Subnational Trends in the Prevalence of Menthol Cigarette Use among Adult Smokers in the United States from 2002 to 2020: Findings from the International Tobacco Control (ITC) US Surveys

Pete Driezen

January 19, 2023

CAsToR Pilot Project Program Lightning Talk

UNIVERSITY OF WATERLOO

Background

Menthol Cigarette Smoking in the United States

- Targeted marketing of menthol cigarettes in the US influences disparities in the prevalence of menthol smoking across demographic groups

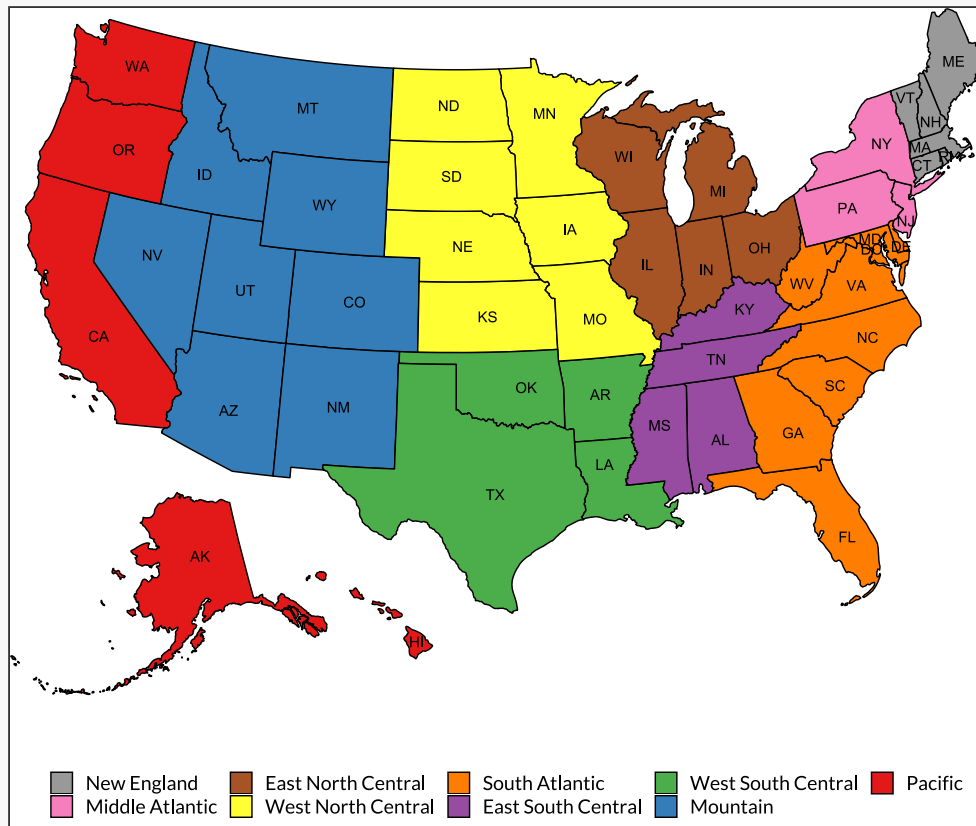# Menthol Cigarette Smoking in the United States

- Targeted marketing of menthol cigarettes in the US influences disparities in the prevalence of menthol smoking across demographic groups

- Trends from TUS-CPS (Seaman et al., 2022):
  - The percentage of current smokers using menthol cigarettes increased from 2003 to 2019
  - Menthol cigarette use is more common among specific demographic subgroups (young adults, females, non-Hispanic Black smokers)
  - Differences in use across broad geographic areas (South vs. Midwest)

Menthol Cigarette Smoking in the United States

- Targeted marketing of menthol cigarettes in the US influences disparities in the prevalence of menthol smoking across demographic groups

- Trends from TUS-CPS (Seaman et al., 2022):
  - The percentage of current smokers using menthol cigarettes increased from 2003 to 2019
  - Menthol cigarette use is more common among specific demographic subgroups (young adults, females, non-Hispanic Black smokers)
  - Differences in use across broad geographic areas (South vs. Midwest)

- <u>Granular</u> information about menthol use at <u>subnational</u> levels (e.g., census divisions) can provide greater insight into the possible effects of the proposed FDA ban on menthol cigarettes

Study Objectives

To estimate trends in the prevalence of menthol use among current adult smokers for each of the nine US census divisions by sex, age group, and race/ethnicity from 2002 to 2020

⬜ New England	🟫 East North Central	🟧 South Atlantic	🟩 West South Central	🟥 Pacific
🟪 Middle Atlantic	🟨 West North Central	🟪 East South Central	🟦 Mountain	

Methods

General Approach: Small Area Estimation (SAE)

- Advantages and features of SAE:
  - Estimate **reliable statistics** using population survey data for specific subgroups having **small sample sizes**
  - Surveys are **not** typically designed for estimation within these subgroups or "domains"
  - Domains of interest are often, but not always, defined by geographic boundaries
  - SAE methods typically estimate these statistics using linear mixed effects models
  - The study presented here relied on a specific type of SAE model called multilevel regression and post-stratification (or "MrP", Gelman & Little, 1997; Zhang et al., 2014; Hanretty, 2020)

Data Sources

The International Tobacco Control (ITC) Four Country Surveys

- Nationally representative samples of current (at least monthly) adult cigarette smokers (ages 18+)

- Stratified sampling design; 12 waves (2002–2020)
  - ITC 4 Country Survey (ITC 4C): 2002–2015 (Wave 9 was split into 2 subwaves for modeling)
  - ITC 4 Country Smoking & Vaping Survey (ITC 4CV): 2016–2020
  - US sample only: 22,703 observations from 12,020 respondents

- Primary outcome measure – use of menthol cigarettes:
  - Self-reported use of menthol cigarettes (Waves 1 to 4 of ITC 4C)
  - Self-reported brand, containing the term menthol (Waves 5 to 9 of ITC 4C and Waves 1 to 3 of ITC 4CV)

Data Sources

External data: BRFSS, ACS, TUS-CPS

- US Behavioral Risk Factor Surveillance System (BRFSS) and the American Community Survey (ACS)
  - Survey years contemporaneous to ITC 4C & 4CV
  - Used to estimate total number of smokers within census divisions for all survey years

- Tobacco Use Supplement of the Current Population Survey (TUS-CPS)
  - Waves 6 (2006/2007) through 10 (2018/2019)
  - Used to validate modeled estimates of menthol use

Multilevel Regression and Post-stratification

Two-step modeling approach: Multilevel logistic regression

- Predict prevalence of menthol use among current smokers for 72 cross-classified demographic groups of smokers:
  - sex (male, female),
  - age group (18-29, 30-49, 50+),
  - race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Other),
  - socioeonomic status (low, moderate, high)

- Demographic measures were fit as <u>fixed effects</u>, fixed temporal effects fit as <u>piecewise linear trends</u>; census divisions as a <u>random intercept</u>; race/ethnicity as a <u>random slope</u>

- Cross-sectional survey weights; model fit using PROC GLIMMIX in SAS (Version 9.4); predictions within census division for each survey year were estimated with PROC PLM

Multilevel Regression and Post-stratification

Two-step modeling approach: Post-stratification step

- Predicted prevalence is weighted by population totals for each of the 72 cross-classified demographic groups and aggregated to the census divison level in each year to obtain:
  - Overall menthol prevalence
  - Menthol prevalence for specific demographic groups

- 95% confidence intervals estimated using a non-parametric bootstrapping procedure (Wang et al., 2021)

- Validation step: compared modeled estimates ("ITC MrP") against external estimates from TUS-CPS ("direct" survey estimates) using the overall concordance correlation coefficient (Barnhart et al., 2002; Lin, 1989; Lin, 2000)

