFAS concentrations and symptoms commonly reported during wax application and other self-reported health conditions.

Study Methods

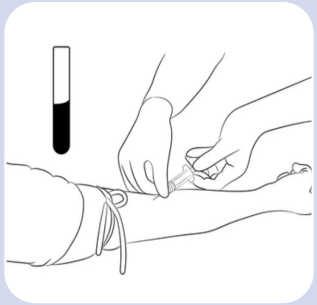
Recruitment

- Active, adult skiers and snowboarders
- Fluorinated wax exposure history
- Written, informed consent



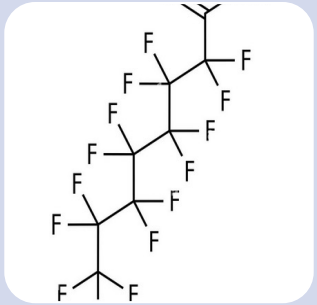
Questionnaire

- Waxing history
- Exposure reduction use
- Health history
- Socio-demographic characteristics



Blood Draw

- Standard phlebotomy
- Silicone-coated, non-additive vacutainers



Targeted PFAS Analysis

- 18 compounds
- NJ Department of Health
- Modified CDC Method No. 6304.09

Heath Biomarker Analysis

- Lipid, thyroid, and immune biomarkers
- Analyzed at Boston Children's Hospital

Pilot Study Participant Characteristics (n=30)

Age	21 (19, 64) years
BMI	23 (20, 27) kg/m^2

53%

47%

30% some college
37% college graduate
13% postgraduate

Skis waxed in a typical year:

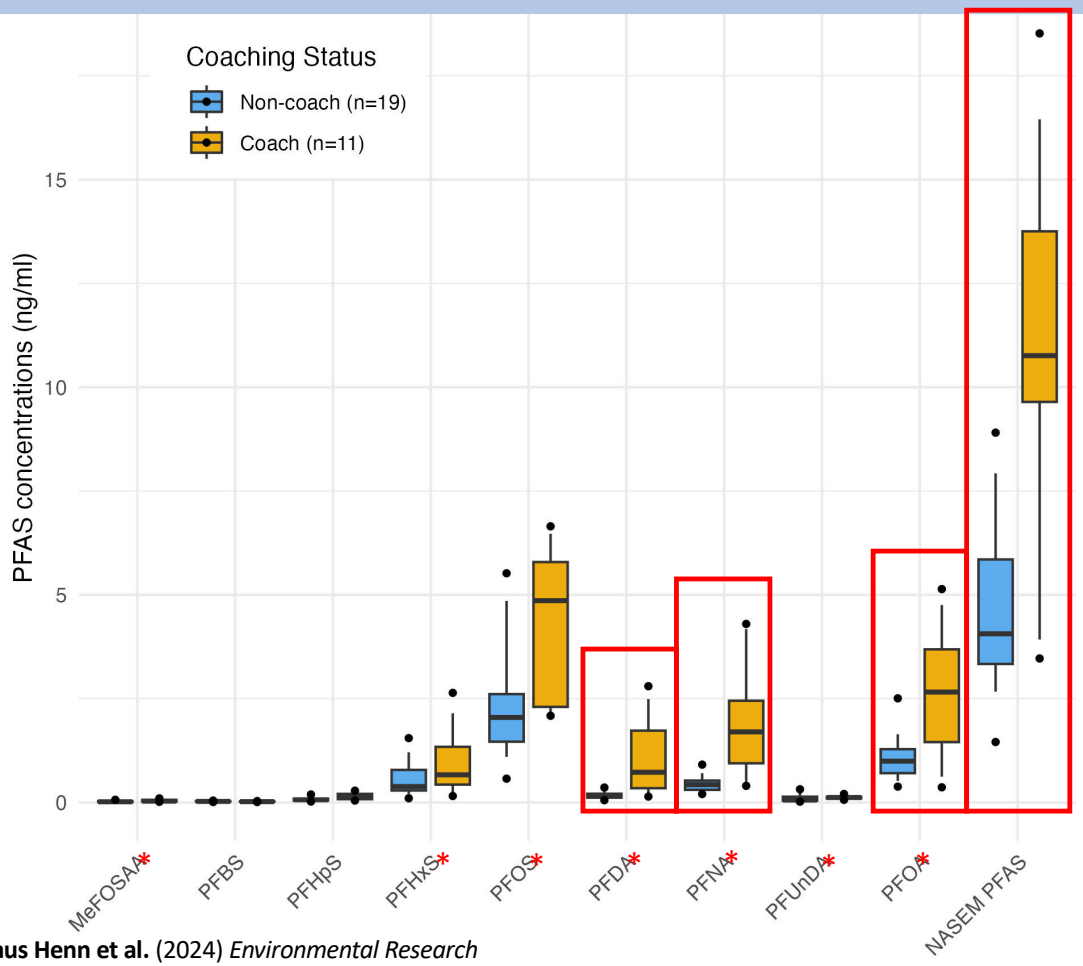
Pre-ban, fluoro	30 (0, 1530)
Post-ban	44 (1, 600)

