Maryland Alcohol Sales Tax and Sexually Transmitted Infections

A Natural Experiment

Stephanie A.S. Staras, PhD,[1] Melvin D. Livingston, PhD,[1,2] Alexander C. Wagenaar, PhD[1]

Introduction: Sexually transmitted infections are common causes of morbidity and mortality, including infertility and certain types of cancer. Alcohol tax increases may decrease sexually transmitted infection rates overall and differentially across population subgroups by decreasing alcohol consumption in general and prior to sex, thus decreasing sexual risk taking and sexually transmitted infection acquisition. This study investigated the effects of a Maryland increase in alcohol beverage sales tax on statewide gonorrhea and chlamydia rates overall and within age, gender, and race/ethnicity subpopulations.

Methods: This study used an interrupted time series design, including multiple cross-state comparisons, to examine the effects of the 2011 alcohol tax increase in Maryland on chlamydia and gonorrhea cases reported to the U.S. National Notifiable Disease Surveillance System for January 2003 to December 2012 (N=120 repeated monthly observations, analyzed in 2015). Effects were assessed with Box—Jenkins autoregressive moving average models with structural parameters.

Results: After the alcohol-specific sales tax increase, gonorrhea rates decreased 24% (95% CI=11%, 37%), resulting in 1,600 fewer statewide gonorrhea cases annually. Cohen's *d* indicated a substantial effect of the tax increase on gonorrhea rates (range across control group models, −1.25 to −1.42). The study did not find evidence of an effect on chlamydia or differential effects across age, race/ethnicity, or gender subgroups.

Conclusions: Results strengthen the evidence from prior studies of alcohol taxes influencing gonorrhea rates and extend health prevention effects from alcohol excise to sales taxes. Alcohol tax increases may be an efficient strategy for reducing sexually transmitted infections.
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Introduction

In 2008, approximately 110 million incident sexually transmitted infections (STIs) occurred in the U.S.[1] STIs increase the risk of acquiring HIV and cause other long-term health problems, including cancer (cervical, vaginal, anal, oral, throat, and penile), infertility, and ectopic pregnancy.[2–4] In the U.S., wide race/ethnicity and age disparities exist. Compared with non-Hispanic whites, STIs are more common among non-Hispanic blacks (two to 22 times) and Hispanics (two times).[5–7] Half of STI cases occur among those aged 15−24 years.[1] Scalable, practical interventions are needed to reduce STI rates, particularly among minorities and young adults.

There are clearly plausible mechanisms by which alcohol taxes may decrease population STI rates. Extensive literature demonstrates that increased alcohol taxes lower alcohol consumption and affect drinking patterns.[8,9] Lower alcohol consumption caused by alcohol tax increases should, on average, translate to lower alcohol consumption prior to sex, reduced alcohol-related sexual risk-taking (i.e., sex, unprotected sex, and casual or new partners), and reduced population-level STIs.[10–15] Additionally, lower alcohol consumption may reduce population STI rates by influencing other alcohol-related STI risk factors (e.g., partner violence, transactional sex, anal sex).[16,17]

From the [1]Department of Health Outcomes and Policy, College of Medicine, and the Institute for Child Health Policy, University of Florida, Gainesville, Florida; and [2]Department of Biostatistics and Epidemiology, School of Public Health, University of North Texas Health Science Center, Fort Worth, Texas

Address correspondence to: Stephanie A. S. Staras, PhD, University of Florida, College of Medicine, Department of Health Outcomes and Policy, 2004 Mowry Road, Room 2238, Gainesville FL 32610. E-mail: sstaras@ufl.edu.

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Alcohol price and tax increases significantly decrease a wide range of alcohol-related morbidity and mortality.[18] A handful of studies suggest alcohol taxes influence STIs.[19–21] A quasi-experimental study accounting for temporal trends in STI rates and income found a 2009 Illinois alcohol excise tax increase reduced statewide gonorrhea and chlamydia rates.[19] A similarly rigorous evaluation, using fixed effects models to adjust for temporal STI rate trends, found state beer and liquor taxes in 1982–1994 were associated with lower statewide gonorrhea and syphilis rates.[21] Adding consistency and evidence for another STI, a less rigorous evaluation found increased state beer taxes associated with decreased gonorrhea (1981–2001) and 8-year lagged AIDS rates (1982–2001).[20] Finally, after accounting for state-level differences, the 1991 federal beer tax increase was associated with lower nationwide gonorrhea and syphilis rates.[21] For public health and policy relevance, the link between alcohol tax and STI rates needs confirmation from additional recent alcohol tax changes.

