Cost-effective strategies of testing for HIV and sexually transmitted infections (STIs)

Question

What are the best practices of cost-effective testing for HIV and bacterial STIs (chlamydia, gonorrhea, syphilis, and trichomoniasis)?

Key Take-Home Messages

- Rates of chlamydia, gonorrhea, and infectious syphilis have risen in Canada from 2015 to 2019 (1). An observed decrease in HIV cases has been detected recently, however a reduction in testing services throughout the COVID-19 pandemic may have impacted screening (2).

- Cost-effective strategies for providing access to HIV/STI testing include self-testing at home (3–5), testing at sex venues (6, 7), in emergency (8–10) and non-emergency health care settings (11, 12), in pharmacies (13, 14), and using partner notification services (15). Evidence of cost-effectiveness was also found in strategies targeted to people experiencing homelessness (16, 17) or residing in detention centres (18).

- Providing accessible, cost-effective HIV/STI testing has potential to reach individuals who have never received such screening before (5, 9, 14). Cost-effective HIV/STI screening can also provide financial benefits (i.e. reduced operational costs) to programs and facilities offering the services, such as hospitals and clinics (8, 9, 11).

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The OHTN Rapid Response Service offers quick access to research evidence to help inform decision making, service delivery, and advocacy. In response to a question, the Rapid Response Team reviews the scientific and grey literature, consults with experts if required, and prepares a review summarizing the current evidence and its implications for policy and practice.

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The Issue and Why it's Important

According to the Public Health Agency of Canada, approximately 90% of people living with HIV in Canada (n=56,200) had been diagnosed in 2020, while an estimated 10% (n=6,590) remained undiagnosed and therefore unaware of their HIV-positive status (2). In 2020, there were 4.3 cases of HIV diagnosed for every 100,000 people in Canada, and 3.5 cases for every 100,000 individuals in Ontario (19); ensuring all people living with HIV are engaged in the HIV care continuum is important for enhancing their health outcomes and reducing the transmission of HIV (2). Additionally, improving access to STI testing is crucial in addressing rising STI rates (1, 20). Vulnerabilities have been observed due to ongoing stigma and discrimination that exists surrounding STIs and other blood-borne infections (20). One 2014 study assessing STI-related stigma among African American male youth in a low-income, urban community in San Francisco with a high burden of STIs identified that stigma was related to decreased STI testing (21). In Canada, there were 139,386 chlamydia cases, 35,443 gonorrhea cases, and 9,245 cases of infectious syphilis reported in 2019 (1). From 2015 to 2019, chlamydia cases have risen by 13.7%, while gonorrhea cases have risen by 69.9% and infectious syphilis cases have risen by 174.4% in Canada (1). Individuals less than 30 years of age made up 74%, 51%, and 39% of the chlamydia, gonorrhea, and infectious syphilis cases in the country, respectively (1). A 2021 U.S. study indicated that only 40% of young adult women are screened for chlamydia, and screening rates are lower for men (22–25). Furthermore, data for trichomoniasis is scarce in Canada; trichomoniasis positivity rates were 2.8% in females and 0.2% in males in a 2017 study evaluating trichomoniasis in Western Canadian STI clinics (26). Enhancing the accessibility and availability to HIV/STI testing to unreached populations is important in minimizing risk and reducing new infections (1, 14). The costs associated with screening have shown to be burdensome on testing services, therefore cost-effective strategies could provide financial benefits (8, 11).

While HIV cases appeared to decrease from 2019 to 2020, it is vital that HIV testing continues to reach undiagnosed people living with HIV, despite having met the 90% testing goal (2). It is important to note that the observed decrease in new HIV diagnoses in 2020 may have been influenced by the reduction in access to HIV testing services due to the COVID-19 pandemic (2). In addition, the four STIs listed above (syphilis, gonorrhea, chlamydia, and trichomoniasis) are curable (27). However, leaving these STIs untreated can lead to severe outcomes, such as reproductive system diseases and disorders, increased risk of transmitting and contracting other STIs, neurological problems, and congenital abnormalities and death (28).

In this review, we will discuss cost-effective ways to conduct HIV and STI screening, focusing exclusively on chlamydia (*Chlamydia trachomatis*), gonorrhea (*Neisseria gonorrhea*), syphilis (*Treponema pallidum*), and trichomoniasis (*Trichomonas vaginalis*) when

References

1. Public Health Agency of Canada. Chlamydia, gonorrhea and infectious syphilis in Canada, 2019. 2021. Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/chlamydia-gonorrhea-infectious-syphili-canada-2019.html Accessed September 21, 2022.

2. Public Health Agency of Canada. Estimates of HIV incidence, prevalence and Canada's progress on meeting the 90-90-90 HIV targets, 2020. Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/estimates-hiv-incidence-prevalence-canada-meeting-90-90-90-targets-2020.html Accessed September 13, 2022.

3. Shrestha RK, Chavez PR, Noble M, Sansom SL, Sullivan PS, Mermin JH, et al. Estimating the costs and cost-effectiveness of HIV self-testing among men who have sex with men, United States. Journal of the International AIDS Society. 2020;23(1):e25445.

4. Smith KS, Kaldor JM, Hocking JS, Jamil MS, McNulty AM, Read P, et al. The acceptability and cost of a home-based chlamydia retesting strategy: Findings from the REACT randomised controlled trial. BMC Public Health. 2016;16:83.

exploring STI testing.

What We Found

In Canada, three primary types of HIV testing exist: rapid tests, laboratory tests, and confirmatory tests (29). Similar versions of these screening methods are also available for STI testing (30, 31); however, the literature examined throughout this review predominantly focuses on rapid HIV/STI tests. Two types of rapid HIV testing technologies exist: point-of-care (POC) tests and self-tests (29). HIV testing can be performed in health care settings (32) or ordered online (33, 34). In Canada, STI screening is typically conducted in sexual health clinics, local public health units, walk-in clinics, or by primary health care providers (35). Online rapid STI testing services are not widely available across the country. GetCheckedOnline is an online HIV/STI testing service provided by the British Columbia Centre for Disease Control (BCCDC) that allows users to confidentially request HIV/STI screening for free; however, participants must go to a laboratory collection facility to give blood/urine samples, and may be provided with a swab kit (36).