Results
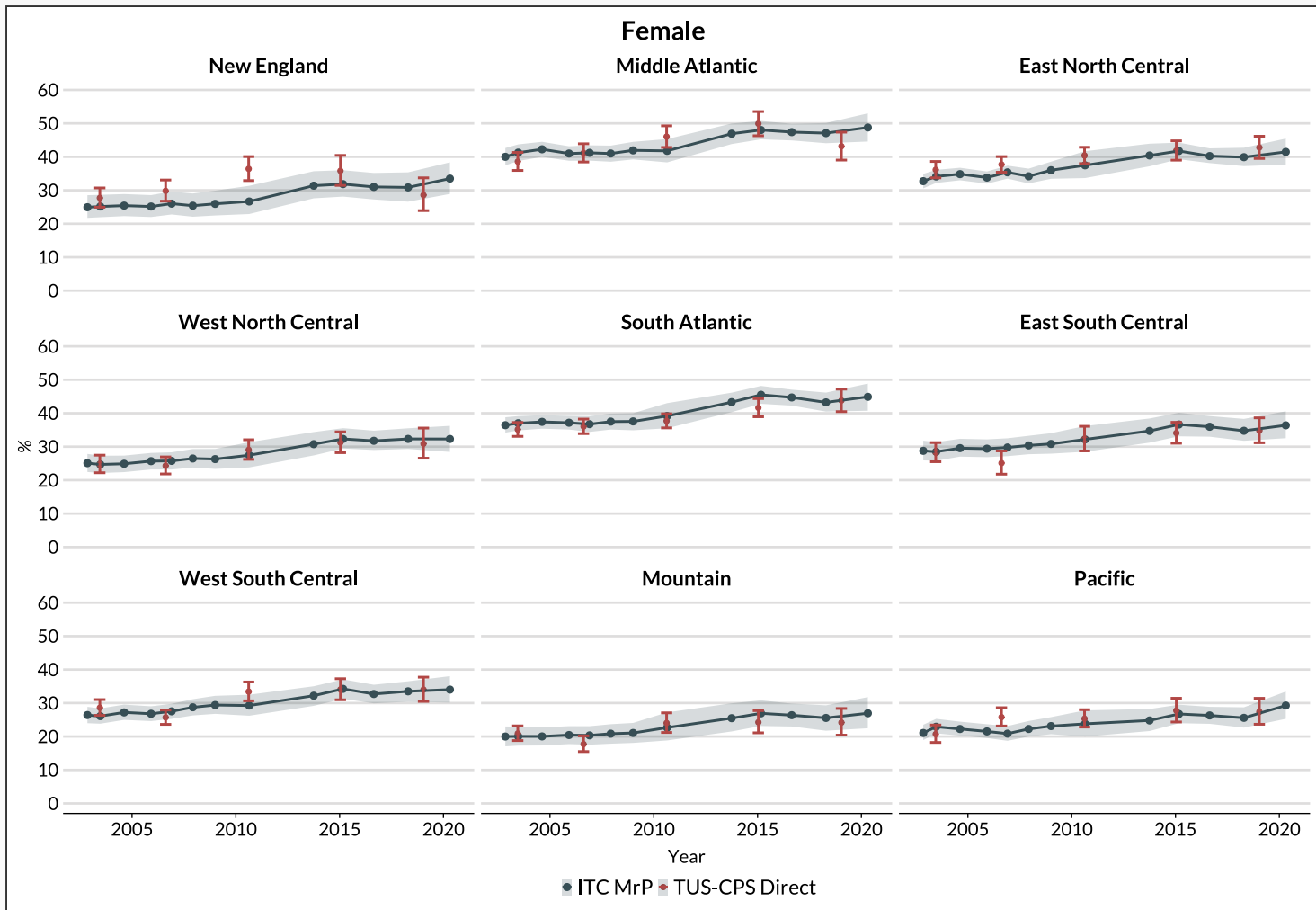
Menthol Use among Cigarette Smokers in the US
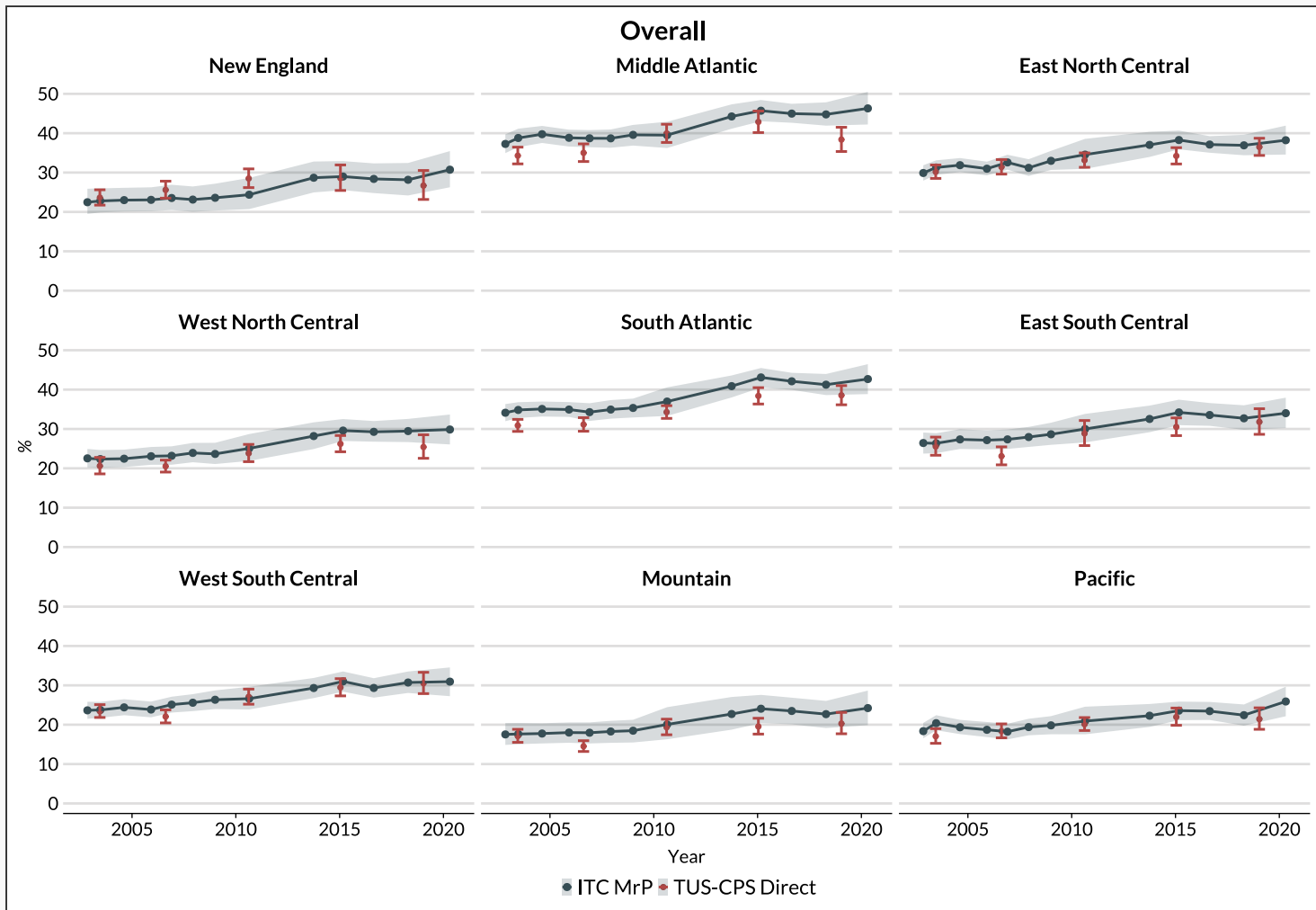
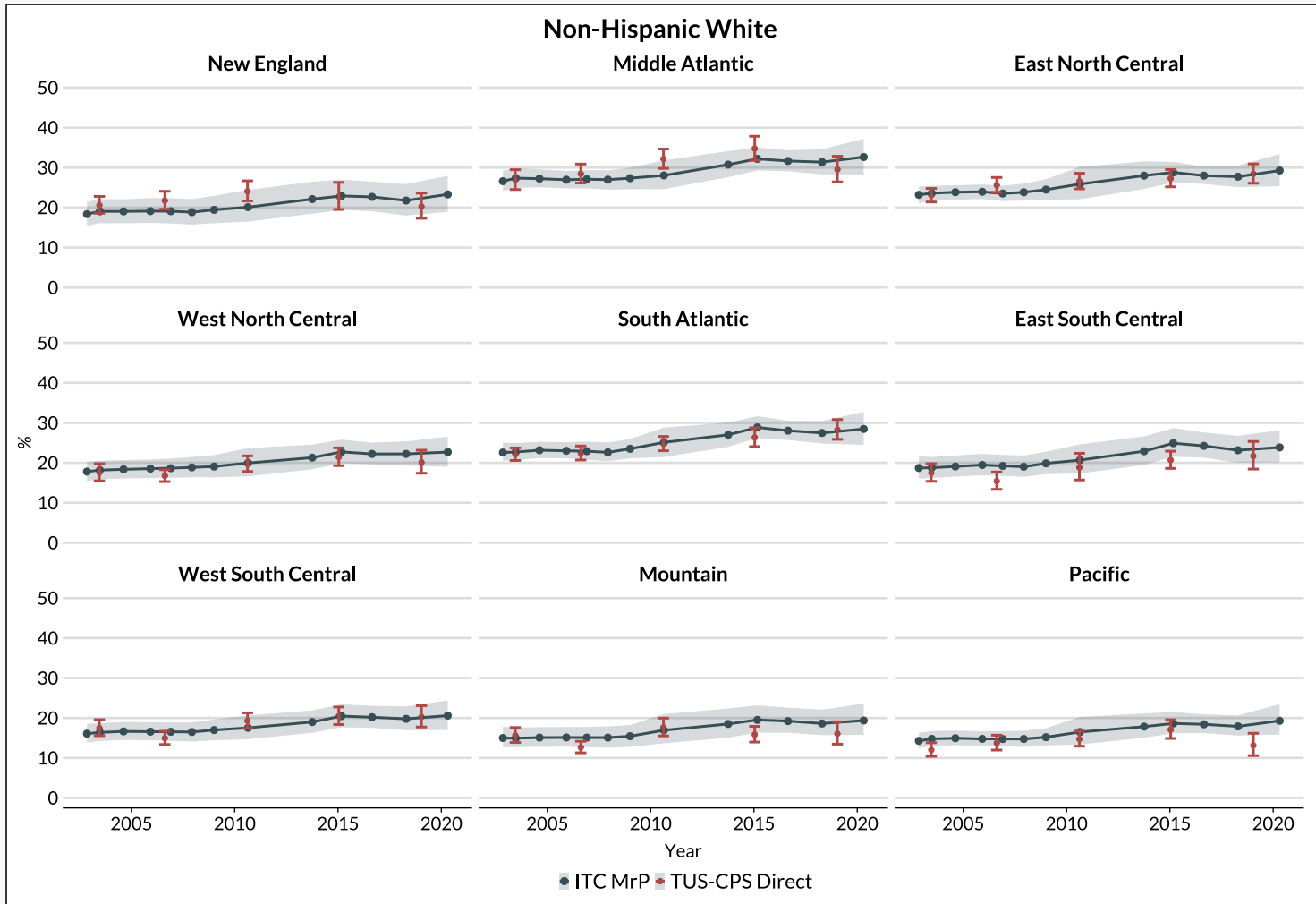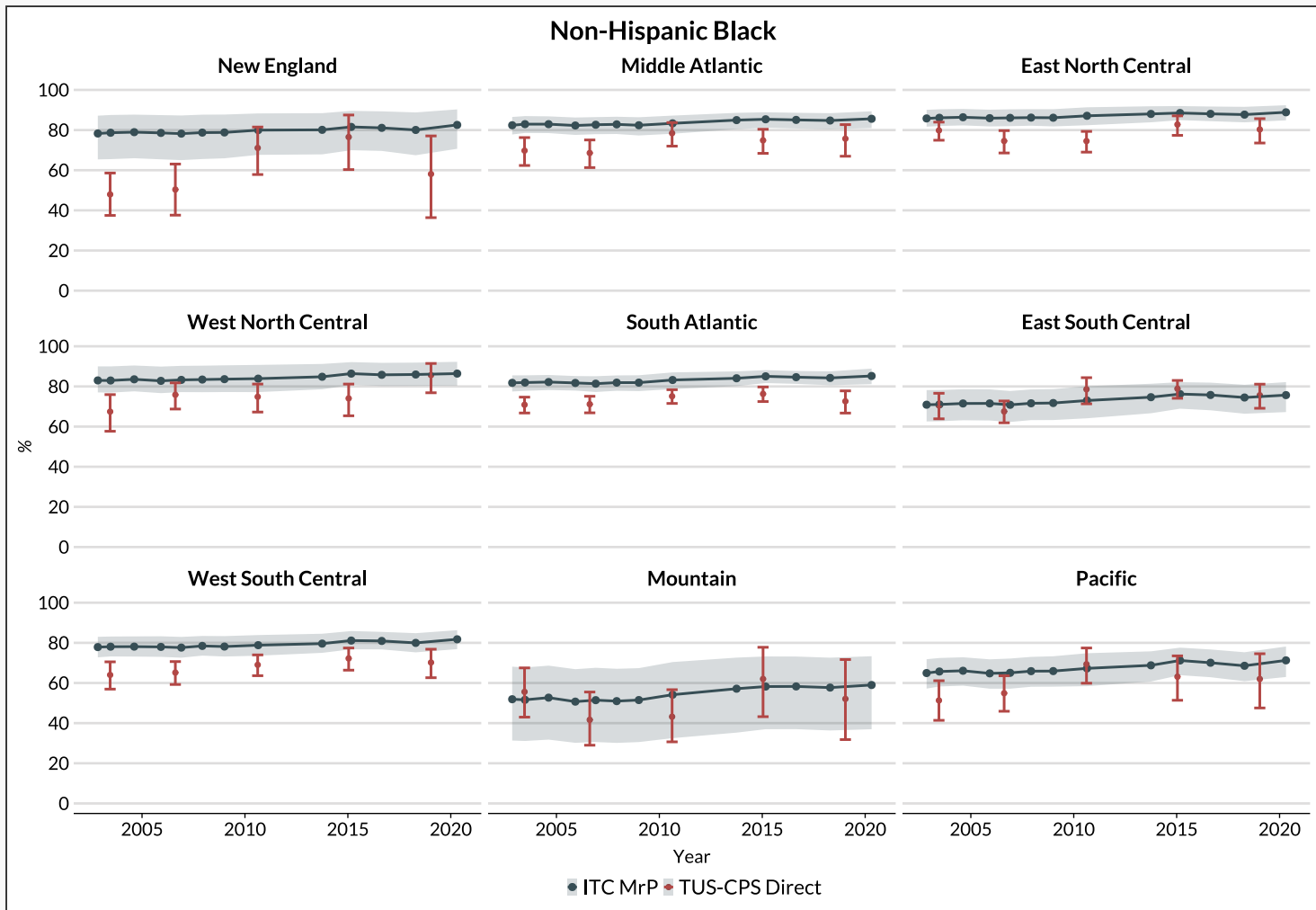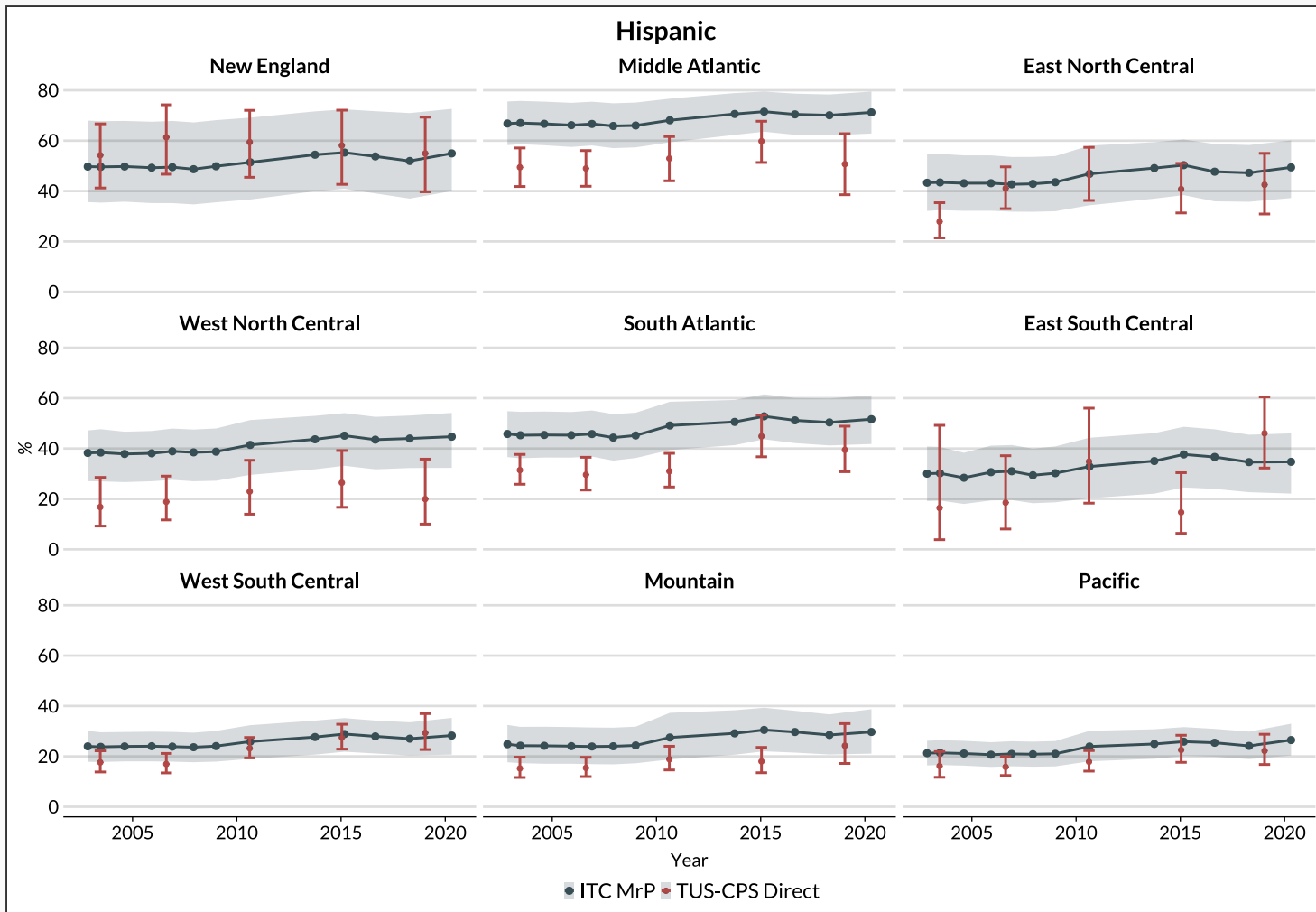# Menthol