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Predicting the impact of sexual behavior change on adolescent STI in the US and New York State: a case study of the teen-SPARC tool

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Abstract

PURPOSE.—Adolescents aged 13–18 bear a large burden of sexually transmitted infections (STIs) and changing adolescent sexual risk behavior is a key component of reducing this burden. We demonstrate a novel publicly-available modeling tool (teen-SPARC) to help state and local health departments predict the impact of behavioral change on gonorrhea, chlamydia, and HIV burden among adolescents.

METHODS.—Teen-SPARC is built in Excel for familiarity and ease and parameterized using data from CDC's Youth Risk Behavior Surveillance System. We present teen-SPARC's methods, including derivation of national parameters and instructions to obtain local parameters. We model

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multiple scenarios of increasing condom use and estimate the impact on gonorrhea, chlamydia and HIV incidence, comparing national and New York State (NYS) results.

RESULTS.—A 1% annual increase in condom use (consistent with Healthy People 2020 goals) could prevent nearly 10,000 cases of STIs nationwide. Increases in condom use of 17.1%, 2.2%, and 25.5% in NYS would be necessary to avert 1000 cases of gonorrhea, 1000 cases of chlamydia, and 10 cases of HIV infection, respectively. Additional results disaggregate outcomes by age, sex, partner sex, jurisdiction, and pathogen.

CONCLUSION.—Teen-SPARC may be able to assist health departments aiming to tailor behavioral interventions for STI prevention among adolescents.

Keywords

Gonorrhea (epidemiology); Chlamydia infections (epidemiology); HIV-1 (epidemiology); adolescents; sexual behavior; United States; mathematical model

INTRODUCTION

After decades of progress towards reducing incidence, sexually transmitted infections (STIs) are rising in the United States (US, 1). Increasing cases create a growing burden of health problems for those affected, including infertility among females. Rising antibiotic resistance, especially in gonorrhea, is a major public health concern. Diagnosis and treatment cost the US health system $16 billion annually (2).

Roughly half the burden of bacterial STIs like gonorrhea and chlamydia is concentrated among youth under age 24 (3). In females, rates of chlamydia incidence top 3% per person-year among 15–19-year-olds (4). Untreated infections are a special concern in young females, since sterility can occur before establishment of fertility intentions. As a life-long infection, HIV is less concentrated among youth; however, roughly 1,400 (5.4% of all US) diagnoses occur annually in males aged 13–19 who have sex with males (4); an unknown number of additional infections occur during this age group but are diagnosed later. Furthermore, youth with HIV have the lowest rates of both linkage to and retention in care (5) and face decades of expensive, complex treatment.

Sexual health promotion among adolescents is challenging but crucial, with consequences for both STIs and pregnancy. Sex education is one important piece of this effort that has strong evidence of success. Numerous school-based programs have been shown through rigorous study designs to yield positive outcomes among US adolescents; one meta-analysis of 62 comprehensive risk-reduction programs found significant overall efficacy for reducing frequency of sexual activity and number of partners and increasing condom use (6). Sexual health promotion goes beyond school-based education (7); for example, some health departments provide adolescent-oriented informational content online. Such modalities may be especially useful for marginalized youth such as sexual and gender minorities; one online curriculum for LGBT young adults yielded large reductions in both condomless anal sex (prevalence ratio = 0.83) and STI incidence (risk ratio=0.60), with larger point estimates for reductions for younger participants (8). Thus, even as screening and treatment have been major foci for STI prevention and control, primary behavioral prevention remains an important lever in this population.

The Youth Risk Behavior Surveillance System (YRBSS) includes national, state, territorial, tribal government, and local school-based surveys of representative samples of 9th- through 12th-grade students. The national Youth Risk Behavior Survey (YRBS) is conducted by CDC, while other surveys are conducted by departments of health and education. Results, including those on sexual behavior, are available online for many jurisdictions (www.cdc.gov/healthyyouth/data/yrbs) or through data requests. While YRBS data are necessary for monitoring behavior changes, they are not sufficient for predicting the number of HIV/STI cases preventable through these changes. This is because many factors interact in complex ways to affect HIV/STI transmission (e.g., current prevalence, sexual networks, diagnosis, treatment) and the combination of those factors and magnitude of behavioral changes ultimately determine prevention impact.

