Appendix

Regular Soda Policies, School Availability, and High School Student Consumption

Sample

Nationally representative data from annual cross-sectional samples of 10th and 12th grade students were obtained from the three 2010-2012 Monitoring the Future (MTF) studies.[1,2] MTF utilizes a multistage stratified random sampling procedure. Stage 1 involves selection of geographic areas (the 28 largest metropolitan areas in the U.S., in addition to 136 other primary areas); Stage 2 involves selection of one or more schools in each area, and Stage 3 involves selection of students within each school.[1] Surveys were administered in classrooms by University of Michigan personnel; students self-completed questionnaires during a normal class period. School participation rates averaged 56% original and 96% with replacement; student response rates averaged 87% and 84% for 10th and 12th grades, respectively. Absenteeism was the primary reason for missing data; less than 1% of students refused participation.

School administrator data were collected from the schools that had completed participation in the MTF study in 2010-2012 through one component of the Youth, Education, and Society (YES) study, which in turn is part of the larger Bridging the Gap initiative supported by the Robert Wood Johnson Foundation.[3] Mailed questionnaires were sent to administrators in the spring following data collection from students. Data were obtained from 333 schools (93% of the eligible MTF sample). Principals/other administrators completed items on general school characteristics and nutrition policies/programs. It was suggested that food service personnel

complete detailed beverage availability questions; this occurred in 52% of schools.
MTF and YES were conducted by the Institute for Social Research at the University of Michigan (ethical approval obtained from the University of Michigan Behavioral Sciences IRB).

State and district policy data were collected by the University of Illinois at Chicago (UIC), also a part of Bridging the Gap. Protocols and materials were approved by the UIC IRB. State laws, effective beginning in September of each school year, were compiled through natural language and Boolean keyword searches of the full text, tables of contents, and indices of codified state statutory and administrative (regulatory) laws (hereafter collectively referred to as "state policies") commercially available from subscription-based legal research providers and validated against publically available secondary sources.[4] Laws were obtained for all states and were verified against secondary sources to ensure complete capture.[5,6,7] "On-the-books" district policies were gathered for districts in which MTF study schools were located through Internet research with telephone and email follow-up.[8] Neither state nor district policies included non-codified, informal policies in practice. District policies were defined broadly to include the following: the district-approved wellness policy; any associated district administrative regulations, rules, procedures, or guidelines issued by the district superintendent; any policies, regulations, or rules embedded by reference in the wellness policy, rules, or regulations (e.g., competitive food or food service policies); and any state laws or model policies embedded by reference.[4] District-level policy collection was completed for 93% of MTF study schools. All state laws and district policies were simultaneously coded by 2 trained coders using a reliable and valid coding scheme originally developed by Schwartz et al.[9] and revised by Bridging the Gap researchers.[8] All state laws and district policies were evaluated for their applicability at the

high school level. Coding agreement was high (95%-100%); discrepancies were resolved through discussion.

Measures

Student consumption. Students were asked, *Regular (non-diet) soft drinks include Coke, Pepsi, Mountain Dew, Dr. Pepper, etc. How many (if any) 12-ounce cans, or bottles (or the equivalent) of regular (non-diet) soft drinks do you drink PER DAY, on average?* Responses included *none, less than 1, one, two, three, four, five or six, 7 or more*. The resulting response distribution was highly skewed; thus, two dichotomous measures were considered: "any consumption" (none versus less than one or more), and "any daily consumption" (one or more versus none or less than one). Modeling was conducted using both "any" and "daily" outcomes as described below. While results were similar for both outcomes, the strength of associations was stronger for the daily consumption dichotomy. Thus, that measure was retained for reported models.

Statistical Analysis

Analyses were conducted in 2014. Survey commands in SAS, version 12.1 (SAS Institute, Inc., Cary NC) were used for descriptive analyses to obtain SE estimates corrected for the MTF multistage complex sample design (using MTF school and stratum identifiers). Descriptive analyses were weighted with the MTF complex sample design survey weight to adjust for differential selection probability. Multivariate structural equation models (SEM) were conducted using Mplus, version 7.2 (Muthén & Muthén, Los Angeles CA).[10,11] Figure 1 presents path diagrams for the general mediation models utilized. For all mediation models, X indicates the independent variable, M the mediating variable, and Y the outcome variable. Parameter *a* represents the direct association between the independent variable and the mediator; *b* represents

the direct association between the mediator and the outcome variable, and *c* represents the direct association between the independent variable and the outcome variable.[12] All parameter estimates reported are non-standardized multivariate regression coefficients.

