

# Changes in Biomarkers of Exposure Among Adult Cigarette Smokers Who Transitioned to ENDS Use or Quit Smoking: The Population Assessment of Tobacco and Health Study, 2013-2019

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## Abstract

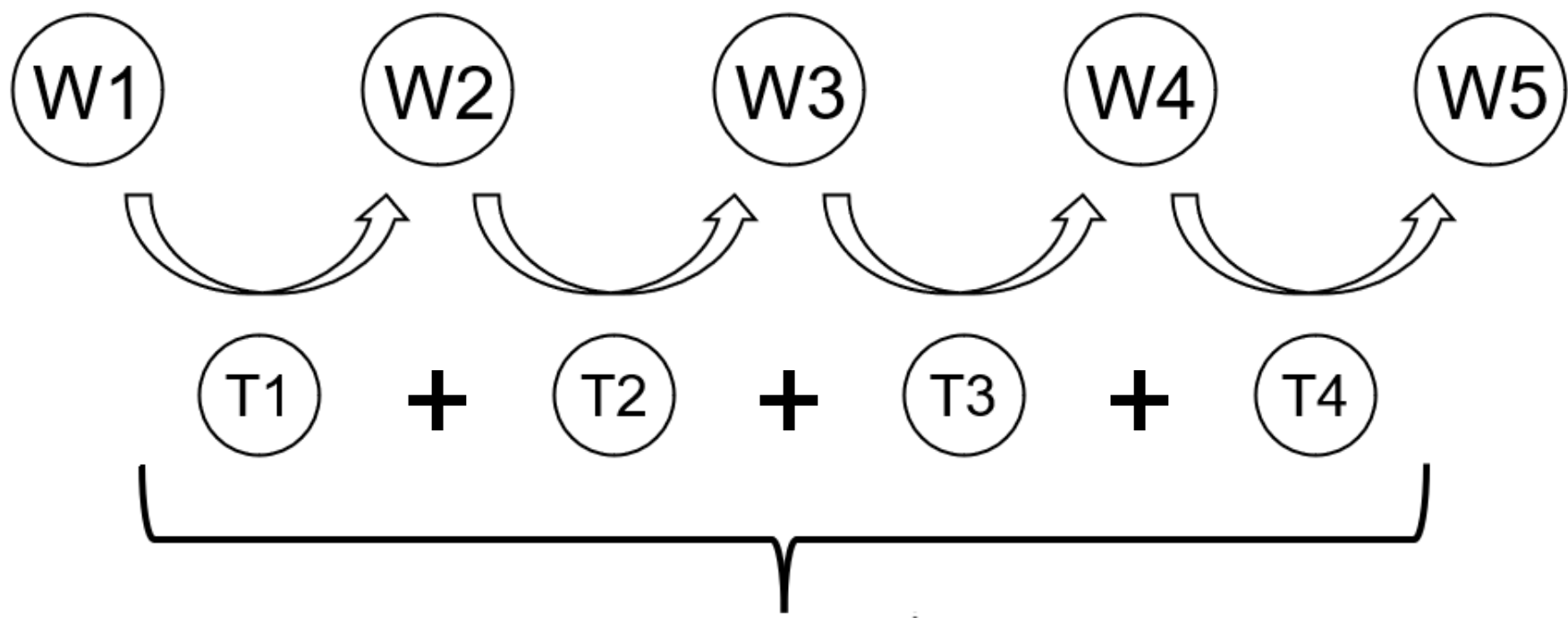
Transitioning from cigarette smoking to electronic nicotine delivery systems (ENDS) or lowering cigarette consumption can reduce exposure to harmful constituents. This research examines changes in biomarkers of exposure (BOEs) among adults who exclusively smoked cigarettes at baseline (AS; n=6,112), using data from the Population Assessment of Tobacco and Health (PATH) Study (2013-2019). We estimated changes in 21 BOEs (representing exposure to tobacco-specific nitrosamines, nicotine, heavy metals, and volatile organic compounds) between baseline and follow-up within wave pairs (W1-W2, W2-W3, W3-W4, W4-W5) using weighted generalized estimating equation models among AS who continued exclusive cigarette smoking (CS; n=5,178), switched to exclusive ENDS use (AE; n=79), smoked cigarettes and used ENDS (ADU; n=311), or reported no past 30-day tobacco use (AQ; n=544) at follow-ups. ADU were further subdivided based on self-reported changes in cigarette consumption (CPD) from the previous wave – substantive (≥50%; n=73) and moderate (up to 50%, n=64) reducers, no change in CPD (n=96), and increasers (n=78). Significant reductions in a majority of BOEs were seen among ADU (13/21), AE (16/21), and AQ (18/21) compared to CS. BOEs were significantly lower among substantive (16/21) and moderate reducers (10/21), while majority of BOEs (19/21) remain unchanged among increasers. There is a clear correlation between BOE levels and CPD. Comparable reductions in BOEs are observed between AE and AQ. These results demonstrate that even a moderate reduction in CPD among AS and ADU can significantly decrease exposure to harmful constituents.

