Predicting Adolescents' Future Smoking Behavior through Anti-Smoking Ad Exposure: A Structural Equation Modeling Approach Based on the Theory of Planned Behavior

by

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Introduction & Rationale

THE PROBLEM

➢ Over 2.22 million High school and Middle school students are current smokers.

➢ Adolescents = key demographic (initiation < age 18).

➢ Smoking = leading cause of preventable death (490,000+ deaths/year in U.S. from tobacco-related illnesses)

INDUSTRY INFLUENCE

➢ $8.6 B spent/ year on tobacco marketing.
➢ Media glamorization normalizes smoking.

KNOWLEDGE GAP

➢ Do anti-smoking advertisements influence adolescents' perceptions or behaviors?

PREVENTION STRATEGY

➢ Anti-smoking ads aim to:
- ✓ Raise risk perception.
- ✓ Strengthen peer disapproval.
- ✓ Empower refusal confidence.

Research Objective & Hypotheses

❖ **Objective**

- Examine how anti-smoking ads and constructs within TPB theory predict smoking intentions and behavior

❖ **Hypothesis**

- H_0: Anti-smoking advertisements have no direct or indirect correlation on adolescents' intentions to use tobacco, nor do they significantly influence attitudes, perceived social norms, or perceived behavioral control in predicting current smoking behavior.
- H_1: Anti-smoking advertisements have a direct and indirect correlation on adolescents' intentions to use tobacco. These advertisements shape key psycho-cognitive factors—such as attitudes, perceived social norms, and perceived behavioral control—which, in turn, influence future smoking intentions and affect current smoking behavior.

Data & Methods

- **Data Source**
  - Dataset: Monitoring the Future (MTF), 2023
  - Design: Cross-sectional, nationally representative
  - Sample: $N \approx 14{,}000$ adolescents (8th & 10th grade)
  - Selection: 3-stage stratified sampling
  - Ethics: No identifiable info on respondents.

- **Variables & Constructs**
  - Latent Constructs (via CFA):
  - Attitudes (ATT) – 3 items
  - Injunctive Norms (INJ) – 2 items
  - Descriptive Norms (DES) – 2 items
  - Perceived Behavioral Control (PBC) – 1 item