Winter sport coach 37%

Use PPE half-face respirator 53%

Apply wax in well-ventilated area 73%

Serum PFAS Summary (ng/ml)



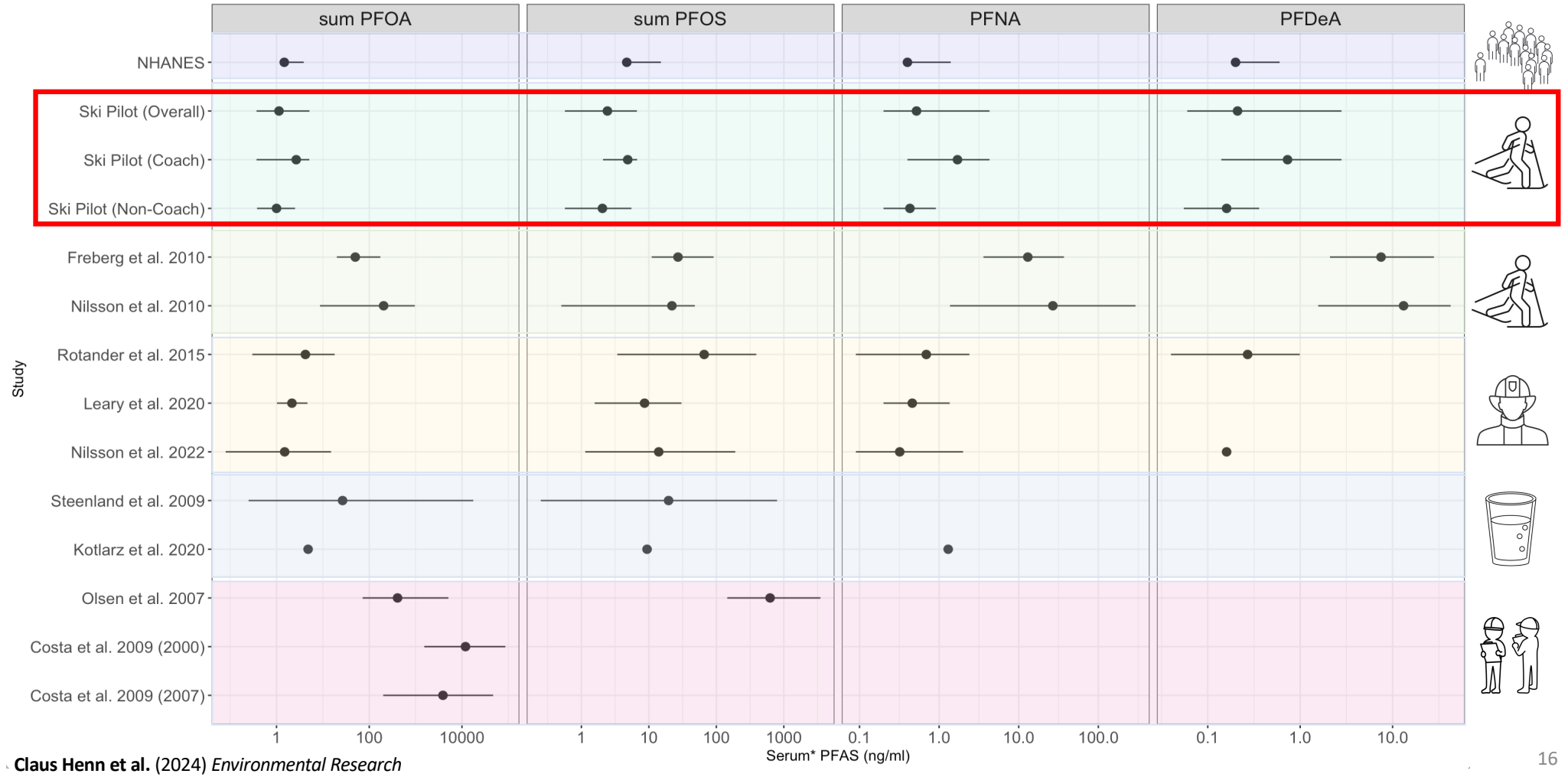
Claus Henn et al. (2024) *Environmental Research*

Key Points:

- 10 compounds detected in ≥60% of samples.
- PFDA, PFNA, PFOA, and NASEM Sum concentrations were positively associated with ski waxing intensity after adjusting for age and gender identity.