HIV/STI self-testing

A 2020 study evaluated the cost and influence of three types of advertisements on a geosocial sexual networking application aimed towards men who have sex with men promoting free at-home HIV self-testing and encouraging participation in an online research study between October 2017 and June 2018 (37). The three advertisements used were: text-only, text with male figure (no face), and text with male figure (with face), costing USD 15,000 for the male figure with face advertisements, USD 5,000 for the remaining (37). Overall, USD 6.21 was spent on advertisements for each participant enrolled in the online study (n=4,023) and USD 10.29 for each participant that underwent HIV testing (n=2,430) (37). However, advertisements with the male figure with face was the most cost-effective: USD 15.87 (n=315), USD 3.01 (n=1,659), and USD 2.44 (n=2,049) was spent on each participant enrolled in the online research study, and USD 22.62 (n=221), USD 5.18 (n=966), and USD 4.02 (n=1,243) on everyone who completed HIV testing for text-only, male figure with no face, and male figure with face, respectively (37). The advertisements with male figures were deemed to be cost-effective (37).

The eSTAMP initiative, Evaluation of Rapid HIV-Self Testing among MSM Project, analyzed costs and cost-effectiveness of HIV self-testing among men who have sex with men in the U.S. with negative or unknown HIV status who were enrolled from March to August 2015 into a 12-month study (3). A total of 2,665 participants were randomly assigned into the self-testing (n=1,325) or the control (n=1,340) arms of the trial (3). Participants in the self-testing arm were mailed four HIV self-tests free-of-charge, whereas those

5. Ahmed-Little Y, Bothra V, Cordwell D, Freeman Powell D, Ellis D, Klapper P, et al. Attitudes towards HIV testing via home-sampling kits ordered online (RUClear pilots 2011–12). Journal of Public Health. 2016;38(3):585–90.

6. Bennett C, Knight V, Knox D, Gray J, Hartmann G, McNulty A. An alternative model of sexually transmissible infection testing in men attending a sex-on-premises venue in Sydney: A cross-sectional descriptive study. Sexual Health. 2016;23:23.

7. Stafylis C, Natoli LJ, Murkey JA, Gordon KK, Young SD, McGrath MR, et al. Vending machines in commercial sex venues to increase HIV self-testing among men who have sex with men. Began with 2015. 2018;4:51.

8. Hsieh YH, Holtgrave DR, Peterson S, Gaydos CA, Rothman RE. Novel emergency department registration kiosk for HIV screening is cost-effective. AIDS Care. 2016;28(4):483–6.

9. Knapp H, Chan K. HIV rapid testing in a VA emergency department setting: Cost analysis at 5 years. Value in Health. 2015;18(5):735–7.

10. Leblanc J, Hejblum G, Costagliola D, Durand-Zaleski I, Lert F, de Truchis P, et al. Targeted HIV screening in eight emergency departments: The DICI-VIH cluster-randomized two-period crossover trial. Annals of Emergency Medicine. 2018;72(1):41–53.e9.

in the control arm of the trial did not receive self-tests (3). In the self-testing arm of the trial, 73% (n=971) of men completed 5,368 HIV self-tests, and 46% (n=619) completed 1,463 tests (3). Over the course of the study period, those who received HIV self-tests were able to distribute the tests throughout their social network and could request additional HIV self-testing kits after completing a series of follow-up surveys (3). Overall, 59 HIV infections were detected among participants in the self-testing arm and their social network associates compared to eleven new HIV diagnoses among those in the control arm of the study (3). A number of different costs related to HIV self-testing were estimated: the cost of each HIV self-test was USD 61; the cost per person tested a minimum of one time was USD 145; and the incremental cost per new HIV diagnosis was USD 9,365 (3). Additionally, the cost to implement the eSTAMP programme was nearly USD 450,000 (3). It was estimated that the initiative averted 3.34 HIV transmissions, which translates to saving nearly USD 1.6 million in lifetime HIV treatment costs (3).

An Australian randomized controlled trial called REACT evaluated the acceptability and cost-effectiveness of chlamydia retesting methods to detect reinfections (4). A total of 600 individuals (200 women, 200 heterosexual men, and 200 men who have sex with men) were asked to complete an online survey to assess if participants preferred home-based chlamydia retesting over clinic-based rescreening (4). Among these participants, 50.3% (n=302) represented the home-based retesting arm of the study and 49.7% (n=298) represented the clinic-based retesting arm (4). In the home-testing arm, 61% (n=184) of participants retested for chlamydia: 73% (n=134) self-tested at home and 27% (n=50) retested at a clinic (4). Overall, the chlamydia retesting pathway in the home-based screening arm of the trial cost an average of AUD 154 per person (4). In the clinic-based testing arm, 39% (n=117) retested at the clinic (4). The clinic-based retesting pathway cost an average of AUD 169 per person, higher than the at-home chlamydia retesting pathway (4). Overall, 31 chlamydia reinfections were identified with home-based retesting, compared to 12 with clinic-based rescreening (4). The authors determined that the overall cost of a detected chlamydia reinfection would be AUD 1409.20 for home-based retesting and AUD 3132.60 for clinic-based retesting (4).

A literature review published by the Canadian Agency for Drugs and Technologies in Health (CADTH) in 2016 compared self-testing and clinician-based sample collection for STIs in women (38). Among the articles reviewed, two economic evaluations presenting hypothetical modelling scenarios were examined (38–40). Evidence found within these papers is presented below.

- One economic evaluation conducted in the U.S. assessed internet-based at-home STI sampling versus clinic-based STI testing methods in women (38, 39). The STIs screened were chlamydia, gonorrhea, and trichomoniasis (38, 39). The internet-based home-sampling strategy was costlier for health care payers than a clinic-based referral method,

11. Wilson JD, Wallace HE, Loftus-Keeling M, Ward H, Davies B, Vargas-Palacios A, et al. Swab-Yourself Trial With Economic Monitoring and Testing for Infections Collectively (SYSTEMATIC): Part 2. A diagnostic accuracy and cost-effectiveness study comparing rectal, pharyngeal, and urogenital samples analyzed individually, versus as a pooled specimen, for the diagnosis of gonorrhea and chlamydia. Clinical Infectious Diseases. 2021;73(9):e3183–e93.

