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Modeling the Cost-Effectiveness of Express Multisite Gonorrhea Screening Among Men Who Have Sex With Men in the United States

Rebecca Earnest, MPH,*† Minttu M. Rönn, PhD,† Meghan Bellerose, BA,†
Anatole S. Menon-Johansson, MD,‡ Andrés A. Berruti, PhD,§ Harrell W. Chesson, PhD,§
Thomas L. Gift, PhD,§ Katherine K. Hsu, MD,¶ Christian Testa, BA,† Lin Zhu, PhD,||
Yelena Malyuta, MPH,† Nicolas A. Menzies, PhD,† and Joshua A. Salomon, PhD†||

Background: Men who have sex with men (MSM) experience high rates of gonococcal infection at extragenital (rectal and pharyngeal) anatomic sites, which often are missed without asymptomatic screening and may be important for onward transmission. Implementing an express pathway for asymptomatic MSM seeking routine screening at their clinic may be a cost-effective way to improve extragenital screening by allowing patients to be screened at more anatomic sites through a streamlined, less costly process.
Methods: We modified an agent-based model of anatomic site-specific gonococcal infection in US MSM to assess the cost-effectiveness of an express screening pathway in which all asymptomatic MSM presenting at their clinic were screened at the urogenital, rectal, and pharyngeal sites but

forewent a provider consultation and physical examination and self-collected their own samples. We calculated the cumulative health effects expressed as gonococcal infections and cases averted over 5 years, labor and material costs, and incremental cost-effectiveness ratios for express versus traditional scenarios.
Results: The express scenario averted more infections and cases in each intervention year. The increased diagnostic costs of triple-site screening were largely offset by the lowered visit costs of the express pathway and, from the end of year 3 onward, this pathway generated small cost savings. However, in a sensitivity analysis of assumed overhead costs, cost savings under the express scenario disappeared in the majority of simulations once overhead costs exceeded 7% of total annual costs.
Conclusions: Express screening may be a cost-effective option for improving multisite anatomic screening among US MSM.

In the United States, men who have sex with men (MSM) experience a disproportionately high rate of reported gonococcal infections, with 6508 diagnoses per 100,000 MSM in 2018.[1] This represents a 375.5% increase since 2010 among the 6 jurisdictions continuously participating in the STD Surveillance Network between 2010 and 2018.[1] The burden of infection is a pressing public health challenge in light of substantial screening efforts required for gonorrhea control and reports of increasing antimicrobial resistance to the remaining first-line antibiotics.[1–3] Revisiting existing strategies for the control of gonorrhea is needed to evaluate the most cost-effective alternatives.

The Centers for Disease Control and Prevention recommends that MSM be screened at each anatomical site of exposure regardless of condom use at least annually and every 3 to 6 months for men who report risk behaviors such as multiple anonymous partners or substance abuse.[4] Urogenital gonococcal infection in males is frequently symptomatic, whereas rectal and pharyngeal (i.e., extragenital) infections are mostly asymptomatic,[5,6] and symptom-based testing often misses extragenital infections. Asymptomatic infections may serve as transmission reservoirs,[3,7–10] yet levels of extragenital asymptomatic screening are likely lower than recommended.[10–15] Potential explanations for this include provider time constraints and discomfort with taking sexual risk histories.[16]

Express sexually transmitted infection (STI) screening clinics could potentially enable more men to receive triple-site screening (i.e., be screened at all 3 anatomical sites) without increasing costs. The structure and operationalization of these clinics varies, but the most basic model involves allowing asymptomatic patients who are not sexual contacts of a positive case to be tested more quickly by not including a provider consultation and physical examination in the visit. Additional features included in express STI screening may include self-collection of samples, computer-assisted self-registration and risk history elicitation, and the receipt of results via online platforms or text.[17] Express screening currently remains limited in the United States, but there

is growing interest in its implementation as diagnosed infections continue to rise and many STI clinics grapple with capacity and budgetary challenges.[1,17–21] Express screening can increase clinic efficiency and reduce barriers to care, allowing more patients to be screened without expending further resources.[17,20–27] However, previous studies have not evaluated the potential impact and cost-effectiveness of express screening as a way to improve extragenital screening among MSM. Some clinics also exclude MSM from express screening options[20,21,24] or require them to undergo an initial provider visit before becoming eligible for express screening.[22,25] In addition, it is particularly important to consider opportunities to improve patient convenience and comfort while providing quality care given that the medical community is recommending that MSM be screened relatively frequently.[22]