As part of a larger collaboration between CDC's Division of Adolescent and School Health (part of the National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention) and university-based researchers, we developed teen-SPARC (STI Prevention and Risk Calculator) version 1.0, a publicly available modeling tool designed to help state and local health jurisdictions predict the impact of behavioral change on their burden of three STIs among adolescents: the most common (gonorrhea and chlamydia) and the most costly per case (HIV) among those that are nationally reportable. Developed within Excel for ease of use, it is designed to incorporate relevant data from the national YRBS, a local jurisdiction's YRBS, and/or other adolescent behavioral surveys. In this paper, we present teen-SPARC's basic methods, including sources for parameters, both national defaults and those for local users. We then use teen-SPARC to model multiple scenarios regarding changes in condom use and their impact on incidence of gonorrhea, chlamydia and HIV. We compare national results with those for a single YRBS jurisdiction, New York State (NYS), selected for its large size and existing data collaborations between our team and the state Department of Health. Finally, we consider how these types of results might help jurisdictions like NYS predict and interpret patterns of STI diagnoses across multiple dimensions following observed or anticipated behavior changes that commonly result from comprehensive sex education.

MATERIALS AND METHODS

Teen-SPARC overview

Teen-SPARC is available at http://www.emorycamp.org/teensparc, which contains four files: the Excel tool; Quick Start Guide; User Manual; and a SAS file to simplify analyzing and outputting YRBS data. Teen-SPARC requires Microsoft Windows and Excel 2016 or later. Here we summarize key model components and considerations; the User Manual contains extensive additional detail. All development occurred in consultation with a Public Health Advisory Board comprising state and local public health officials.

Teen-SPARC focuses on the sexually active population *attending high school* (HS)—high schools comprise the sampling frame of YRBS—and addresses three STIs: gonorrhea

(*Neisseria gonorrhea*), chlamydia (*Chlamydia trachomatis*), and HIV (Human immunodeficiency virus). The model considers three age groups (13–15, 16–17, and 18+, with the vast majority of the last group being 18). It also considers three "sexual partnering groups" (SPGs) with large STI burden and sufficient behavioral data to estimate model parameters: males who have sex with males (MSM), males who have sex with females only (MSF), and females who have sex with males (FSM). We see the term *SPG* as potentially less stigmatizing for youth than common descriptors like "risk groups" since it emphasizes partnering over transmission. Both MSM and FSM include individuals who have sex with both males and females; they are combined with those having only male partners given data availability and the fact that transmission probabilities from a male partner are generally higher than from a female partner across STIs.

The model aims to integrate data on sexual behavior, demographics, and HIV/STI surveillance, in combination with standard transmission probability calculations, to make one-year predictions of STI incidence under various scenarios. For base (non-intervention) scenarios, key outputs include the expected number of annual infections and diagnoses among HS students, overall or by age group or SPG. For intervention scenarios, users select changes to behavioral inputs; outputs include change in the above measures relative to base scenarios.

For any subgroup, expected incident cases are a function of the (1) number of people not currently infected; (2) contact rate (number of partners and acts/partner); (3) probability a partner is infected; and (4) probability of transmission given sexual contact. Items 1 and 3 involve knowing current prevalence for each SPG, which is a function of diagnoses, proportion of incident cases diagnosed (for gonorrhea and chlamydia) or proportion of adolescents diagnosed to date (for HIV), mean duration of infection (for gonorrhea and chlamydia), and population size.

Teen-SPARC inputs are organized into worksheets, including *population sizes*, *sexual behavior*, *diagnoses*, and *advanced options*; Table 1 lists inputs by worksheet. For *population sizes*, teen-SPARC requires inputs from the US Census (data.census.gov) and YRBS, one to measure all 13–18-year-olds and the other only HS students. The *sexual behavior* worksheet includes data on number of partners, number of coital acts per partnership, and condom use. The last derives directly from YRBS, while the first comes indirectly from YRBS—inputs include lifetime partner counts and age of first sex, and teen-SPARC automatically back-calculates annual numbers. For coital acts, the National Survey of Family Growth (NSFG) provides national means; we expect few users to have local numbers, so most will use national defaults. *Diagnoses* come from state or local STI and HIV health department surveillance systems and include the annual number of chlamydia and gonorrhea diagnoses among 13–18-year-olds by SPG and the number of MSM aged 13–18 living with diagnosed HIV. These numbers are *not* restricted to HS students. Jurisdictions that cannot determine SPG from surveillance data will need to make assumptions; the manual describes options.

