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Improving exposure assessment in epidemiological studies

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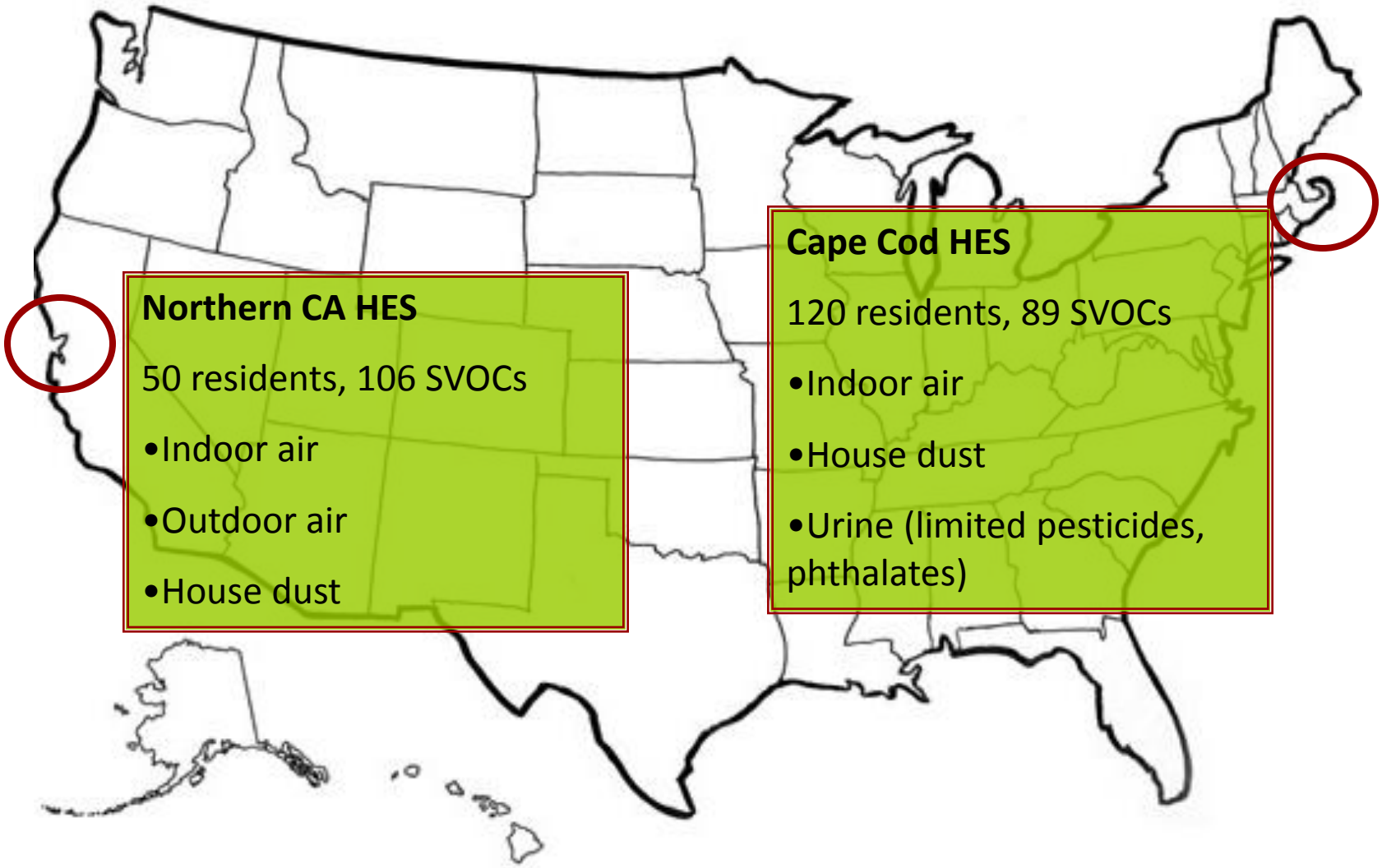
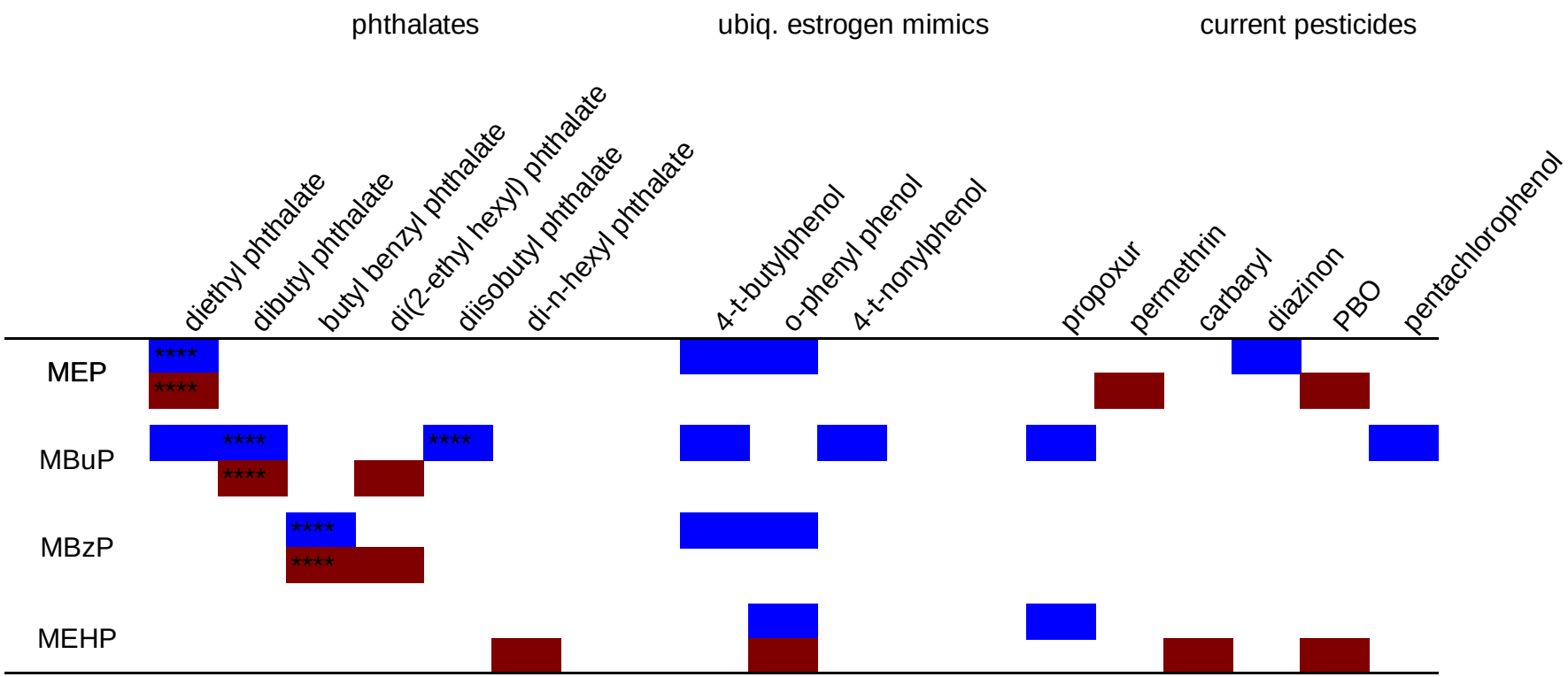
Silent Spring's Household Exposure Study