12. Bartelsman M, van Rooijen MS, Alba S, Vaughan K, Faber WR, Straetemans M, et al. Point-of-care management of urogenital Chlamydia trachomatis via Gram-stained smear analysis in male high-risk patients. Diagnostic accuracy and cost-effectiveness before and after changing the screening indication at the STI Clinic in Amsterdam. Sexually Transmitted Infections. 2015;91(7):479–84.

13. Collins B, Bronson H, Elamin F, Yerkes L, Martin E. The "No Wrong Door" approach to HIV testing: Results from a statewide retail pharmacy-based HIV testing program in Virginia, 2014–2016. Public Health Reports. 2018;133(2_suppl):34S–42S.

14. Lecher SL, Shrestha RK, Botts LW, Alvarez J, Moore JH, Jr., Thomas V, et al. Cost analysis of a novel HIV testing strategy in community pharmacies and retail clinics. Journal of the American Pharmacists Association. 2015;55(5):488–92.

yielding costs of USD 96,088 and USD 71,668, respectively (38, 39). However, an increased number of STI diagnoses were identified using the at-home sampling methods: 75 new STI infections using at-home testing compared to 45 with clinic-based screening (38, 39). The overall cost of home-based sampling was USD 1,281 per STI detected versus USD 1,593 per STI identified using clinic-based testing (38, 39).

- The second economic evaluation, also completed in the U.S., evaluated chlamydia screening in women using home-based and clinic-based testing strategies (38, 40). At-home self-sampling was reported to cost USD 860,000 for health care payers compared to USD 902,000 using clinic-based screening (38, 40). Using the chlamydia self-sampling method, 303 new diagnoses were identified versus 232 with clinic-based testing (38, 40)

The above articles present information regarding at-home HIV/STI self-sampling and their associated costs. Self-testing can also be performed outside of a home setting, such as sex venues, as described in the following articles.

- From November 2012 to May 2014, the costs and outcomes associated with gay and bisexual men attending a non-staffed STI screening service for chlamydia and gonorrhea co-located in a sex-on-premises venue in Sydney was evaluated (6). All patrons who attended the STI screening service during the study period had access to testing (6). In total, 402 participants used 499 STI tests over the duration of the trial (6). Among 63 patrons, 77 STIs were detected, and chlamydia and gonorrhea infections accounted for approximately 68% (n=52) and 33% (n=25) of them, respectively (6). Each STI detected cost AUD 312.47 (6). The data collected from the sex-on-premises venue study was compared with general clinic STI testing data throughout the same time period (6). Of 37,309 STI tests conducted in men, 3,004 (8.1%) chlamydia and gonorrhea infections were detected, costing AUD 891.80 per STI detected (6). Furthermore, the authors concluded that AUD 11,876.20 was saved compared to traditional clinic-based STI testing, and AUD 6,342.29 was saved compared to a fast-track STI testing service offered by the Sydney Sexual Health Centre (6).

- A 2018 study installed two vending machines in two downtown commercial sex venues in Los Angeles where men who have sex with men could receive an HIV test kit free-of-charge from January 2016 to July 2017 (7). Participants visiting the vending machine could request a PIN to acquire a free HIV test kit by sending a text message with their cell phone (7). Patrons could fill out a survey regarding the testing process, and those with reactive

15. Li XC, Kusi L, Marak T, Bertrand T, Chan PA, Galarraga O. The cost and cost-utility of three public health HIV case-finding strategies: Evidence from Rhode Island, 2012–2014. AIDS & Behavior. 2018;22(11):3726–33.

16. Anaya HD, Butler JN, Knapp H, Chan K, Conners EE, Rumanes SF. Implementing an HIV rapid testing-linkage-to-care project among homeless individuals in Los Angeles County: A collaborative effort between federal, county, and city government. American Journal of Public Health. 2015;105(1):85–90.

17. Williams AM, Berruti AA. Costs of identifying cases of syphilis using rapid syphilis tests in multiple nonclinical settings in the United States. Sexually Transmitted Diseases. 2021;48(11):895–9.

18. Burghardt NO, Chow JM, Steiner A, Bauer HM. Trends in chlamydia screening, test positivity, and treatment among females in California juvenile detention facilities, 2003–2014. Sexually Transmitted Diseases. 2016;43(1):12–7.

19. Public Health Agency of Canada. Estimates of HIV incidence, prevalence and Canada's progress on meeting the 90-90-90 HIV targets. 2020. Available from: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/hiv-2020-surveillance-highlights.html Accessed September 22, 2022.

HIV tests were offered linkage to care (7). Over the study period, 1,398 HIV test kits were dispensed, and 110 patrons completed the survey (7). Among the men who have sex with men who completed the survey, 87.3% (n=96) utilized an HIV test kit from the vending machine, and 17.7% (n=17) of participants who used a test kit reported a positive HIV test result (7). The cost of each kit vended, including the total intervention costs (i.e. vending machines, test kits, remote monitoring services), was USD 41.57, though the price was USD 34.42 when only the recurring costs were included (7). Costs of a program evaluating HIV point-of-care testing in pharmacies and retail clinics (14) and a study examining the costs of community-based clinic testing (41) were calculated and compared to the commercial sex venue data (7). The HIV point-of-care testing was estimated to cost USD 63.10 (7, 14, 42), and the community-based clinic testing cost USD 36.68 for patients with a non-reactive test, USD 44.42 for patients with a positive HIV test (7, 41).

HIV/STI testing in health care settings

Emergency departments

HIV/STI testing has been evaluated in emergency department (ED) settings. However, there appears to be more literature regarding HIV screening costs in EDs compared to STI testing. Both will be examined in this section.