Use within Census Divisions by Sex
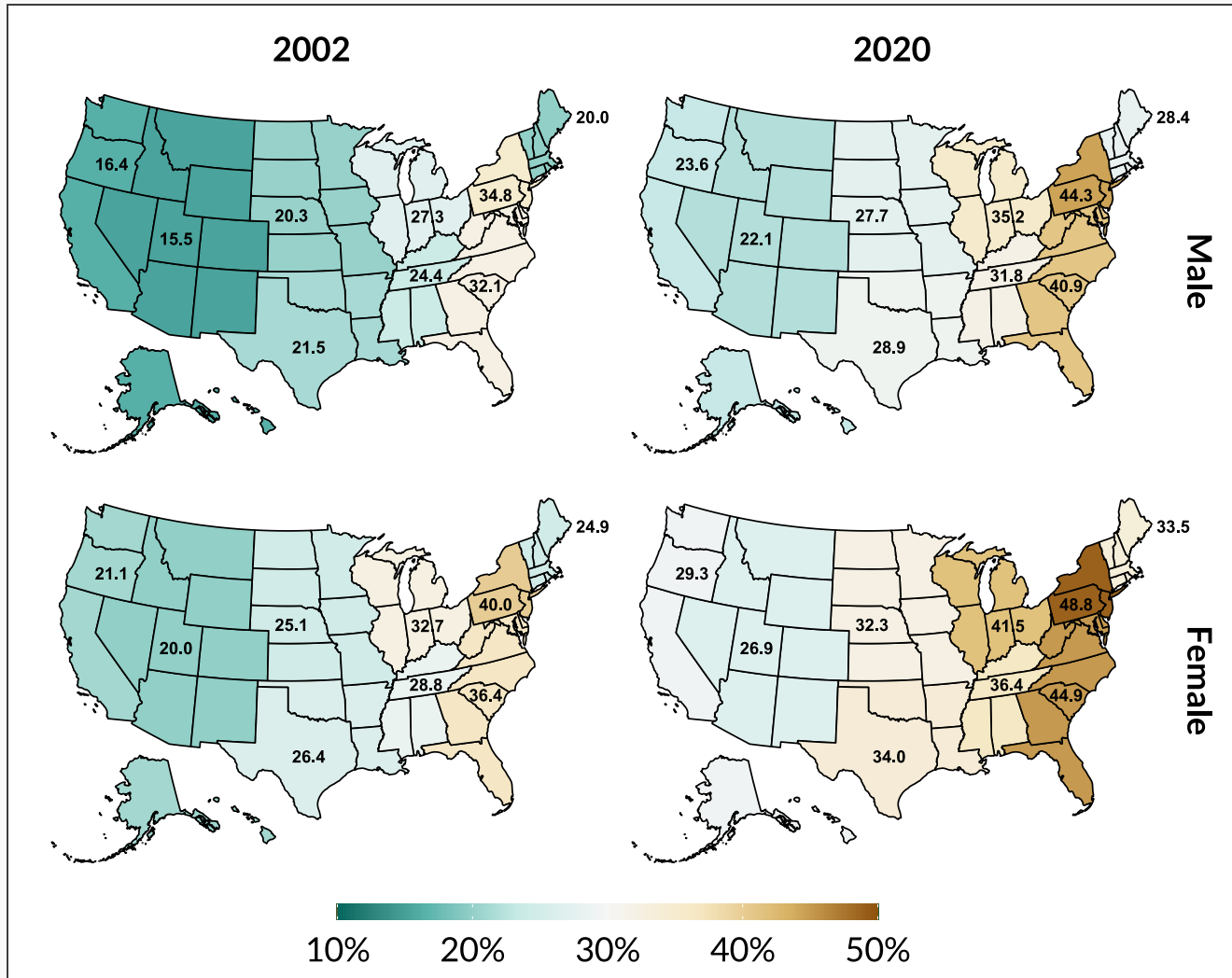
Menthol Use among Cigarette Smokers in the US
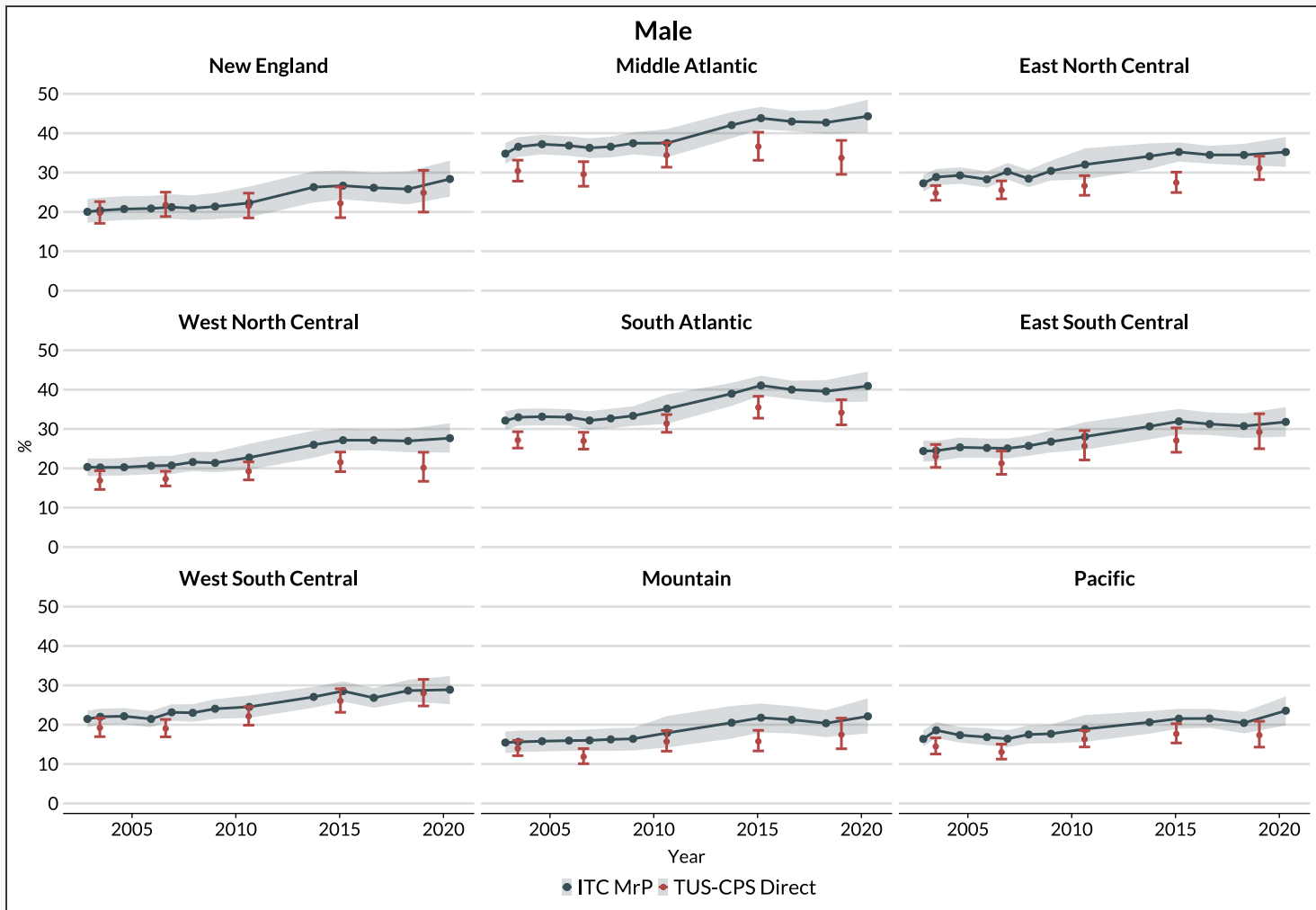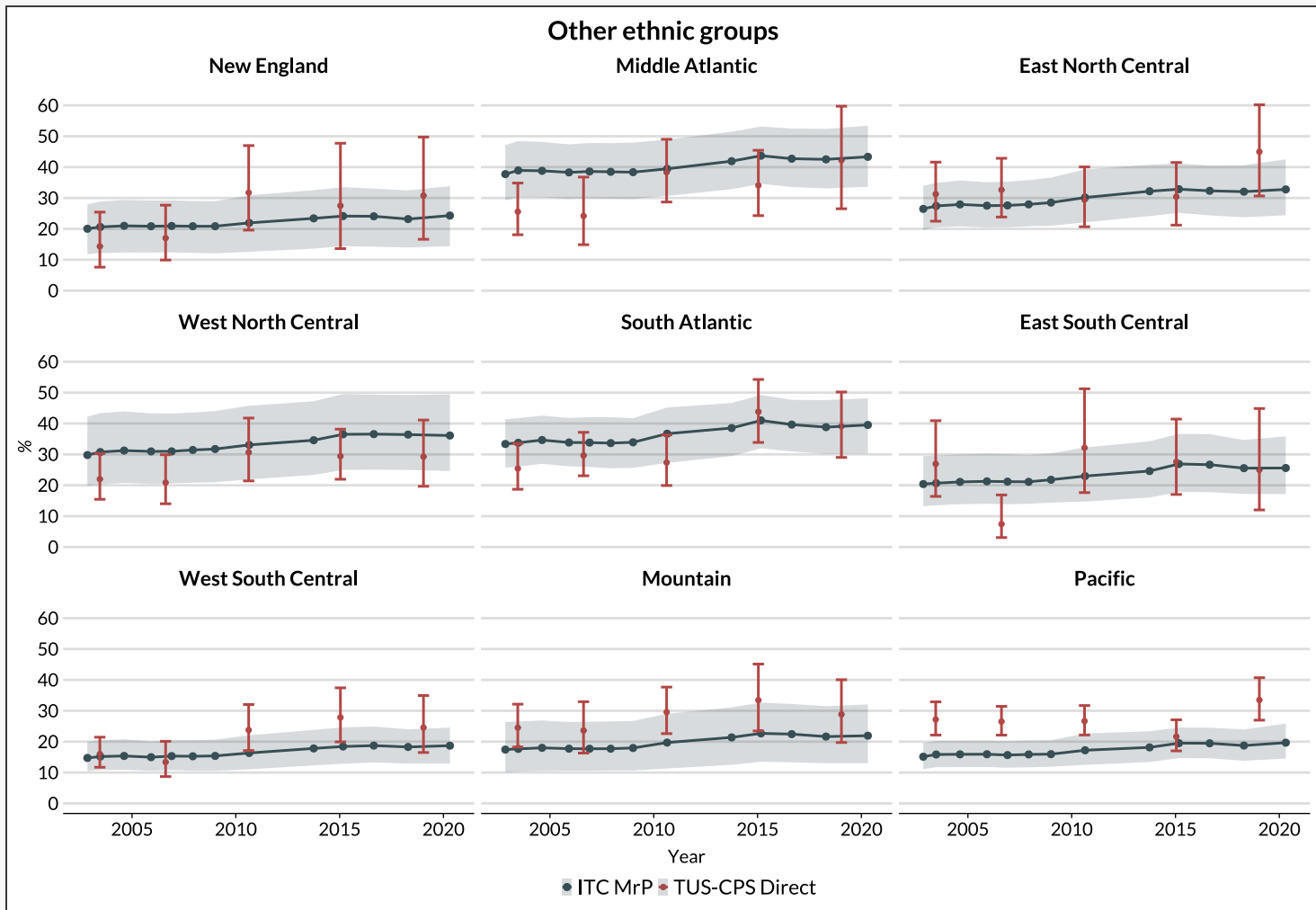
Menthol Use among Cigarette Smokers in the US