Differential responses to increased alcohol taxation across subpopulations (e.g., age, gender, and race/ethnicity) are possible, owing to differing STI rates, beverage preferences, drinking locations, and price sensitivity.[1,5,22] For example, alcohol taxation may have a stronger influence on STIs among younger than older adults because those aged <25 years are more likely to have STIs and to drink on-trade (i.e., venues where they may meet new sex partners).[22] Similarly, alcohol taxation may have a stronger influence on STI rates among women than men because women appear more sensitive to alcohol price changes.[22] The few studies considering differing effects of alcohol taxes on alcohol-related health outcomes across subpopulations show conflicting results.[19,20,23]

To increase understanding of the influence of alcohol tax increases on STI rates, this study investigated the effects of a 2011 alcohol-specific sales tax increase in Maryland on statewide gonorrhea and chlamydia rates overall and across age, gender, and race/ethnicity subgroups. The Maryland case is noteworthy for two reasons[9,18]: (1) the 50% tax rate increase is large compared with typical tax adjustments and (2) the sales tax change is a different tax mechanism than excise taxes evaluated in most previous studies.

Tax mechanisms influence whether taxes are included in the posted price (excise taxes) or added at the cash register (sales taxes) and potentially affect the salience to and behavior of consumers.[24] Gonorrhea and chlamydia are required to be reported nationally (resulting in quality measurement), have a relatively high incidence compared with other STIs (increasing statistical power), and have a lag time of 2–3 weeks between acquisition and symptoms (decreasing the time between exposure and diagnosis).[29,25] Because the same behaviors lead to many STIs, observed alcohol tax policy effects on well-measured gonorrhea and chlamydia rates are likely applicable to other STIs, including HIV.

Methods

Design and Sample

In 2015, the authors used an interrupted time series quasi-experimental design to examine the effect of a July 2011 Maryland alcohol sales tax increase on gonorrhea and chlamydia rates. Gonorrhea and chlamydia cases were obtained from the National Notifiable Disease Surveillance System for available months: January 2003 to December 2012—102 months prior to and 18 months following the alcohol tax increase. To account for possible effects of unmeasured factors affecting STI rates, three control groups were considered: (1) a multistate comparison group; (2) a similarity-based control; and (3) a regional control.

For the multistate comparison group, the authors chose all of the 48 U.S. contiguous states that did not: (1) have alcohol tax changes during the study period; (2) share a geographic border with Maryland to avoid potential bias from residents avoiding the tax increase by purchasing alcohol in an adjacent state; and (3) have a government monopoly system for sales of any major alcoholic beverage type.

Government monopoly systems have a fundamentally different definition of alcohol tax because state Alcoholic Beverage Control administrators can change prices at will and such changes are not included in legislated taxes. The multistate comparison group included California, Arizona, Colorado, Indiana, Wisconsin, New Mexico, Texas, North Dakota, South Dakota, Oklahoma, Louisiana, Florida, and Rhode Island.

Within the multistate comparison group, the authors selected similarity-based states as states with the most similar baseline gonorrhea and chlamydia series using an integrated periodogram dissimilarity index (Colorado for gonorrhea and Oklahoma for chlamydia).[26,27] To adjust for possible regional variations, Rhode Island was selected—the only state in the northeast U.S. meeting the comparison criteria.

