Increased Human Exposure to Quaternary Ammonium Compounds during the COVID-19 Pandemic

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Disinfecting during the pandemic

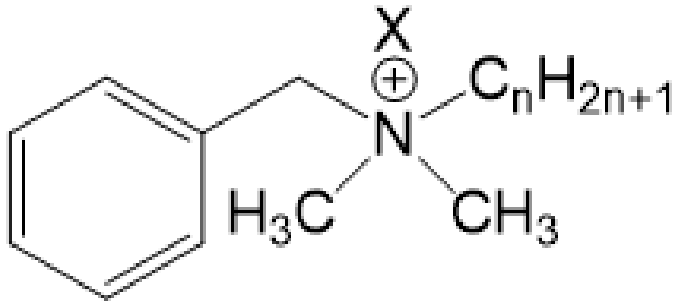
C&EN
Penn Medicine
National Guard

Quaternary ammonium compounds (QACs)

- U.S. EPA ***List N*** has 430 products listed effective for SARS-CoV-2
- QACs are active ingredients in ~200 products
- Cationic surfactants, used in cleaning products, biocides, personal care, medical and pharmaceutical products, textiles.

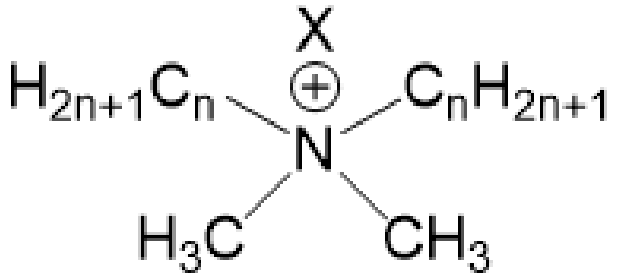
Three major QAC groups

X: chloride or bromide



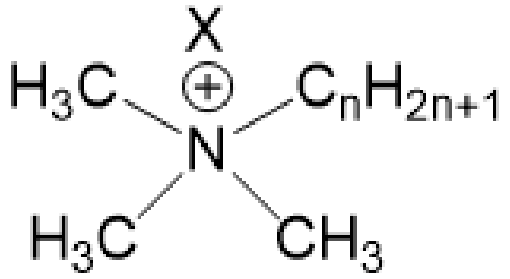
n=6, 8, 10, 12, 14, 16, 18

Benzylalkyldimethyl ammonium compounds (BACs)



n=8, 10, 12, 14, 16, 18

Dialkyldimethyl ammonium compounds (DDACs)



n=8, 10, 12, 14, 16, 18

Alkyltrimethyl ammonium compounds (ATMACs)

X = chloride or bromide

Environmental occurrence and toxicity

- Detected in wastewater, sludge, surface waters, sediments, soils
- Birth defects, lipid metabolism, developmental toxicity, asthmagens
- Human exposure pathways and health effects are unknown.

Objectives

- Investigate the occurrence of 19 QACs in residential dust
- Compare the levels in dust collected before and during the outbreak of COVID-19
- Evaluate the effects of using disinfecting products and disinfection frequency on the levels of QACs in the indoor environment
- Zheng et. al, EST Letters, 2020

Study design

Sample collection (all near Bloomington, IN)

- Dust collected before the pandemic (2018-2019, n=21)
- Dust collected during the pandemic (June 2020, n = 40)
- Common disinfecting products (sprays and wipes, n = 7)
- Passive air samples (polyurethane foam, n = 3)