- **Observed Variables**
  - Intention (INT) – Future smoking plan
  - Behavior (SMK) – Past 30-day smoking
  - Anti-Smoking Ad Exposure (ADS) – Binary
  - Controls: Gender, Race, Grade, Parental Presence
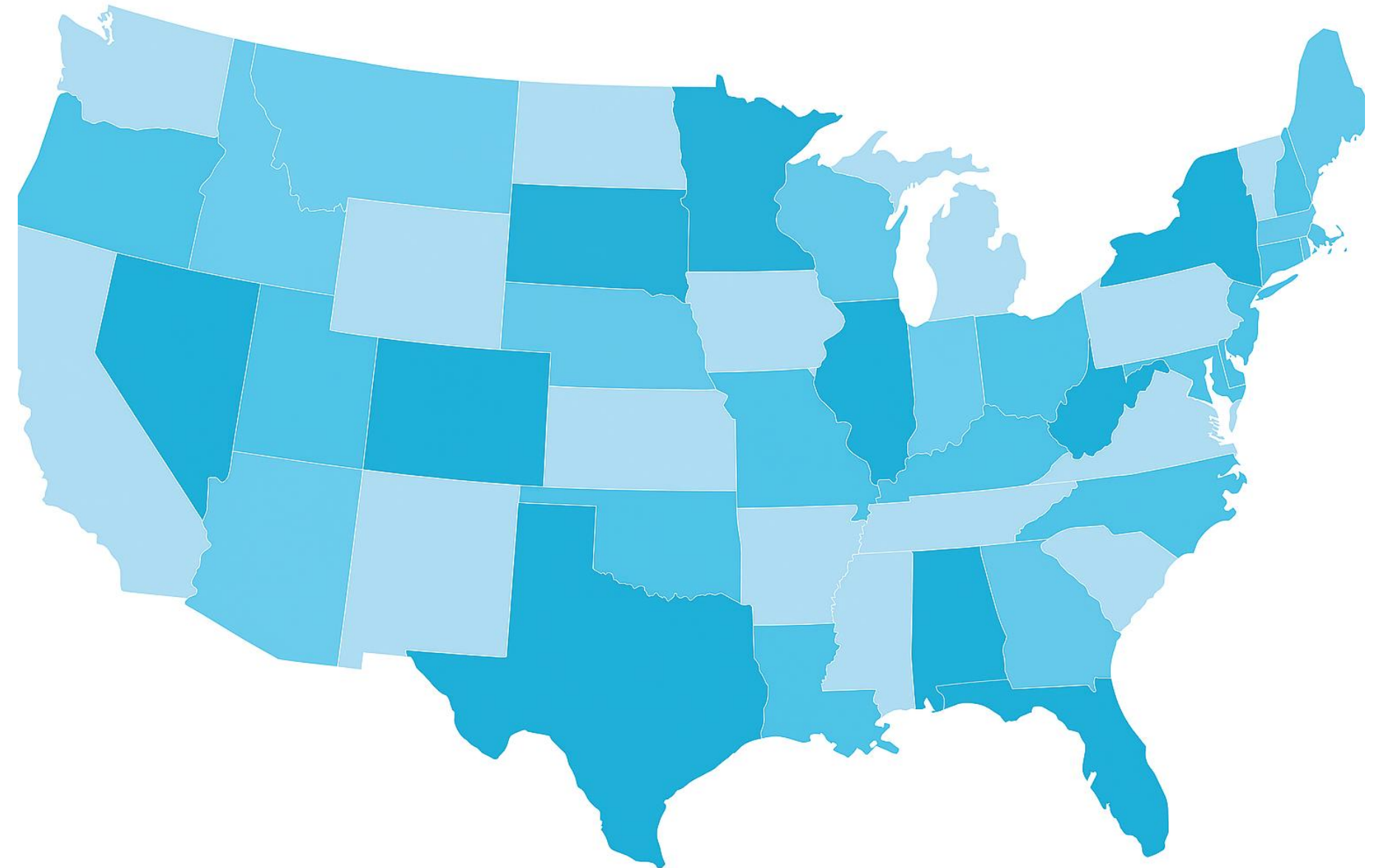
Source: Choropleth map of the contiguous United States. Image generated by OpenAI's DALL·E. July 2025.
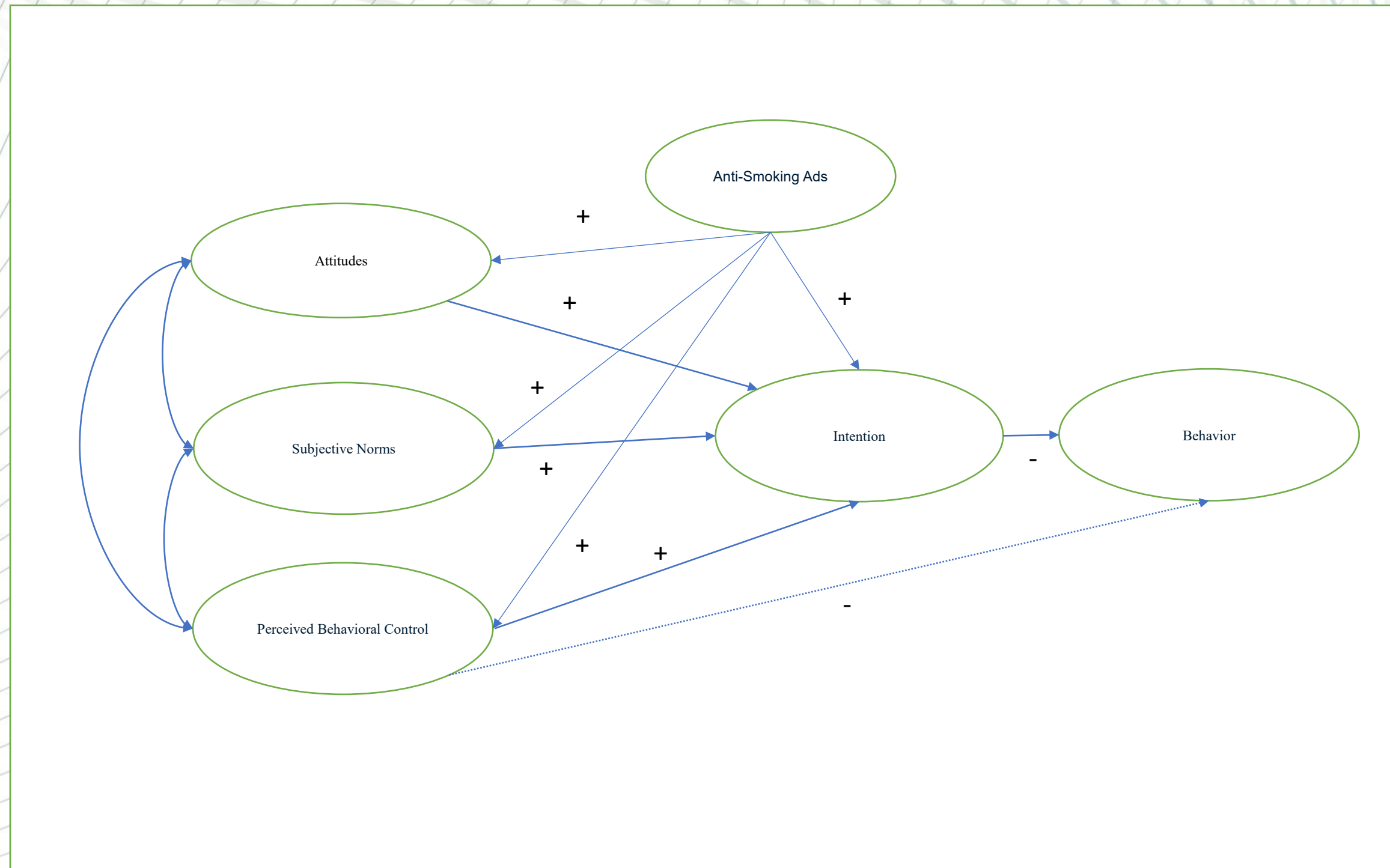
Measurement Model: Constructs and Indicators