Menthol Use among Cigarette Smokers in the US

Menthol Use among Cigarette Smokers in the US
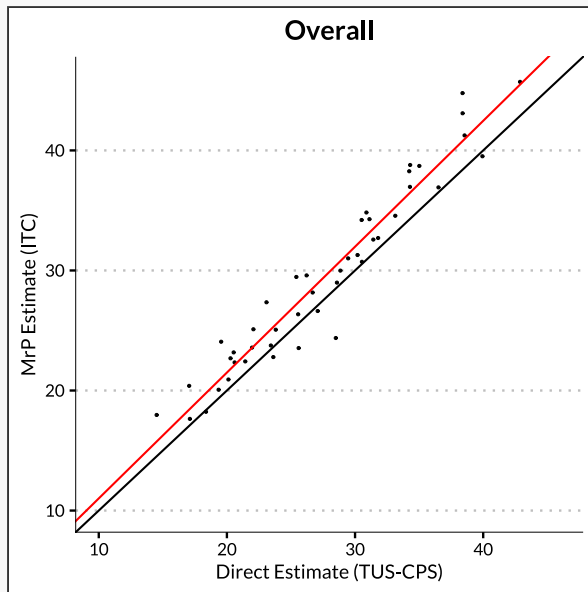
Menthol Use among Cigarette Smokers in the US

Hispanic

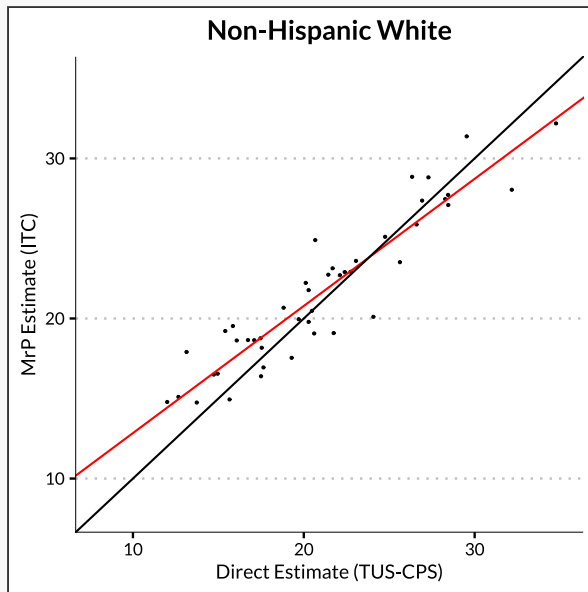# Menthol Use among Cigarette Smokers in the US

Validity of Modeled Estimates

Black line: concordance line (perfect agreement)
Red line: line of best fit

Estimate	CCC	Precision	Accuracy
Overall	**0.9317**	**0.9657**	**0.9648**
Male	0.8334	0.9668	0.8620
Female	0.9300	0.9314	0.9985
White	0.9137	0.9312	0.9812
Black	0.5533	0.7490	0.7387
Hispanic	0.7021	0.8105	0.8662
Other	0.5216	0.5315	0.9812

CCC = overall concordance correlation coefficient
CCC = precision * accuracy
Precision: Pearson correlation
Accuracy: Measure of bias
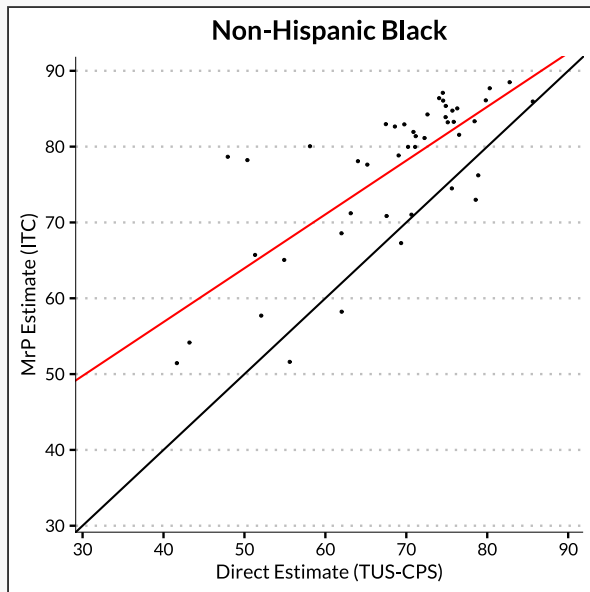
Validity of Modeled Estimates