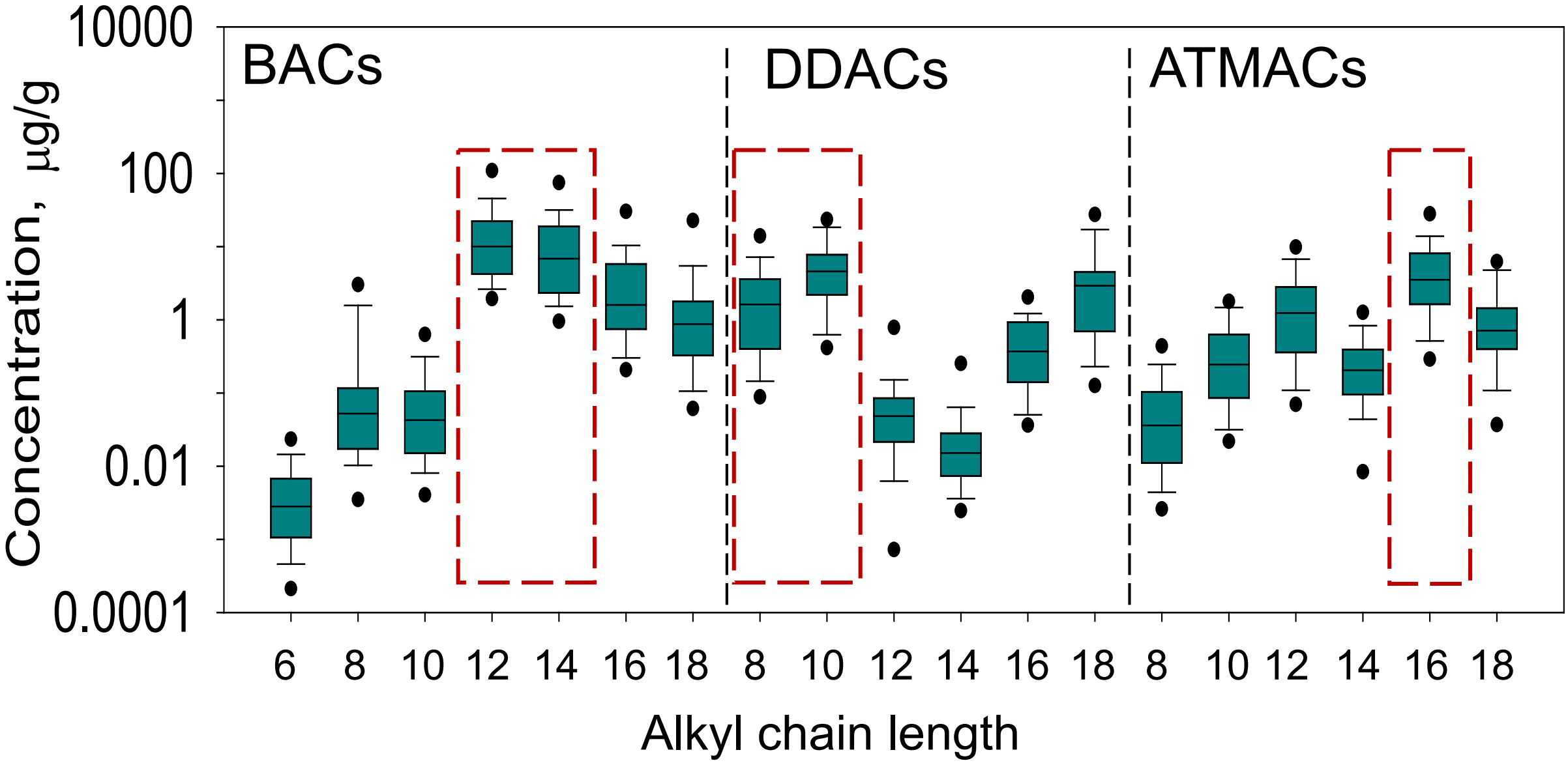
Survey information

- Products used in homes
- Disinfecting practices (before vs. during the pandemic)
- Disinfection frequency (during the pandemic)

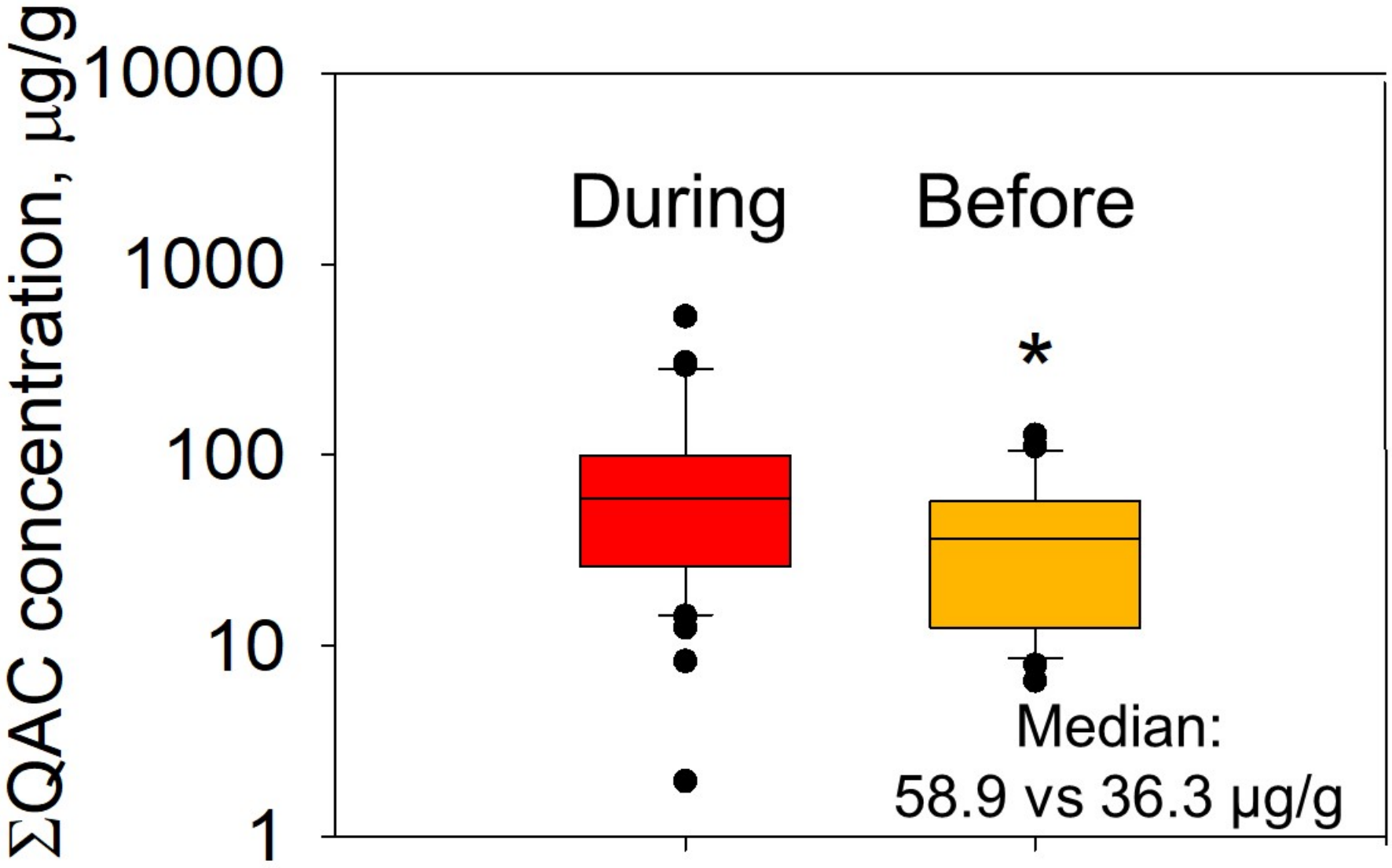
Dust analysis

- Sieved (500 μm mesh size) and ultrasonicated with acetonitrile
- Surrogate recoveries: 110±4 to 117±3%
- Method detection limits (MDLs): 0.1-2.5 ng/g
- Blanks: <0.1% sample levels
- Liquid chromatography tandem mass spectrometry
- Analyzed for C6-C18 BACs, C8-C18 DDACs, C8-C18 ATMACs (total of 19 QACs)