We examined whether express screening could be a cost-effective way to reduce gonorrhea incidence among MSM. We compared health and economic outcomes from traditional and express screening pathways using a previously calibrated site-specific agent-based model of gonorrhea transmission among MSM in the United States and detailed cost data from express clinics serving an MSM population implemented in the United Kingdom.[28,29]

MATERIALS AND METHODS

Mathematical Model

We adapted our previous gonorrhea model for this study,[28] which was developed as an extension of the EpiModelHIV modeling platform.[30] The model is a stochastic agent-based model that simulates multisite, dynamic gonorrhea transmission among an open population of approximately 10,000 18- to 39 year-old non-Hispanic Black and White MSM.[28] In the model, men can acquire infection at the urogenital, rectal, and/or pharyngeal sites through anal, oral, and ororectal sex. The probability of transmission is influenced by factors such as condom use, condom failure, and sex act rates, which can differ based on the type of sexual partnership (main, casual, or one-time). The model allows for symptomatic testing, asymptomatic screening, and treatment pathways. The model was calibrated to site- and race-specific gonorrhea incidence and prevalence using the approximate Bayesian computation with sequential Monte Carlo method.[31s]

For the present study, the model was modified to include an express screening pathway, in which 100% of asymptomatic men who presented for urogenital screening underwent a streamlined process. In this process, 100% of patients were screened at all 3 anatomic sites but did not undergo a provider consultation or physical examination and self-collected their specimens. This pathway is described in detail in the Scenarios section.

Data

Sexual partnership and behavioral data were primarily sourced from two 2011–2014 Atlanta sexual network studies among MSM and a national survey of 24,787 MSM that asked men about their sexual behaviors during their most recent sexual event.[32s–35s] Urogenital and rectal incidence and prevalence calibration targets were from the 2 Atlanta studies.[32s,33s,35s] These studies did not test for pharyngeal gonorrhea, so we obtained those targets from a prospective cohort of California MSM.[36s] The epidemiological model and its calibration are detailed in a prior paper and technical appendix.[28]

Staff and material costs for each step of the patient visit were from the Integrated London Sexual Health Tariff project provided by Pathway Analytics.[29] We used UK data because similarly detailed US data were not available for express screening programs. Material costs did not include equipment purchases. In this project, experts from sites around London mapped the resources used for 140 patient care pathways in sexual and reproductive health clinics, including express STI screening clinics. The costs were designed to be setting independent and were drawn from the British National Formulary, local suppliers, and Department of Health salary scales. We converted the costs in UK pounds to US dollars based on the June 2016 exchange rate, and then adjusted for inflation between June 2016 and June 2020 using the medical care component of the US Bureau of Labor Statistics consumer price index.[37s,38s]