Maryland Alcohol Taxes

Maryland imposes an excise tax on businesses engaged in manufacturing or wholesaling alcoholic beverages.[28] Tax rates have been stable since 1972 for beer and wine and since 1955 for distilled spirits. Maryland counties and municipalities may not impose alcoholic beverage taxes.[28]

Maryland levies a general sales tax on the retail sale of tangible personal property, including alcoholic beverages.[29] From January 1, 1989 to June 30, 2008, the general sales tax rate was 5%.[30] Effective July 1, 2008, the rate increased to 6% and remained at that rate until July 1, 2011.[31] Effective July 1, 2011, Maryland increased the sales tax rate for alcoholic beverages to 9%.[32] Sales tax rates for all other tangible personal property remained at 6%.

Sexually Transmitted Infection Rates

The authors obtained all available months (January 2003 through December 2012) of state-level STI counts.[33] STI counts were available separately by race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, American Indian or American Native, Asian or Pacific Islander, and unknown), age (15−19, 20−24, 25−29, and ≥30 years), and gender. To control for differences in population size between race/ethnicity, age, and gender subgroups within Maryland and between Maryland and comparison groups, monthly STI rates were calculated overall and for each subgroup with estimated population sizes.[34,35]

Statistical Analysis

To account for potential autocorrelations of STI rates over time within Maryland, including potential seasonality, Box−Jenkins autoregressive moving average (ARIMA) models with structural parameters were run in SAS, version 9.3. Gonorrhea and chlamydia were considered independent STIs. Thus, for each STI, the overall population-level effect was estimated with the following form:

$$Y_t = \beta_0 + \beta_1{}^*GenTax_t + \beta_2{}^*AlcTax_t + \beta_3{}^*X_t + \text{ARIMA noise model}$$

Y_t represents the Maryland STI rate (cases per 100,000) at month t. $GenTax_t$ indicates the July 2008 general sales tax increase in month t. The authors did not consider the general sales tax change an important predictor because the 1% increase applied to all products, and thus is not expected to cause a shift in purchasing from alcohol to other products. $AlcTax_t$ is an indicator for the July 2011 alcohol-specific sales tax increase in month t. X_t is the control group STI rate in month t. Following accounting for the ARIMA noise model form $(1,0,0)(1,0,0)_{12}$, visual inspection of residual autocorrelation and partial autocorrelation functions demonstrated adequate fit. Noise model residuals were indistinguishable from white noise up to the 24th lag (Box−Ljung test). The authors assumed stationary data (augmented Dickey−Fuller $p < 0.0001$) and normally distributed residuals (mean events per month ≥20).

Four models were estimated for each STI: unadjusted, adjusted for the multistate control, adjusted for the similarity-based control, and adjusted for the regional control. All parameter estimates were converted into percentage change (relative to baseline period series mean) and Cohen's *d* (estimated with the baseline period series SD).

The authors performed two additional sensitivity analyses to assess finding robustness. To assess the influence of parametric decisions, STI counts and log-transformed rates were used as the outcome. To assess the influence of the early baseline period years, models were restricted to the most recent 36 months (18 months pre and post tax change).

To assess whether the alcohol sales tax increase affected subgroups differentially, a pooled time series approach was used with the arima() and lrtest() functions in R, version 3.1.3.[36] Subgroup time series were linked together in a single super-vector. Dummy variables distinguished subgroups and represented the group-specific tax effects. Differential effects were tested across subgroups with likelihood ratio tests. An ARIMA noise model of the form $(5,0,0)(0,0,0)_{12}$ was used because it can approximate a large number of underlying ARIMA models, find a sufficient correlation structure for the whole super series, and likely produces accurate effect estimates when subgroup variability causes misspecification.[37–39]

Results

In Maryland, monthly gonorrhea rates ranged from six to 15 cases per 100,000 population, with a mean of 11 cases per 100,000 per month before the tax increase (January 2003 to June 2011) and from six to 12 cases per 100,000, with a mean of nine cases per 100,000 per month following the tax increase (July 2011 to December 2012) (Figure 1). Prior to the tax increase in Maryland, gonorrhea rates in the multistate control group ranged from six to 11 cases per 100,000 population, with a mean of nine cases per 100,000 (Figure 1A). Visual inspection suggests that prior to the tax increase, gonorrhea rates in Maryland were higher than rates in the similarity-based and regional controls (Figure 1B and 1C). Following the tax change, the gonorrhea rate appears to decrease in Maryland and not among the three control groups. The figure is included to visually observe the monthly gonorrhea rates before and after the tax change, but interpretation should be limited to ARIMA modeling results.