Non-Hispanic White

MrP Estimate (ITC) vs. Direct Estimate (TUS-CPS)

Black line: concordance line (perfect agreement)
Red line: line of best fit

Estimate	CCC	Precision	Accuracy
Overall	0.9317	0.9657	0.9648
Male	0.8334	0.9668	0.8620
Female	0.9300	0.9314	0.9985
White	**0.9137**	**0.9312**	**0.9812**
Black	0.5533	0.7490	0.7387
Hispanic	0.7021	0.8105	0.8662
Other	0.5216	0.5315	0.9812

CCC = overall concordance correlation coefficient
CCC = precision * accuracy
Precision: Pearson correlation
Accuracy: Measure of bias
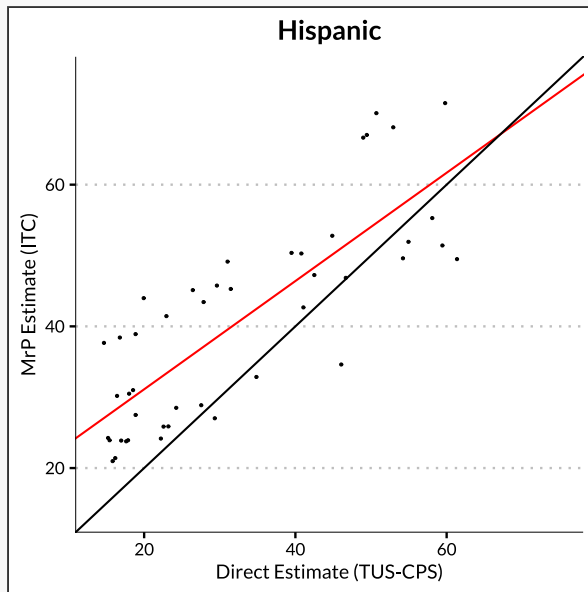
Validity of Modeled Estimates

Non-Hispanic Black

Black line: concordance line (perfect agreement)
Red line: line of best fit

Estimate	CCC	Precision	Accuracy
Overall	0.9317	0.9657	0.9648
Male	0.8334	0.9668	0.8620
Female	0.9300	0.9314	0.9985
White	0.9137	0.9312	0.9812
Black	**0.5533**	**0.7490**	**0.7387**
Hispanic	0.7021	0.8105	0.8662
Other	0.5216	0.5315	0.9812

CCC = overall concordance correlation coefficient
CCC = precision * accuracy
Precision: Pearson correlation
Accuracy: Measure of bias
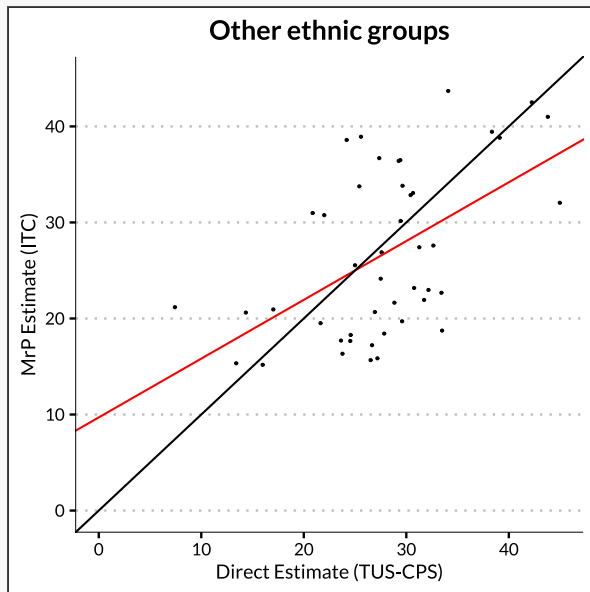
Validity of Modeled Estimates

Black line: concordance line (perfect agreement)
Red line: line of best fit

Estimate	CCC	Precision	Accuracy
Overall	0.9317	0.9657	0.9648
Male	0.8334	0.9668	0.8620
Female	0.9300	0.9314	0.9985
White	0.9137	0.9312	0.9812
Black	0.5533	0.7490	0.7387
Hispanic	**0.7021**	**0.8105**	**0.8662**
Other	0.5216	0.5315	0.9812

CCC = overall concordance correlation coefficient
CCC = precision * accuracy
Precision: Pearson correlation
Accuracy: Measure of bias

Validity of Modeled Estimates

Black line: concordance line (perfect agreement)
Red line: line of best fit

Estimate	CCC	Precision	Accuracy
Overall	0.9317	0.9657	0.9648
Male	0.8334	0.9668	0.8620
Female	0.9300	0.9314	0.9985
White	0.9137	0.9312	0.9812
Black	0.5533	0.7490	0.7387
Hispanic	0.7021	0.8105	0.8662
Other	**0.5216**	**0.5315**	**0.9812**

CCC = overall concordance correlation coefficient
CCC = precision * accuracy
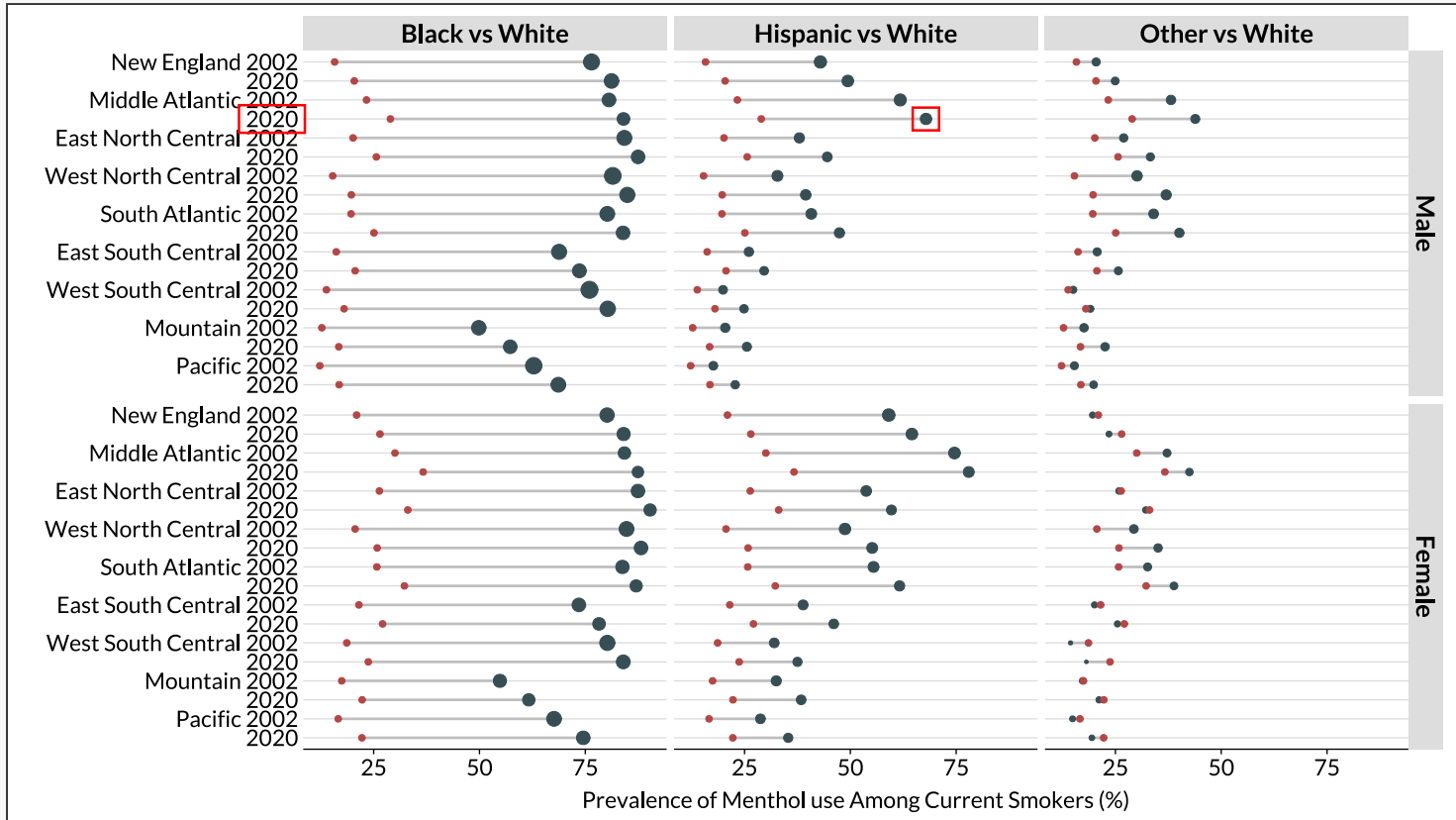Precision: Pearson correlation
Accuracy: Measure of bias