| Construct	Indicators	Survey Question (Paraphrased)	Scale
Attitudes	att1, att2, att3	Perceived risk from using tobacco	1 = No risk → 4 = Great risk
Injunctive Norms	inj1, inj2	Friends' disapproval of smoking	1 = Not disapprove → 3 = Strongly disapprove
Descriptive Norms	des1, des2	Friends' tobacco usage	1=All → 5=None
Perceived Control	pbc	Ability/confidence to avoid smoking	1 = Not at all → 4 = Very
Intention	int	Intention of smoking in the next five years	1 = Definitely not → 4 = Definitely yes
Behavior	smk	Current smoking behavior	0 = No / 1 = Yes
Ad Exposure	ads	Exposure to anti-smoking ads	0 = No / 1 = Yes

Note: All indicators are ordinal categorical variables from a nationally representative questionnaire.

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Conceptual Model

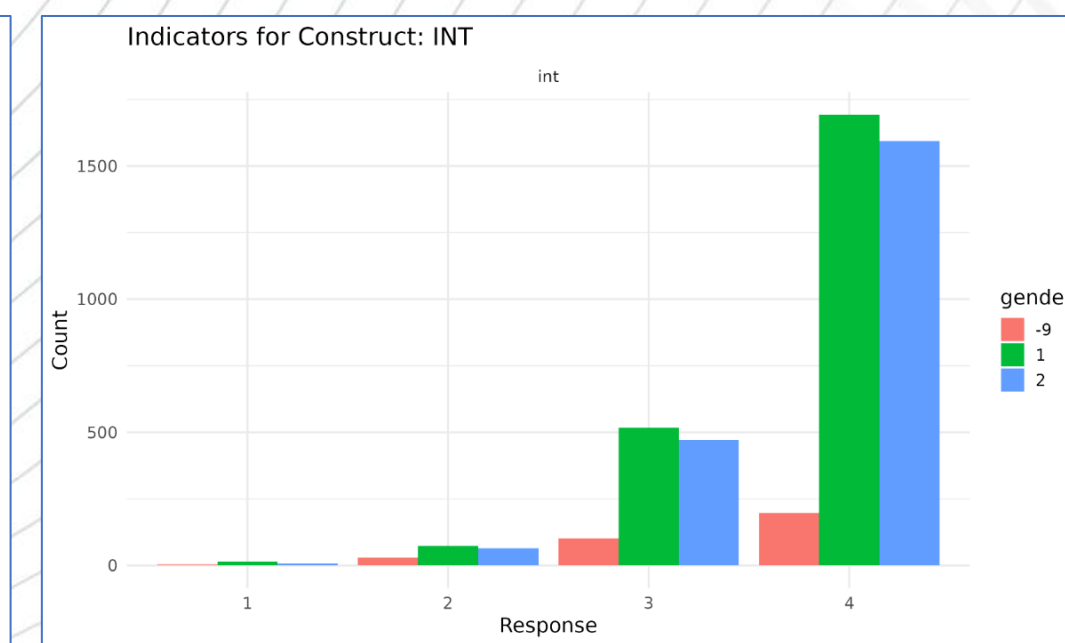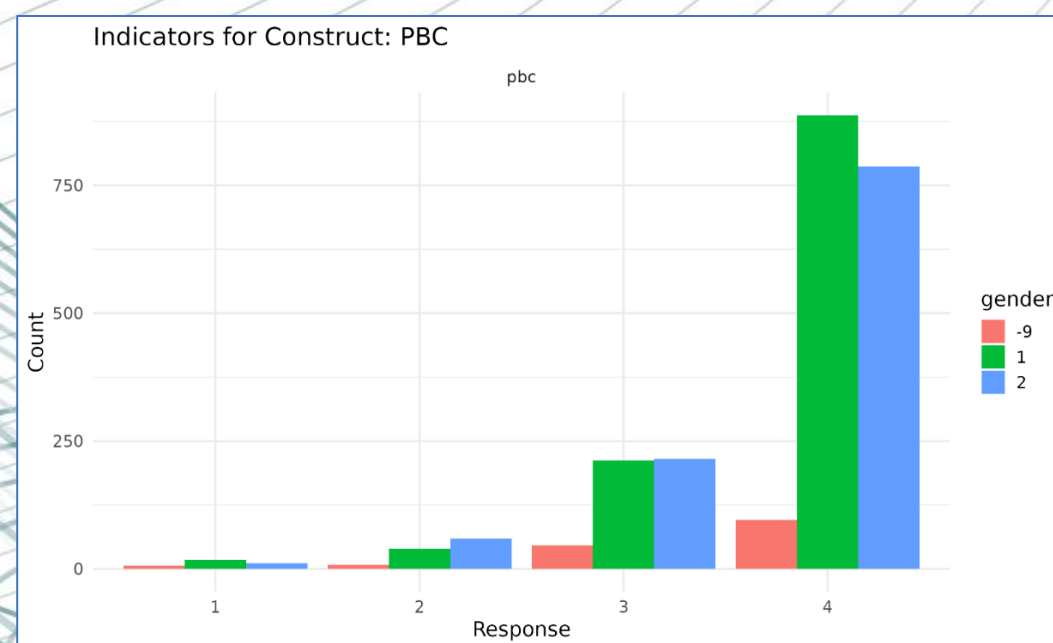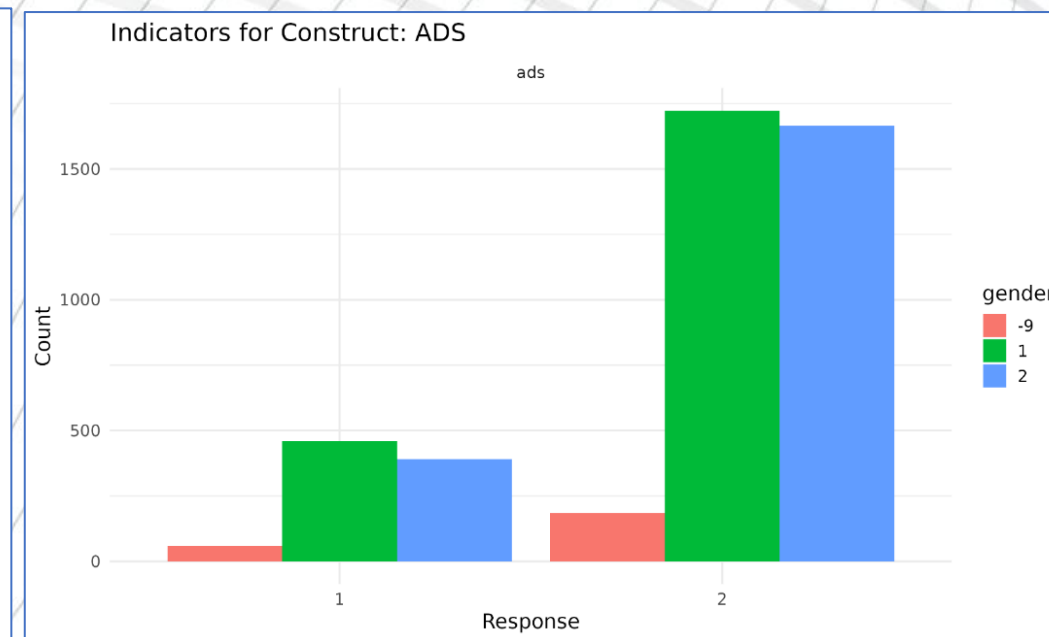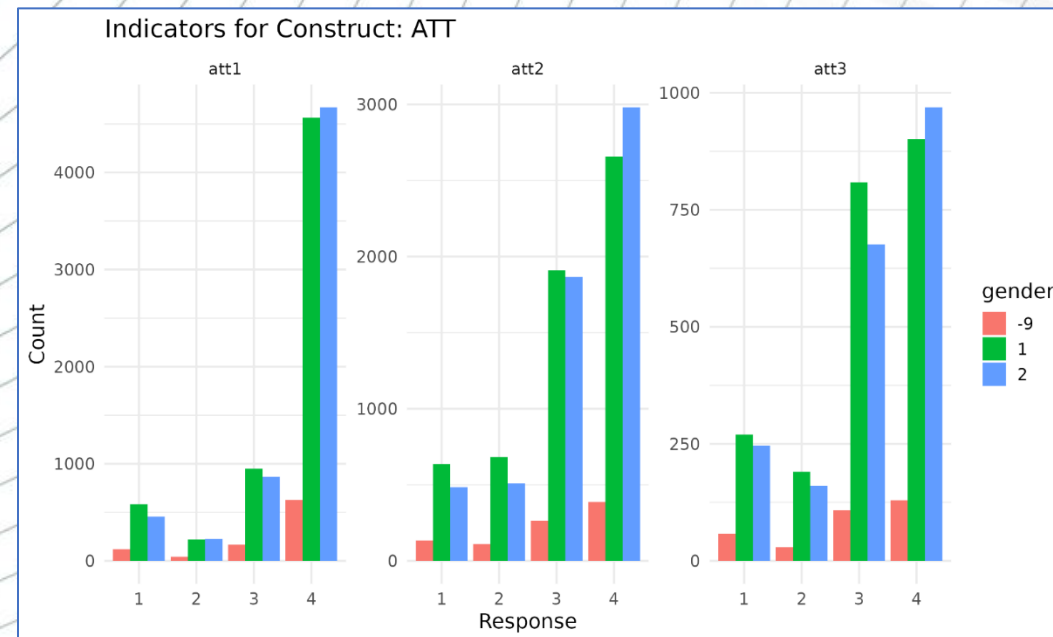Theoretical Framework: Theory of Planned Behavior with Ads & Demographics