Rudel et al. 2003; Rudel et al. 2010; Dodson et al. 2015

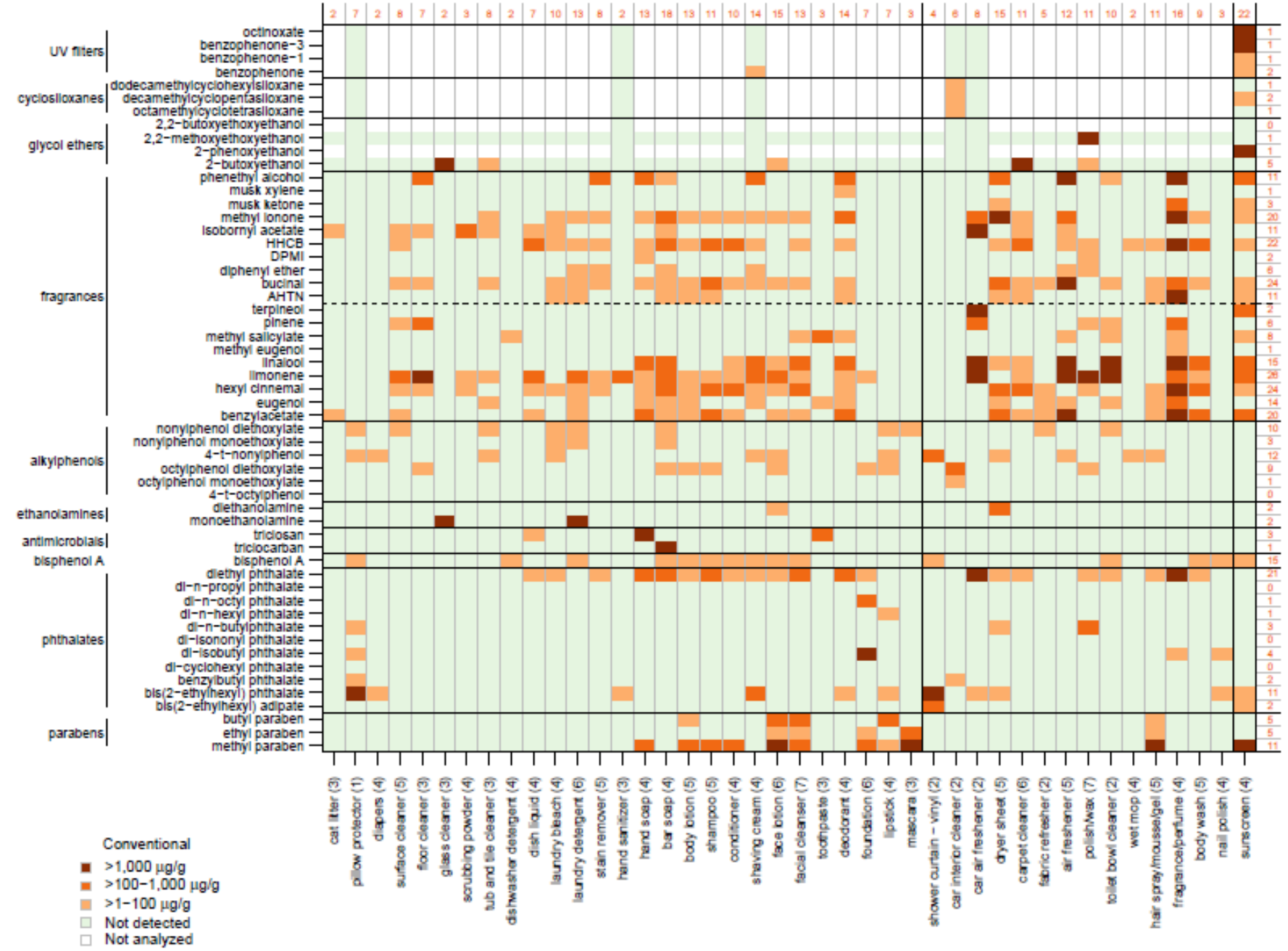
Chemical Class	Potential Sources	Example Chemical
Phthalates	Vinyl and other plastic, nail polish and other cosmetics	dibutyl phthalate
Alkylphenols	Detergents, plastic, pesticide formulations	nonylphenol
Flame retardants	Furniture foam or stuffing, carpets and drapes, electronic equipment (TVs, computers)	polybrominated diphenyl ether (PBDE 47)
Polycyclic aromatic hydrocarbons (PAHs)	Combustion sources such as fireplaces; stoves and heaters, cigarette smoke, outdoor air pollution and auto exhaust	benzo[*a*]pyrene
Polychlorinated biphenyls (PCBs)	Older electrical equipment, fish, pre-1978 building materials like caulk	PCB 52
Banned pesticides	Historical pesticide use in/near the home	DDT, dieldrin, chlordane
Current-use pesticides	Recent pesticide use in/near the home	chlopyrifos, permethrin
Other phenols and miscellaneous	Disinfectants, polycarbonate plastics, cosmetics	*o*-phenyl phenol, bisphenol A, parabens