***Note:** The NASEM Sum was calculated from Me-PFOAS-AcOH, PFHxS, n-PFOS, Sm-PFOS, n-PFOA, Sb-PFOA, PFNA, PFDeA, and PFUnA in accordance with National Academies of Sciences, Engineering, and Medicine (NASEM)., 2022 https://doi.org/10.17226/26156

Population Comparison



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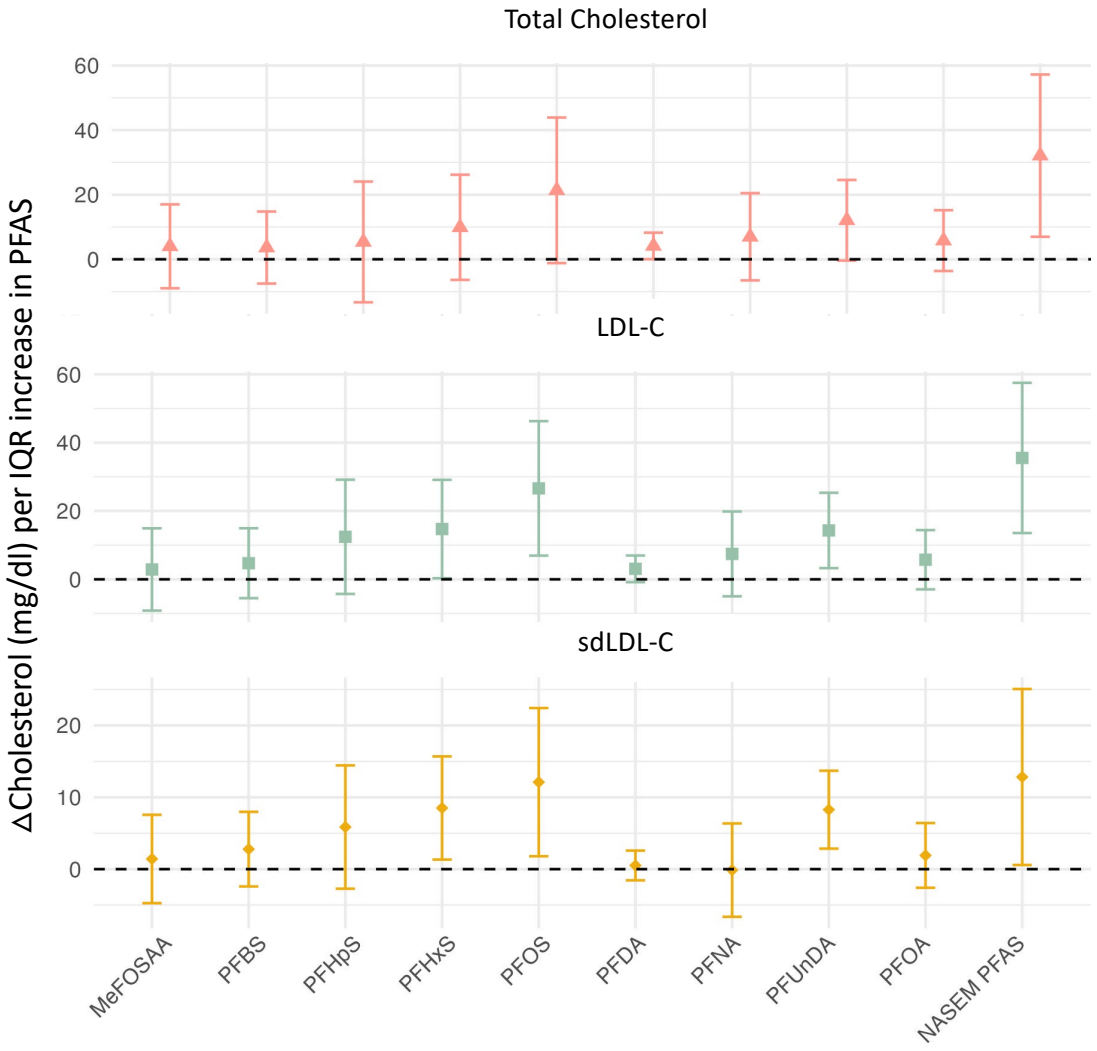
PFAS, Health Biomarkers



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Key Points:

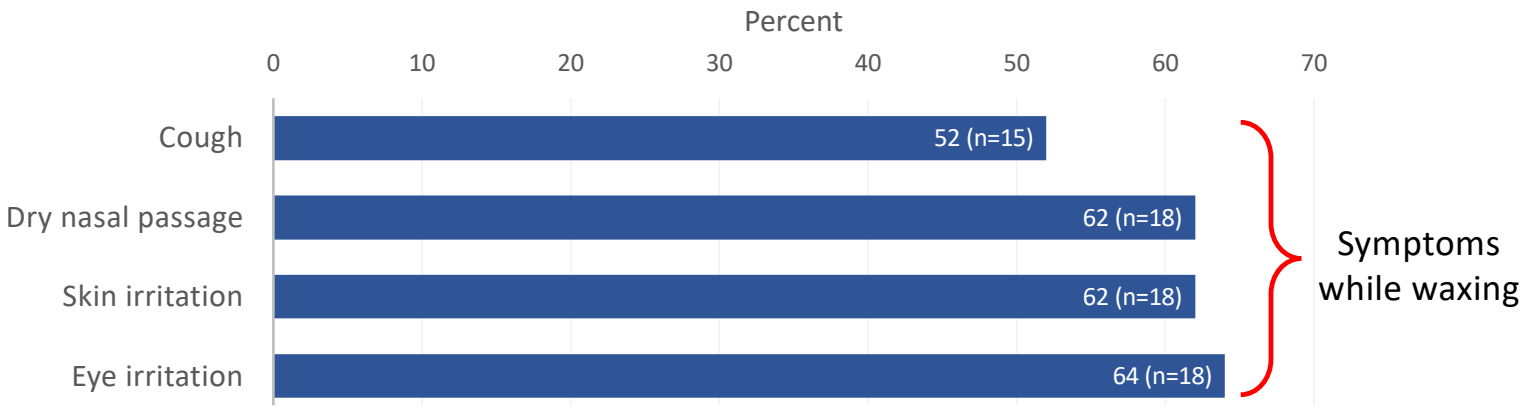
- ↑ associations with total, LDL, and sdLDL cholesterol, all PFAS.
- ↑ associated with self-reported high cholesterol, all PFAS.