Following the 2011 Maryland alcohol tax increase, a significant reduction in gonorrhea infections was found regardless of the control group ($p \leq 0.001$) (Table 1). Controlling for changes in the multistate comparison group, the Maryland tax increase reduced the number of diagnosed gonorrhea infections by 2.6 per month per 100,000 people—equivalent to nearly 1,600 fewer cases per year. Gonorrhea cases were reduced by 24% with a large intervention effect (Cohen's d=1.43). Effect estimates were similar when the similarity-based control, the regional control, and no adjustment were used (Table 1).

Sensitivity analyses produced little or no change in the estimated effect of the alcohol tax increase on gonorrhea rates. Effect estimates for counts and log-transformed rates were similar. Restricting the baseline period to the 18 months prior to the tax change resulted in marginally higher effect estimates. There was no difference in the effects of the Maryland alcohol sales tax for gonorrhea across race/ethnicity, age, and gender subgroups. The 2008 general sales tax was not associated with gonorrhea rates.

In Maryland, monthly chlamydia rates ranged from 12 to 69 cases per 100,000, with a mean of 35 cases per 100,000 per month before the tax increase (January 2003 to June 2011) and from 23 to 52, with a mean of 39 cases per 100,000 per month following the tax increase (July 2011 to December 2012) (Figure 2). Compared with the gonorrhea series (Figure 1), the chlamydia rate series were more similar between Maryland and each

