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Impacts of Federal Prevention Funding on Reported Gonorrhea and Chlamydia Rates

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Abstract

Introduction: The Centers for Disease Control and Prevention allocates funds annually to jurisdictions nationwide for sexually transmitted infection prevention activities. The objective of this study was to assess the effectiveness of federal sexually transmitted infection prevention funding for reducing rates of reported sexually transmitted infections.

Methods: In 2017–2018, finite distributed lag regression models were estimated to assess the impact of sexually transmitted infection prevention funding (in 2016 dollars per capita) on reported chlamydia rates from 2000 to 2016 and reported gonorrhea rates from 1981 to 2016. Including lagged funding measures allowed for assessing the impact of funding over time. Controls for state-level socioeconomic factors, such as poverty rates, were included.

Results: Results from the main model indicate that a 1% increase in annual funding would cumulatively decrease chlamydia and gonorrhea rates by 0.17% ($p<0.10$) and 0.33% ($p<0.05$), respectively. Results were similar when stratified by sex, with significant decreases in rates of reported chlamydia and gonorrhea in males of 0.33% and 0.34% (both $p<0.05$) respectively, and in rates of reported gonorrhea in females of 0.32% ($p<0.05$). The results were generally consistent across alternative model specifications and other robustness tests.

Conclusions: The significant inverse associations between federal sexually transmitted infection prevention funding and rates of reported chlamydia and gonorrhea suggest that federally funded sexually transmitted infection prevention activities have a discernable effect on reducing the burden of sexually transmitted infections. The reported sexually transmitted infection rate in a given year depends more on prevention funding in previous years than on prevention funding in the current year, demonstrating the importance of accounting for lagged funding effects.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2018.09.012.

INTRODUCTION

Public health funding is critical for managing the burden of notifiable sexually transmitted infections (STIs) in the U.S.[1–4] In recent years, nationwide rates of reported chlamydia and gonorrhea have increased substantially.[5] Rates of reported chlamydia and gonorrhea cases in the U.S. in in 2016 were 497.3 and 145.8 per 100,000 population, reflecting a 4.7% and 18.5% increase from 2015 rates, respectively. At the same time, declining budgets of state and local public health departments have reduced their ability to engage in effective prevention efforts.[5,6] The Division of STD Prevention (DSTDP) at the Centers for Disease Control and Prevention (CDC) serves as a major source of annual STI prevention funding to state and local health departments.[7] This funding helps to accomplish DSTDP's goals of increasing access to sexual health services and reducing the rate of STIs and their complications through promotion of (1) STI screening and treatment, (2) partner services and outreach, and (3) health promotion and prevention education.[8,9]

Previous studies suggest that federal STI prevention funding effectively decreases STI case rates. The study by Chesson et al.[1] analyzed data from 1981 to 1999 and found that a $1.00 increase in per capita federal STI and HIV prevention funding was associated with an approximately 21% decrease in gonorrhea rates. Further, Chesson and Owusu-Edusei[2] analyzed data from 1997 to 2005 and found that a $0.10 increase in per capita federal syphilis elimination funding decreased syphilis rates by 28.5%. These papers complement recent work demonstrating the broader health impacts of public health spending.[10–12]

This paper makes three important contributions to the existing literature on the impact of federal STI prevention funding allocations. First, STI prevention funding and case report data through 2016 are included. Second, chlamydia is included as an outcome measure in addition to gonorrhea. The study focuses on chlamydia and gonorrhea and excludes syphilis, as syphilis rates tend to be more geographically concentrated than for chlamydia or gonorrhea. For example, in 2016, 64.2% of reported syphilis cases occurred in just 70 counties.[5] Because of this geographic concentration, a state-level analysis may be less appropriate for syphilis than for chlamydia and gonorrhea. Third, by using a modeling structure that incorporates the potential for a delayed impact of prevention funding, this study provides more reliable estimates of the impact of STI prevention funding on rates of reported chlamydia and gonorrhea.