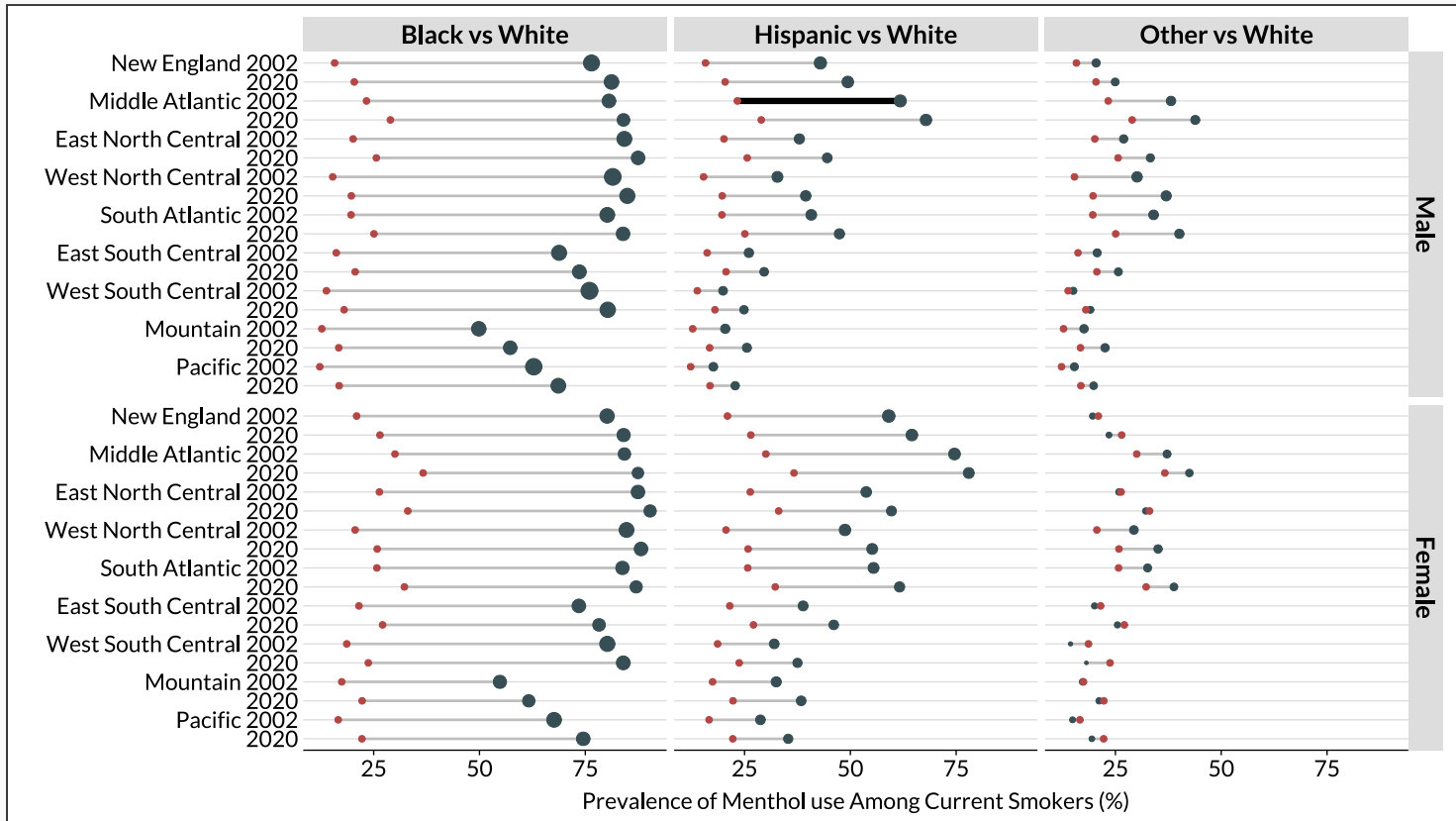# Disparities in Menthol Use by Sex and Ethnicity
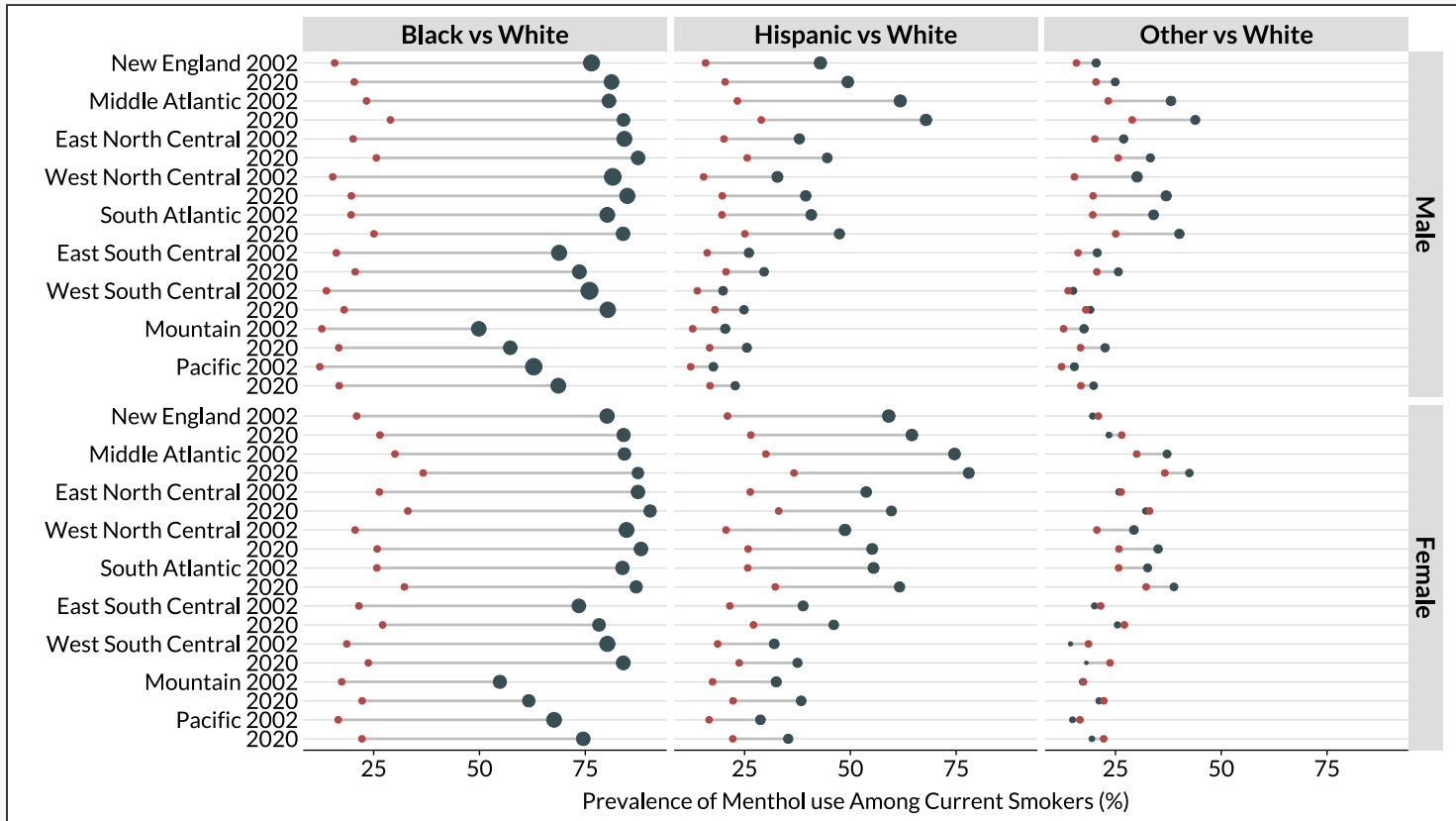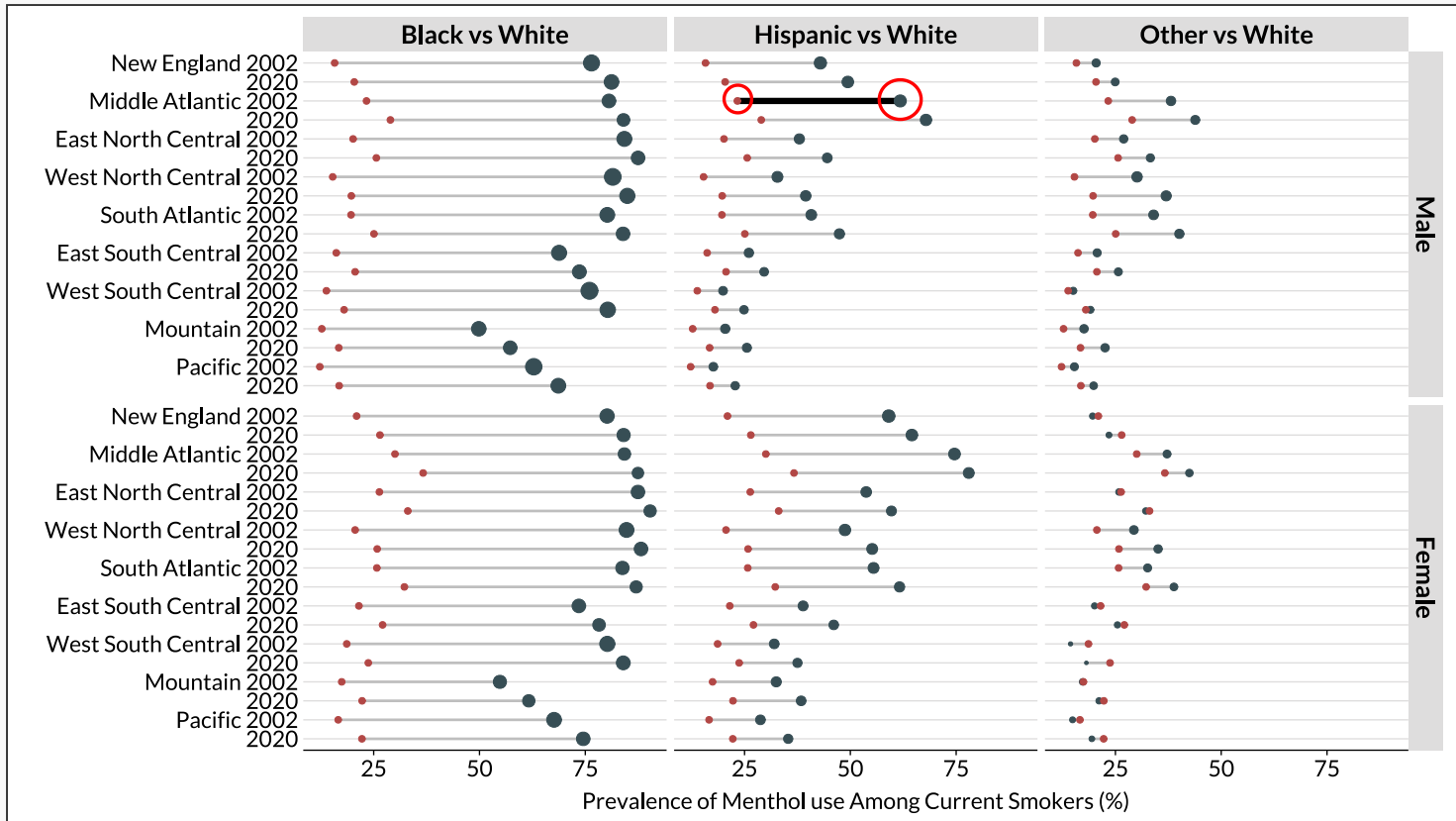
Disparities in Menthol Use by Sex and Ethnicity
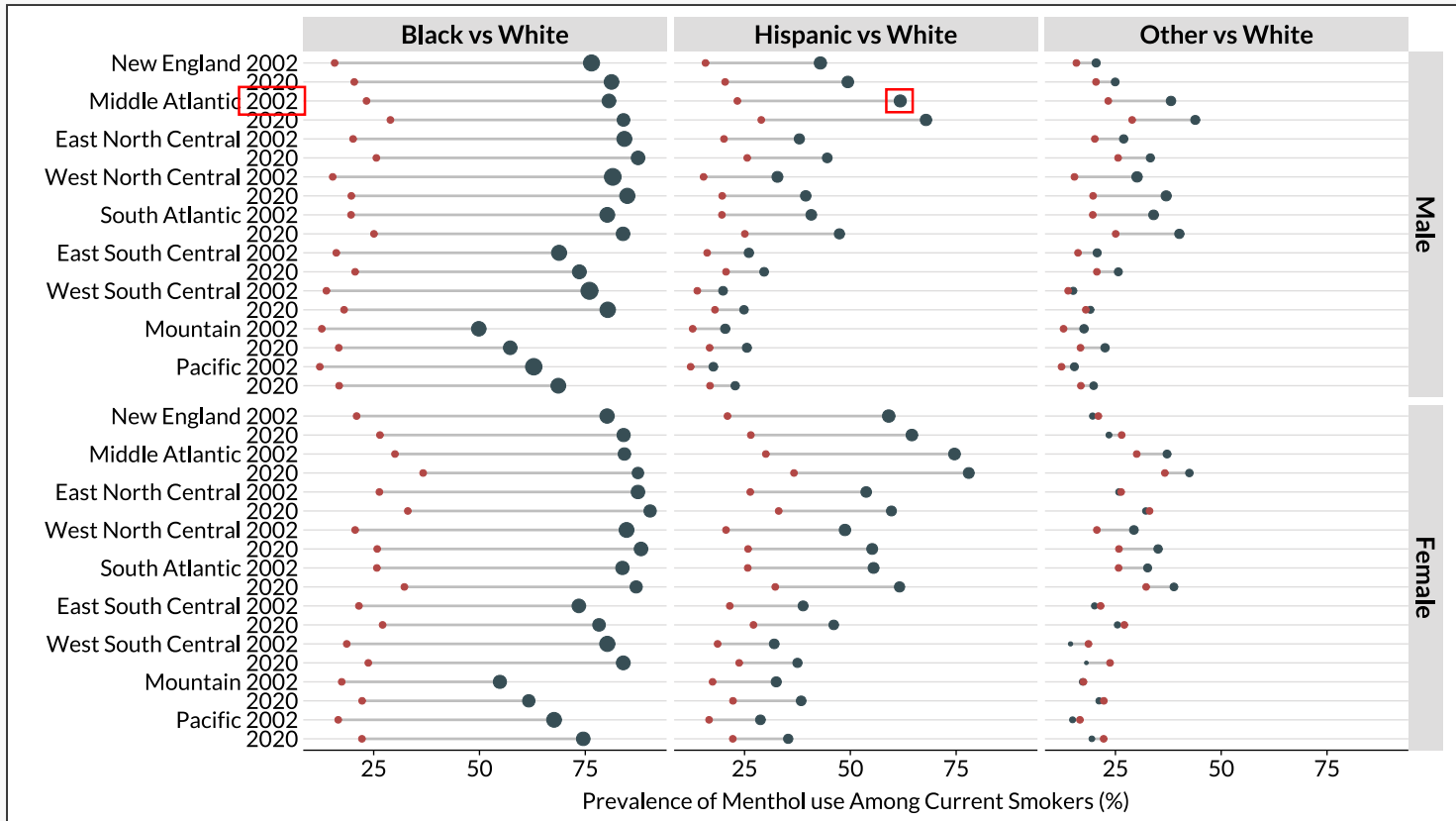
Disparities in Menthol Use by Sex and Ethnicity