Additional Points:

- Imprecise ↑ associations with TSH, most PFAS.
- ↑ associations with immunoglobulins, perfluoroalkane sulfonic acids (PFSAs).

Note: All models were adjusted for age and gender identity

Self-Reported Health Conditions



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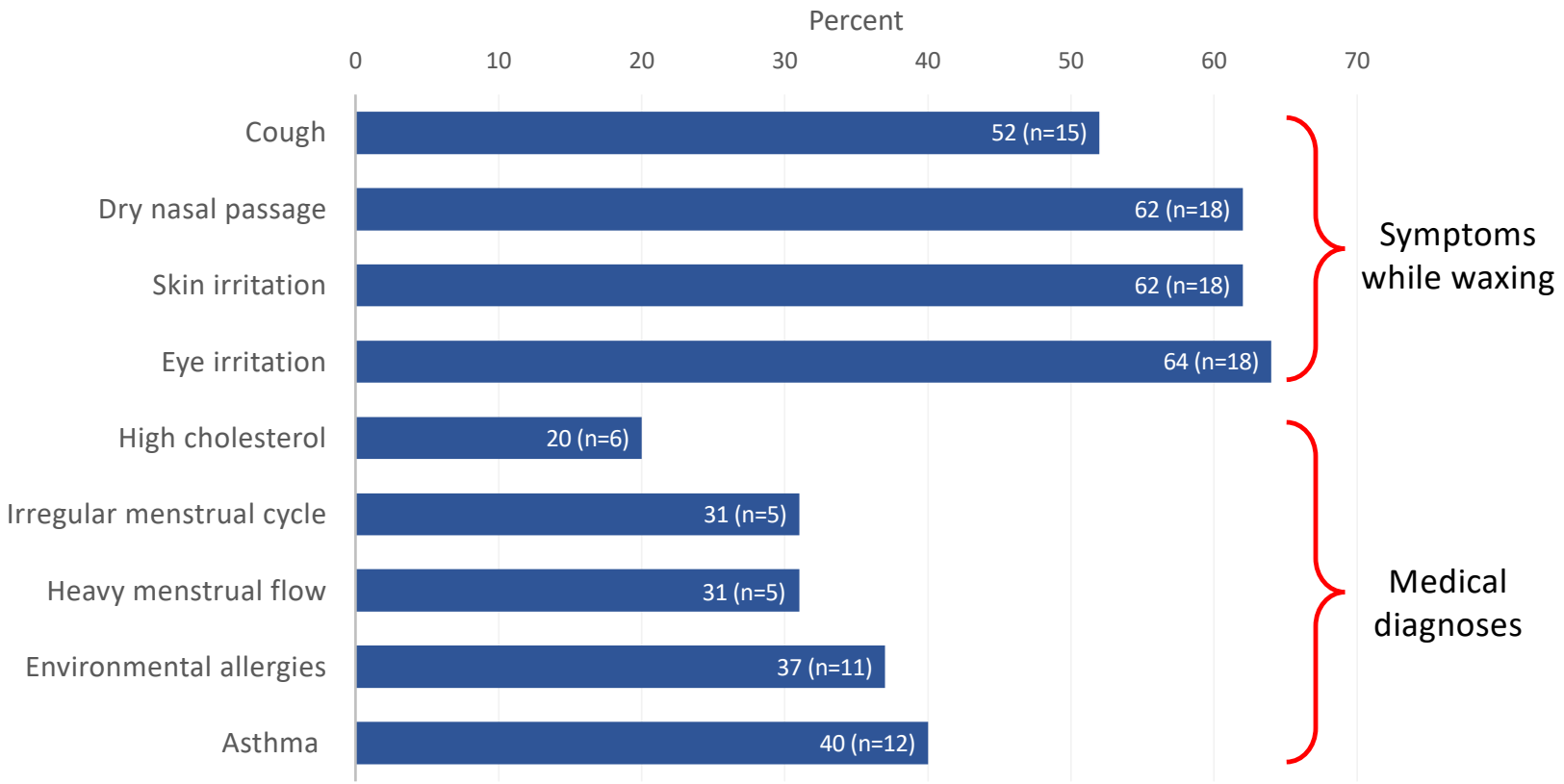
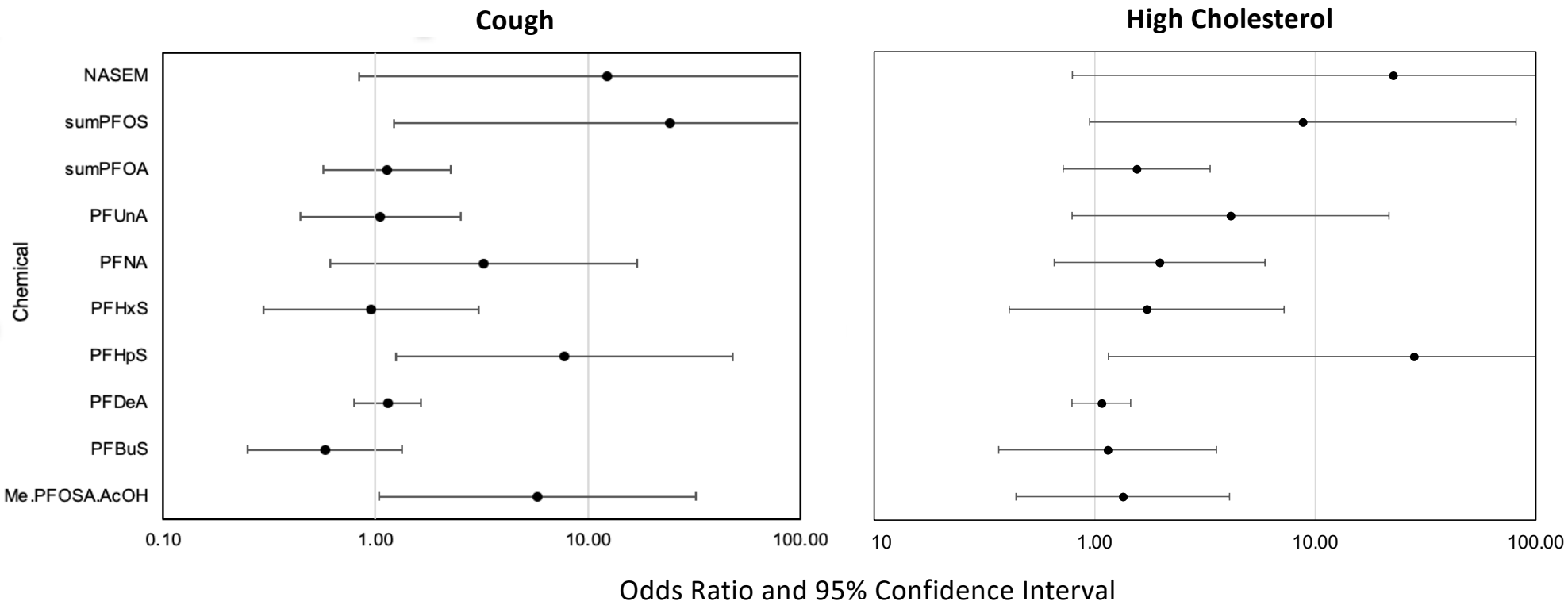
Self-Reported Health Conditions