By default, teen-SPARC contains parameter values reflecting the entire US, using 2015 National YRBS data, the most recent available when parameterization was conducted. The SAS file can help generate sexual behavior inputs from jurisdiction-specific YRBS data and export them into Excel for easy copy/paste. For jurisdictions without local YRBS data, teen-SPARC is flexible: one can use other data sources or existing defaults, or explore a range of assumptions, something for which modeling is well-suited.

The *advanced options* worksheet houses additional parameters for which we expect most users will accept defaults, either because they are consistent across jurisdictions (probability of transmission per discordant act) or because a jurisdiction does not have local data (proportion of cases diagnosed, ever or to date). Users may change these if they wish.

We calibrated the national model so that each SPG reproduced the expected incident annual cases for each STI in the absence of new interventions. We did so by varying per-act transmission probabilities, given their wide range in the literature and relative consistency across settings. The User Manual provides full technical detail.

Once baseline parameters are entered, users can choose either or both of two behavioral changes: overall frequency of sex and probability of condom use. These were selected because the abovementioned meta-analysis (6) identified them as the behavioral outcomes from comprehensive sex education with the greatest effect size (condom use) and consistency (sex frequency). Users can apply changes uniformly or make age- and/or SPG-specific changes.

Case study: comparing the impact of behavior change among adolescents nationwide and in NYS

We developed a case study to provide examples of the types of questions users can answer with the tool and strategies for examining and interpreting results. We analyze scenarios using default US parameters and parameters calculated from NYS YRBS and surveillance data (Table 2).

We began with seven scenarios to estimate population-level effects of increasing condom use. We first estimated cases averted if condom use increased by 1% in one year (Scenario 1), a figure compatible with Healthy People 2020's goal of increasing condom use by 10% over 10 years among sexually active adolescents (9). We then expand this from 1% to 5% (Scenario 2). We next imagined a "what-if" scenario in which declines in condom use observed among HS students in CDC's 2007–2017 YRBS trend report (10) had not occurred (Scenario 3). In that report, condom use was 14% higher in 2007 than in 2017 nationwide; using the online YRBSS Analysis Tool (https://nccd.cdc.gov/YRBSSanalysis/), we determined that this figure was also 14% for NYS. Next, we implemented a hypothetical intervention that increased condom use by 25% overall (Scenario 4) and within specific age groups (Scenarios 5–7), a level of behavior change we considered highly optimistic but potentially achievable through widespread adoption of a tested intervention (11). We then disaggregated results by SPG, focusing on gonorrhea as an example.

Finally, we estimated independently the percent increases in condom use or decreases in sex acts needed to avert a fixed number of incident cases of each STI among HS students in NYS. We chose 1,000 for gonorrhea and chlamydia and 10 for HIV, given large differences in case load; these represent 26.9%, 3.1% and 14.9% of estimated incident cases/year for gonorrhea, chlamydia, and HIV, respectively. We did not compare with nationwide numbers since the focus on absolute counts makes this difficult to interpret.

RESULTS

When considering interventions that increased condom use across-the-board (Scenarios 1–4), teen-SPARC predicted that HIV reductions (0.5%–14.5% for NYS and 0.6%–17.6% nationwide) would be smaller than either bacterial STI (gonorrhea: 1.6%–39.4% and 1.4%–35.1%, respectively; chlamydia: 1.4%–37.1% and 1.3%–34.0%, respectively). Overall, similar proportions of cases among HS students would be averted in NYS and nationally (Table 3). These numbers are slightly higher in NYS than nationwide for the bacterial STIs and slightly lower for HIV; e.g., in Scenario 3 gonorrhea reduced by 22.0% in NYS vs. 19.6% nationwide, and HIV by 7.9% vs. 9.4%, respectively.