A 2016 cost-analysis study determined the cost-effectiveness of a kiosk-based approach compared to a dedicated testing staff method for offering HIV testing in an urban adult ED in the U.S. (8). In the first phase of the trial, from August to September 2011, dedicated testing staff offered an HIV test to patients occupying a bed in the ED and collected demographic and risk factor information (8). In the second phase, from December 2011 to January 2012, an automatic, front-end stand-alone kiosk was placed next to registration and the first ED triage to collect general medical and public health information, as well as the patient's interest in receiving HIV testing (8). Those who expressed interest in HIV screening were self-referred to a private area with a back-end stand-alone kiosk that gathered patient demographic and risk information (8). In the same area, HIV testing was conducted by an ED staff member once consent had been given (8). In the first phase, 0% (n=0) of the 538 tested patients received HIV-positive test results (8). In the second phase, 0.5% (n=2) of the 430 patients screened for HIV yielded a reactive test result (8). Authors used this data to estimate the number of patients who were screened, as well as the number who received a positive HIV test result had the phases been carried out over a one-year period (8). Sensitivity analyses estimated that 5,434 patients would have been screened for HIV in the ED during a year of conducting the first phase of the trial, with 0.2% (n=9) receiving positive HIV diagnoses (8). It

20. Centre for Communicable Diseases and Infection Control. A summary of the Pan-Canadian framework on sexually-transmitted and blood-borne infections. Canada Communicable Disease Report. 2018;44(7/8):179–81.

21. Morris JL, Lippman SA, Philip S, Bernstein K, Neilands TB, Lightfoot M. Sexually transmitted infection related stigma and shame among African American male youth: Implications for testing practices, partner notification, and treatment. AIDS Patient Care and STDs. 2014;28(9):499–506.

22. Berman SM, Satterwhite CL. A paradox: Overscreening of older women for chlamydia while too few younger women are being tested. Sexually Transmitted Diseases. 2011;38(2):130–2.

23. Thompson EL, Griner SB, Galvin AM, Lowery AD, Lewis MA. Correlates of STI testing among US young adults: Opportunities for prevention. Prevention Science. 2021;22(2):216–26.

24. National Committee for Quality Assurance. Chlamydia screening in women: The HEDIS measure. 2016. Available from: https://www.ncqa.org/hedis/measures/chlamydia-screening-in-women/ Accessed September 22, 2022.

25. Hoover KW, Leichliter JS, Torrone EA, Loosier PS, Gift TL, Tao G, et al. Chlamydia screening among females aged 15–21 years—Multiple data sources, United States, 1999–2010. MMWR Suppl. 2014;63(2):80-8.

was also projected that 4,571 patients would have been tested for HIV during one year of the second phase, with 0.5% (n=12) yielding a reactive HIV test result (8). These projections estimated that for one new HIV diagnosis, the cost would be USD 22,381 (range: USD 11,216 to USD 67,044) during the first phase, and USD 13,950 (range: USD 4,207 to USD 72,790) (8) during the second phase, highlighting the cost-effective potential of kiosk-based testing in EDs (8).

In a Virginia ED, Quality Enhancement Research Initiative for HIV (QUERI-HIV), was developed to improve HIV diagnostics and patient care (9). From June 2008 to July 2013, ED registered nurses administered oral HIV rapid tests to patients, and the costs of this initiative were evaluated (9). After five years, 2,620 tests were administered, and the cost per HIV test completed was USD 2.94 (9). Costs were reduced with policy changes in August 2009 explaining that verbal consent was sufficient for nurses to deliver tests rather than previously-required written consent (9). Requiring verbal consent reduced pretest counseling from five minutes to one minute, decreasing the time and costs needed to deliver each HIV test (9). Costs of nurse-initiated HIV rapid testing in the urgent care and EDs were also calculated: the cost per one test was USD 13.80 before the policy change, reduced to USD 10.84 after the new policy was implemented (9).

Cost-effectiveness studies regarding HIV testing in EDs in high-income countries outside of North America have also been conducted. The following studies evaluate targeted and non-targeted HIV testing in the European emergency care settings:

- Nurse-driven targeted HIV screening alongside physician-directed HIV testing was assessed in eight EDs from June 2014 to June 2015 in France (10). In this study, nurse-driven targeted screening combined with physician-directed diagnostic testing (intervention strategy) was compared with physician-directed diagnostic testing alone (control strategy). Patients aged 18 to 64 in the EDs presenting for reasons other than possible HIV exposure within less than 48 hours were among the study population (10). In the control and intervention arms of the study, physicians always offered HIV testing to patients presenting with HIV symptoms (10). However, throughout the intervention period, patients were asked to complete a questionnaire. Based on how the participants answered the questions, nurses identified if they were in a high-risk HIV group, and those patients were offered HIV screening (10). A total of 74,161 patients were included in the intervention arm: 22.2% (n=16,468) completed the questionnaire, of which 26.4% (n=4,341) were placed in high-risk group for HIV infection (10). Of the patients in the high-risk group, 64.9% (n=2,818) consented to and received an HIV test, and 0.5% (n=13) of those individuals yielded a reactive HIV test (10). In the control arm of the study, 74,166 patients were included, and

26. Gratrix J, Plitt S, Turnbull L, Smyczek P, Brandley J, Scarrott R, et al. Trichomonas vaginalis prevalence and correlates in women and men attending STI clinics in western Canada. Sexually Transmitted Diseases. 2017;44(10):627–9.

27. World Health Organization. Sexually transmitted infections (STIs). 2022. Available from: https://www.who.int/news-room/fact-sheets/detail/sexually-transmitted-infections-(stis) Accessed September 23, 2022.

28. World Health Organization. Four curable sexually transmitted infections—all you need to know. 2019. Available from: https://www.who.int/news-room/feature-stories/detail/four-curable-sexually-transmitted-infections---all-you-need-to-know Accessed September 23, 2022.

29. CATIE. HIV testing technologies. 2022. Available from: https://www.catie.ca/hiv-testing-technologies Accessed September 15, 2022.

30. Action Canada for Sexual Health & Rights. STI testing FAQs. 2019. Available from: https://www.actioncanadashr.org/resources/sexual-health-info/sexually-transmitted-infections/sti-testing-faqs Accessed September 15, 2022.

31. Mayo Clinic. STD testing: What's right for you? 2022. Available from: https://www.mayoclinic.org/diseases-conditions/sexually-transmitted-diseases-stds/in-depth/std-testing/art-20046019 Accessed September 15, 2022.