PFAS, Self-Reported Health Conditions



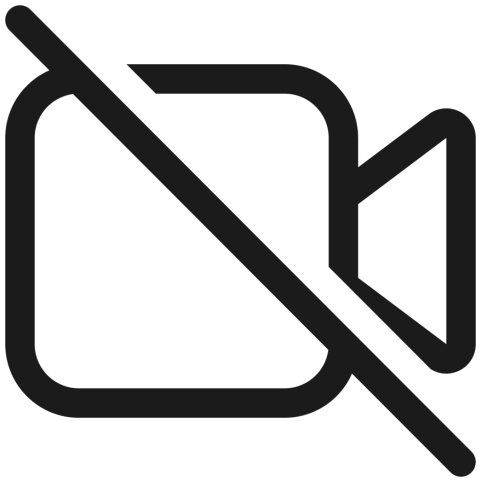
Claus Henn et al. (2024) *Environmental Research*

Note: All models adjusted for age and gender identity

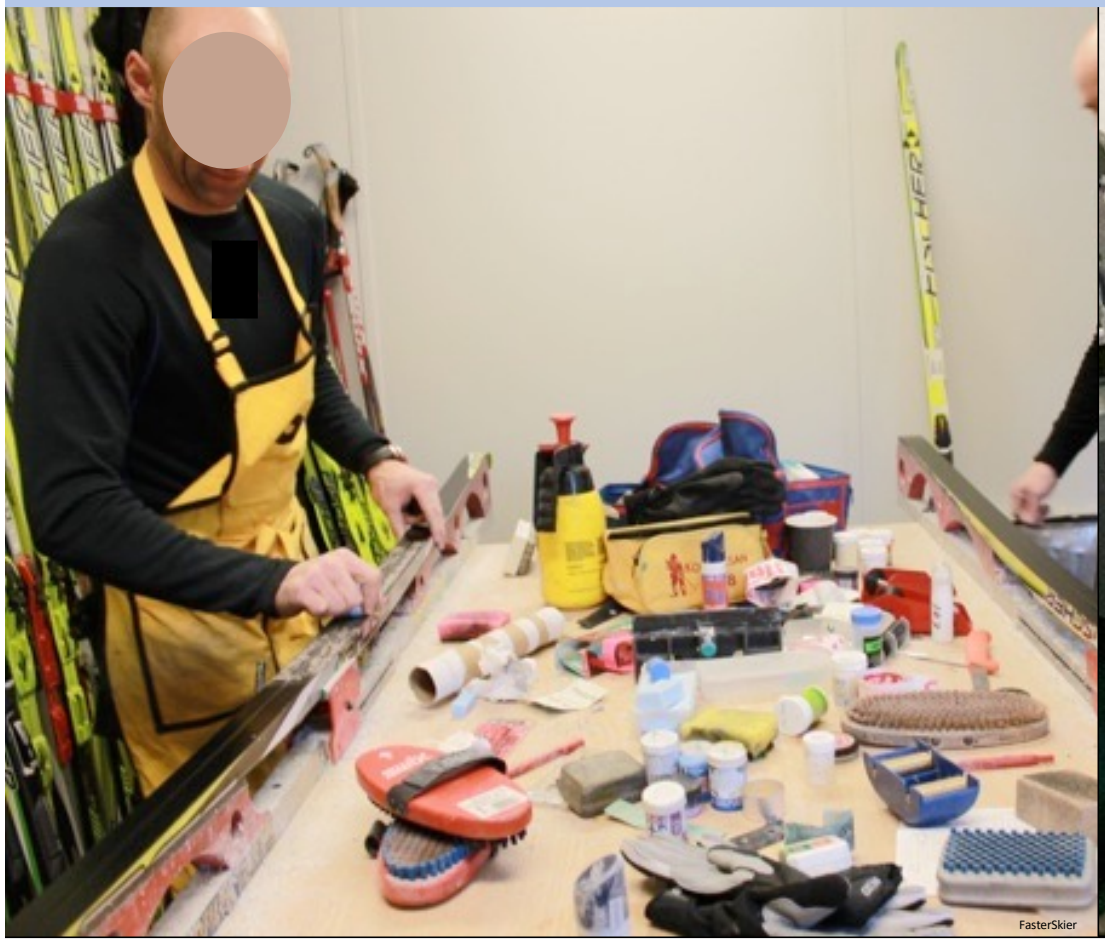
Check-In Question

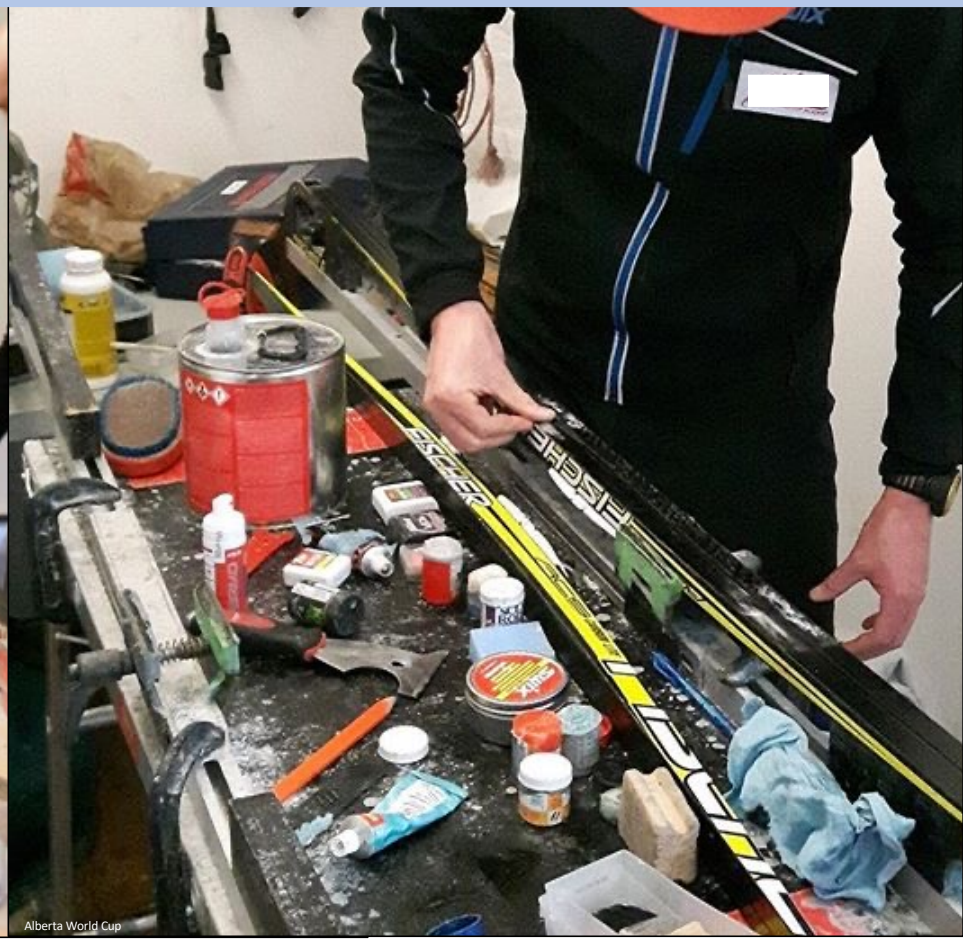
Which of the following health outcomes was associated with PFAS exposure among skiers in *this* study?