## Introduction

Cigarette smoking is a major health concern, but quitting is often difficult. For those who cannot or will not quit smoking cigarettes, switching to smoke-free products like Electronic Nicotine Delivery Systems (ENDS) can reduce exposure to harmful and potentially harmful constituents (HPHC) and potentially lower disease risk.<sup>1,2</sup> Recent studies show that adults who exclusively use ENDS have lower exposure to HPHCs than those who smoke cigarettes. Further research indicates a significant reduction in HPHCs when adults who smoke switch to ENDS, except for nicotine and its metabolites.<sup>3,4,5</sup> However, these studies had small sample sizes (e.g., <50) due to low ENDS adoption. This study aims to update this evidence using more recent PATH data.

## Results

### Study Design



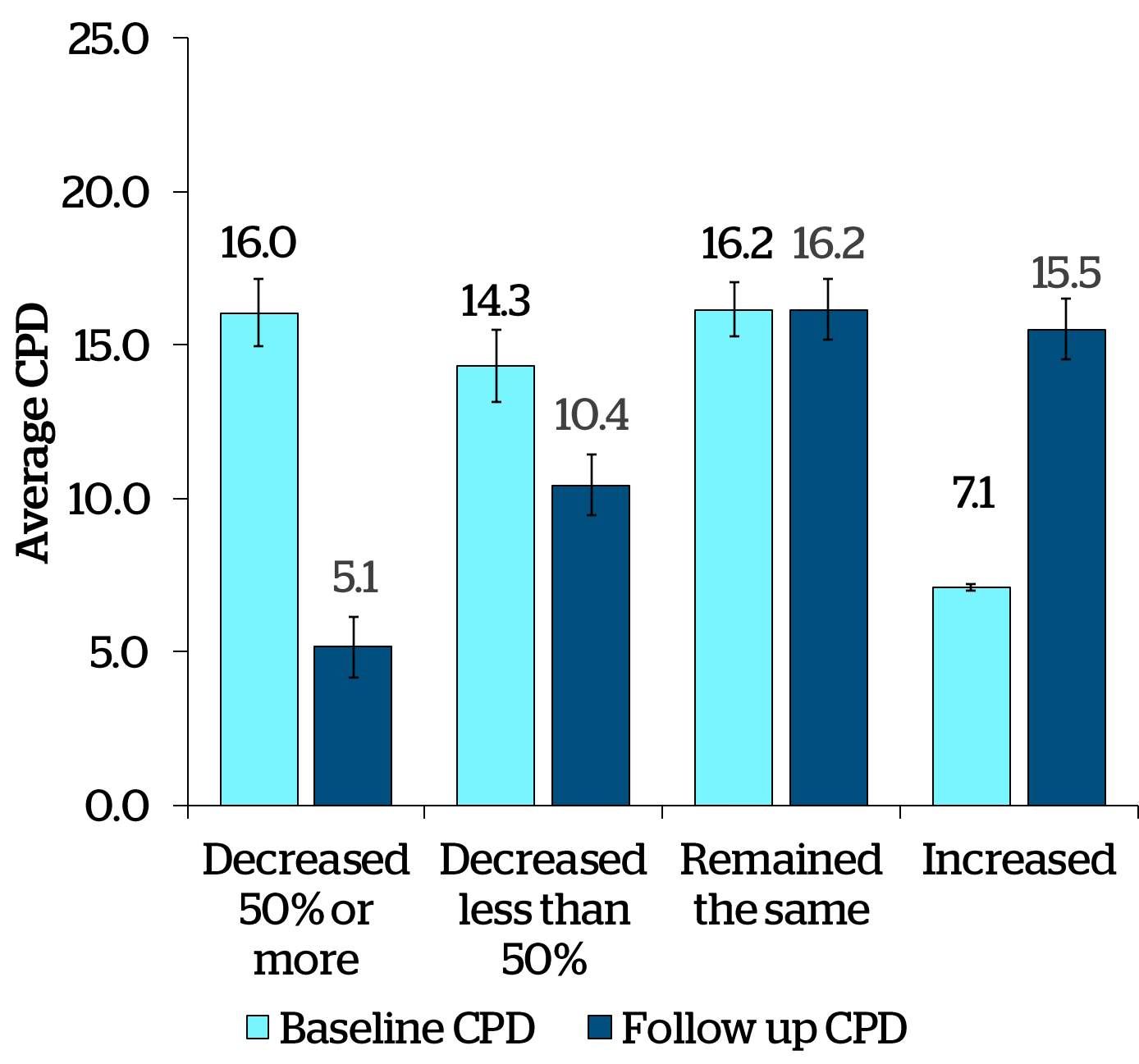
Tobacco User Group	Abbr.	Number of Observations
Exclusive Established Cigarette Smokers	CS	5,178
Exclusive Established ENDS Users	AE	79
Exclusive Established Dual Users of Cigarettes and ENDS	ADU	311
Former Smokers	AQ	544