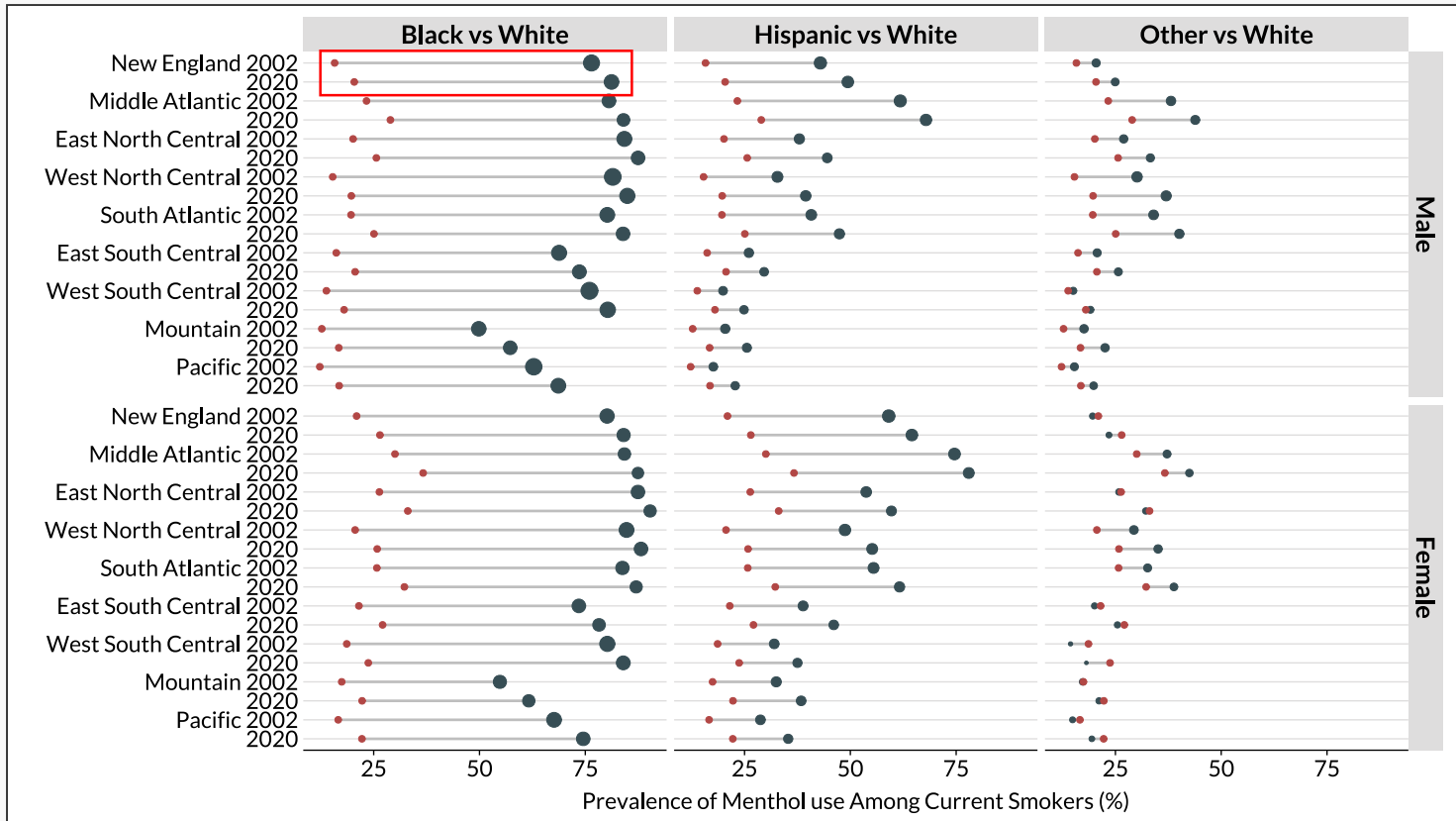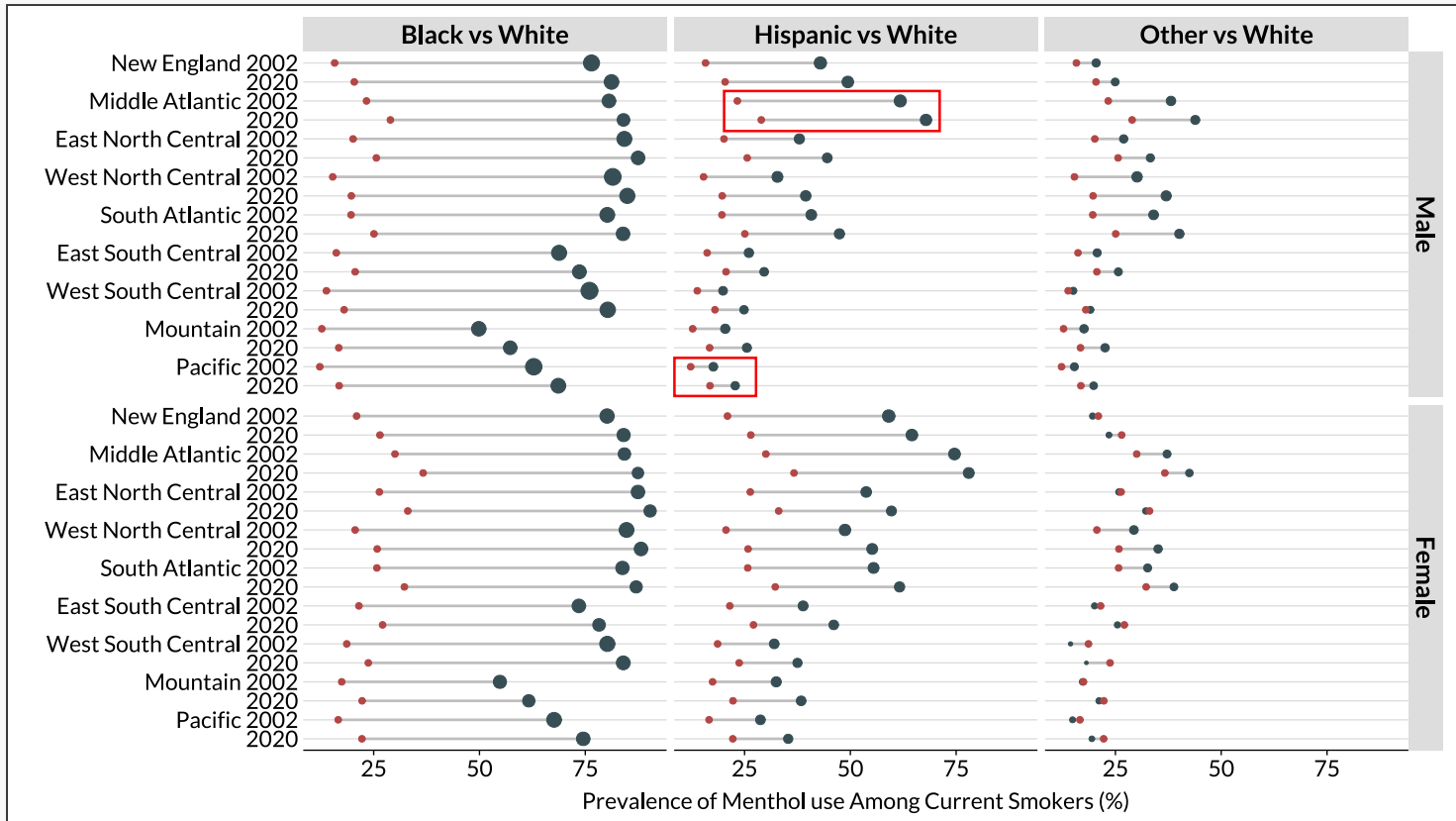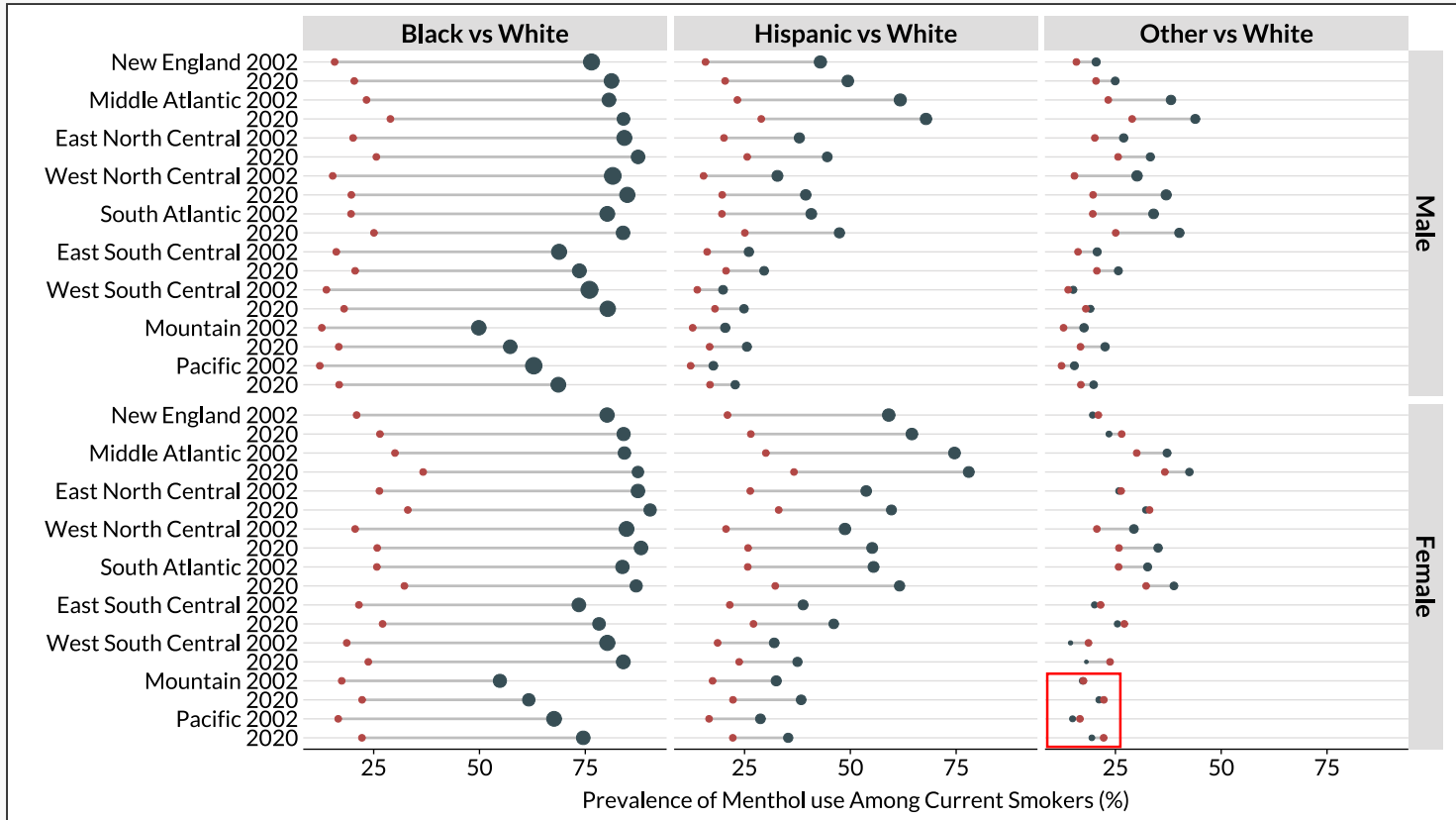# Disparities in Menthol Use by Sex and Ethnicity