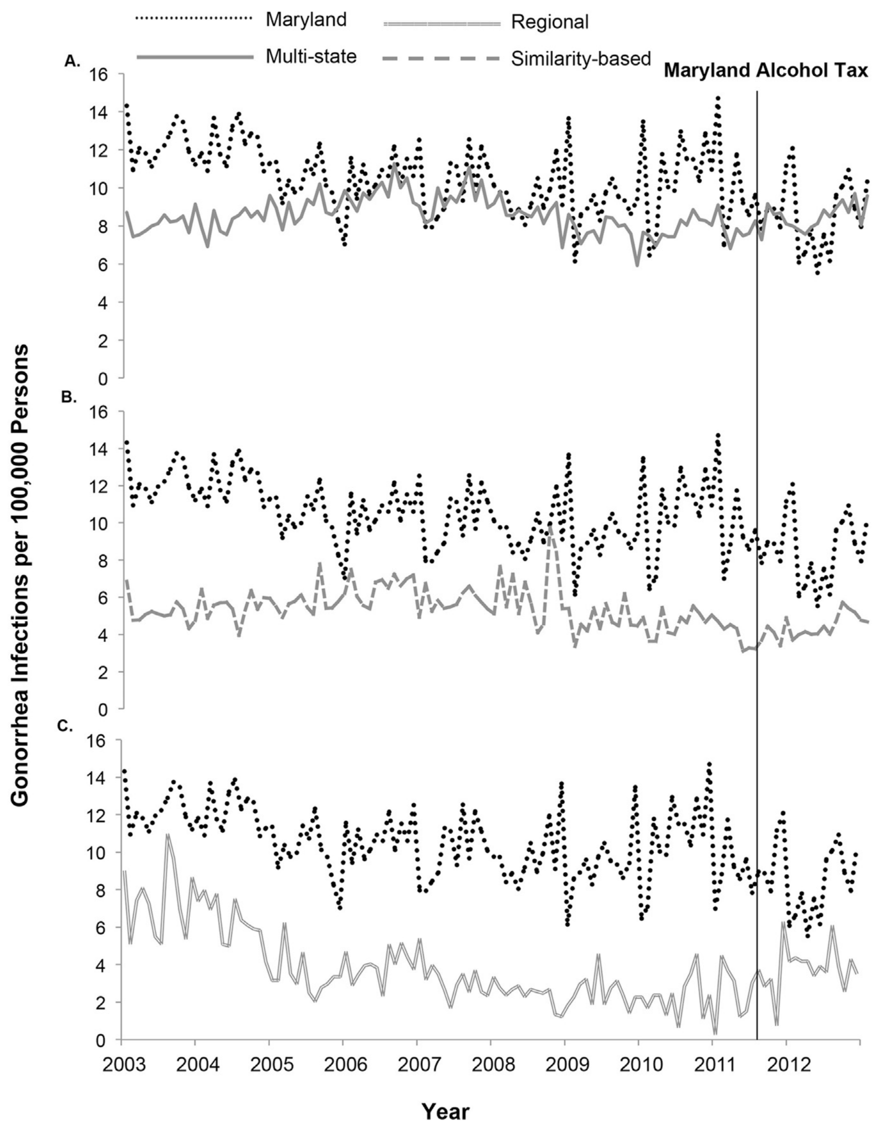

Figure 1. Monthly gonorrhea rates in Maryland and comparison groups from 2003 to 2012.

comparison group (Figure 2). Across groups, chlamydia rates appeared to increase similarly across time.

Regardless of the control group that was considered, results showed no significant changes in chlamydia cases following the tax increase overall (Table 1) or within subgroups. Similar null results were found with count and log-transformed rate outcomes. When restricting the baseline period to the 18 months prior to the tax change, chlamydia rates decreased 5.5 cases per 100,000 people per month in Maryland compared with the multistate control group (p=0.03). The 2008 general sales tax was not associated with chlamydia rates in any model.

Discussion

A 2011 Maryland 50% increase in alcohol-specific sales tax decreased statewide gonorrhea rates by an estimated 24%—preventing nearly 1,600 gonorrhea cases annually. Findings are consistent with the few previous studies showing decreased STIs with increased alcohol taxes.[19–21] State-level alcohol policies may be one answer to the national call for interventions, with potential to substantially reduce population-wide STI rates, possibly including HIV.

The observed effect of the Maryland alcohol tax strengthens evidence of an effect of alcohol taxes on gonorrhea rates by providing a more recent and robust analysis, and expanding the literature from excise to sales tax effects.[19–21] It remains difficult to compare the magnitude of tax effects across studies because of numerous tax nuances, including mechanism (percentage versus cents per gallon), differing baseline tax rates, and size of legislated changes, as well as differences in STI rates across states. Given such cross-state differences and

Table 1. Effects of Maryland 2011 Alcohol Sales Tax Increase Adjusting for Various Comparison Groups

	Change in rate per 100,000 individuals per month (SE)	*p*-value	% Change (95% CI)	Cohen's *d*
Effect of alcohol tax increase on gonorrhea				
Unadjusted	−2.3 (0.6)	<**0.001**	−21.8 (−33.1, −10.5)	−1.28
Adjusted for multi-state control[a]	−2.6 (0.7)	<**0.001**	−24.3 (−37.0, −11.5)	−1.42
Adjusted for similarity-based control[b]	−2.3 (0.6)	<**0.001**	−21.3 (−33.0, −9.7)	−1.25
Adjusted for regional control[c]	−2.6 (0.5)	<**0.001**	−26.7 (−33.5, −13.9)	−1.39
Effect of alcohol tax increase on chlamydia				
Unadjusted	−2.0 (2.6)	0.452	−6.0 (−21.7, 9.6)	−0.25
Adjusted for multi-state control	−2.0 (2.6)	0.434	−6.3 (−21.9, 9.3)	−0.26
Adjusted for similarity based control	−1.9 (2.6)	0.461	−6.0 (−21.7, 9.8)	−0.25
Adjusted for regional control	−2.7 (2.6)	0.304	−8.4 (−24.2, 7.5)	−0.35

Note: Boldface indicates statistical significance ($p < 0.05$).
[a]All of the 48 U.S. contiguous states that did not: (1) have alcohol tax changes during the study period, (2) share a geographic border with Maryland, and (3) have a government monopoly system for sales of any major alcoholic beverage type. California, Arizona, Colorado, Indiana, Wisconsin, New Mexico, Texas, North Dakota, South Dakota, Oklahoma, Louisiana, Florida, and Rhode Island.
[b]Colorado for gonorrhea and Oklahoma for chlamydia. Selected with an integrated periodogram dissimilarity index to detect the most similar baseline gonorrhea and chlamydia series.
[c]Rhode Island, the only state in the northeast U.S. not excluded based on the criteria listed above for multi-state control.

that this study is the only STI outcome study assessing a U.S. state alcohol sales rather than excise tax change, it is unclear whether the findings are consistent with suggestions that sales taxes are less salient to consumers.[24] But, at least in Maryland, alcohol sales taxes have beneficial health effects similar to those of excise taxes.