### Percent Changes in BOEs Among Adults Who Smoke Cigarettes Who Switched to Exclusive ENDS or Quit Tobacco vs. Continued Smoking

Category	BOE	AE (n=79)	AQ (n=544)	ADU (n=311)
Nicotine	NICEQ	-18%	-75%	0%
	NNAL	-96%	-91%	-26%
	NNN	-55%	-42%	-31%
Metals	Cadmium	0%	-1%	-4%
	Lead	-14%	-7%	0%
	Uranium	-18%	-6%	-23%
	CEMA	-54%	-43%	-14%
	MHA2	-65%	-55%	-6%
Volatile Organic Compounds	MHA34	-69%	-56%	-15%
	AAMA	-53%	-38%	-14%
	AMCA	-54%	-48%	-11%
	CYMA	-93%	-88%	-32%
	HEMA	-65%	-46%	-21%
	HPM2	-51%	-38%	-14%
	HPMA	-70%	-60%	-23%
	HPMM	-79%	-61%	-16%
	IPM3	-87%	-70%	-20%
	MADA	-39%	-27%	-8%
	MHB3	-80%	-67%	-19%
	PHGA	-35%	-22%	-2%
	PMA	-12%	3%	2%

Bold signifies statistically significant difference at p<0.05

### Cigarette Consumption at Baseline and Follow-up Among Dual Users (ADU), Grouped by CPD Change

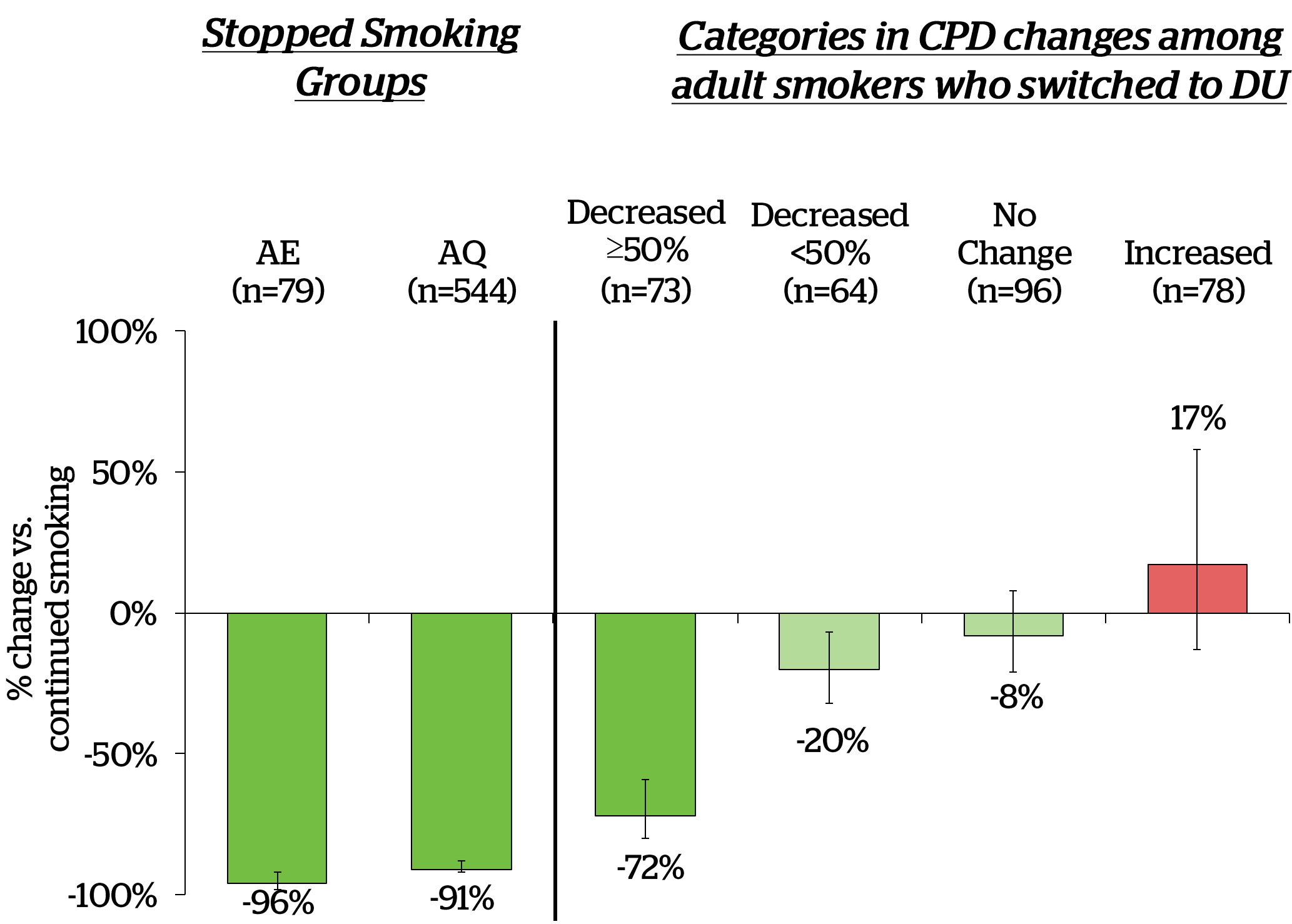


### Changes in the BOEs Among Adults Who Smoke Cigarettes Who Switched to DU and Adjusted Their Cigarette Consumption vs. Continued Smoking

Category	BOE	Decreased ≥50% (n=73)	Decreased <50% (n=64)	No Change (n=96)	Increased (n=78)
Nicotine	NICEQ	-12%	-20%	9%	10%
	NNAL	-72%	-20%	-8%	17%
	NNN	-49%	-43%	-8%	-26%
Metals	Cadmium	-3%	9%	-11%	-1%
	Lead	-5%	1%	4%	-1%
	Uranium	-28%	-15%	-14%	-35%
	CEMA	-42%	-3%	14%	-19%
	MHA2	-35%	-15%	21%	3%
Volatile Organic Compounds	MHA34	-47%	-19%	0%	-3%
	AAMA	-39%	-12%	-9%	5%
	AMCA	-43%	-17%	10%	1%
	CYMA	-74%	-28%	1%	-6%
	HEMA	-44%	-39%	2%	-8%
	HPM2	-44%	-15%	8%	-7%
	HPMA	-59%	-22%	7%	-8%
	HPMM	-57%	-17%	7%	3%
