A Peek Into the Future: How a Pandemic Resulted in the Creation of Models to Predict the Impact on Sexually Transmitted Infection(s) in New York State (Excluding New York City)

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Abstract: During the initial height of COVID-19 in New York State excluding New York City in March 2020, reports of sexually transmitted infections declined. Prediction models developed to estimate the incidence of early syphilis and gonorrhea during the COVID-19 pandemic were used to study impact on STI diagnoses/reporting and inform sexual health program planning.

G onorrhea (GC) and syphilis, 2 nationally notifiable sexually transmitted infections (STIs) in the United States, have reached epidemic levels.1 As of 2018, the most recent year of national data, these STIs had been increasing for 5 consecutive years.2,3 In New York State excluding New York City (NYS), the increase noted nationally was sustained through the end of 2019 and into the first 2 months of 2020.4 However, contrary to observed sustained STI increases experienced in prior years, there was a decline in reporting of STIs in March 2020 corresponding with the increase in coronavirus disease (COVID-19) in NYS. The impact of COVID-19 on sexual activity and STIs are not yet known, although early research shows a decline in sexual activity with casual partners due to stay-at-home orders,4 although early research shows a decline in sexual activity with casual partners due to stay-at-home orders,4 and an impact on sexual health services including reduced access to STI screening.7,8-13 Although the former suggests STI incidence may decline, the latter suggests individuals with STIs may not be accessing sexual health services as needed, leading to an artificial decline in diagnoses due to a decline in STI screening and reporting.

To inform STI prevention, control, planning, and program during and after the COVID-19 pandemic, jurisdictions need a way to estimate the probable burden of STIs. Creating a prediction tool that jurisdictions can use for planning purposes, regardless of another epidemic/pandemic, will be critical for successful program planning. To address these needs, this analysis focused on estimating the incidence of early syphilis (ES) and GC in NYS amid the COVID-19 pandemic.14

METHODS

Data Sources

New York State STI surveillance data, consisting of laboratory confirmed diagnoses of ES and GC (per the Centers for Disease Control and Prevention case definitions and surveillance data reporting requirements) between January 2015 and August 2020 in NYS, were extracted from the NYS surveillance system.15–18 Monthly reported NYS COVID-19 diagnoses were extracted from NYS Statewide COVID-19 public dashboard.19

Statistical Analysis

Reported diagnoses of ES and GC from January 2015 to December 2019 in NYS were used to predict the expected monthly diagnoses for 2020. Reported monthly diagnoses of ES and GC from March to August of 2020 were compared with predicted monthly ES and GC diagnoses from March to August of 2020, and reported monthly ES and GC diagnoses from March to August of 2019. Reported COVID-19 diagnoses for the same 2020 time were used for additional comparisons.

Specifically, monthly reports of ES and GC diagnoses were used to inform autoregressive integrated moving average (ARIMA) models. The ARIMA models, a time series model widely used for forecasting approaches with the advantage of modeling trends and seasonal variation, were developed for each STI of interest.20 Aggregated data were used for conducting the augmented Dickey-Fuller test, and a trend and correlation analysis to identify the best fit of the order of difference of the dependent series. Models were built on the results of tests and analyses of residual and outliers, and diagnostic statistics were checked. Models were then used to predict the numbers (and 95% confidence intervals) of monthly ES and GC diagnoses for 2020. Data extraction and statistical analyses were conducted using SAS 9.4 software.

RESULT

Early Syphilis

Model predictions show a higher number of estimated ES diagnoses from March to August 2020 as compared with reported diagnoses (Fig. 1). Seasonality was not significant and therefore not accounted for in the ARIMA model. The number of reported ES diagnoses in 2020 decreased from 130 diagnoses in January to 68 and 53 in March and April, respectively, followed by
increases in subsequent months. The number of reported ES diagnoses in March to August 2020 was lower than both the predicted numbers (including lower limit 95% confidence interval) and those in the same period in 2019.

**Gonorrhea**

Model predictions show an overall lower number of GC diagnoses from March to August 2020 as compared with reported diagnoses (Fig. 2). Seasonality was included based on prior empirical GC data. The numbers of reported GC diagnoses in March and April of 2020 (1027 and 870, respectively) were lower than that reported in January (1299), followed by increases in subsequent months. With an exception of April, reported GC diagnoses in June to August 2020 were similar or higher than the predicted diagnoses and higher than reported diagnoses in 2019.