Two differences between gonorrhea and chlamydia may explain the findings of an effect of the alcohol tax on gonorrhea and not chlamydia. First, compared with chlamydia cases, gonorrhea cases are typically more geographically concentrated and restricted to higher-risk populations (e.g., high levels of sexual mixing, concurrent partners).[40,41] Thus, a population-based intervention might influence the population rate of gonorrhea quicker than chlamydia. Second, the outcome data may be less sensitive to changes in chlamydia than gonorrhea. Surveillance data are more likely to under-represent chlamydia than gonorrhea infections because chlamydia-infected individuals are less likely to seek testing, owing to an increased probability of asymptomatic or mild infections and a lack of chlamydia partner-notification services.[1,42]

When considered with other studies,[19,23] the present findings of nondifferential effects across subgroups suggest alcohol tax effects on alcohol-related morbidity and mortality across subpopulations are complex. For example, the apparent contrast between this study and the most similar previous study (showing larger tax effects on STI rates among younger and minority populations in Illinois) may be explained by differences in the alcohol taxes and base populations.[19] First, the alcohol taxes were different—across beverage types, Maryland increased sales tax proportionately, but Illinois increased excise tax differentially. A disproportionate tax increase would create subgroup differences in effects by beverage preferences.[22] For example, some subgroups tend to prefer beer, others spirits. A legislated tax change that increases the beer tax a tiny amount but increases the spirits tax a large amount is more likely to induce subgroup differences in effects. Second, the base populations were different—baseline STI rates and mean incomes (influencing discretionary income and alcohol purchasing) across racial/ethnic groups were more similar in Maryland than in Illinois prior to the tax changes.[43,44]

These findings add to the mounting evidence that alcohol tax increases appear to be efficient structural intervention for STIs, especially STIs in concentrated or high-risk populations like gonorrhea and HIV. The only structural intervention promoted by CDC is condom distribution.[45] The observed alcohol tax effects (24% decrease in gonorrhea) are similar to effects of condom distribution (23%–30% decrease).[46] Moreover, condom distribution programs cost, whereas alcohol taxes generate revenues.

Limitations

This study has three important limitations. First, like all nonrandomized policy interventions, this study did not have a randomly assigned control group. Thus, the true