	IPM3	-68%	0%	7%	-6%
	MADA	-36%	-13%	10%	6%
	MHB3	-63%	-10%	15%	-5%
	PHGA	-24%	-5%	1%	8%
	PMA	-8%	-26%	15%	15%

Bold signifies statistically significant difference at p<0.05

### Percent Changes in NNAL vs. Continuing Smoking



Abbreviations: **NICEQ**: Nicotine Equivalents - 3; **NNAL**: 4-(methylnitrosamino)-1-1(3-pyridyl)-1-butanol; **NNN**: N'-Nitrosornicotine; **CEMA**: N-Acetyl-S-(2-carboxyethyl)-L-cysteine; **MHA2**: 2\_methylhippuric\_acid; **MHA34**: 3-4-Methylhippuric acid; **AAMA**: N-Acetyl-S-(2-carbamoyl-ethyl)-L-cysteine; **AMCA**: Aminocabonyl Mercapturic Acid; **CYMA**: N-Acetyl-S-(2-cyanoethyl)-L-cysteine; **HEMA**: Mercapturic acid; **HPM2**: N-Acetyl-S-(2-hydroxypropyl)-L-cysteine; **HPMA**: N-Acetyl-S-(3-hydroxypropyl)-L-cysteine; **HPMM**: N-Acetyl-S-(3-hydroxypropyl-1-methyl)-L-cysteine; **IPM3**: N-Acetyl-S-(4-hydroxy-2-methyl-2-buten-1-yl)-L-cysteine; **MADA**: Mandelic acid; **MHB3**: N-Acetyl-S-(4-hydroxy-2-buten-1-yl)-L-cysteine; **PHGA**: Phenylglyoxylic acid; **PMA**: Phenylmercapturic acid.

## References

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## Conclusions

- Transitioning from exclusive cigarette smoking to ENDS or reducing cigarette consumption can significantly decrease exposure to harmful constituents.
- Comparable reductions in BOEs, except for nicotine equivalents, are observed among those who completely switched to ENDS and those who reported no past 30-day tobacco use.



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