METHODS

Study Sample

National chlamydia and gonorrhea case data reported to CDC for each state and the District of Columbia were examined. Data for gonorrhea were obtained for the years 1981 to 2016, and data for chlamydia were obtained for the years 2000 to 2016. Chlamydia reporting was not required by all U.S. jurisdictions until 2000, so data in prior years may be incomplete. These data also contain information on population, race/ethnicity, sex, and age group. Rates of reported chlamydia and gonorrhea cases were calculated for males, females, and the overall population as the number of cases divided by the corresponding population, multiplied by 100,000. Tuberculosis (TB) data were also included for model testing

purposes. TB case rate data during 1981–1992 were obtained from CDC TB surveillance reports, whereas case rate data during 1993–2016 were obtained from the Wide-ranging Online Data for Epidemiologic Research public health database (WONDER) developed by the CDC.[13] STI prevention funding allocations by state from 1975 to 2016 were obtained from unpublished DSTDP records as described in the Appendix (available online) and were adjusted to 2016 dollars using the Consumer Price Index.[14] Several cities also receive STI prevention funding, which were included as part of the funding of the respective state (e.g., funding to New York City was included as funding for the state of New York). Annual data on STI prevention funding from state and local governments were not available, so the analysis relied solely on federal funds allocated by CDC.

Measures

Crime and poverty have been shown to be correlated with STI rates over time and can be correlated with hard-to-measure social determinants of state-level STI rates.[1,2,15] Therefore state-level poverty and violent crime rates were included as control variables. Poverty data, measured as the percentage of households below the federal poverty threshold, were obtained from the Annual Social and Economic Supplement of the Current Population Survey carried out by the U.S. Census Bureau.[16] State-level violent crime data, measured as the number of violent crimes per 1,000 population, came from the Federal Bureau of Investigation's Annual Crime in the United States reports.[17]

Statistical Analysis

In 2017–2018, panel data regression models were used to estimate the marginal impact of funding on rates of reported chlamydia and gonorrhea cases. Various models and specifications were employed in order to validate the robustness of the findings. Ordinary least squares models of the form:

$$\begin{aligned} Ln(Rate_{i,t}) &= \beta_1 Ln(Funding_{i,t}) \\ &+ \sum_{1}^{K} \beta_{1+k} Ln\left(Funding_{i,t-k}\right) + \gamma X_{i,t} + State_i \\ &+ Year_t + State_i \times Trend + \varepsilon_{i,t} \end{aligned} \tag{1}$$

were estimated, where $Rate_{i,t}$ is the number of reported cases per 100,000 population in state i at time t. Separate regressions were run for each infection and subpopulation: male gonorrhea, female gonorrhea, overall gonorrhea, and male chlamydia. $X_{i,t}$ includes poverty, violent crime, race/ethnicity, and age controls. Poverty and violent crime were calculated as indicated previously. Race was operationalized as the percentage of the population that is white. Age distribution was represented through two variables: the percentage of the population between the ages of 15 and 24 years and the percentage of the population between the ages of 25 and 44 years. Controlling for age group is particularly important as young adults typically have relatively high rates of reported STIs, ages 15 to 44 years typically account for >90% of reported chlamydia and gonorrhea cases, and females aged ≤24 years are targeted for screening.[5,18,19] $State_i$ and $Year_t$ represent binary variables for

state and year. These variables allow average STI rates and funding to vary across space and time, flexibly controlling for unobserved factors within years or state that may be related to rates of reported STIs. Trend is a linear variable increasing in year, so the $State_i$ X Trend interaction terms account for state-specific time trends.

The natural log transformation of the dependent variable (rates of reported chlamydia or gonorrhea) was consistent with previous studies and has a natural interpretation.[1,2] Natural log is a concave function that discounts higher levels of the transformed variable and allows any given level of funding to have the same relative, rather than absolute, impact on STI rates. In practice, this means that decreasing STI rates from 101 to 100 requires fewer resources than decreasing from 11 to 10. Similarly, the natural log transformation of funding implies that funding resources exhibit diminishing returns.