0.1% (n=92) were tested for HIV. Of those patients tested, 6.5% (n=6) yielded a positive HIV test result (10). Using this data, the cost per new HIV diagnosis was estimated to be EUR 1,324 (10).

- Non-targeted HIV screening in three EDs the Netherlands was assessed in a 2017 study (43). Adult patients who underwent phlebotomy in these EDs from August 2014 to October 2015 were provided the option to receive HIV testing (43). Overall, 7,577 patients were eligible for HIV testing, 42.5% (n=3,223) accepted further HIV screening, and 0.06% (n=2) of the 3,223 tested patients yielded a positive result (43). The two positive HIV diagnoses had risk factors for HIV infection. For each positive HIV result, it was deemed to be cost-effective if the cost per HIV diagnosis was below EUR 20,000 (43). However, the cost per quality-adjusted life years gained was EUR 77,050 for each HIV diagnosis detected in the study, highlighting that this non-targeted screening method was not cost-effective (43).

Non-emergency health care settings

Sexual health services and clinics play a large role in STI testing. Three studies describing various STI clinic testing approaches are described below.

- A 2021 publication assessed the impact and costs of a 30-minute POC test for chlamydia and gonorrhea compared to standard laboratory-based testing in three sexual health services in England (44). Three patient groups were observed:
    - all attendees at drop-in clinics for less than 25 seconds and select groups from drop-in clinics for all ages, including those who are symptomatic for chlamydia and/or gonorrhea, asymptomatic, symptomatic or asymptomatic and has had contact with a person who tested positive for chlamydia and/or gonorrhea, or are at the drop-in clinic for contraception;
    - those who are symptomatic, asymptomatic and has had contact with a person who tested positive for chlamydia and/or gonorrhea, or are taking long-acting reversible contraception; or
    - are symptomatic, asymptomatic and has had contact with a person who tested positive for chlamydia and/or gonorrhea, or is asymptomatic and is having difficulty accessing services (44).

A total of 225 patients were tested: 118 for the POC test, and 107

32. Government of Canada. Human immunodeficiency virus–HIV screening and testing guide. 2014. Available from: https://www.canada.ca/en/public-health/services/hiv-aids/hiv-screening-testing-guide.html#e6 Accessed October 11, 2022.
33. O'Byrne P, Musten A, Orser L, Horvath C. Invalid results in the GetaKit study in Ottawa: A real-world observation of the INSTI HIV self-test among persons at risk for HIV. Journal of the Association of Nurses in AIDS Care. 2022;26:26.
34. I'm Ready. I'm Ready. 2022. Available from: https://www.readytoknow.ca/ Accessed October 11, 2022.
35. Public Health Agency of Canada. Getting tested for sexually transmitted infections (STI). 2022. Available from: https://www.canada.ca/en/public-health/services/sexual-health/getting-tested-sexually-transmitted-infections.html#a2 Accessed October 3, 2022.
36. GetCheckedOnline. How it works. 2022. Available from: https://getcheckedonline.com/Pages/HowGetCheckWorks.aspx Accessed October 3, 2022.
37. Grov C, Stief M, Westmoreland DA, MacCrate C, Mirzayi C, Nash D, et al. Maximizing response rates to ads for free at-home HIV testing on a men-for-men geosocial sexual networking app: Lessons learned and implications for researchers and providers. Health Education & Behavior. 2020;47(1):5–13.

for the standard laboratory test (44). Across the three sexual health services, the combined average costs were GBP 61.55 for the POC test and GBP 50.88 for the standard laboratory-based test (44). Different groups yielded various results for each sexual health service: for example, the POC tests were cheaper than the standard tests for those who were receiving long-acting reversible contraception in two sexual health services (44). However, the overall cost of delivering POC tests was more expensive than standard testing (44).

- In a prospective randomized control trial in the UK, women (population group 1) and men who have sex with men (population group 2) who presented to a sexual health clinic for chlamydia and gonorrhea testing and were willing to take self-swabs in addition to standard clinician-performed swabs were included in the study (11). The objective was to evaluate clinician-performed STI swabs versus pooled self-taken swabs and determine the cost-effectiveness of each approach (11). Over the duration of the study, 1,793 patients were included: 15.4% (n=276) tested positive for chlamydia, 6.5% (n=116) for gonorrhea (11). The estimated costs are as followed: GBP 54.51 and GBP 50.61 for clinician-performed swabs in females and men who have sex with men and females, respectively, and GBP 39.03 and GBP 35.41 for self-taken swabs in females and men who have sex with men, respectively (11). Pooled self-taken swabs were determined to be more cost-effective (11).

- In an Amsterdam STI clinic, a nurse-led STI Outpatient Clinic offering free POC STI screening sorted patients based on their risk for HIV infection. Between 2008 and 2009, all male high-risk patients were offered testing; however, between 2010 to 2011, the clinic shifted to only offering testing to men who presented symptoms of chlamydia (12). In 2008 to 2009, 7,185 tests were offered, which was lower than the 18,852 tests offered in 2010 to 2011 (12). The cost per correctly managed consultation was lower when the clinic offered testing to symptomatic men (EUR 80.82) compared to all high-risk men (EUR 94.31) (12). However, the percentage of delayed treated infections was higher in 2010 to 2011 (22.8%) versus 2008 to 2009 (10.5%) (12).

One systematic review published in 2016 discussed the availability of effective POC tests for chlamydia, gonorrhea, and trichomoniasis (45). Of the 33 articles included in the systematic review, three articles evaluating cost-effectiveness of POC tests of chlamydia and gonorrhea were included (12, 45–47). One of the three articles is mentioned above (12). The two other studies are not mentioned in this review as they are proposed cost analyses through mathematical models, which will not be explored in detail (46, 47). Overall, the three cost-effectiveness studies assessed in the systematic review found POC tests for chlamydia and gonorrhea to be a cost-effective strategy in STI and genitourinary clinics (12, 45–47).

38. Canadian Agency for Drugs and Technologies in Health, Rapid Response Report. Self-collected versus clinician collected samples for sexually transmitted infection testing in women: A review of comparative clinical effectiveness cost-effectiveness, and guidelines. 2016. Available from: https://www.ncbi.nlm.nih.gov/books/NBK373480/pdf/Bookshelf_NBK373480.pdf Accessed September 22, 2022.