a) Vaccine efficacy
b) Bone fracture
c) Stroke
d) Cholesterol level
e) Height



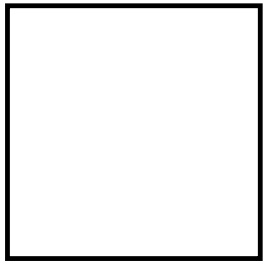
Inside A Wax Room





Wax Room Dust Collection

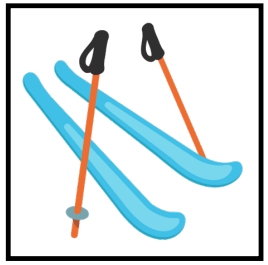
1. Clean ski wax bench with ethanol



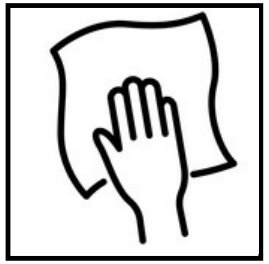
2. Delineate 25 cm^2 area on wax bench

3. Clean 25 cm^2 area on wax bench

4. Collect pre-workday dust sample



5. Wax skis as usual over the course of a workday

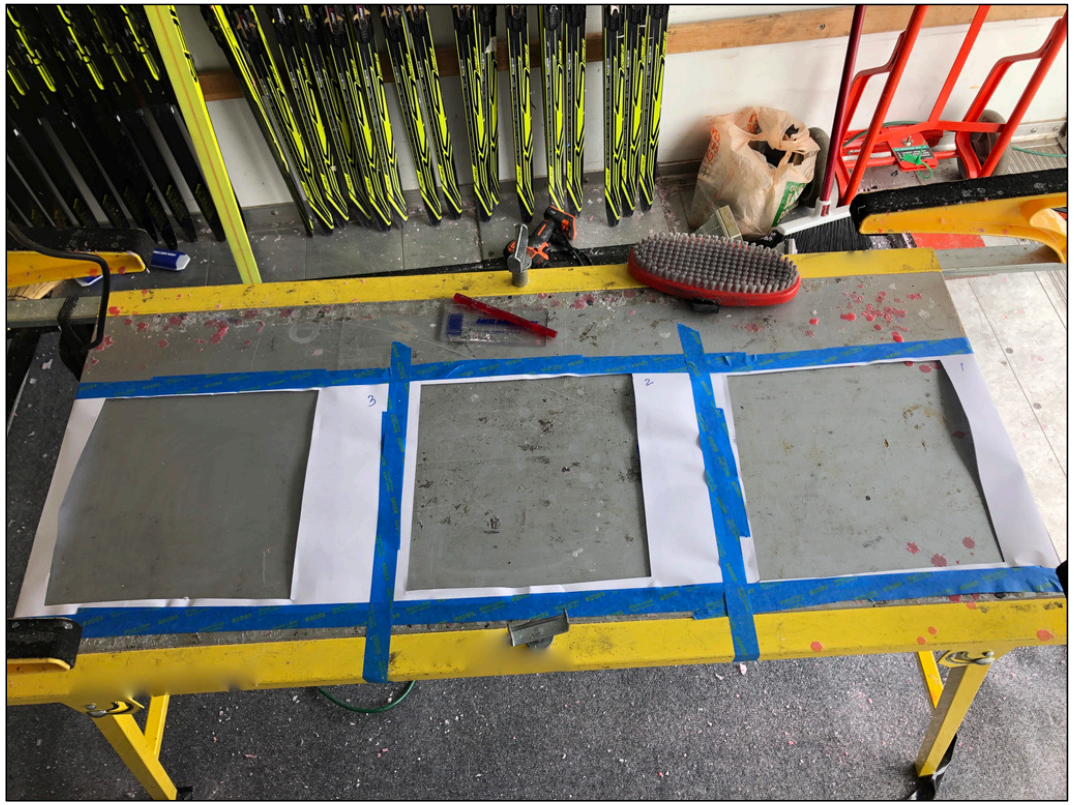


6. Collect post-workday dust sample

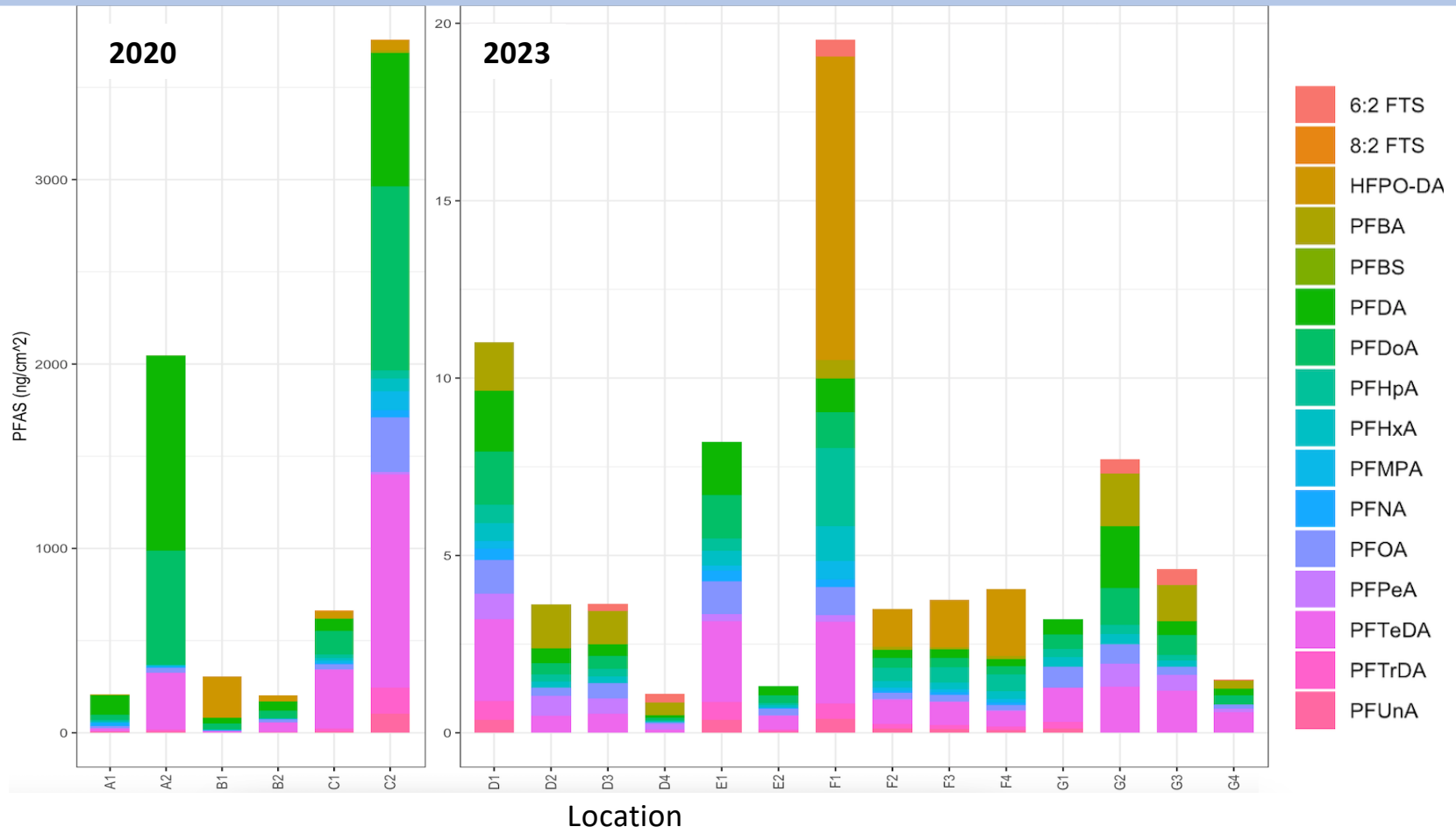
Dust wipes were collected before and after wax application to assess dust accumulation during a workday (reporting difference)

- n=6, March 2020
- n=14, March 2023

PFAS in Wax Room Dust



PFAS in Dust Wipe Samples (ng/cm^2)



Summary

- Engaged participants for epidemiologic study
- Skiers in our pilot study have relatively high intensity, frequency, and duration of waxing-related exposures, including PFAS
- Serum PFAS concentrations are comparable to NHANES in our overall study but are generally elevated among coaches
- Serum PFNA and PFDeA are more elevated among coaches
- Self-reported symptoms and diagnoses tend to be positively associated with serum PFAS, though high imprecision due to small sample size
- PFAS accumulate in waxroom dust during a workday, significant reduction post-fluoro wax bans

Acknowledgements & Questions

- **Study Participants**

- **Collaborators**
  - **Birgit Claus Henn, Boston University School of Public Health**
  - **Emily Leonard, Boston University School of Public Health**
  - **Brett Doherty, Consultant**
  - **New Jersey Department of Health**
  - **Adam Ptolemy, Boston Children's Hospital**
  - **Shaké Ayanian, Boston Children's Hospital**
  - **Sam Byrne, Middlebury College**

- **Student Researchers**
  - **Nicola Hartmann '23.5, Emilia Andersen '22, Celeste Alden '25, Divya Gudur '21**