The benefits of prevention efforts can span multiple years into the future. For instance, efforts to screen and treat chlamydia in young women can help prevent transmission to their current and future sex partners, their partners' partners, and so on. In addition, some prevention funding goes towards activities, like health promotion and education, which may not have an immediate impact on disease rates but will help reduce rates over time. Further, some cases diagnosed and reported in year t may have been acquired in year t−1. For these reasons, prevention funding in period t−1 could have an effect on reported STI rates in period t. The term $\sum_1^K \beta_{1+k} Ln(Funding_{i,t-k})$ accounts for this by including the sum of lagged funding terms from the previous k years. In the main specifications, $K = 2$ lags were used, as described in more detail in the Appendix (available online). For this analysis, the long-term, or cumulative, effect, represented by the sum of the β coefficients, was of primary interest. The β coefficients can be approximately interpreted as the percentage change in STI rates based on a 1% change in funding. The Appendix (available online) includes more details on interpreting the coefficients and the derivation of formal SEs for the cumulative effect. All reported SEs are robust to heteroscedasticity and clustered by state to allow for correlation patterns within groups across time.[20]

To test that the regression model was not unduly influenced by confounding factors, the regression model was repeated using TB rates as an outcome variable instead of STI rates. STI prevention funding is not expected to have a direct impact on TB rates, so these estimates serve as falsification tests. Finding a significant impact of STI prevention funding on TB rates would suggest that the associations for chlamydia and gonorrhea were driven by other unobserved factors or health trends.

RESULTS

During the sample period, the mean overall reported rate (new cases per 100,000 population) was 178.3 for gonorrhea and 375.3 for chlamydia (Table 1). Average reported gonorrhea case rates were higher for males than for females, but average reported chlamydia case rates were consistently lower for males. Mean state-level STI prevention funding per capita in 2016 dollars was 38 cents, and on average 13% of households were below the federal poverty threshold. The percentages of the population between the ages of 15–24 years and 25–44 years were 15% and 29%, respectively.

Results from the models, presented in Table 2, show that for a permanent 1% increase in funding starting in year t−2, the overall rate of reported gonorrhea cases is 0.33% ($p<0.05$) lower in year t than it would have been in the absence of a funding change. Similar results were observed for gonorrhea when stratified by sex, with significant decreases of 0.34% in males and 0.32% in females (both $p<0.05$). The results also suggest that for every 1% increase in funding, the overall rate of chlamydia cases in males was 0.33% lower than it would have been otherwise ($p<0.05$). Decreases were observed in overall chlamydia rates (−0.17%) and rates of reported chlamydia in females (−0.12%), but these findings were not statistically significant at the $p<0.05$ level.

Figure 1 shows how the effect of funding accrues over time. For each STI, coefficients for current funding, last year's funding, and funding from 2 years previous are presented for both male and female reported rates. The effect of funding is strongest in years t−1 and t−2 for gonorrhea, though the coefficients do not vary greatly across periods. For instance, a funding increase in period t, t−1, and t−2 was associated with reductions in reported male gonorrhea rates of −0.08, −0.13, and −0.13, respectively. A different pattern emerges for chlamydia; funding in year t was associated with a very small change in reported rates, but the effect strengthens over time. For reported female rates, the association was 0.03 in period t, −0.04 in period t−1, and −0.1 in period t−2. Changes in reported rates for males and females track very closely over time for both chlamydia and gonorrhea.

Table 3 includes expanded results for overall gonorrhea and chlamydia rates, including funding effects for each period and covariates. The lagged funding coefficients give insight into the importance of accounting for the effect of prevention funding over time, because funding in previous years was found to have a strong impact on current reported rates. Specifically, funding in year t−2 accounts for 35.1% of the cumulative effect of funding on overall reported gonorrhea rates (0.11 percentage points of 0.33) and 80.1% of the cumulative effect of funding on overall reported chlamydia rates (0.14 percentage points of 0.17).

Poverty, violent crime, and the percentage of the population aged between 25 and 44 years were found to be statistically related to reported gonorrhea rates, but none of these covariates had statistically significant associations with reported chlamydia rates. A detailed discussion of the covariate results is available in Section 4 of the Appendix (available online). When applying models with alternative specifications (e.g., examining actual per capita funding instead of the logged value) or outcome variables (reported STI rates for ages 15–24 years only), the estimates of the impact of STI prevention funding on STI rates were largely consistent with the results of the main model (Appendix Tables 3 and 4, available online). Finally, the results from the TB falsification test found no statistically significant relationship between STI prevention funding and TB rates.