39. Blake DR, Spielberg F, Levy V, Lensing S, Wolff PA, Venkatasubramanian L, et al. Could home STI specimen collection with e-prescription be a cost-effective strategy for clinical trials and clinical care? Sexually Transmitted Diseases. 2015;42(1):13–9.

40. Huang W, Gaydos CA, Barnes MR, Jett-Goheen M, Blake DR. Cost-effectiveness analysis of Chlamydia trachomatis screening via internet-based self-collected swabs compared with clinic-based sample collection. Sexually Transmitted Diseases. 2011;38(9):815–20.

41. Pinkerton SD, Bogart LM, Howerton D, Snyder S, Becker K, Asch SM. Cost of rapid HIV testing at 45 U.S. hospitals. AIDS Patient Care & STDs. 2010;24(7):409–13.

42. Scheim AI, Travers R. Barriers and facilitators to HIV and sexually transmitted infections testing for gay, bisexual, and other transgender men who have sex with men. AIDS Care. 2017;29(8):990–5.

In addition to STI testing in non-ED health care settings, one study from England assessed the cost of diagnosing HIV infections in 27 general care practices located in two areas of the country and two acute general medical admission units (ACUs) from 2009 to 2010 (48). HIV testing was routinely offered to patients (48). In general practices, new registrants were offered POC HIV tests, and patients in ACUs collected blood samples for HIV screening (48). In total, 2,351 tests were conducted in the ACUs, 4,186 in the general practices (48). The HIV positivity rate ranged from 1.42 to 10.66 over 1,000 tests in the ACUs and from 1.36 to 7.00 per 1,000 tests in the general practices (48). The total cost per HIV test performed ranged from GBP 8.55 to GBP 9.90 in the ACUs, GBP 10.15 to GBP 13.48 in the general practices (48). It was concluded that the cost for each new HIV infection detected at an HIV positivity rate of two cases per 1,000 tests was GBP 3,230 in the ACUs and GBP 7,930 in the general practices when the tests were completed by a non-medical staff member (48). Furthermore, each new HIV diagnosis cost GBP 5,940 in the ACUs and GBP 18,800 in the general practices when testing was performed by hospital consultants or general practitioners (48). Shorter offer times were detected in ACUs (two minutes) compared to general practices (five minutes), which was suggested to be a factor impacting lower costs in ACUs (48).

Pharmacy-based testing

From February 2011 to June 2012, STI screening for women using emergency contraception in New York City was evaluated in pharmacy and home-based environments (49). STI tests for chlamydia and gonorrhea were offered (49). In the first phase, customers purchasing emergency contraception from eight pharmacies in Manhattan received free vouchers for free STI testing at onsite medical clinics (49). In the second phase, three Facebook advertisements targeted emergency contraception users to connect them with free home-based STI kits (49). Overall, 38 individuals enrolled in the first phase, 0% (n=0) testing positive for STIs (49). In the second phase, 81 STI test kits were requested from online users, yielding 7.4% (n=6) positive test results (49). The cost of each test kit was USD 55 (40, 49).

CAPUS, the Care and Prevention in the United States project, aimed to reduce HIV-related morbidity and mortality among racial/ethnic minority groups in eight states throughout the U.S. (13). Using Census data from 2010 and estimates from the American Community Survey from 2007 to 2011, the Virginia Department of Health selected Walgreens stores located in census tracts where at least 30% of the population was Black and/or Hispanic/Latino and/or where at least 20% of the population was living at or below the federal poverty level (13). Pharmacists delivered rapid tests to participants of the program from June 2014 to September 2016 (13). Throughout the study period, HIV tests were performed on 3,630 patients, 0.8% (n=30) testing positive for HIV (13). The average cost

43. Luiken GPM, Joore IK, Taselaar A, Schuit SCE, Geerlings SE, Govers A, et al. Non-targeted HIV screening in emergency departments in the Netherlands. Netherlands Journal of Medicine. 2017;75(9):386–93.

44. Huntington S, Weston G, Adams E. Assessing the clinical impact and resource use of a 30-minute chlamydia and gonorrhoea point-of-care test at three sexual health services. Therapeutic Advances in Infectious Disease. 2021;8:20499361211061645.

45. Herbst de Cortina S, Bristow CC, Joseph Davey D, Klausner JD. A systematic review of point of care Testing for Chlamydia trachomatis, Neisseria gonorrhoeae, and Trichomonas vaginalis. Infectious Diseases in Obstetrics & Gynecology. 2016;2016:4386127.

46. Huang W, Gaydos CA, Barnes MR, Jett-Goheen M, Blake DR. Comparative effectiveness of a rapid point-of-care test for detection of Chlamydia trachomatis among women in a clinical setting. Sexually Transmitted Infections. 2013;89(2):108–14.

47. Turner KM, Round J, Horner P, Macleod J, Goldenberg S, Deol A, et al. An early evaluation of clinical and economic costs and benefits of implementing point of care NAAT tests for Chlamydia trachomatis and Neisseria gonorrhoea in genitourinary medicine clinics in England. Sexually Transmitted Infections. 2014;90(2):104–11.

of each HIV test was USD 41.79, and the average total cost of each test yielding a positive HIV result was USD 5,057 (13). Of the 3,630 individuals tested in a pharmacy setting, 46% (n=1,668) had never been tested or were unsure if they had ever been tested for HIV (13). Thus, testing for HIV in pharmacies may be a financially acceptable option for people who have had difficulty accessing HIV screening (13).