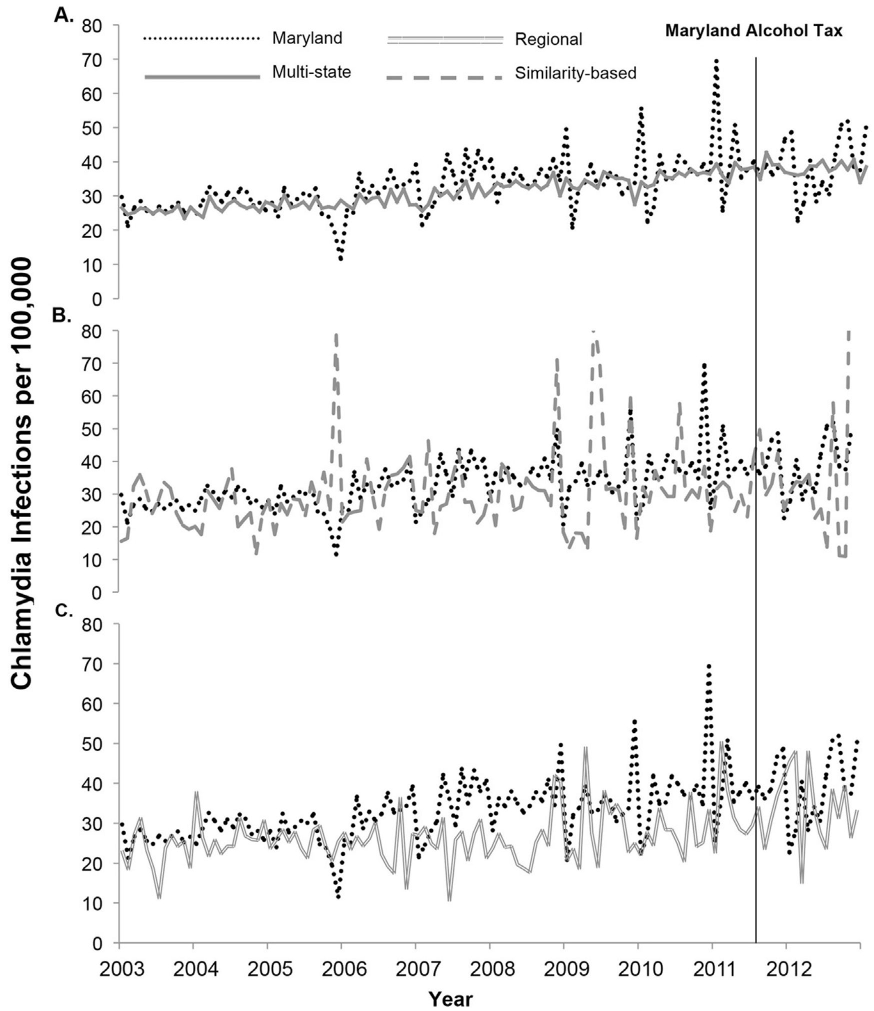

Figure 2. Monthly chlamydia rates in Maryland and comparison groups from 2003 to 2012.

counterfactual is unknown. The authors addressed this limitation by comparing to states with similar alcohol pricing regulations, considering three control groups, and eliminating some competing explanations (i.e., around the time of the tax change, Maryland did not change STI diagnostics or conduct STI prevention campaigns; E Liebow, Maryland Department of Health and G Olthoff, Baltimore Health Department, unpublished observations, 2014). Second, owing to the time lag for available STI data, the authors were only able to assess short-term tax effects. Third, STI rates were obtained from surveillance data, which is susceptible to under-reporting (e.g., through providers' failure to report and undiagnosed infections). Under-reporting is unlikely to be differential by the alcohol tax increase; thus, any potential bias is anticipated to be toward the null.

Strengths

This study has three important strengths. First, it used a quasi-experimental controlled time-series design: an experimental design producing confident causal conclusions.[47,48] Second, the long time series (10 years of continual monthly data) allowed for good characterization of STI patterns over time. Third, demonstrating effects of the few recent alcohol tax increases, especially a sales tax, has important practical utility in guiding policymakers on the health benefits of potential tax changes.

Conclusions

An increase in alcohol retail cost of $0.03 per $1.00 appears to have decreased gonorrhea infections in Maryland. During the 1.5-year examined post period, an estimated 2,400 cases of gonorrhea were prevented, saving an estimated $519,600 in direct medical expenses (in 2010 U.S. dollars).[49] Even more-dramatic reductions in suffering and health costs would likely be seen if alcohol tax increases were more similar to the five times higher 2008 Maryland tobacco tax increase.[50,51] Although increased research on STI reductions following alcohol tax increases of various types and magnitudes is warranted, it seems clear from the evidence to date that alcohol tax increases reduce gonorrhea incidence.[19–21] Moreover, this evidence for STIs is consistent with the much larger literature on other diseases and injuries demonstrating beneficial population health effects of higher alcohol taxes.

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Staras drafted the manuscript, supervised data analyses, and participated in interpretation of results; Livingston conducted all statistical analyses and drafted the methods section; Wagenaar was Principal Investigator for the study, edited the manuscript, and participated in interpretation of analytic results.

This study was approved by the University of Florida IRB under protocol number 556-2011 as non-human research, as only aggregate sexually transmitted infection counts and rates were analyzed.

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