For age-specific scenarios (5–7), increasing condom use by 25% among 16–17-year-olds would have more impact (22.7%/23.5% cases of chlamydia/gonorrhea averted in NYS and 19.6%/19.7% nationwide) than that for 18-year-olds (9.8%/11.3% cases of chlamydia/gonorrhea averted in NYS and 10.4%/11.5% nationwide). Although this may not seem surprising given that the former age category is wider, more youths have begun having sex by age 18 (Table 2). Although percentages for NYS and nationwide are overall similar, the precise relationship depends on age; e.g., an intervention focused late in HS, affecting 18-year-olds' behavior only, would have a slightly smaller impact on chlamydia in New York (9.8%) than nationwide (10.4%), but the reverse is true for 16–17-year-olds (22.7% vs. 19.6%).

Applying equal relative increases in condom use to all SPGs resulted in very different percentages of gonorrhea cases averted within each group (Table 4). MSM had the lowest proportion of cases averted for most scenarios, and MSF the highest. For example, a 25% increase in condom use among all groups in NYS (Scenario 4) averted 20.7% of gonorrhea cases among MSM, 58.1% among MSF, and 35.2% among FSM.

We found that 17.1%, 2.2%, and 25.5% increases in condom use in NYS would be necessary to avert 1000 cases of gonorrhea, 1000 of chlamydia, and 10 of HIV infection, respectively (Table 5). Point estimates for sex frequency reductions are higher than condom use increases for gonorrhea (27.1% vs 17.1%) and chlamydia (3.5% vs 2.2%) but lower for HIV (20.8% vs 25.5%).

DISCUSSION

The teen-SPARC tool provides a means for health departments to combine data from multiple sources with a projection model in an accessible platform (Excel), serving multiple purposes. It can help jurisdictions understand the amount of behavior change needed to achieve a desired reduction in disease burden. For jurisdictions planning to implement an intervention for youth, it can help estimate expected epidemiological impact (absolute or proportional). It enables comparison of the impact of interventions by age, sex, or SPG, and could thus help with intervention design and target-setting by group. It allows jurisdictions to contextualize their estimates alongside other jurisdictions or the nation. More indirectly, for programs that collect limited behavioral data and do not participate in YRBS, or for those with limited surveillance data (e.g., under-counting or lacking SPG data), teen-SPARC can help them argue for data collection improvements. To our knowledge, it is the first publicly available tool of this type. Further online and in-person dissemination will include periodic updates with new data and the development of a user listserv to share questions, feedback, and feature requests with developers and other users, accessible through registration on the teen-SPARC website. This feedback will feed into future development, including additional behavioral changes.

The results yielded both general similarities and some striking differences across pathogens, SPGs and ages, and between NYS and the US. Although our analyses cannot precisely identify causes for each pattern given the numerous model parameters, we can make general observations. For instance, differences in outcomes between gonorrhea and chlamydia must stem from inputs that differ by pathogen (e.g., transmission probability, background prevalence) and not from differences in sexual behavior; this is not true for differences between these pathogens and HIV, since for the latter we only modeled MSM. Similarly, differences across jurisdictions could be caused by behavioral differences, but not by epidemiological factors held constant between jurisdictions. These guidelines can help jurisdictions understand the patterns in their model results across ages and SPGs, and relative to the US as a whole.

Many of the differences in outcome between NYS and the US are consistent with a single behavioral difference observed in YRBS: background condom-use levels. For different condom-use levels, a fixed-percentage increase protects a different proportion of previously unprotected sexual acts; i.e. a 10% increase protects 2.5% of previously unprotected acts with 20% background condom use ([0.1][0.2]/[1–0.2]), but 6.7% with 40% background condom use ([0.1][0.4]/[1–0.4]). Our parameterization revealed that condom use was higher in NYS than nationwide for MSF and FSM (Table 2) but lower for MSM. MSF and FSM numerically dominate the population modeled for gonorrhea and chlamydia, and for these, condom use increases yielded greater proportional incidence reductions in NYS. However, for HIV (only MSM), impact in NYS was lower; and when disaggregated by SPG, impact on gonorrhea was also lower in NYS for MSM. These insights can help jurisdictions like NYS understand how increased condom use—a common outcome of sex education and a Healthy People 2020 goal— can yield multiple distinct signatures in their epidemiological data relative to other jurisdictions, providing context for on-the-ground assessment of these changes. Advanced users may consider additional counterfactual scenarios to isolate differences and identify causal pathways more completely, a particular strength of modeling tools.