Urinary phthalate correlations with air and dust



Included if significant at $p<0.05$

****indicates parent-metabolite pair



Dodson et al. 2012

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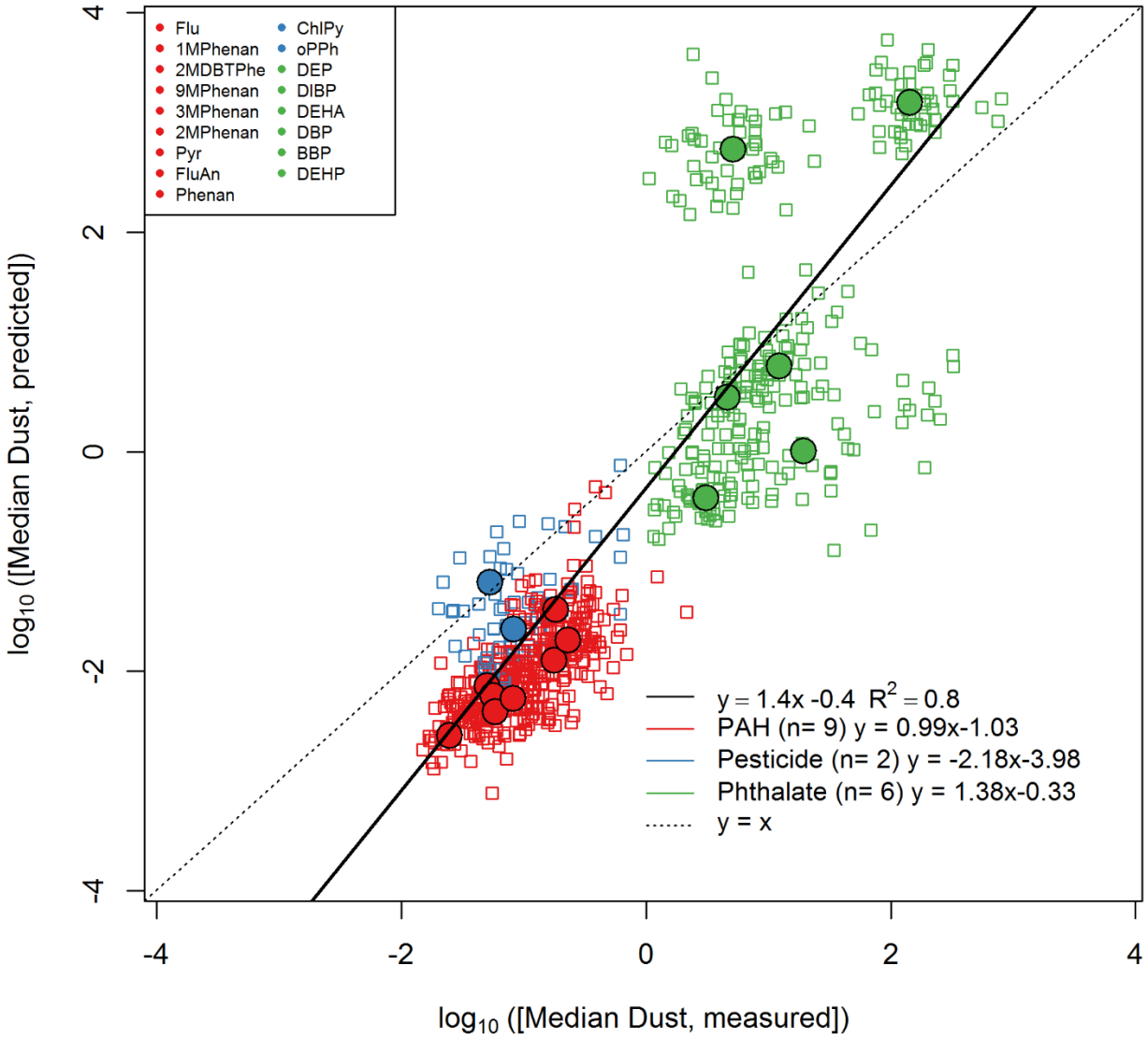
Table 2. Priority chemicals for breast cancer–relevant epidemiology and biomonitoring.