Disparities in Menthol Use by Sex and Ethnicity

Disparities in Menthol Use by Sex and Ethnicity

Disparities in Menthol Use by Sex and Ethnicity

Disparities in Menthol Use by Sex and Ethnicity

Summary of Disparities in Menthol Use

- Prevalence of menthol use increased among all groups from 2002 to 2020

- Differences in menthol use between ethnic groups changed little from 2002 to 2020 but varied significantly across census divisions

- Relative to non-Hispanic White people, disparities in use were:
  - Largest for Black people across all census divisions
  - Larger for Hispanic female smokers in New England, the Middle Atlantic, and South Atlantic divisions
  - Smaller for male Hispanic smokers in the Pacific and Mountain divisions

Discussion

Implications

Implications

- The proposed US FDA menthol ban may exert different effects across geographic and demographic subgroups
  - Overall effects will depend on the demographic composition of the population of smokers in different areas of the US
  - But the percentage of menthol smokers expected to quit following the ban <u>may/may</u> not differ across divisions. E.g., Fong et al. (2022): 7.3% greater quit rate among menthol vs. non-menthol smokers. Will this apply across all areas in the US?

Implications

- The proposed US FDA menthol ban may exert different effects across geographic and demographic subgroups
  - Overall effects will depend on the demographic composition of the population of smokers in different areas of the US
  - But the percentage of menthol smokers expected to quit following the ban <u>may/may</u> not differ across divisions. E.g., Fong et al. (2022): 7.3% greater quit rate among menthol vs. non-menthol smokers. Will this apply across all areas in the US?

- Smoking cessation interventions in different states should tailor services to smokers' specific needs to encourage menthol smokers to quit following implementation of the FDA ban

Implications

- The proposed US FDA menthol ban may exert different effects across geographic and demographic subgroups
  - Overall effects will depend on the demographic composition of the population of smokers in different areas of the US
  - But the percentage of menthol smokers expected to quit following the ban <u>may/may</u> not differ across divisions. E.g., Fong et al. (2022): 7.3% greater quit rate among menthol vs. non-menthol smokers. Will this apply across all areas in the US?

- Smoking cessation interventions in different states should tailor services to smokers' specific needs to encourage menthol smokers to quit following implementation of the FDA ban

- Some areas of the US will face larger challenges supporting menthol smokers in their efforts to quit than others, given the size of the population and prevalence of menthol use in those areas (e.g., states in the Middle Atlantic and South Atlantic)

Future Directions

- Adapting small area estimation methods for tobacco control policy evaluation at subnational levels using population survey data

- Applying the methods to other areas, e.g., problematic cannabis use at subnational levels in Canada

Acknowledgements

Acknowledgements

- Shannon Gravely, University of Waterloo

- Karin A. Kasza, Roswell Park Comprehensive Cancer Center

- Mary E. Thompson, University of Waterloo

- Andrew Hyland, Roswell Park Comprehensive Cancer Center

- K. Michael Cummings, Medical University of South Carolina

- Geoffrey T. Fong, University of Waterloo

References

1. Seaman EL, Corcy N, Chang JT, Chomenko D, Hartman AM, Kittner DL, Reyes-Guzman CM. (2022). Menthol cigarette smoking trends among United States adults, 2003-2019. *Cancer Epidemiology, Biomarkers & Prevention,* 31: 1959-1965. https://doi.org/10.1158/1055-9965.EPI-22-0095

2. Gelman A, Little TC. (1997). Poststratification into many categories using hierarchical logistic regression. *Survey Methology,* 23:127-135. https://www150.statcan.gc.ca/n1/en/pub/12-001-x/1997002/article/3616-eng.pdf?st=aHTy4L00

3. Zhang X, Holt JB, Lu H, Wheaton AG, Ford ES, Greenlund KJ, Croft JB. (2014). Multilevel regression and poststratification for small-area estimation of population health outcomes: A case study of chronic obstructive disease prevalence using the Behavioral Risk Factor Surveillance System. *American Journal of Epidemiology,* 179: 1025-1033. https://doi.org/10.1093/aje/kwu018

4. Hanretty C. (2020). An introduction fo multilevel regression and post-stratification for estimating constituency opinion. *Political Studies Review,* 18: 630-645. https://doi.org/10.1177/1478929919864773

5. Wang Y, Zhang Z, Lu H, Croft JB, Greenlund KJ. (2022). Constructing statistical intervals for small area estimates based on generalized linear mixed model in health surveys. *Open Journal of Statistics,* 12: 70-81. https://doi.org/10.4236/ojs.2022.121005

6. Barnhart HX, Haber M, Song J. (2002). Overall concordance correlation coefficient for evaluating agreement among multiple observers. *Biometrics,* 58: 1020-1027. https://doi.org/10.1111/j.0006-341X.2002.01020.x

7. Lin L-IK. (1989). A concordance correlation coefficient to evaluate reproducibility. *Biometrics,* 45: 255-268. https://www.jstor.org/stable/2532051

8. Lin L-IK. (2000). A note on the concordance correlation coefficient. *Biometrics,* 56: 324-325. https://doi.org/10.1111/j.0006-341X.2000.00324.x

9. Fong GT, Chung-Hall J, Meng G, Craig LV, Thompsone ME, Quah ACK, Cummings KM, Hyland A, O'Connor RJ, Levy DT, Delnevo CT, Ganz O, Eissenberg T, Soule EK, Schwartz R, Cohen JE, Chaiton MO. (2022). Impact of Canada's menthol cigarette ban on quitting among menthol smokers: pooled analysis of pre–post evaluation from the ITC Project and the Ontario Menthol Ban Study and projections of impact in the USA. *Tobacco Control.* https://doi.org/10.1136/tobaccocontrol-2021-057227