**COVID-19**

The largest numbers of reported COVID-19 diagnoses in NYS at the time of this analysis were in March and April of 2020, with the highest number reported in April (n = 102,351). March and April correspond to months where there was an observed decline in reported ES and GC diagnoses, and the largest discrepancy between reported diagnoses and model predictions.

**DISCUSSION**

The COVID-19 pandemic and subsequent stay-at-home orders coincided with an unexpected reduction in STI diagnoses, with no ability to determine if this was a decline in incidence or screening. Models developed for local use provided insight into the observed declines. Overall, there were notable differences in the predicted and reported STIs in NYS from March to August 2020. The magnitude of the difference was most notable during the height of the COVID-19 pandemic (March–April 2020), and this difference decreased as COVID-19 diagnoses declined. These findings suggest the decline of reported diagnoses is, in part, a result of a change in care-seeking practices during the pandemic and not a true decline in incidence. As suggested by the rapid increase in both ES and GC in May, NYS will likely see a high rebound morbidity, which will affect public health service delivery.

Modeling results for ES aligned with what we expected based on the evidence of reduced STI screening due to changes in health care access, availability, and individual care-seeking behaviors. However, ES was harder to model because of factors related to the way syphilis samples were collected, tested, and interpreted. COVID-19 likely impacted these diagnostic services owing to stay-at-home orders resulting in a possible delay in serologic testing. Furthermore, there is an inherent lag in reporting of syphilis diagnoses, as surveillance and disease intervention specialists (DIS) staff must first determine if there is a syphilitic serologic history to determine the accurate diagnostic stage. Therefore, findings from the ES model are considered less robust, to date. That said, findings suggest that there are more individuals with ES than laboratory reporting alone reveals.

Counter to findings from the ES model, the higher number of GC diagnoses reported compared with what was predicted was
not what was anticipated. One reason for this difference could be the pathology of GC, which may result in more persons seeking STI screening (i.e., a shorter latency period and, although a high proportion are asymptomatic infections, symptoms that are not self-limited). As a result, we would see an increase in reported GC diagnosis as compared with ES. However, if we assume care-seeking behaviors are less impacted by COVID-19 than ES, the model results suggest NYS is experiencing an increase of GC incidence. These results at minimum suggest the need to reinforce primary prevention messages. Expedited partner therapy for GC is one such supported practice to treat and prevent reinfections. In addition, resources on preventing COVID-19 while continuing to enjoy sex should be widely distributed.

There are several limitations to this analysis. First, models did not account for any covariates such as region of NYS, age, sex, current gender identity, race/ethnicity, or sex of sex partner. Some populations disproportionally impacted by COVID-19 mirror those disproportionally impacted by STIs. For example, sexual minorities are particularly adversely affected, and any deprioritization of their health may lead to an increase in STIs within this impacted population. Second, changes in sexual activity could not be modeled, and although GC increases indicate sexual activities continued during stay-at-home orders, modes of how individuals met partners or the impact of fewer sexual encounters was not studied and cannot be reflected in these findings. Lastly, because population-level screening data are unavailable, we cannot deduce if there are any delays in reporting and/or declines in screening. For example, it is possible that GC increases from June to August are the result of individuals accessing STI screening after a lifting of the stay-at-home orders in NYS.

In NYS and most other jurisdictions, public health follow-up by DIS staff is limited to only those with laboratory-confirmed STI diagnoses. Therefore, if results of these models are conservatively accurate, we are unable to reach individuals infected but undiagnosed with GC and/or ES in NYS through traditional DIS programming. This disease intervention gap may not only result in sustained transmission of GC and ES to individuals’ sex partners but also increase the risk of contracting HIV. If COVID-19 continues, or at minimum, less care seeking continues, jurisdictions may need to explore opportunities to conduct DIS interventions for individuals treated for STIs via syndromic management.

Because of COVID-19 prevention practices, updated interventional strategies, such as at-home STI screening, will need to be implemented to reach all populations. Continuous/real-time monitoring of STI surveillance using these models is important during the COVID-19 pandemic to inform redirection of resources and changing strategies to interrupt disease transmission. These models can also be used to predict diagnostic testing needs, perhaps enabling jurisdictions to work collaboratively in sharing of resources when shortages are noted. Further research is needed to study the causes of true decreases/increases in diagnoses and its effect on future morbidity.

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