Scenarios

We compared traditional and express scenarios for asymptomatic screening. The traditional scenario was represented by our calibrated model. In this scenario, asymptomatic men (regardless of infection status) had a 1% weekly probability of presenting at the clinic for urogenital screening (Fig. 1). This value was derived
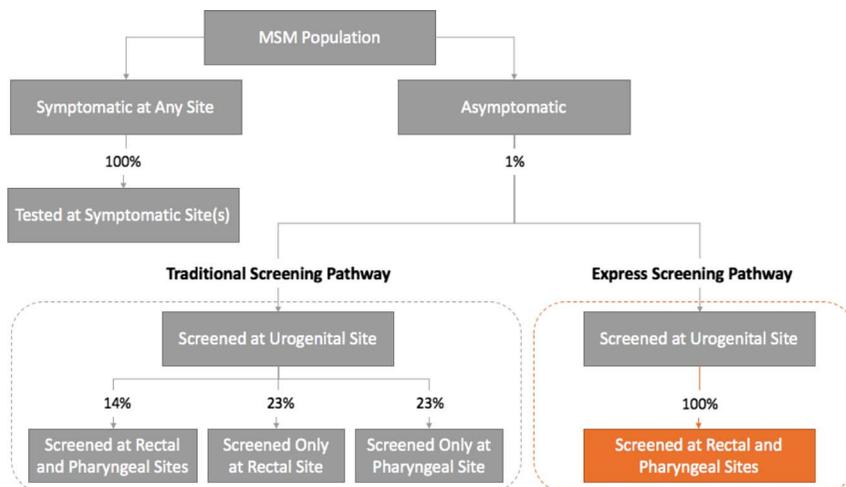
Figure 1. Patient Testing and Screening Pathways. Symptomatic testing and asymptomatic screening pathways for the traditional and express screening scenarios. All (100%) symptomatic men were tested at the symptomatic site(s). For asymptomatic men, there was a weekly 1% probability that they presented for urogenital screening. In the traditional model, if this occurred, there was a 23% probability of being screened at only the rectal site or only the pharyngeal site and a 14% probability of being screened at both extragenital sites. In the express model, 100% of men presenting for urogenital screening were also screened at both extragenital sites.

TABLE 1. Asymptomatic Screening Costs (June 2020 US Dollars) in the Traditional Versus Express Scenarios

	Anatomic Sites Screened			
	Traditional			Express
Cost Component	Single Site: Urogenital Only	Dual Site: Urogenital + (Rectal or Pharyngeal)	Triple Site: Urogenital + Rectal + Pharyngeal	Triple Site: Urogenital + Rectal + Pharyngeal
1. Registration	3.98	3.98	3.98	4.01
2. Consultation	13.44	13.44	13.44	0.00
3. Sample collection	11.38	18.58	25.79	10.86
4. Counseling	14.02	14.02	14.02	14.02
5. Testing	20.30	40.60	60.91	60.91
6A. Negative patient notification	5.24	5.24	5.24	3.91
6B. Positive patient notification	14.81	14.81	14.81	3.94
Total if all sites screened are negative*	68.35	95.86	123.37	93.70
Total if any site screened is positive*,[†]	77.92	105.43	132.94	93.73

*Totals may not match the sum of applicable rows because of rounding.

[†]Higher-level staff members notify positive patients of their diagnosis, and this is reflected in the increased screening cost for these patients.

from a previous model-based estimate of the national annual screening rate for MSM.[39s] Men then had a 38% independent probability of also being screened at each of the rectal or pharyngeal sites,[10,11,15,40s,41s] which translated into an approximate 23% probability of being screened at only the rectal site or only the pharyngeal site and a 14% probability of being screened at both sites in addition to urogenital screening. Asymptomatic patients received the standard level of care, which involved registering at the clinic upon arrival, consulting with a provider, undergoing a physical examination with sample collection by a provider, and counseling. Afterward, they were contacted with their results and told whether they needed to return to the clinic.

In the express scenario, men had the same probability of presenting at the clinic for urogenital screening as in the traditional scenario. Upon presenting for urogenital screening, however, 100% of men were then also screened at the rectal and pharyngeal sites regardless of exposure. Asymptomatic patients followed a streamlined process, forgoing the provider consultation and physical examination and self-collecting their own specimens. We assumed that express patients still received some form of counseling, which represents a blend of staff time and materials (e.g., STI literature, condoms, and lubricant) costs. In addition, staffing levels were optimized in the express scenario to prioritize higher-level staff members for symptomatic patients who required more specialized medical care.

In both scenarios, symptomatic testing and treatment procedures remained the same: symptomatic patients in the express scenario underwent a traditional provider visit. All patients with

positive test results at any site were assumed to be treated based on studies showing high levels of return for treatment.[20,42s–44s] Details on cost assumptions for the 2 scenarios appear in Tables 1–3. We simulated each scenario 128 times for 5 years after a 60-year burn-in period.