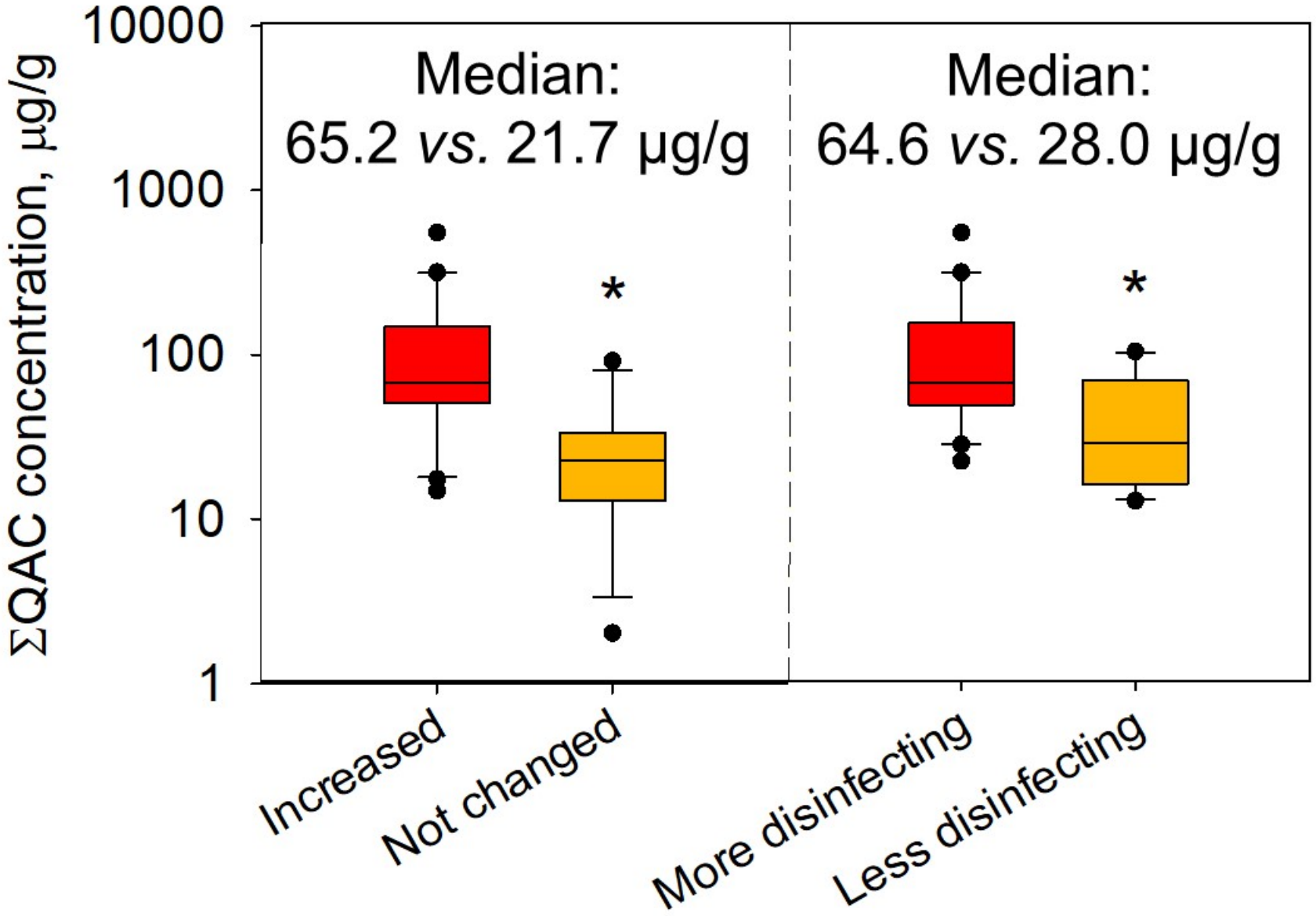
Dust concentrations



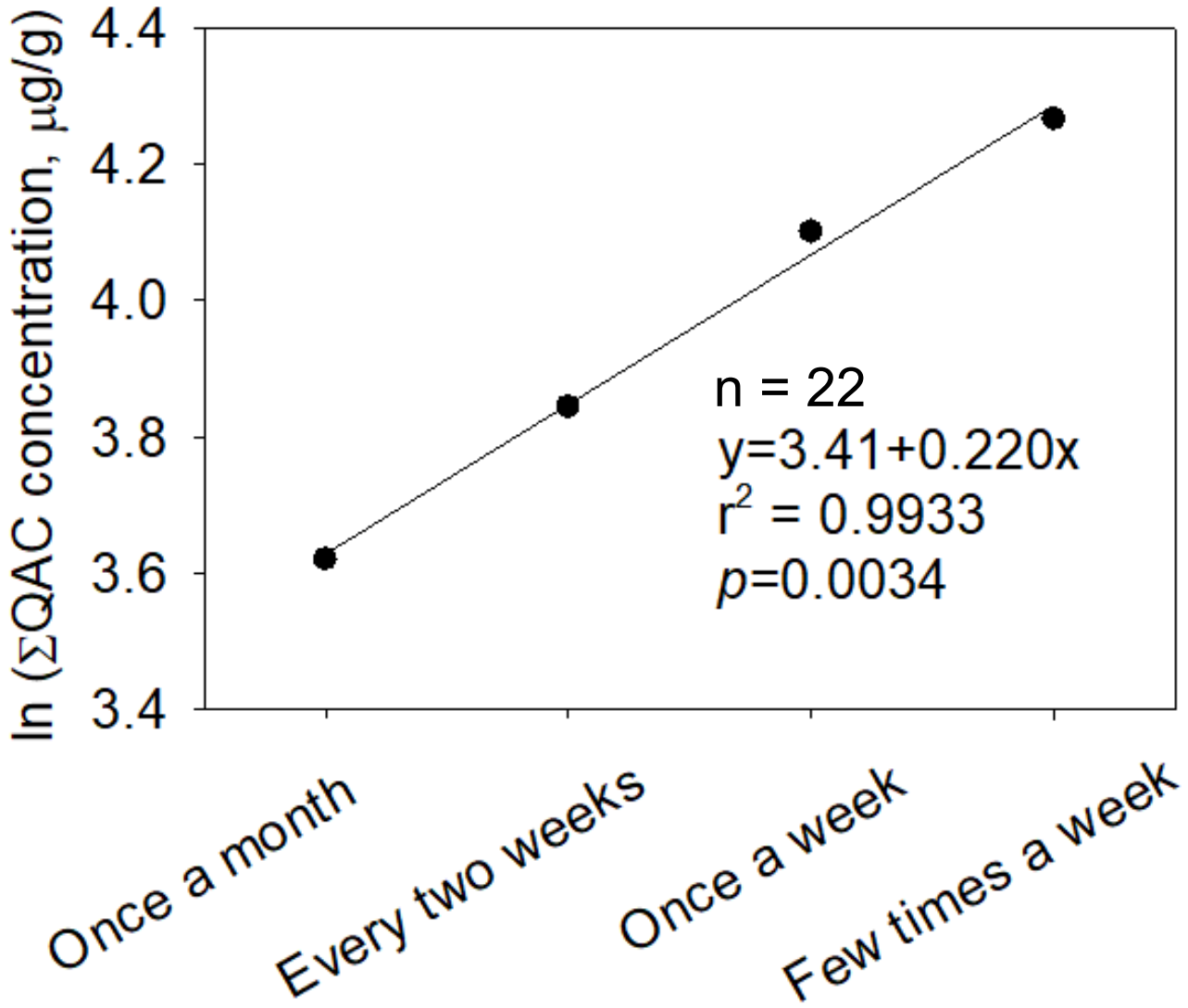
QAC levels are higher during the pandemic