Chemical	Common exposure sources	Biomarkers
1,3-Butadiene	Gasoline, vehicle exhaust, tobacco smoke, heating of some cooking oils	DNA and hemoglobin adducts in blood, derived from epoxide metabolites; mercapturic acid metabolites in urine
Acrylamide	Cooked food, tobacco smoke, water-treatment by-products, some consumer products	Hemoglobin adducts of acrylamide and glycidamide in blood; urinary mercapturic acid metabolites of acrylamide and glycidamide
Aromatic amines I: TDA and TDIs	Uncured or newly finished polyurethane foam, spray-in insulation, sealants and coatings, some breast implants	TDA and hemoglobin adducts in blood, TDA in urine (Most studies have tested occupationally exposed populations, but many find TDA in "unexposed" controls)
Aromatic amines II: benzidine and aniline dyes, combustion products, other	Hair and textile dyes; used in the production of paints, printing inks, liquid crystal displays, and inkjet and laser printers, and in the food industry	Parent compound in blood or urine; DNA and hemoglobin adducts in blood or breast milk
Benzene	Gasoline, vehicle exhaust, tobacco smoke, solvents	DNA and protein adducts in blood and dried blood spots; urinary metabolites sPMA (specific to benzene) and ttMA (metabolite of benzene and the common food preservative sorbate)
Halogenated organic solvents (e.g., methylene chloride)	Dry cleaning, spot remover, glues, degreasers, paint strippers, aerosol propellants, contaminated drinking water (Use is decreasing over time)	Parent compound in whole blood and urine Infrequently detected in blood from general population but widespread occupational exposure has been documented; parent compounds have been detected in urine from occupationally exposed populations, and methylene chloride has been detected in urine from general population
Ethylene oxide, propylene oxide	Tobacco smoke, food and medical sterilization, vehicle exhaust, paint	DNA and hemoglobin adducts in blood; mercapturic acid metabolites in urine
Flame retardants and degradation products [2,2-bis(bromomethyl)-1,3-propanediol, 2,3-dibromo-1-propanol]	Flame retardants; primarily used in plastics and foams	Parent compound or metabolite in urine
Heterocyclic amines	Grilled meat	Parent compound, protein adducts, and DNA adducts in blood; parent compound in urine and hair
Hormones and endocrine disruptors (e.g., endogenous and exogenous estrogens and estrogen mimics)	Pharmaceutical hormones, consumer products, and commercial chemicals with hormonal activity	Clinical and research methods are available to measure endogenous hormone levels in blood and urine; the MCF-7 cell proliferation assay has been used to measure estrogenic activity in extracts of adipose tissue from breast cancer cases and controls; development of methods to conduct this assay in blood, and to distinguish endogenous and exogenous estrogen signals, would allow integrated assessments of exposure to xenoestrogens
MX	Water disinfection	Urinary trihaloacetic acids are used as exposure biomarkers for chlorinated drinking water, but improved exposure biomarkers are needed for MX and other highly genotoxic disinfection by-products
Nitro-PAHs (e.g., 1-nitropyrene)	Diesel exhaust	Hemoglobin adducts in blood, metabolites in urine
Ochratoxin A	Mycotoxin in grains, nuts, pork; also present in moldy environments	Ochratoxin A and its metabolites in blood, urine, breast milk
PAHs (e.g., BaP)	Vehicle exhaust, tobacco smoke, charred food	Protein adducts and DNA adducts in blood; oxidized metabolites in urine; parent compounds measured in hair, breast milk (Improved exposure biomarkers are needed)
PFOA, related compounds	Grease-, water-, and stainproof coatings; contaminated drinking water	Parent compound in blood and breast milk
Pharmaceuticals (nonhormonal)	A number of over-the-counter, veterinary, and prescription medicines that induce mammary tumors	Few exposure biomarkers have been developed for use in the general population, but in many cases LC-MS/MS methods have been reported for the parent compound in plasma or metabolites in urine; in some cases exposure can be ascertained from self-report or medical records
Styrene	Building materials and consumer products made from polystyrene; indoor air, cigarette smoke, polystyrene food packaging	Parent compound in whole blood; urinary mercapturic and mandelic acid metabolites

Abbreviations: BaP, benzo[*a*]pyrene; LC-MS/MS, liquid chromatography–tandem mass spectrometry; PFOA, perfluorooctanoic acid; sPMA, *S*-phenylmercapturic acid; TDA, 2,4-toluene diamine; TDI, toluene diisocyanates; ttMA, *trans, trans*-muconic acid. For more information, including a list of chemicals in each group, see Supplemental Material, Table S1.