Although STI clinics incur numerous types of annual costs, our data set only included costs related to labor and materials. In particular, we wanted to understand how different assumptions of unmeasured annual overhead/administrative costs would change the cumulative total cost difference between the traditional and express scenarios. We conducted a sensitivity analysis varying annual overhead costs in 1% increments from 1% to 10% of total annual labor and materials costs for both scenarios. We assumed this range to test a wide range of estimates given a lack available data on these costs. We compared how the cumulative total cost difference varied for each combination of assumed annual overhead costs levels for the traditional and express scenarios.

Outcomes

We calculated gonorrhea outcomes at the infection level and the patient level; the infection-level analysis measured each infected anatomic site within an individual separately, and the patient-level analysis measured whether or not the individual was infected at any site. In the rest of the article, we refer to patient-level outcomes as "cases." Outcomes included prevalence and incidence per 100 person-years and the cumulative incremental cost-effectiveness ratio (ICER).

TABLE 2. Symptomatic Testing Costs (June 2020 US Dollars) for Both Scenarios

	Anatomic Sites Tested*		
Cost Component	Single Site: Urogenital Only	Single Site: Rectal Only	Dual Site: Urogenital + Rectal
1. Registration	3.98	3.98	3.98
2. Consultation	13.44	13.44	13.44
3. Sample collection	11.38	9.54	18.58
4. Counseling	14.02	14.02	14.02
5. Testing	20.30	20.30	40.60
6A. Negative patient notification*	—	—	—
6B. Positive patient notification	14.81	14.81	14.81
Total if all sites tested are negative[†]	—	—	—
Total if any site tested is positive[‡]	77.92	76.09	105.43

*There was not symptomatic triple-site screening because the model assumed that 0% of pharyngeal infections are symptomatic.

[†]All symptomatic patients in the model were infected.

[‡]Totals may not match the sum of applicable rows because of rounding.

TABLE 3. Treatment Costs (2020 US Dollars) for Both Scenarios

	Anatomic Sites Treated
Cost Component	All Infected Sites*
1. Registration	3.98
2. Treatment	26.61
3. Counseling	11.46
Total[†]	42.04

*Treatment was the same regardless of infected site(s). Patients were only treated if they have a positive diagnostic test result.

[†]Totals may not match the sum of applicable rows because of rounding.

The cumulative ICER was calculated as (cumulative total cost difference/cumulative number of infections or cases averted). The cumulative total cost difference was (cumulative total costs in the express scenario − mean of the cumulative costs in the traditional scenario across simulations). Total costs were the sum of screening, testing, and treatment costs. The cumulative number of infections averted was (mean cumulative number of infections in the traditional scenario − cumulative number of infections in the express scenario). The cumulative number of cases averted was calculated similarly. We used bootstrapping to draw 100 samples of the cumulative total cost difference and the cumulative number of infections or cases averted. For each sample, we then calculated the ratio of the mean total cost difference to the mean difference in infections or cases. We reported the 95% confidence interval for the mean ratios across the samples. We chose infections and cases averted as the benefit instead of quality-adjusted life years because 2 of the primary drivers of quality-adjusted life-year losses associated with gonorrhea in MSM are related to the increased risk of HIV acquisition or the development of antimicrobial resistant infection, neither of which was explicitly modeled.[1] Costs and benefits were each discounted at 3% annually using the midpoint method.

RESULTS

The express scenario reduced site-specific infection and overall case prevalence (Fig. 2) and incidence (Fig. 3) by approximately 30% each over the 5-year period.
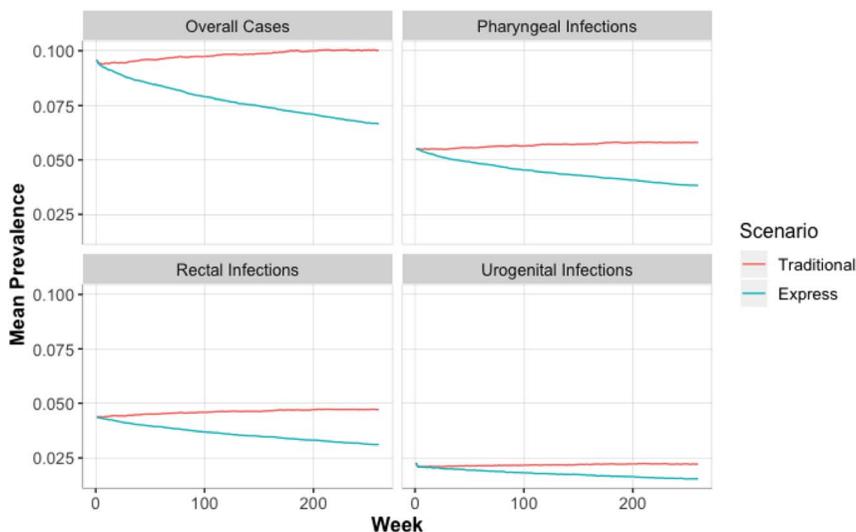
Costs