One study mentioned earlier in this review discussing the implementation of HIV POC tests in pharmacies and retail clinics provided information on the cost-effectiveness of this screening approach. POC rapid HIV testing in 18 U.S. community pharmacies, one retail clinic, one Indian Health Service nurse-run clinic, and one multisite venue from May 2012 to July 2013 was evaluated (14). However, the cost analysis focused on six of these sites: two community pharmacies, one speciality community pharmacy, one independent community pharmacy, one retail clinic, and one Indian Health Service Clinic (14). Over the study period, 939 HIV rapid tests were performed, 1.8% (n=17) of those positive for HIV (14). The average cost of each test per person was estimated at USD 47.21, though with recurring costs, the authors calculated the POC HIV rapid tests to cost USD 32.17 per person (14). It was concluded that HIV testing in pharmacies was cost-effective (14). Furthermore, pharmacies increased availability and accessibility of HIV tests in the U.S. (14). This study was included and emphasized in a systematic review published by Crawford *et al.* in 2021, describing how the cost of pharmacy-based HIV testing was low (14, 50).

Partner notification services and social network strategies

In addition to emergency and non-emergency health care settings playing significant roles in cost-effective HIV/STI testing strategies, we have also identified studies highlighting the value of partner notification services and social network strategies when screening for HIV and STIs.

- Three HIV testing strategies (rapid POC and laboratory blood tests) were assessed and compared in a large urban medical centre in Chicago from February 2011 to December 2016: routine screening in an inpatient and outpatient setting by opt-in, without prior HIV antibody test result, prompted by emergency medical records; modified partner services among networks of patients recently diagnosed with HIV through contact tracing and incentives; and a respondent driven, sampling-based social network targeting young African American men who have sex with men through recruitment at social spaces and incentives (51). The routine screening program completed 57,308 tests yielding 0.28% (n=165) new HIV diagnoses; modified partner services conducted 146 HIV tests, 5.0% (n=8) individuals

48. Ong KJ, Thornton AC, Fisher M, Hutt R, Nicholson S, Palfreeman A, et al. Estimated cost per HIV infection diagnosed through routine HIV testing offered in acute general medical admission units and general practice settings in England. HIV Medicine. 2016;17(4):247–54.

49. Habel MA, Scheinmann R, Verdesoto E, Gaydos C, Bertisch M, Chiasson MA. Exploring pharmacy and home-based sexually transmissible infection testing. Sexual Health. 2015;12(6):472–9.

50. Crawford ND, Myers S, Young H, Klepser D, Tung E. The role of pharmacies in the HIV prevention and care continuums: A systematic review. AIDS & Behavior. 2021;25(6):1819–28.

51. Skaathun B, Pho MT, Pollack HA, Friedman SR, McNulty MC, Friedman EE, et al. Comparison of effectiveness and cost for different HIV screening strategies implemented at large urban medical centre in the United States. Journal of the International AIDS Society. 2020;23(10):e25554.

52. Zulliger R, Maulsby C, Solomon L, Baytop C, Orr A, Nasrullah M, et al. Cost-utility of HIV testing programs among men who have sex with men in the United States. AIDS & Behavior. 2017;21(3):619–25.

receiving a positive HIV diagnosis; and 508 tests were performed using the respondent-driven sampling-based social network approach, 7.2% (n=37) of the individuals testing positive for HIV (51). It was estimated that each new HIV diagnosis cost USD 16,773 for routine screening, USD 61,418 for modified partner services, and USD 15,683 for the social network program (51). Authors discussed how the routine screening with social network testing were comparable in costs and, in combination, may be the most effective for detecting new HIV infections in settings with a high prevalence of HIV and HIV screening (51).

- In Rhode Island, rapid HIV tests were used in clinical settings, community-based organizations, and partner notification services from 2012 to 2014 to determine which setting was most cost-effective (15). The average total cost for each new HIV diagnosis was USD 5,446, USD 33,015, and USD 33,818 in clinical settings, community-based organizations, and partner notification services, respectively (15). It was determined that implementing the rapid HIV tests in clinical settings was cost-saving, whereas it was cost-effective with community-based organizations and partner notification services; if the cost of each HIV diagnosis was higher than USD 100,000, it was not considered cost-effective (15).

- The MSM Testing Initiative (MTI) was created to improve access to HIV screening and to enhance individual and societal health among men who have sex with men by diagnosing previously undiagnosed HIV-positive men who have sex with men throughout the U.S. and link them to care (52). From January 2013 to March 2014, the costs and cost-utility of venue-based testing, couples voluntary counseling and testing, and social network strategies among men who have sex with men were implemented by sites in 15 U.S. cities (52). At-home testing and large-scale testing events were observed throughout this study, though cost-analyses were only conducted with the three strategies listed above (52). The cost of venue-based HIV testing ranged from USD 18,759 to USD 564,284 throughout different U.S. cities for nine to 15 months of the implementation of the MTI program (52). Couples voluntary counseling and testing cost USD 227 to USD 21,712 across U.S. cities, and limited data was available for the social network strategy. However, the social network strategy was deemed to be cost-saving in Houston; the cost of implementing the strategy was USD 977, and cost-saving is defined as "…programs that identify at least one individual with newly diagnosed HIV infection per $20,645…" (52). Two HIV infections were detected in Houston's partner notification service program (52).

53. Silverman RA, Katz DA, Levin C, Bell TR, Spellman D, St John L, et al. Sexually transmitted disease partner services costs, other resources, and strategies across jurisdictions to address unique epidemic characteristics and increased incidence. Sexually Transmitted Diseases. 2019;46(8):493–501.

54. Schaffer DH, Sawczuk LM, Zheng H, Macias-Konstantopoulos WL. Community-based, rapid HIV screening and pre-exposure prophylaxis initiation: Findings from a pilot program. Cureus. 2022;14(1):e20877.

55. Lederman E, Blackwell A, Tomkus G, Rios M, Stephen B, Rivera A, et al. Opt-out testing pilot for sexually transmitted infections among immigrant detainees at 2 immigration and customs enforcement health service corps-staffed detention facilities, 2018. Public Health Reports. 2020;135(1_suppl):82S–9S.

56. Spaulding AC, MacGowan RJ, Copeland B, Shrestha RK, Bowden CJ, Kim MJ, et al. Costs of rapid HIV screening in an urban emergency department and a nearby county jail in the southeastern United States. PLoS ONE. 2015;10(6):e0128408.