Hypothesized Model
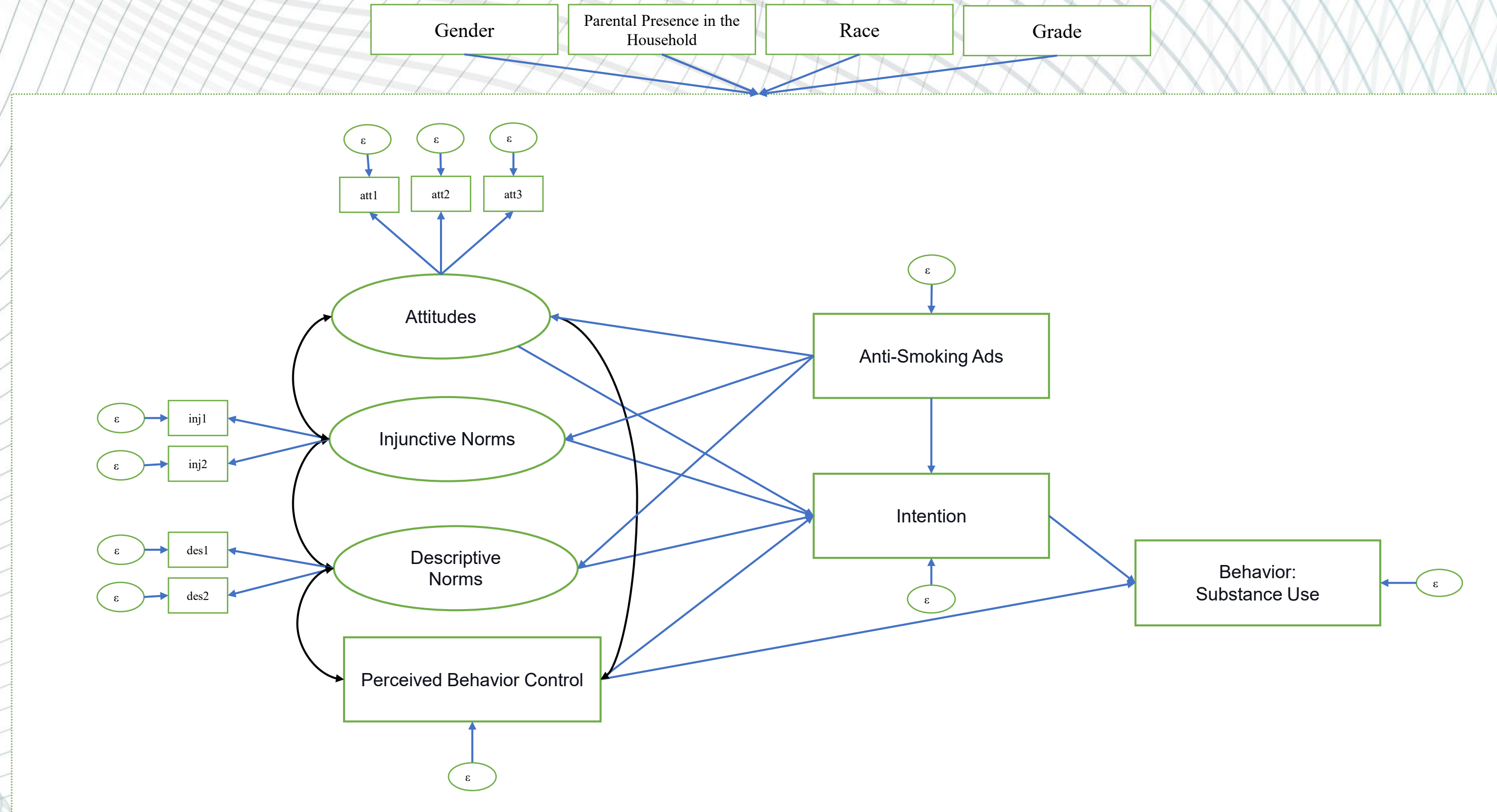
Latent & Observed Constructs with Demographics Visualizer