Rudel et al. 2014

Validating models with empirical data



Dodson et al. 2015

Green Housing Study

CDC-directed study investigating links between indoor environmental quality and asthma in green renovated and non-renovated subsidized housing

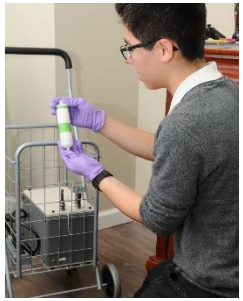
Just after renovation

6 months post

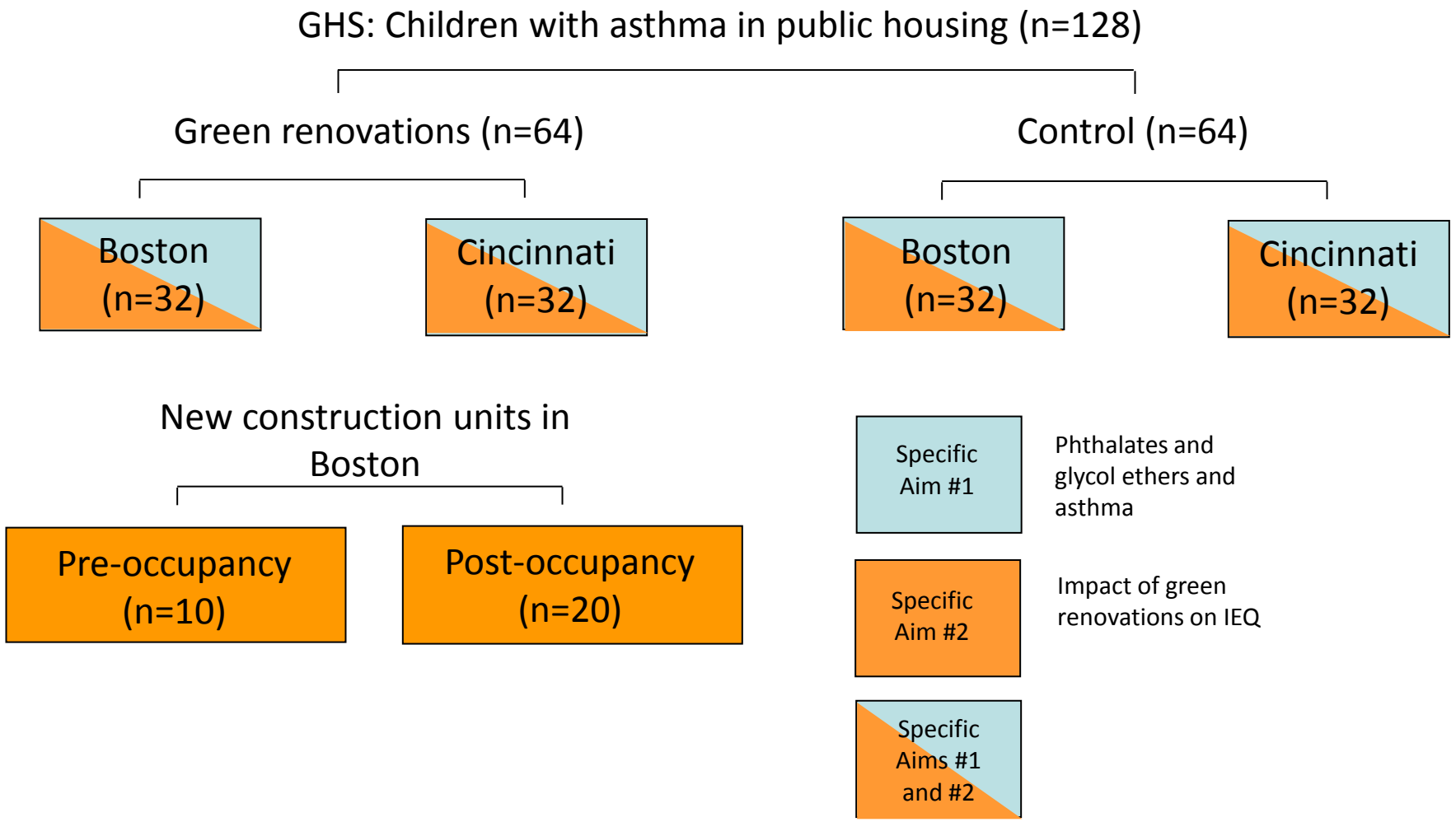
12 months post

Traditional IEQ: PM, VOCs, pesticides

Expanded IEQ: SVOCs, including phthalates, phenols



Green Housing Study



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