DISCUSSION

This paper provides an indirect assessment of the impact of federally funded STI prevention activities by examining the association between STI prevention funding and rates of reported STIs. Consistent with previous evidence, a strong association between funding

and gonorrhea rates was found, indicating that greater funding in a given year is associated with reductions in gonorrhea rates in the same year and subsequent years, all else equal. This paper further contributes to the field by including chlamydia as an outcome measure, finding that federal funds for STI prevention are associated with reductions in chlamydia rates as well. Importantly, the effect of funding is found to accrue over time, so accounting for lagged funding effects is crucial. Using distributed lag regression models, the reported STI rate in a given year was found to depend more on prevention funding in previous years than on prevention funding in the given year.

Associations between funding and reported chlamydia rates were found to be much stronger in males than in females. Because chlamydia is often asymptomatic, changes in reported rates of this disease may be particularly affected by changes in screening patterns. A portion of the federal funding allocation, including funding earmarked for the Infertility Prevention Project, was aimed at increasing chlamydia screeng in females, which may explain the differences in estimated effects of STI prevention funding on male and female chlamydia rates. To the extent that changes in screening are driving changes in case finding and reporting, this paper's findings are conservative estimates of the true effect of funding on rates of reported chlamydia (i.e., funding increased screening, which improved diagnosis and treatment, but also led to an initial increase in reported cases). Improvements in diagnostic tests, increased use of electronic laboratory reporting, and inclusion of chlamydia screening as a Healthcare Effectiveness Data and Information Set performance measure have also potentially led to more reported chlamydia cases since 2000.[21,22] Further, in the absence of partner notification and treatment, reinfection rates may be high and lead to lower effectiveness of prevention efforts. To account for these factors, binary year variables were included to control for nationwide trends in reporting. The models also included state-specific time trends, which allow for idiosyncrasies in how states report chlamydia cases or adopt new technology and practices over time.

The cumulative effects of STI prevention funding on reported gonorrhea rates were similar for both males and females. Gonorrhea is less likely to be asymptomatic in males than in females, so changes in reported gonorrhea rates in males are likely more reflective of a change in actual incidence than changes in reported gonorrhea rates in females, which might be more reflective of changes in screening.[23] Finding similar effects of STI prevention funding on male and female gonorrhea rates partially alleviates concerns about the effect of confounding screening practices on reported gonorrhea rates.

Limitations

There are several empirical challenges when estimating the impact of STI prevention funding on reported rates of STIs. States may use funds to increase STI screening efforts, which may lead to more cases being detected even if true incidence remains unchanged. Increased case detection through screening would bias the analysis towards finding a positive association between prevention funding and reported STI rates; however, a negative association was found. Further, associations between funding in previous years and rates are less likely to be driven by increased screening efforts, so the inclusion of lagged funding measures partially alleviated this concern.

The analysis could be biased if federal STI prevention funding allocations are targeted to states expected to have higher than average increases in STI rates. However, although states with higher STI burden generally receive more federal funding, annual changes in funding are related to changes in overall funding availability and historic burden and allocation, rather than anticipated changes in STI rates. If bias does exist, the expected direction would be towards finding a positive correlation between prevention funding and STI rates, even if funding is effective at reducing the burden of disease.

A final challenge arises from having incomplete data on STI prevention funding. STI prevention funding allocations from 1975 to 2016 were compiled from a wide range of unpublished records that differed in format and completeness across years (Appendix, available online). Further, only federal funds allocated by CDC were included and funding from all other sources, such as state and local governments, was excluded. Federal funding was allocated directly to only six cities, which were combined with federal funding allocations to states. As such, the findings should be interpreted as the estimated effect of federal STI prevention funding in the context of average funding from state and local governments and other sources. The state-level analysis also limited the ability to control for other potentially important factors, such as urbanicity. Future analyses at the county or city level could illuminate more intricacies of the impact of STI prevention funding, such as differences in the impact of funding in urban and rural areas.