Screening was the most substantial cost for both scenarios, followed by testing and treatment (Fig. 4). Cumulative screening costs at the end of the 5-year intervention period were higher under the express versus traditional scenario, whereas testing and treatment costs were slightly lower. Total costs for the 2 scenarios were relatively close over the 5 years, with the express scenario saving an average of $31,000 in discounted costs compared with the traditional scenario by the end of the intervention.

Cost-Effectiveness

The cumulative ICER from our initial analysis showed that, over the 5 years, the additional cost per infection and case averted decreased under the express scenario compared with the traditional scenario (Table 4). By the end of year 3 of the intervention, the express scenario generated small cost savings while reducing infections and cases compared with the traditional scenario.

In the sensitivity analysis, we tested how sensitive the numerator of the ICER, the cumulative total cost difference, was to changes in overhead costs unmeasured in our primary analysis (Fig. 5). Throughout the analysis, we maintained the cumulative number of cases and infections averted reported in Table 4. As the overhead cost level for the express scenario increased, the percentage of simulations in which there were cost savings decreased. In each simulation, we varied the traditional overhead cost level. When the express overhead cost level was between 1% and 2% of total annual costs, we observed cost savings by the end of year 5 in 100% of the simulations. The cumulative cost savings ranged from −$311,798 to −$375, implying an ICER ranging from −$89 to $0 per infection averted and −$137 to $0 per case averted. When the express overhead cost level was between 3% and 7%, we observed cost savings in 50% to 90% of the simulations. Cumulative cost savings ranged from −$251,355 to $156,766, indicating an ICER of −$72 to $45 per infection averted and −$110 to $69 per case averted. Once the express overhead cost level exceeded 7% of annual total costs, we noted higher cumulative total costs for the express scenario versus the traditional scenario in the majority of simulations. In this instance, the cumulative cost savings ranged from −$95,913 to $249,929, yielding

Figure 2. Case and anatomic site-specific infection prevalence in the traditional versus express scenarios. Weekly prevalence, averaged across simulations, for overall cases and site-specific infection for the traditional (red) versus express (blue) scenario.
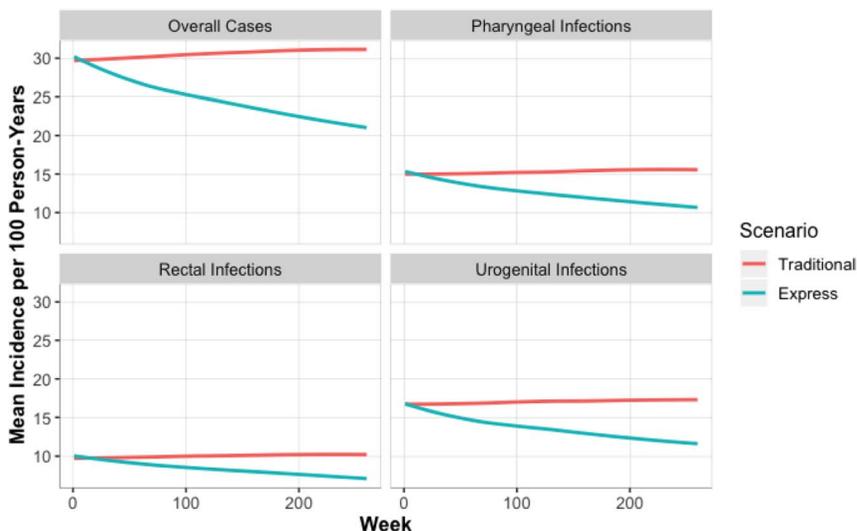
Figure 3. Case and anatomic site-specific infection incidence in the traditional versus express scenarios. Weekly incidence per 100 person-years, averaged across simulations, for overall cases and site-specific infection for the traditional (red) versus express (blue) scenario.

an ICER of −$28 to $72 per infection averted and −$42 to $110 per case averted.