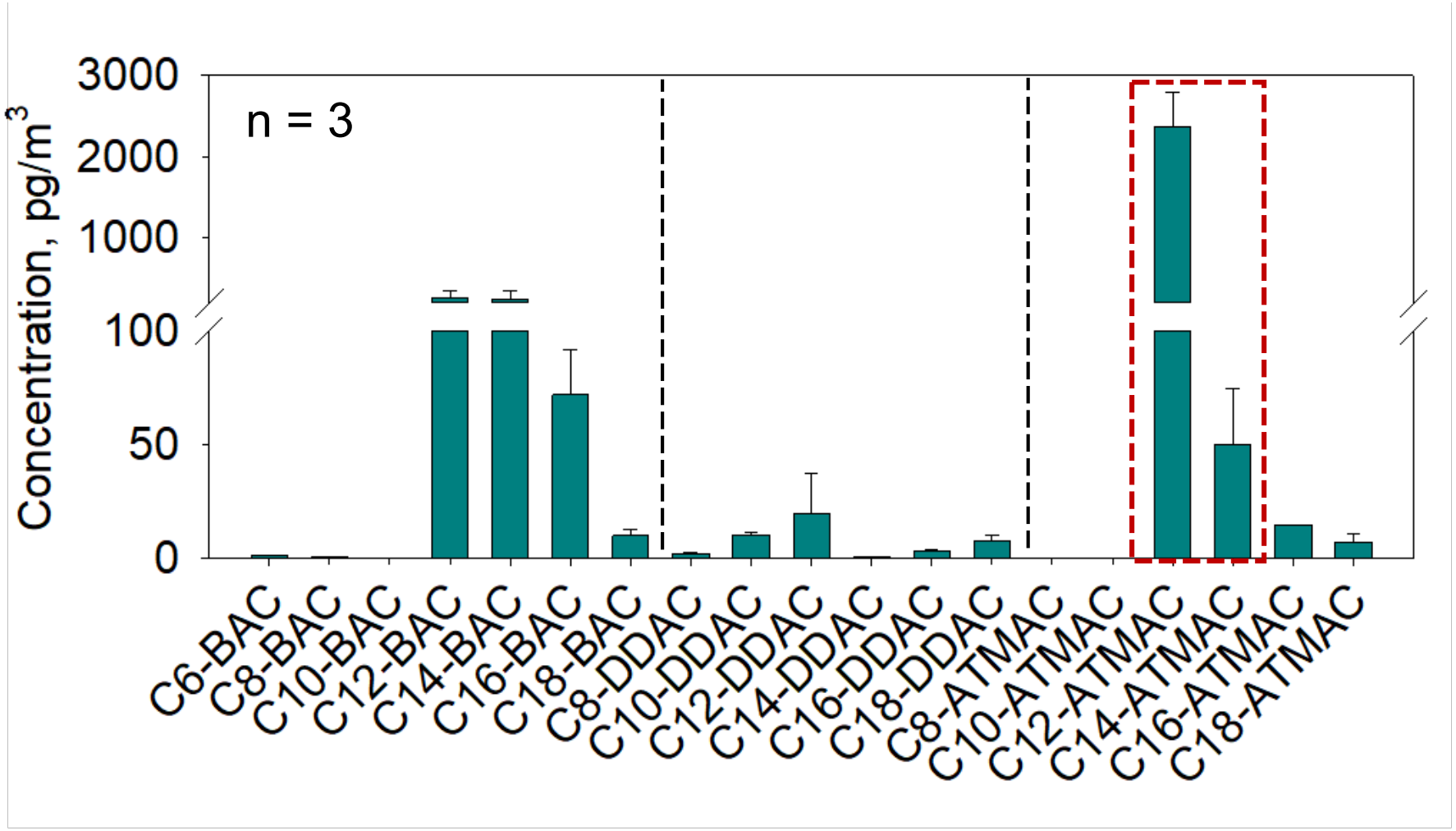
The effect of disinfecting practices



The effect of disinfecting practices

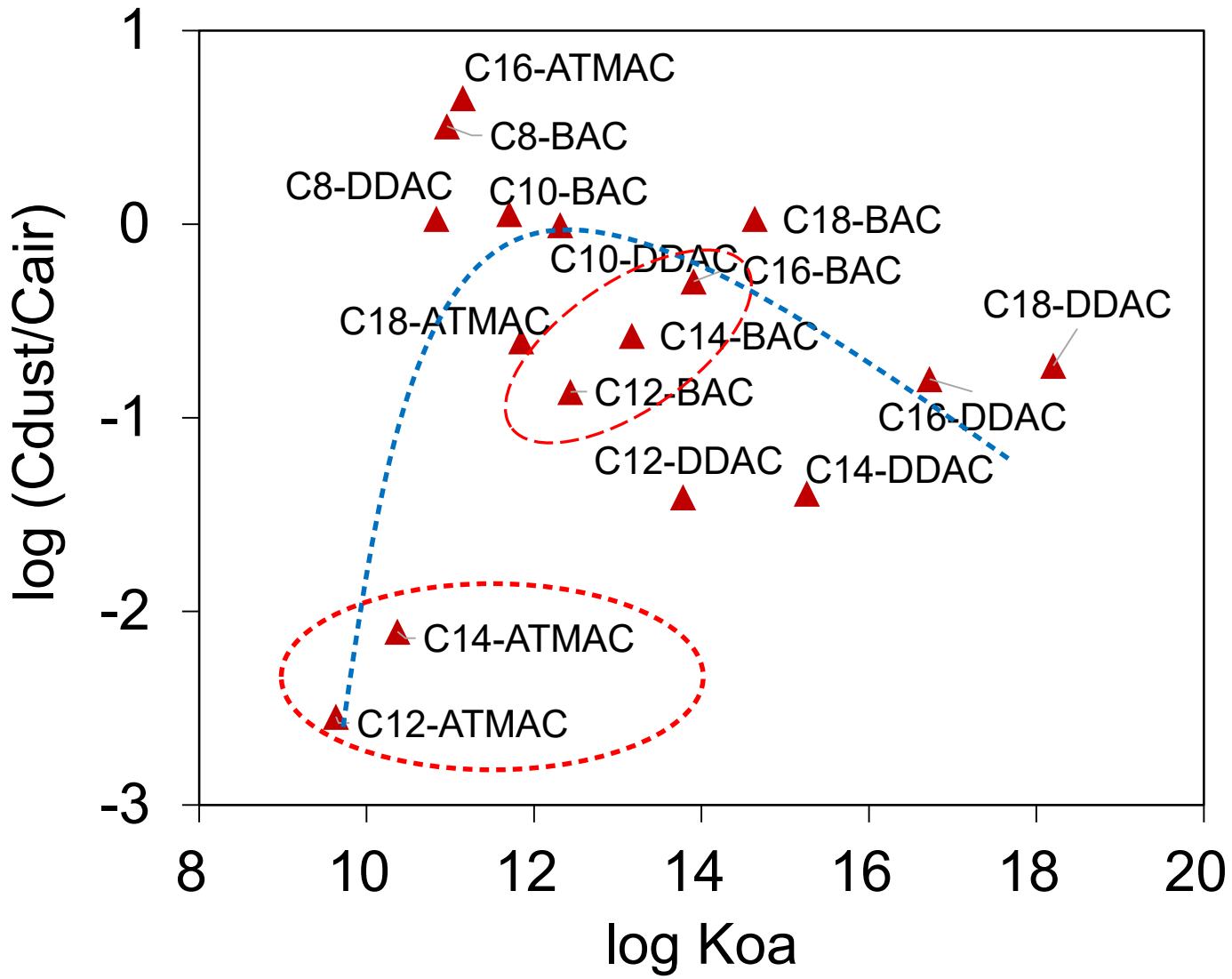


Air concentrations

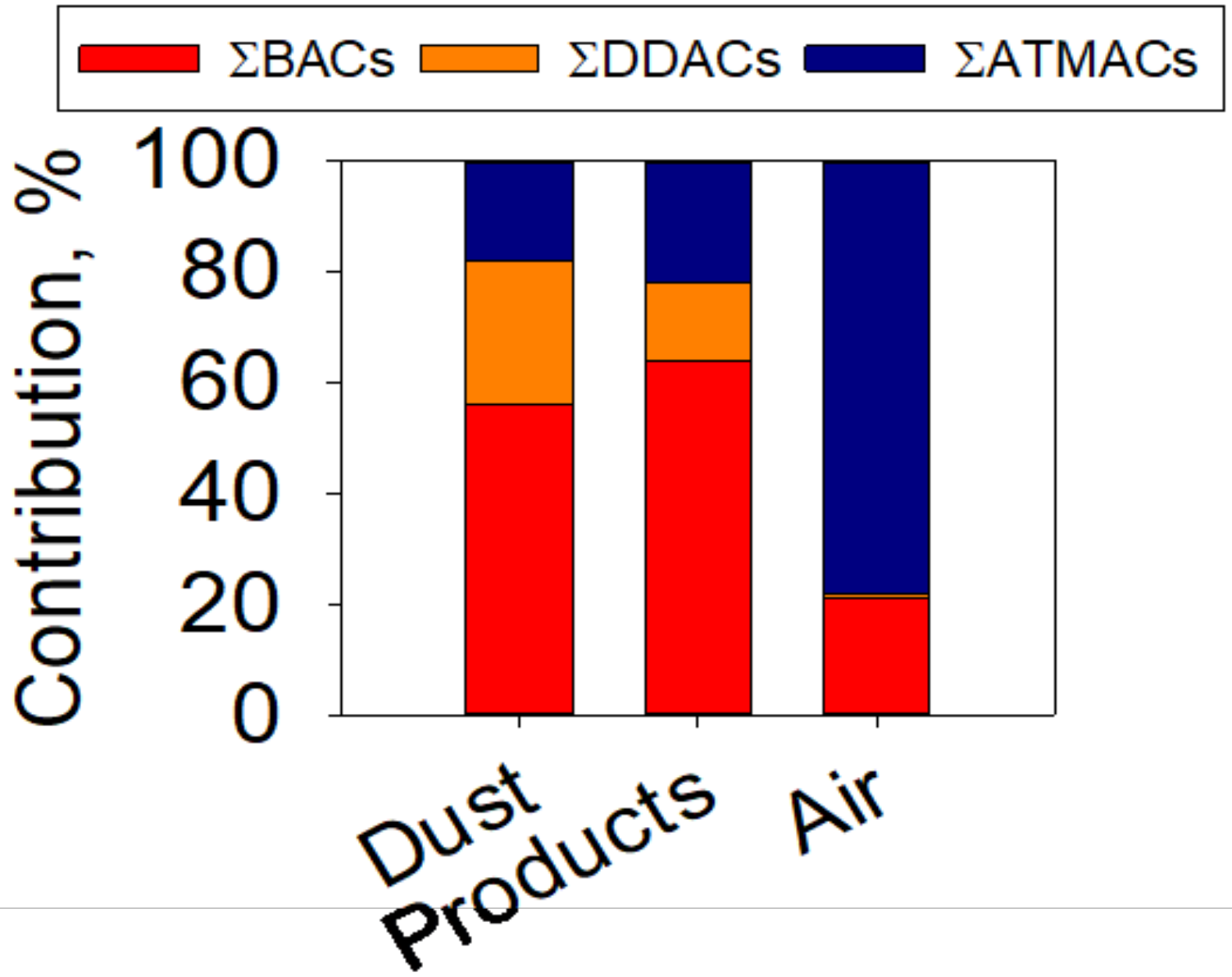


Mean ± SE ΣQAC concentration: 4000 ± 1420 pg/m^3

QAC air-dust partitioning



Disinfecting products as a significant indoor source



Conclusions

- The indoor exposure to QACs is widespread.
- QACs can be detected in air.
- QAC levels are significantly higher in dust collected during the pandemic.
- QAC levels are significantly higher in homes with higher disinfecting frequencies.
- Disinfecting products can be a significant source of QACs in house dust.

Biomonitoring of QACs

Sample collection

- Indiana University Biobank
- Blood collected before the pandemic (serum)