Teen-SPARC includes numerous limitations, detailed in the User Manual. We purposefully developed the model to work in a familiar platform (Excel) to attract a range of users; however, this required trade-offs between realism and simplicity. Notably, the model only projects one year and excludes indirect effects (e.g., changes in prevalence among FSM do not impact future incidence for MSF). Moreover, the tool is not required to “balance”, i.e., for information about contacts reported by females having sex with males to harmonize with those reported by males having sex with females. Thus, comparing model outputs for these two groups in particular should be done cautiously. The teen-SPARC model is deterministic, meaning it yields point estimates without error measures; however, users could choose to conduct sensitivity analyses by varying input parameters over desired ranges.

Our calibration focused on one parameter for tractability, but in reality many unmeasured phenomena and estimated parameters distinguish our model from perfect truth. Model parametrization revealed that some data needed to come from multiple sources (coital act counts from NSFG) or be back-calculated with assumptions (partners per year), or required various forms of harmonization (data representing all 13–18-year-olds vs. those attending HS). Individual youth may change SPG over time, which our models only implicitly address through SPG population proportions by age. Each of these reveals considerations for future data collection. Teen-SPARC also masks considerable variation in STI risk by race/ethnicity, socioeconomic status and other attributes. Users may model specific sub-populations (e.g. African-Americans) by using the population-specific data available in their jurisdiction, and our ongoing research will extend these models to account for heterogeneity by race/ethnicity.

Finally, we do not know prevalence among adolescents' partners, but must estimate it using quantities available within the model, including prevalence among other sexually-active adolescents. Adolescents undoubtedly have older partners (12, 13), but without modeling all ages (increasing model complexity and data requirements), we absorbed this unmeasured difference into the calibration process. Future extensions may investigate this more explicitly if requested by users.

STIs represent one of the largest and costliest health burdens for adolescents. They emerge from a complex mix of behavioral, demographic and clinical factors, and YRBS represents an ongoing source of information for understanding changes in the behavioral components. Teen-SPARC is, to our knowledge, the first tool for modeling STI prevention efforts geared at health departments. It uses available YRBS data and runs in an environment that does not require specialized training in modeling. Given all of the elements of a comprehensive STD program that health departments invest in—surveillance, laboratory services, public education, partner services, clinical services and beyond—this tool may help health departments plan and allocate resources around behavioral prevention to reduce STI burden in adolescents.

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LIST OF ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
DASH	Division of Adolescent and School Health
FSM	females who have sex with males (and potentially with females)
MSF	males who have sex with females only
MSM	males who have sex with males (and potentially with females)
SPG	sexual partnering group
STI	sexually transmitted infection
teen-SPARC	teen STI Prevention and Risk Calculator
YRBS	Youth Risk Behavior Survey
YRBSS	Youth Risk Behavior Surveillance System

LITERATURE

1. Centers for Disease Control and Prevention. Sexually transmitted disease surveillance 2017 https://www.cdc.gov/std/stats17/2017-STD-Surveillance-Report_CDC-clearance-9.10.18.pdf. Atlanta: 2018.
2. Owusu-Edusei K Jr., Chesson HW, Gift TL, Tao G, Mahajan R, Ocfemia MC, et al. The estimated direct medical cost of selected sexually transmitted infections in the United States, 2008. Sexually transmitted diseases. 2013;40(3):197–201. [PubMed: 23403600]
3. Satterwhite CL, Torrone E, Meites E, Dunne EF, Mahajan R, Ocfemia MCB, et al. Sexually transmitted infections among US women and men: prevalence and incidence estimates, 2008. Sexually transmitted diseases. 2013;40:187–93. [PubMed: 23403598]
4. Centers for Disease Control and Prevention. HIV surveillance report, vol. 29: diagnoses of HIV infection in the United States and dependent areas, 2017 https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf. Atlanta: 2018.
5. Centers for Disease Control and Prevention. HIV surveillance – adolescents and young adults https://www.cdc.gov/hiv/pdf/library/slidesets/cdc-hiv-surveillance-adolescents-young-adults-2017.pdf. Atlanta: 2017.
6. Chin HB, Sipe TA, Elder R, Mercer SL, Chattopadhyay SK, Jacob V, et al. The effectiveness of group-based comprehensive risk-reduction and abstinence education interventions to prevent or reduce the risk of adolescent pregnancy, human immunodeficiency virus, and sexually transmitted infections: two systematic reviews for the Guide to Community Preventive Services. American Journal of Preventive Medicine. 2012;42(3):272–94. [PubMed: 22341164]
7. Shackleton N, Jamal F, Viner RM, Dickson K, Patton G, Bonell C. School-based interventions going beyond health education to promote adolescent health: systematic review of reviews. Journal of Adolescent Health. 2016;58(4):382–96. [PubMed: 27013271]