Interact Live with Shiny App for Data Visualization: mye-chow.shinyapps.io/rstudio

Purpose of the Interactive Tool:

The Shiny App enables real-time exploration of the Theory of Planned Behavior (TPB) theory, allowing users to visualize the impact of anti-smoking ad exposure and psycho-cognitive predictors across demographic subpopulations.

What the Visualization Shows:

Each TPB construct is displayed through its observed indicators, stratified by demographic groups such as gender, grade, race, and parental presence. Users can interactively select constructs and compare response distributions across groups.

Note: Figures showing some examples of the plots created using the R Shiny App.

Measurement Validity: CFA

- **CFI** (Comparative Fit Index) = **0.978**
- **TLI** (Tucker-Lewis Index) = **0.959**
- **RMSEA** (Root Mean Square Error of Approximation) = **0.047**
- **SRMR** (Standardized Root Mean Square Residual) = **0.084**

Note: Figure created with Jupyter Notebook using Python script

Factor Analysis of Latent Constructs

- Purpose
  - Validate the latent constructs (Attitudes, Injunctive Norms, Descriptive Norms) using CFA prior to SEM path analysis.
  - Assess how well observed indicators reflect their theoretical factors under the TPB framework.

- Key Findings
  - Strong Internal Consistency:
    - Attitudes (ATT): CR = 0.93, AVE = 0.82
    - Injunctive Norms (INJ): CR = 0.94, AVE = 0.59
    - Descriptive Norms (DES): CR = 0.89, AVE = 0.53.
- Interpretation
  - Latent constructs are psychometrically strong and have great internal alignment.

SEM Path Analysis

- INT strongest predictor: PBC ($\beta = 0.817$)
- INT → SMK: $\beta = -1.340$
- PBC → SMK: Unexpected positive $\beta = 0.556$
- ADS → INT: Unexpected negative $\beta = -0.283$