DISCUSSION

In our agent-based model of site-specific gonorrhea transmission, we evaluated the cost-effectiveness of implementing an express pathway for asymptomatic MSM seeking routine screening at their clinic. The baseline estimates from the model implied an approximately 30% decrease in infection and case prevalence (Fig. 2) and incidence (Fig. 3) under the express scenario as a result of the implemented triple-site screening. Express screening detected additional extragenital infections that would sometimes be missed during traditional screening and averted onward transmissions from these sites. We found in our earlier modeling study describing site-specific infection and case dynamics that treating

asymptomatic rectal infections that would have gone undetected can play a particularly important role in reducing onward transmission.[28]

Express screening costs were higher than traditional screening costs because of triple-site screening for every asymptomatic patient (Fig. 4). However, the increased cost of screening more anatomic sites per patient was somewhat offset by the lower costs for other components of the express screening visits, resulting in fairly similar costs over time. In contrast, higher incidence under the traditional screening scenario led to more symptomatic testing and treatment costs, demonstrating that express screening may be a way to improve multisite gonorrhea screening and reduce incidence without expending more resources.

The cumulative ICER (Table 4) demonstrates this as well. For both infections and cases, we observed that the cumulative ICER decreased over the 5-year intervention period as total cumulative traditional screening costs began to exceed express costs,
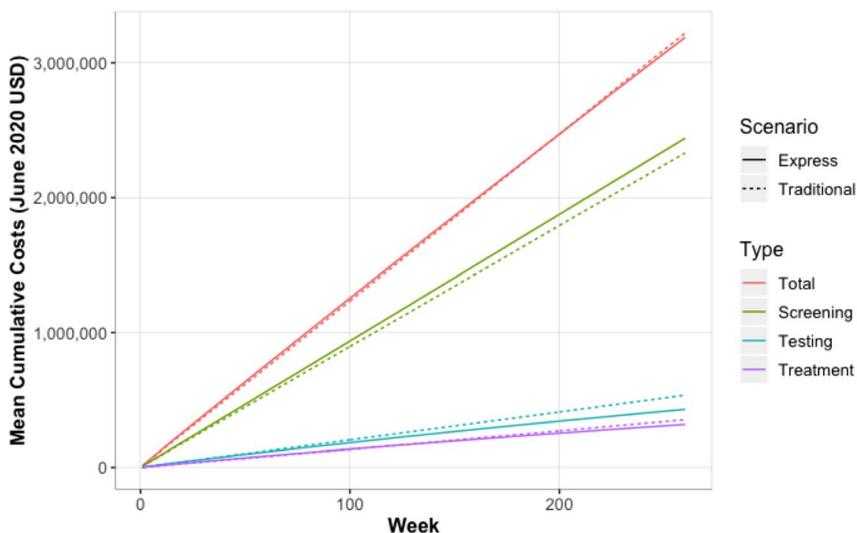

Figure 4. Mean cumulative costs in the traditional versus express scenarios. Mean weekly cumulative undiscounted costs over time for the express (solid line) and traditional (dashed line) scenarios for total (red), asymptomatic screening (green), symptomatic testing (blue), treatment (purple) costs.