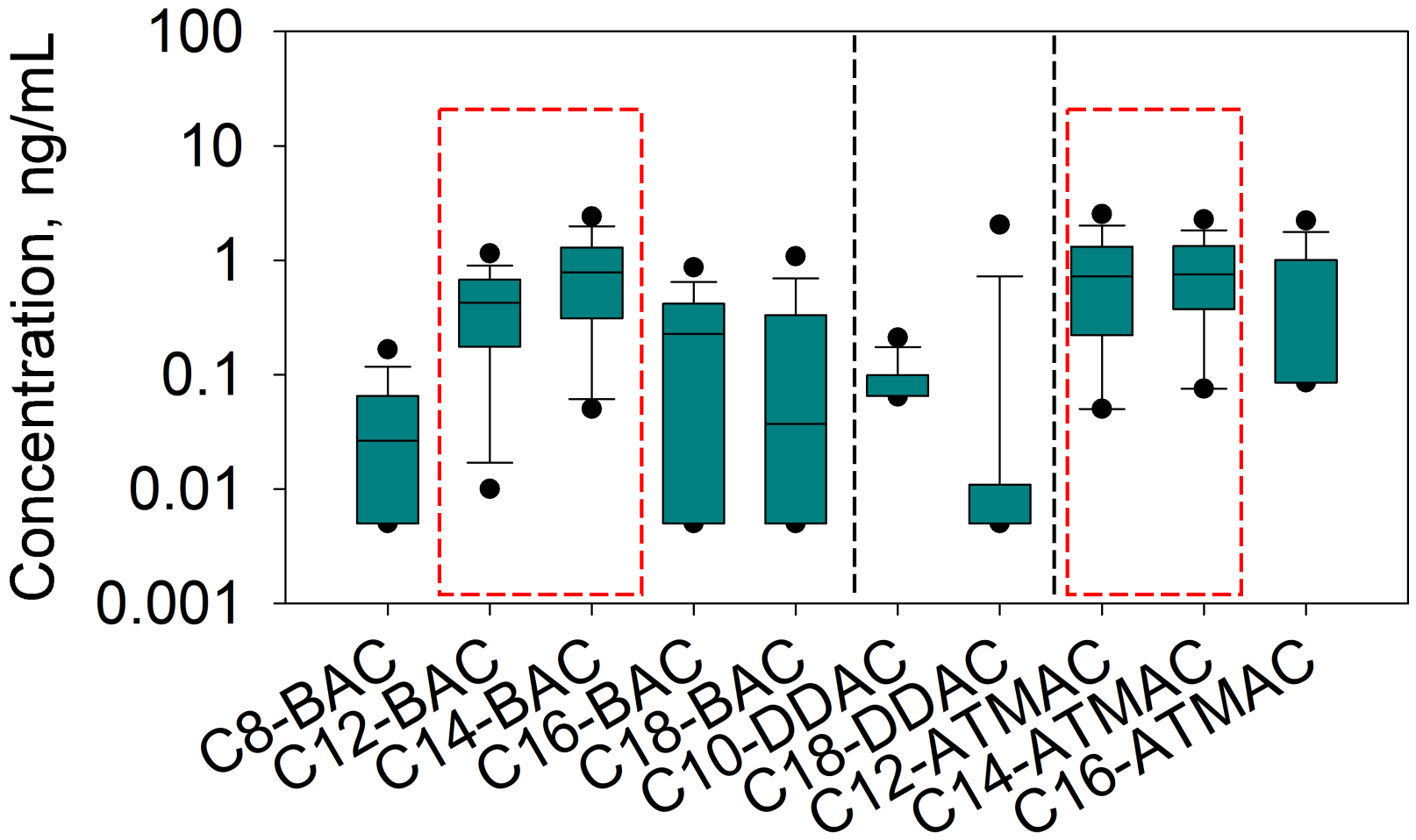
  February–August 2019, n = 111
- Blood collected during the pandemic (serum)

  April-August 2020, n = 111
- Participants matched on age, gender, race, smoking, BMI
- Approved by Indiana University IRB

Blood analysis

- Extracted with acetonitrile; WCX column clean-up
- Recoveries: 91±1.5 to 98±1.6%
- Blank levels: 0.08, 0.09, 0.25, 0.35 ng/mL for C12-BAC, C14-BAC, C12-ATMAC, C14-ATMAC, respectively.
- MDLs: 0.01–0.37 ng/mL
- All concentrations were blank-corrected by subtracting blank levels from sample levels.