Unlike HIV, fewer studies observed STI testing using partner notification services and social network strategies. However, Silverman *et al.* published a 2019 study examining health departments in Washington State delivering STI (chlamydia, gonorrhea, and syphilis) partner notification services and estimating financial costs associated with these programs from 2016 to 2017 (53). Throughout these partner notification service programs, STI interviews were conducted by disease intervention specialists primarily over the phone to link individuals to care, promote HIV prevention (e.g. HIV testing, PrEP), and to provide partner therapy for heterosexuals positive for gonorrhea or chlamydia (53). Using data collected on the number of hours on disease intervention specialists take conducting these programs, the cost of each interview ranged from USD 164 to USD 547 for chlamydia, USD 219 to USD 484 for gonorrhea, and USD 527 to USD 2,210 for syphilis (53). It was concluded that using disease intervention specialists to promote HIV/STI care, including STI testing, could be highly cost-effective (53).

HIV/STI testing in non-clinical settings

Screening for HIV/STI in non-clinical settings has also been evaluated.

One Health Tent (OHT) is a non-profit organization, and in 2017, OHT erected a pop-up HIV screening and PrEP initiation program in Washington, DC (54). From October 2017 to November 2019, 846 people were screened for HIV, 0.7% (n=6) receiving a positive result (54). Including the PrEP education sessions, an estimated USD 138,367 was spent on the HIV screening/PrEP program (54). The authors claimed that the program is cost-effective, though a cost-effective analysis was not conducted (54).

In a 2015 study, the HIV-status of people experiencing homelessness in targeted shelters across Los Angeles was identified through rapid HIV testing (16). If an individual received a positive test result, counsellors consulted a list of area hospitals and clinics offering free confirmatory testing and HIV care to schedule an appointment to confirm their HIV status and place them into long-term HIV care (16). Overall, 817 people experiencing homelessness were tested, and 0.86% (n=7) HIV-positive individuals were identified (16). The average cost of an HIV test was USD 48.95, and the cost per positive HIV diagnosis was USD 5,714 (16). Researchers determined that there was evidence of cost-effectiveness in this study (16).

Another study identified the cost of identifying syphilis among people experiencing homelessness and LGBTQ populations in high prevalence areas using rapid syphilis tests across the U.S. (17). From May to October 2017, 595 rapid syphilis tests were performed by two outreach screening programs and 3.9% (n=23) tested positive (17). On average, each rapid syphilis test cost USD 213 and each positive syphilis diagnosis cost USD 5,517, ranging from USD 3,604 at a rehabilitation facility to USD 13,140 at LGBTQ venues served by a mobile clinic (17). It was noted that personnel contributed the most to the total costs (56.4%) (17). It was determined that outreach screenings using rapid syphilis tests may be a cost-effective strategy when targeting high-prevalence localities and hard-to-reach populations (17).

In addition, analysis of costs in HIV/STI testing initiatives have been conducted throughout various detention centres. Three articles describing the costs associated with HIV/STI screening among populations in detention centres will be examined below.

- Chlamydia screening data was retrospectively examined in females in juvenile detention facilities in 12 counties in California from 2003 to 2014 (18). Over the study period, high screening rates were recorded (75.1% to 79.4%), and chlamydia positivity decreased from 14.8% in 2003 to 2004 to 11.5% in 2013 to 2014 (18). The median cost for each chlamydia diagnosis was USD 708, ranging from USD 669 to USD 894 (18). Facilities with the highest rates of chlamydia had the lowest costs per diagnosis (18). Costs were kept low in high-volume juvenile detention facilities; evidence of cost-efficiency was found in centres with larger populations and higher chlamydia test positivity (18).

- The feasibility of a national, opt-out STI testing program for immigrant detainees was observed in two detection facilities in Arizona and Texas from June to August 2018 (55). In total, 1,041 immigrant detainees were offered STI testing, 47.5% (n=494) received testing, and 8.5% (n=42) tested positive for at least one STI, including chlamydia, gonorrhea, syphilis, hepatitis B, and HIV (55). The estimated cost to diagnose one individual with an STI ranged from USD 500 to USD 961, whereas the cost to diagnose one individual with HIV ranged from USD 22,497 to USD 43,244 (55). Regarding cost-effectiveness, the data is limited; however, the routine screening program was described to be feasible (55).

- The costs of rapid HIV screening in the Grady Memorial Hospital in Atlanta and at the Fulton County Jail were analyzed from June 2008 to December 2011 in a cost-analysis study (56). The Grady Memorial Hospital Emergency Department (GMHED) implemented a rapid HIV screening program where HIV testing staff offered screening separate from the regular ED services (56). In the ED, 15,510 HIV tests were delivered (56). Overall, 242 (positivity rate 1.56%) new HIV diagnoses were detected over the study period, costing USD 2,981 per HIV diagnosis (56). In the Fulton County Jail, the study only took place for approximately ten months, beginning in 2011 (56). In this setting, 11,819 tests were performed and 0.35% (n=41) of those tested yielded positive HIV diagnoses. In the jail setting, each HIV positive diagnosis was estimated to cost USD 6,688 (56). Authors determined that the cost of diagnosing new HIV infections was low; however, the different methods for confirming HIV diagnoses prevents conclusions being drawn that one setting is more cost-effective than the other (56).

Factors That May Impact Local Applicability

There is a substantial heterogeneity in studies included in this review in terms of study populations, structural and methodological differences (e.g. assumptions made for cost-effectiveness analysis), study settings, and other parameters. Many studies were conducted outside of Canada, therefore extrapolation of information to Canada and Ontario may be complicated due to the presence of different financial circumstances, government structure, and policy arrangements in other countries. Additionally, health care service delivery may differ in Canada compared to that of other high-income countries included in this review. Therefore the methodology behind the implementation of these strategies should be considered before utilizing these approaches in a local context.

What We Did

We searched Medline (including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) using terms (HIV or chlamydia or gonorrhea or gonorrhoea or syphilis or sexually transmitted disease* or STIs or sexually transmitted infection* or STD*) in titles or abstracts AND (testing or screening) in titles or abstracts AND cost* in titles or abstracts. Searches were conducted on May 11, 2022 and results limited to English articles published from 2015 to present. Studies from low- and middle-income countries were excluded. Reference lists of identified articles were also searched. Google (grey literature) searches using different combinations of these terms were also conducted. The searches yielded 1,457 references from which 56 were included.