TABLE 4. Mean Cumulative ICER for Infections and Cases Comparing the Traditional and Express Scenarios

Year	Cumulative Total Cost Difference	Infections (Mean and 95% CI)		Cases (Mean and 95% CI)	
		Cumulative Number Averted	Cumulative ICER	Cumulative Number Averted	Cumulative ICER
1	8147 (7951 to 8342)	172 (169–176)	48 (46 to 49)	117 (114 to 119)	71 (68 to 73)
2	5701 (5263 to 6139)	714 (706 to 722)	8 (7 to 9)	470 (465 to 476)	12 (11 to 13)
3	−1256 (−1765 to −747)	1475 (1461 to 1488)	Cost saving	953 (944 to 961)	Cost saving
4	−13,980 (−14,775 to −13,185)	2410 (2389 to 2430)	Cost saving	1577 (1566 to 1589)	Cost saving
5	−31,334 (−32,278 to −30,390)	3500 (3476 to 3523)	Cost saving	2275 (2263 to 2288)	Cost saving

Mean cumulative ICER comparing the traditional and express scenarios for the end of each year for infections and cases. The ICER numerator (the cumulative discounted total cost difference) and denominator (the cumulative number of infections or cases averted) were reported for infections and cases.

driving incremental cost savings for each additional infection and case averted toward the end of the intervention period. However, as costs were only available for labor and materials and estimates of program overhead costs were unavailable, we conducted a sensitivity analysis. Figure 5 shows that, if we assumed relatively low overhead cost levels for the express scenario, the ICER would be negative, even if traditional scenario overhead cost levels were relatively low. However, as we increased the overhead cost level for the express scenario, the ICER increasingly became more likely to be positive for a given overhead cost level for the traditional scenario, demonstrating the sensitivity of our findings to unmeasured overhead costs in both scenarios. Varying the overhead cost level for each of our scenarios effectively changed the slope of the cumulative total cost curves seen in Figure 4, influencing the point at which the traditional scenario becomes more expensive than the express scenario. Overhead costs would depend in part on the type of express STI clinic implemented. In some places, express screening was added to an existing traditional STI clinic, and the overhead costs might be similar to those before implementation.[20–26] In others, express screening was implemented as a new clinic, and overhead costs might differ more substantially between the traditional and express clinics depending on how the express clinic was set up.[27] Express visits could potentially be established in dedicated STI clinics or alternative clinics; many jurisdictions provide STD care in general public health or other nondedicated STI clinics.[18,45s]

Some express clinics have previously excluded MSM from express screening, requiring them to be seen by a provider. These restrictions are in part due to high rates of extragenital gonorrhea (not all express clinics triple-site screen MSM) combined with a previous lack of an approved nucleic acid amplification test (NAAT) for these specimens and the need to provide more comprehensive services for MSM.[20,21,24] However, the Food and Drug Administration approved the first NAATs for extragenital gonorrhea in 2019, and numerous clinics have successfully implemented express screening for MSM.[14,22,25,27,46s] In addition, some of these clinics required that MSM patients be seen first via a traditional provider visit before using the express pathway.[22,25] We assumed in the express scenario that 100% of asymptomatic men were screened via the express pathway. If we instead assumed that only some asymptomatic men received express screening, this would reduce the epidemiological impact found in our model, as fewer men would be triple-site screened and some infections would be missed. Similarly, there would be a reduction in cost savings as we would then observe more symptomatic infections requiring more costly testing and treatment. In addition, we assumed full adherence to triple-site screening in the express pathway. If this adherence were reduced, it could similarly reduce the epidemiological impact of our findings. Lastly, we did not vary site-specific gonorrhea screening by HIV or preexposure prophylaxis status because of a lack of reliable data.
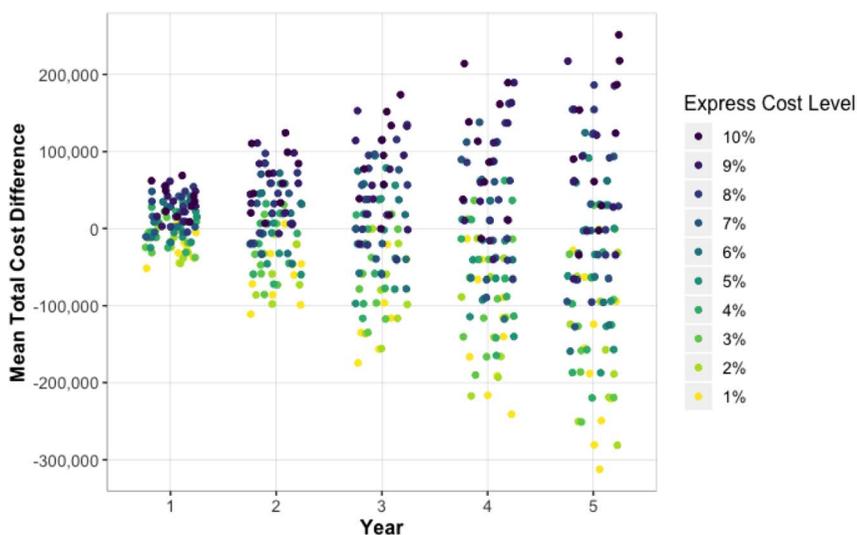