Importantly, many of the key challenges outlined above would be expected to bias the results towards finding that prevention funding is associated with increases, not decreases, in reported STI rates. In addition, a falsification test used reported TB rates as an outcome variable, and no significant association with STI prevention funding was found. This further validates the model and suggests that broader, unrelated changes to the healthcare system over time are not driving the estimated associations between STI prevention funding and rates of reported STI cases.

CONCLUSIONS

This updated and expanded analysis adds to the existing literature that demonstrates a link between increases in federal STI prevention funds and reductions in rates of reported STIs. The findings here suggest that targeted public health funding may be an effective policy lever to address the burden of gonorrhea and chlamydia in the U.S. Having up-to-date, reliable estimates of the impact of STI prevention funding is essential not only to document program impact, but also to inform resource allocation decisions and illustrate potential future trends in STI rates. In a time of rising reported STI rates, STI prevention funding remains crucial for reducing the burden of STIs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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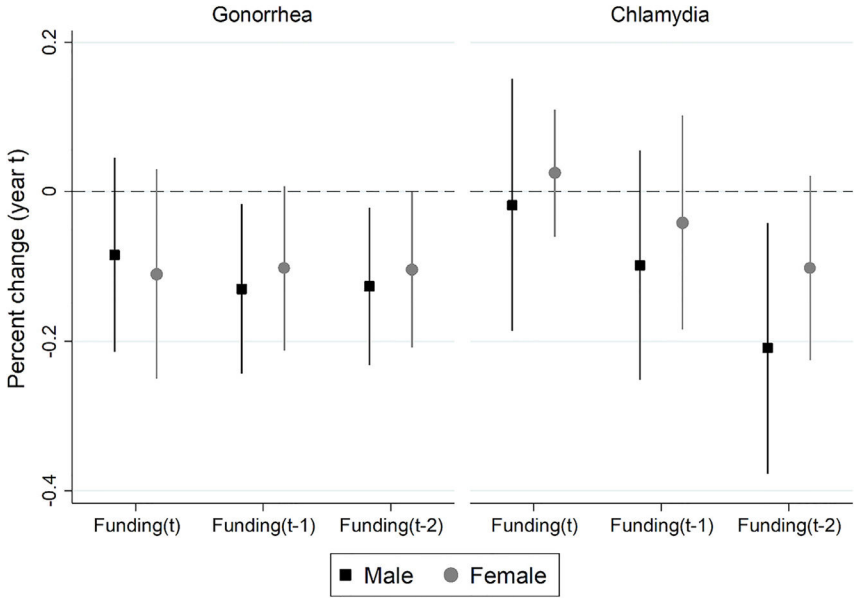

Figure 1.

Estimated percentage change in reported rates associated with a 1% change in current and lagged funding.

Note: Funding terms are log-transformed. Coefficients presented come from the regression model in equation 1. Separate regressions were run for each outcome: reported rates of male gonorrhea, female gonorrhea, male chlamydia, and female chlamydia. Lines reflect 95% CIs from robust SEs clustered by state. Models estimated using gonorrhea data from 1981–2016 and chlamydia data from 2000–2016.

STI, sexually transmitted infection.

Table 1.

Summary Statistics for Distributed Lag Model Variables

Variable	M (SD)
Gonorrhea rate	
Number of reported cases (all ages) per 100,000 population, 1981–2016	
Overall	178.3 (230.6)
Male	200.0 (324.7)
Female	158.3 (158.8)
Chlamydia rate	
Number of reported cases (all ages) per 100,000 population, 2000–2016	
Overall	375.0 (148.7)
Male	203.8 (107.2)
Female	539.6 (198.8)
Poverty	
Percent of households below the federal poverty threshold[12]	0.13 (0.04)
Funding rate	
STI prevention funding per capita in 2016 dollars, 1975–2016	0.38 (0.28)
Funding change[a]	
Change in funding per capita from 1981–2016	−0.02 (0.13)
Violent crime rate	
Violent crimes committed per 1,000 population[13]	4.42 (2.98)
Proportion aged 15–24 years	
Percent of the total population between the ages of 15–24 years	0.15 (0.02)
Proportion aged 25–44 years	
Percent of the total population between the ages of 25–44 years	0.29 (0.03)
Proportion white	
Percent of the total population that is non-Hispanic white	0.79 (0.14)

Note: Sources for poverty and violent crime data are noted in the table. All other data were obtained from the Centers for Disease Control and Prevention as described in the Methods section.