8. Mustanski B, Parsons JT, Sullivan PS, Madkins K, Rosenberg E, Swann G. Biomedical and behavioral outcomes of Keep It Up!: An eHealth HIV prevention program RCT. American Journal of Preventive Medicine. 2018;55(2):151–8. [PubMed: 29937115]

9. Centers for Disease Control and Prevention. Healthy People 2020: family planning 2014 [6 18, 2018]. Available from: https://www.healthypeople.gov/2020/topics-objectives/topic/family-planning/objectives.

10. Centers for Disease Control and Prevention. Youth Risk Behavior Survey: data summary and trends report 2007–2017. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/trendsreport.pdf. Atlanta: 2018.

11. Coyle K, Basen-Engquist K, Kirby D, Parcel G, Banspach S, Collins J, et al. *Safer choices*: reducing teen pregnancy, HIV, and STDs. Public Health Reports. 2001;116 Suppl 1:82–93. [PubMed: 11889277]

12. Masho SW, Chambers GJ, Wallenborn JT, Ferrance JL. Associations of Partner Age Gap at Sexual Debut with Teenage Parenthood and Lifetime Number of Partners. Perspectives on sexual and reproductive health. 2017;49(2):77–83. [PubMed: 28301095]

13. Staras SA, Cook RL, Clark DB. Sexual partner characteristics and sexually transmitted diseases among adolescents and young adults. Sexually transmitted diseases. 2009;36(4):232–8. [PubMed: 19265739]

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TABLE 1:

List of inputs to the teen-SPARC tool

Tool worksheet	Item	Likely source for most users
Population sizes	Number of 13- to 18-year-olds, by age and sex	US Census Bureau
	Total population attending high school (HS)	US Census Bureau
	Composition of HS population by age and sex	YRBS
	Proportion of HS students who have had sexual intercourse, by age and SPG	YRBS
Sexual behavior	Mean number of new sexual partners per year, by age and SPG	YRBS
	Mean number of coital acts per partnership, by age and SPG	NSFG
	Probability of condom use, by age and SPG	YRBS
Diagnoses	Annual number of chlamydia diagnoses among 13–18-year-olds, by SPG	Local surveillance
	Annual number of gonorrhea diagnoses among 13–18-year-olds, by SPG	Local surveillance
	Number of 13–18-year old MSM living with an HIV diagnosis	Local surveillance

SPG = sexual partnering group

YRBS = Youth Risk Behavior Survey

NSFG = National Survey of Family Growth

MSM = males who have sex with males

TABLE 2:

Key parameter differences between the national and New York State (NYS) teen-SPARC model analyses