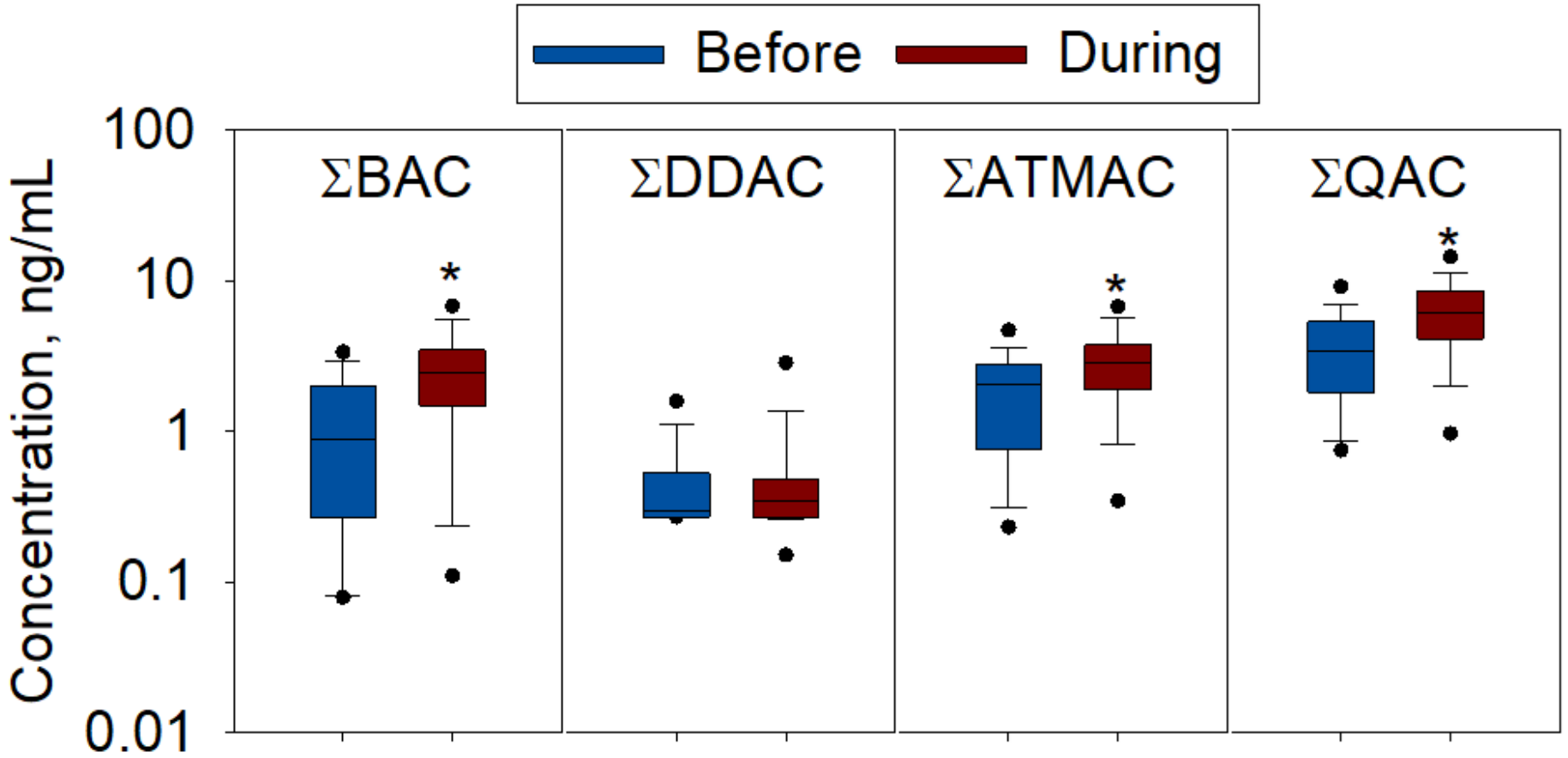
Blood concentrations



Detection frequencies > 40%

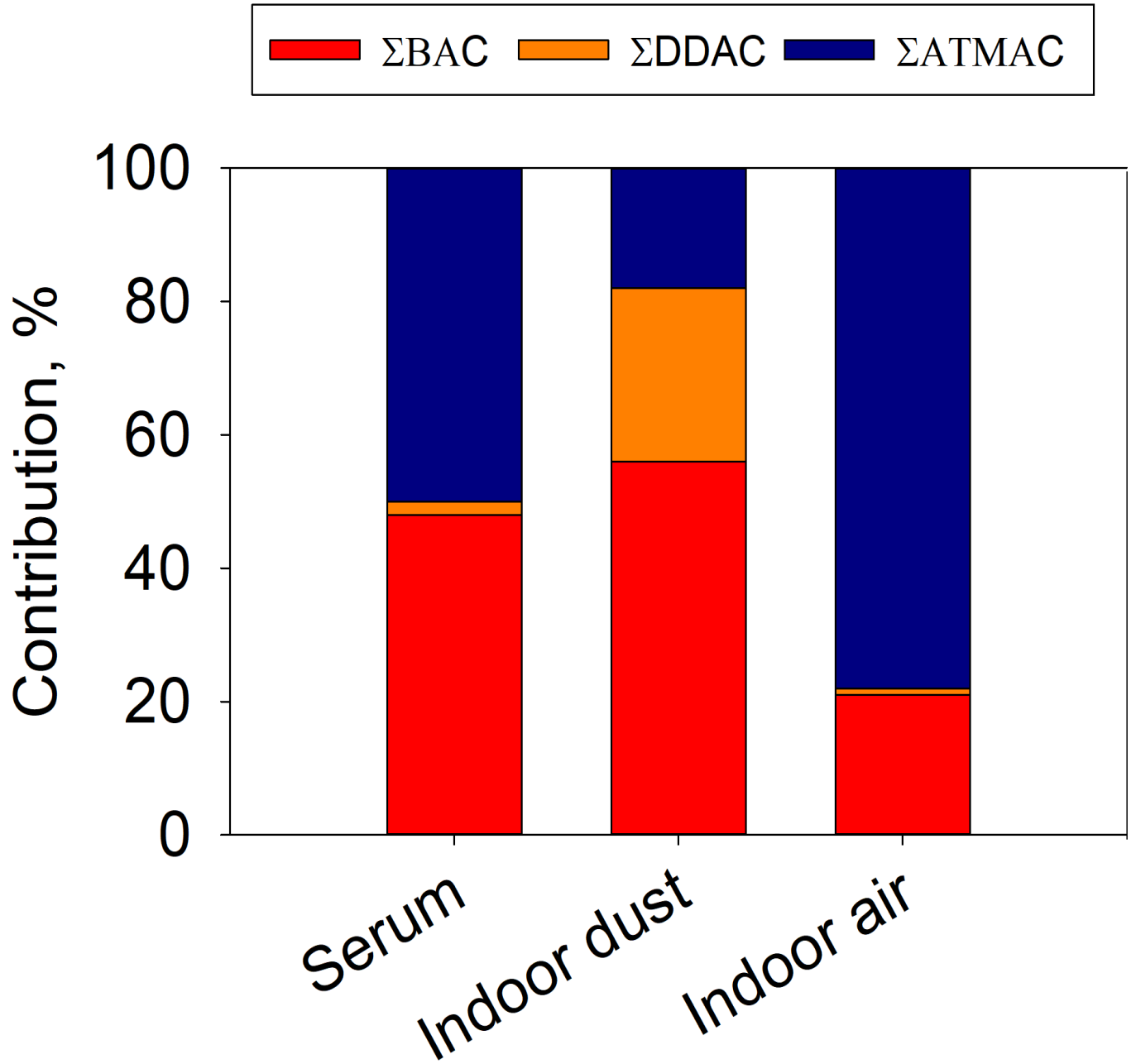
Zheng and Salamova, in prep.

QAC levels are higher in blood collected during the COVID-19 pandemic



- Serum levels during the COVID-19 pandemic are significantly higher (medians 3.41 *vs.* 6.04 ng/mL; increase of 77%)

QAC patterns in blood vs. air and dust



Limitations

- Limited sample size and geographic coverage.
- Pre- and post-pandemic dust and blood samples were not paired.
- Urine samples were not included and QAC metabolites could not be measured.

Acknowledgements

Collaborators:

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