[a]Included for descriptive purposes. Mean inflation-adjusted per capita funding was $0.33 in 1981 and peaked in 2002 at $0.52.

STI, sexually transmitted infection.

Table 2.

Estimated Percentage Change in Reported Rates Associated With a 1% Change in Funding

	Gonorrhea			Chlamydia		
	Male	**Female**	**Overall**	**Male**	**Female**	**Overall**
Estimated effect	−0.341**	−0.317**	−0.325**	−0.325**	−0.118	−0.171*

Note: Boldface indicates statistical significance (*p<0.1, **p<0.05). Models estimated using gonorrhea data from 1981–2016 and chlamydia data from 2000–2016. Distributed lag regression models were used to estimate the cumulative effect of sexually transmitted infection prevention funding on reported gonorrhea and chlamydia case rates over time at the state level. Separate regressions were run for each outcome: reported rates of male gonorrhea, female gonorrhea, overall gonorrhea, male chlamydia, female chlamydia, and overall chlamydia. The estimated effects of funding changes reflect the cumulative effects over the current and 2 lagged years, as illustrated in Table 3. For example, a permanent 1% increase in sexually transmitted infection prevention funding in year t-2 would be expected to reduce male gonorrhea rates by 0.341% in year t. All models included the covariates in equation 1. Appendix Table 2 (available online) provides complete regression results.

Table 3.

Estimated Change in Overall Reported Rates Associated With a 1% Change in Funding

Variables	Gonorrhea	Chlamydia	Tuberculosis
Funding			
Log(funding$_t$)	−0.096 (−0.228, 0.036)	0.017 (−0.077, 0.112)	−0.051 (−0.120, 0.019)
Log(funding$_{t-1}$)	**−0.115** ** (−0.225, −0.006)	−0.051 (−0.187, 0.085)	−0.006 (−0.0957, 0.083)
Log(funding$_{t-2}$)	**−0.114** ** (−0.216, −0.012)	**−0.137** ** (−0.261, −0.013)	0.002 (−0.0679, 0.072)
Cumulative effect	**−0.325** ** (−0.577, −0.073)	−0.171 * (−0.370, 0.028)	−0.055 (−0.182, 0.072)
Covariates			
Poverty	**−2.116** *** (−3.48, −0.751)	−0.343 (−1.22, 0.534)	−0.027 (−0.834, 0.779)
Violent crime	**0.089** *** (0.025, 0.153)	−0.002 (−0.034, 0.030)	**0.033** *** (0.0123, 0.054)
Percent white	−0.938 (−8.452, 6.575)	0.750 (−2.075, 3.574)	0.652 (−2.521, 3.824)
Percent ages 15–24 years	3.616 (−5.592, 12.82)	1.678 (−1.508, 4.864)	2.663 (−2.010, 7.335)
Percent ages 25–44 years	**13.240** ** (2.647, 23.84)	−1.778 (−4.560, 1.003)	1.146 (−3.801, 6.092)
Constant	**−367.0** *** (−448.1, −286.0)	**−97.5** *** (−136.2, −58.77)	182.1 * (−22.29, 386.4)
Number of observations	1,830	867	1,826
R^2	0.794	0.899	0.861
Number of states	51	51	51

Note: Values are % change (95% CI) unless otherwise indicated. Boldface indicates statistical significance (*p<0.1, **p<0.05, ***p<0.01). All models include state and year fixed effects and a state-specific time trend. All funding variables are log-transformed. Models included the covariates in equation 1. Separate regressions were run for each outcome: reported rates of gonorrhea, chlamydia, and tuberculosis. For the purposes of this study, Washington, DC was considered a state. The cumulative effect equals the sum of all three funding terms. 95% CIs from robust SEs, clustered by state, are included in parentheses.