	National					NYS				
	Ages	Males	Females	Total		Ages	Males	Females	Total	
Population in high school (HS)[1]	13–15	3,115,193	3,047,250	6,162,443		13–15	208,947	208,849	417,796	
	16–17	4,170,010	4,127,546	8,297,556		16–17	230,735	233,189	463,924	
	18	1,418,313	1,104,076	2,522,389		18	59,671	40,043	99,714	
	Total	8,703,517	8,278,872	16,982,389			499,354	482,080	981,434	
	Ages	MSF	FSM	MSM		Ages	MSF	FSM	MSM	
Proportion who have had sexual intercourse[2]	13–15	22.4%	18.4%	1.3%		13–15	12.4%	11.9%	0.9%	
	16–17	41.7%	41.2%	2.2%		16–17	23.5%	34.1%	1.8%	
	18	50.0%	52.7%	2.6%		18	36.4%	43.7%	1.0%	
	Ages	MSF-F	FSM-M	MSM-M	MSM-F	Ages	MSF-F	FSM-M	MSM-M	MSM-F
Number of new partners per year (among those who are sexually active)	13–15	1.32	1.38	0.90	0.15	13–15	1.31	1.36	0.92	0.15
	16–17	1.32	1.31	1.08	0.18	16–17	1.33	1.45	0.96	0.16
	18	1.32	1.31	1.08	0.18	18	1.33	1.45	0.96	0.16
	Ages	MSF	FSM	MSM[3]		Ages	MSF	FSM	MSM[3]	
Probability of condom use	13–15	69%	61%	55%		13–15	75%	65%	50%	
	16–17	65%	57%	50%		16–17	68%	58%	43%	
	18	61%	52%	45%		18	70%	60%	45%	
	Infection	MSF	FSM	MSM	Total	Infection	MSF	FSM	MSM	Total
Estimated past year incident cases in HS population[4]	GC	31,046	55,311	6,508	92,865	GC	896	2,491	336	3,723
	CT	219,652	410,928	13,432	644,012	CT	6,761	24,559	777	32,097
	HIV	---	---	1,298	1,298	HIV	---	---	67	67
	Infection	MSF	FSM	MSM		Infection	MSF	FSM	MSM	
Estimated prevalence in HS (among those who have had sexual intercourse)[5]	GC	0.22%	0.91%	0.85%		GC	0.24%	0.98%	1.32%	
	CT	2.78%	10.08%	3.12%		CT	4.28%	11.66%	5.99%	
	HIV			2.44%		HIV	---	---	3.66%	

MSF = male who have sex with females (only); FSM = females who have sex with males; MSM = males who have sex with males MSF-F = MSF's female partners; FSM-M = FSM's male partners; MSM-M = MSM's male partners; MSM-F = MSM's female partners GC = gonorrhea, CT = chlamydia

Sources: population sizes = US Census Bureau; partners per year = YRBS; Condom use = YRBS.

[1] These numbers represent the product of the total HS-attending population (for the Census Bureau) and the estimated distribution of HS students by age and sex (from YRBS).

[2] Proportions having sex are out of the sex-specific population. For example, 41.7% of 16–17-year-olds in HS report having had sexual intercourse with females (but not males), while 2.2% report having had sex with males. The remainder (i.e., 56.1%) report not having had sex at all.

[3] These numbers reflect reports of anal sex with other MSM. For MSM's small number of acts of vaginal sex with FSM, the rates listed for MSF are used.

[4] Calculated within teen-SPARC using reported diagnoses among those in and out of school, the relative sizes of the population in and out of school, and inputs on the estimated proportion of cases ever diagnosed (for gonorrhea and chlamydia) or percent aware of status (for HIV).

[5] Calculated within teen-SPARC using the estimated incidence from the prior step and the inputs on estimated duration of infection (for gonorrhea and chlamydia) or the ratio of estimated incidence and estimated prevalence among adolescents, itself a function of mean time between infection and age 18 (for HIV).

TABLE 3:

Number and proportion of cases averted for each pathogen by teen-SPARC model intervention scenario for New York State (NYS) and nationwide[a]