Figure 5. Mean cumulative total cost difference by year in a sensitivity analysis of overhead costs. Mean cumulative total cost difference by year varying the overhead cost level as a percentage of total annual costs. Each dot represents the yearly cumulative total cost difference for a given combination of assumed express and traditional scenario overhead cost levels. The color indicates the express scenario overhead cost level. Within each year, the spread of dots for each color represents how the cost difference varied given different values of the traditional scenario overhead cost level.

Express clinics serving MSM communities generally provide gonorrhea and chlamydia NAAT screening via the express pathway with the option to include provider-administered HIV and syphilis blood testing afterward to meet screening recommendations for MSM.[22,25,27] We did not include chlamydia screening in the model, although our diagnostic costs were for bundled gonorrhea and chlamydia NAATs, so there are likely further benefits not realized in our model. We did not include syphilis and HIV testing, as this is generally provided as an add-on service for men being express screened for gonorrhea and chlamydia and was not the focus of our article. Additional limitations include that we did not model changes in screening demand and supply (the availability of visits). We maintained a constant weekly probability at which asymptomatic men (regardless of infection status) presented for urogenital screening constant in both scenarios, although the volume of men presenting would depend on the number of asymptomatic men in the population. Demand for services could increase if the patient population found express screening a more attractive and convenient option, or if such services fulfilled an unmet need.[27,47s] In addition, among clinics experiencing capacity constraints and asking asymptomatic patients to return at a later date, express screening could increase supply,[20–27] potentially reducing the time to treatment by allowing clinics to see patients sooner and/or by using in-house diagnostic platforms with faster turnarounds.[27] Our time to treatment in the express scenario remained the same as in our traditional scenario with men diagnosed and treated within 1 week, the time step used in our baseline calibrated model. We did not explicitly model changes in demand and supply because of a lack of data, but incorporating these into a future analysis could increase both the benefits and costs observed under the express scenario. Finally, the studies from which we sourced many of our sexual partnership and behavioral parameters and site-specific incidence and prevalence calibration targets may not be representative of MSM in other locations. In addition, sexual behaviors, screening norms, and diagnostic test sensitivity have changed over time. However, the strength of the Atlanta cohort studies is that sexual partnership, behavioral, and prevalence and incidence data (excluding for pharyngeal gonorrhea) were all measured within the same population. The lack of more recent, detailed data underlines the need for further research in this area.

We did not include start-up costs, which could vary based on whether the express clinic was established as a standalone clinic or simply incorporated as a new service at an existing clinic. We focused on ongoing costs in the form of labor, materials, and overhead costs, as these would not be amortized over time in the way that start-up costs would be. Because of a lack of comparably detailed cost data for the United States, we directly translated UK costs to US dollars, which would not reflect national differences in labor and materials costs. Also, the costs do not reflect idle capacity of clinics and/or differences in costs across regions.

Although this modeling analysis is exploratory, this is the first to demonstrate that express screening may be a cost-effective option for improving multisite anatomic screening among MSM in the United States while maintaining similar ongoing costs. Future analysis could consider the use of pooled testing of samples from the 3 anatomic sites to further increase the cost-effectiveness.[48] Increased multisite screening will be especially important as antimicrobial resistance continues to spread, rendering gonorrhea more challenging to control in an already burdened population.[1] This analysis also demonstrates how the cost-effectiveness of express screening programs is sensitive to how such programs are structured, and careful consideration is required when determining patient eligibility criteria for express screening, services provided, the local burden of disease, and operational and infrastructure changes required.

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For further references, please see "Supplemental References," http://links.lww.com/OLQ/A689.