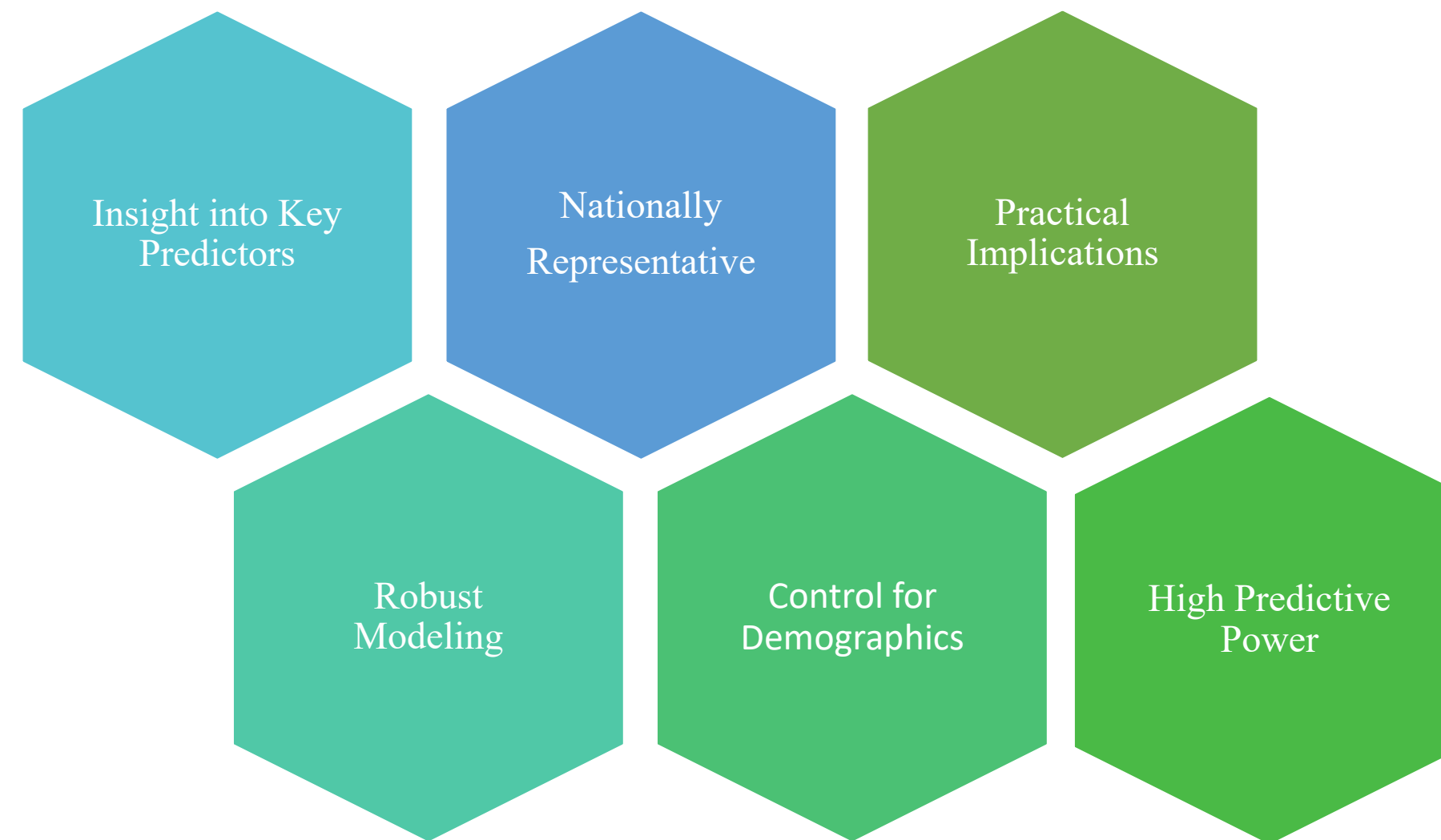|	INT			SMK			ADS		
	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value
PBC	0.817	0.013	< .05	0.556	0.074	< .05	-	-	-
ATT	0.193	0.021	< .05	-	-	-	0.294	0.022	< .05
INJ	0.425	0.025	< .05	-	-	-	0.356	0.025	< .05
DES	0.368	0.024	< .05	-	-	-	0.170	0.029	< .05
SMK	-1.340	0.073	< .05	-	-	-	-	-	-
ADS	-0.283	0.038	< .05	-	-	-	-	-	-

Demographic Insights

- Males have lower ATT, INT, but higher PBC and DES than females.
- Parental presence: higher ATT, DES, and ADS.
- 10th Grade: higher ATT, INT, SMK.
- 8th Grade: lower DES and PBC.

	ATT			INJ			DES			INT			PBC			ADS			SMK		
	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value	β	S.E.	p-value
MALE	-0.045	0.012	< .05	-0.018	0.019	0.330	0.065	0.016	< .05	-0.053	0.025	0.035	0.073	0.027	0.007	-0.030	0.022	0.163	-0.017	0.037	0.647
HISP	-0.040	0.012	0.001	-0.039	0.019	0.045	0.024	0.016	0.126	-0.049	0.025	0.046	-0.004	0.027	0.897	-0.060	0.022	0.005	-0.186	0.041	< .05
BLACK	-0.059	0.012	< .05	0.048	0.019	0.013	0.095	0.017	< .05	-0.105	0.028	< .05	0.148	0.031	< .05	-0.071	0.021	0.001	-0.052	0.042	0.209
GRADE	0.129	0.012	< .05	-0.028	0.019	0.142	-0.115	0.016	< .05	0.115	0.026	< .05	-0.066	0.027	0.016	-0.004	0.022	0.866	0.200	0.039	< .05
PLH	0.033	0.012	0.004	0.025	0.020	0.195	0.035	0.016	0.026	0.003	0.026	0.903	0.012	0.028	0.678	0.074	0.021	< .05	-0.040	0.036	0.269

Discussion

- SEM results rejected the null hypothesis (H_0) and statistically confirmed that anti-smoking ads play a significant role in shaping adolescents' smoking-related beliefs and intentions.

- Strategic targeting and early intervention are essential because adolescents are the future adults of tomorrow.

- Anti-smoking ads are insufficient if not paired with adolescents perceived attitudes, norms, and behavior control to predict future smoking behavior.

- Adolescents' sense of perceived behavior control truly protects them against future smoking, more than anti-smoking ads and peer disapproval.

Strength of the Research

Insight into Key Predictors

Nationally Representative

Practical Implications

Robust Modeling

Control for Demographics

High Predictive Power

Limitations of the Research

Cross-sectional Design — Not able to predict actual future behavior or infer causality due to lack of longitudinal data for the respondents' intentions.