Setting	Intervention description	Gonorrhea			Chlamydia			HIV		
		Incident cases	#averted	%averted	Incidentcases	#averted	%averted	Incident cases	#averted	%averted
NYS	Baseline model	3,723	-	-	32,097	-	-	67	-	-
	1. Increase by 1% (following Healthy People 2020)	3,664	58	1.6%	31,640	457	1.4%	67	0[b]	0.5%
	2. Increase by 5%	3,430	293	7.9%	29,797	2,300	7.2%	65	2	2.7%
	3: Increase by 14%: All ages (reverse 2007–2017 change)	2,903	820	22.0%	25,556	6,540	20.4%	62	5	7.9%
	4: Increase by 25%: All ages	2,256	1,467	39.4%	20,190	11,907	37.1%	57	10	14.5%
	5: Increase by 25%: 13–15-year-olds only	3,552	171	4.6%	30,639	14,58	4.5%	NA[c]	NA	NA
	6: Increase by 25%: 16–17-year-olds only	2,847	876	23.5%	24,797	73,00	22.7%	NA	NA	NA
	7: Increase by 25%: 18-year-olds only	3,303	420	11.3%	28,947	31,49	9.8%	NA	NA	NA
National	Baseline model	92,864	-	-	644,012	-	-	1,298	-	-
	1. Increase by 1% (following Healthy People 2020)	91,565	1,299	1.4%	635,451	8,561	1.3%	1,290	8	0.6%
	2. Increase by 5%	86,366	6,498	7.0%	601,038	42,974	6.7%	1,256	42	3.3%
	3: Increase by 14%: All ages (reverse 2007–2017 change)	74,650	18,214	19.6%	522,599	121,412	18.9%	1,176	123	9.4%
	4: Increase by 25%: All ages	60,297	32,568	35.1%	424,797	219,214	34.0%	1,070	228	17.6%
	5: Increase by 25%: 13–15-year-olds only	89,236	3,628	3.9%	618,069	25,943	4.0%	NA[c]	NA	NA
	6: Increase by 25%: 16–17-year-olds only	74,572	18,293	19.7%	517,538	126,473	19.6%	NA	NA	NA
	7: Increase by 25%: 18-year-olds only	82,218	10,647	11.5%	577,213	66,798	10.4%	NA	NA	NA

a) Absolute number of cases (total or averted) reflect those among high school students and include both those diagnosed or not. Percent of cases averted also reflects these definitions. However, given model assumptions, the same *percent* also applies to changes in diagnoses, even though the absolute number is different.

b) Cases are rounded to the nearest whole number throughout this table for simplicity of presentation; the expected number of averted HIV cases here is 0.36.

c) HIV outcomes for the age-specific scenarios are not included given the relatively small case numbers and sample sizes for parameterization, especially for New York State, so as to avoid over-interpretation.

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TABLE 4:

Proportion of cases averted by sexual partnering group (SPG) for gonorrhea: New York State (NYS) and nationwide

Setting	Intervention description	% of incident cases averted		
		MSM	MSF	FSM
NYS	Baseline model	-	-	-
	1. Increase by 1% (following Healthy People 2020)	0.8%	2.3%	1.4%
	2. Increase by 5%	4.1%	11.6%	7.0%
	3: Increase by 14%: all ages (reverse 2007–2017 change)	11.6%	32.5%	19.7%
	4: Increase by 25%: All ages	20.7%	58.1%	35.2%
	5: Increase by 25%: 13–15-year-olds only	5.1%	9.5%	2.9%
	6: Increase by 25%: 16–17-year-olds only	13.0%	29.9%	22.7%
	7: Increase by 25%: 18-year-olds only	3.6%	18.7%	9.7%
National	Baseline model	-	-	-
	1. Increase by 1% (following Healthy People 2020)	1.0%	1.8%	1.2%
	2. Increase by 5%	4.9%	9.0%	6.1%
	3: Increase by 14%: all ages (reverse 2007–2017 change)	13.8%	25.2%	17.2%
	4: Increase by 25%: All ages	24.6%	45.0%	30.7%
	5: Increase by 25%: 13–15-year-olds only	3.2%	6.5%	2.6%
	6: Increase by 25%: 16–17-year-olds only	13.1%	24.5%	17.8%
	7: Increase by 25%: 18-year-olds only	8.3%	14.1%	10.4%

MSM = males who have sex with males; MSF = male who have sex with females (only); FSM = females who have sex with males; NYS = New York State.

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TABLE 5:

Estimated percent change in behavior needed to avert a given number of cases of gonorrhea, chlamydia, or HIV in New York State

Infection	Number of cases to avert	% increase in condom use	% decrease in frequency of sex acts
Gonorrhea	1,000	17.1%	27.1%
Chlamydia	1,000	2.2%	3.5%
HIV	10	25.5%	20.8%