State policy, district policy, school availability. The first two research questions involved state-district-school associations. As noted above, the MTF sample design does not include state- or district-level stratification; thus, it was not necessary to include either state or district as separate levels in a multilevel modeling context. The policy domains of interest at both state and district levels classified schools simply as having or not having a mandated competitive venue soda ban; no attempt was made to measure state- or district-specific heterogeneity in regards to policy implementation or associations. Therefore, state, district and school were conceptualized as being on the same level in these models. The modeling approach used was a design-based 1-1-1 SEM model in Mplus, using TYPE=COMPLEX (with CLUSTER equal to the MTF design strata variable), ESTIMATOR=MLR, and INTEGRATION=montecarlo. State-district-school models were all weighted by the sampling weight designed for use when school is the unit of analysis; results are thus interpreted as indicating the percentage of students attending schools with various characteristics, including state and district policy domains. For these analyses:

a measured the direct association between state policy banning school competitive venue soda (X) and the likelihood of a similar ban at the district level;

b measured the direct association between district policy banning competitive venue soda and the likelihood of school competitive venue soda availability (Y), controlling for state policy (X);

c measured the direct association between state policy banning school competitive

venue soda (X) and the likelihood of school competitive venue soda availability (Y), controlling for district policy (M);

The presence of a mediated or indirect[13,14] association between state policy (X) and school soda (Y) through district policy (M) was tested using the MODEL INDIRECT command in Mplus.

Policy, school availability, student consumption. The third research question focused on policy-school-student associations. Results of the previous analyses indicated state policy was associated more strongly with school availability than was district policy. Given that the MTF sample design does not include state-level stratification, analyses utilized a 2-2-1 model (see bottom of Figure 1), with X (state policy) and M (school soda availability) measured at Level 2, and Y (student soda consumption) measured at Level 1. A hybrid model-/design-based approach[15,16] in Mplus specifically focused on multilevel SEM modeling with complex survey data was used by specifying TYPE=COMPLEX TWOLEVEL (with CLUSTER equal to the MTF design strata and school ID variables), ESTIMATOR=MLR, and INTEGRATION=montecarlo.[10] Student-level controls were modeled at the within level; school- and state-level covariates were modeled at the between level. MTF currently does not have separate student- and school-level weights designed for multilevel modeling. Instead, the MTF complex sample survey weight was included as a model covariate (grand-mean centered) and covariates specifically relating to probability of selection were included in all models (school total enrollment and population density of the school district). The SUBPOPULATION command was used to run models specifically focusing on African American high school students. For these analyses:

a measured the direct association between state policy banning school competitive

venue soda (X) and the likelihood of schools having competitive venue soda availability;

b measured the direct association between school competitive venue soda availability (M) and the proportion of students in a school reporting daily soda consumption (latent school-level Y), controlling for state policy (X);

c measured the direct association between state policy banning school competitive venue soda (X) and the proportion of students in a school reporting daily soda consumption (latent school-level Y), controlling for school availability (M);

The presence of a mediated or indirect[13,14] association between state policy (X) and student daily soda consumption (latent school-level Y) through school competitive venue soda availability (M) was tested by using the MODEL CONSTRAINT command in Mplus (computing *a*b* and testing for significance).

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Appendix Table 1. State Policy, School Soda Availability and Overall High School Student Soda Consumption, 2010-2012[a]

		Coefficient[b]	(SE)	p
All High School Students				
Separate non-mediation multivariate total association analyses[c]				
State mandated soda ban → Student consumption		-0.072	(0.077)	0.353
School soda availability → Student consumption		0.049	(0.062)	0.429
2-2-1 Multivariate mediation analyses				
Level 2 State mandated soda ban				
Level 2 School soda availability				
Level 1 Student daily soda consumption				
a	State ban → Schools soda availability	**-0.208**	(0.066)	0.002
b	School soda availability → Student consumption	0.016	(0.059)	0.786
c	State ban → Student consumption	-0.084	(0.086)	0.324
a*b	Mediation or indirect effect	-0.003	(0.012)	0.779

[a]Models clustered by school and sample design strata and included the sample design weight as a grand mean centered covariate. All models simultaneously controlled for Level 1 student characteristics (race/ethnicity, gender, average parental education), Level 2 school characteristics (grade, percentage of student body eligible for free and reduced price lunch, total enrollment, population density), and Level 2 state characteristics (percent white population, population density, adolescent obesity rates, region) and year. Level 1 n = 7,877; Level 2 n = 266.

[b]Boldface for coefficients indicates significant p values.

[c]Models examining total associations run separately for state bans and school availability.