Modest Intervention Impact — Anti-smoking ad exposure had a minimal but negative influence on future smoking avoidance intentions.

Measurement Simplifications — Injunctive and Descriptive Norms measured using only two indicators each.

Possible Social Desirability Bias — Self-reported behaviors and intentions may reflect socially desirable responses rather than actual attitudes or behaviors.

Low Smoking Prevalence — Only ~1% reported recent smoking, possibly limiting the variability needed for stronger behavioral inference.

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From Model to Prevention: Strategic Implications

Evidence-Based Prevention Tactics:

Peer-led campaigns > Traditional Media

Leverages Public Data = Cost-effective
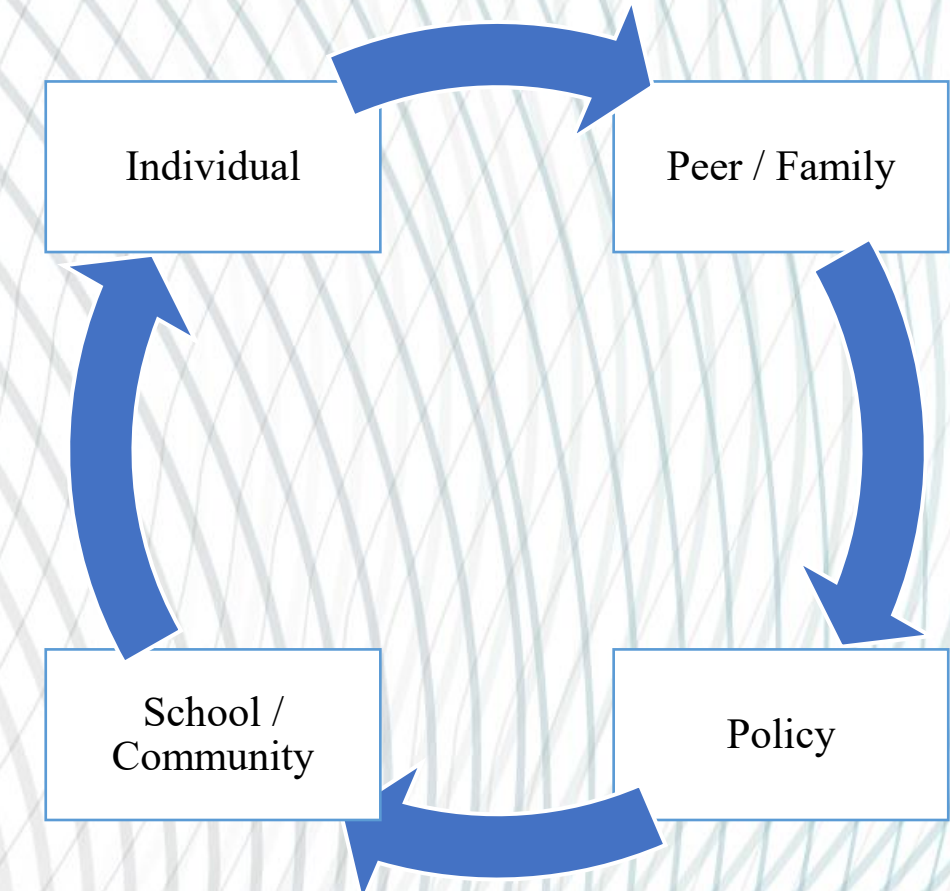
As a Screening Tool to identify High-Risk adolescents early.

Peer Engagement and Family influence in Media-Centric Messaging.

Multi-Level Strategy:

Empowers Peers.

Reinforce Behavior Control.

Transform Norms.

Individual → Peer / Family → Policy → School / Community → Individual

✓ Culturally tailored, scalable, and cost-efficient.

✓ Real-world model for Smoke-free adolescent environments.

Acknowledgments

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- **Dr. Kirpich** – I am especially thankful for your inspiration and encouragement, which motivated me to pursue Biostatistics as my academic path.

- **My family** – For your constant support, love, and belief in me every step of the way. Your presence has been my foundation.

Competencies Demonstrated Through this Master's Thesis

Core Competencies:

1. MPH 3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming, and software, as appropriate.
2. MPH 4. Interpret results of data analysis for public health research, policy, or practice.
3. MPH 22. Apply systems thinking tools to a public health issue.

Concentration Competencies:

1. MPH BSTP 3. Apply advanced (multivariate) descriptive and inferential techniques used with public health data.
3. MPH BSTP 8. Interpret results of statistical analyses found in public health studies.

Questions

Thank you for your attention. Please feel free to ask any questions or share feedback.