Clinical effectiveness and analytical quality of a national point-of-care testing network for sexually transmitted infections integrated into rural and remote primary care clinics in Australia, 2016–2022: an observational program evaluation

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Summary

Background To address inequitable diagnostic access and improve time-to-treatment for First Nations peoples, molecular point-of-care (POC) testing for chlamydia, gonorrhoea and trichomonas was integrated into 49 primary care clinics across Australia. We conducted an observational evaluation to determine clinical effectiveness and analytical quality of POC testing delivered through this national program.

Methods We evaluated (i) implementation by measuring trends in mean monthly POC testing; ii) clinical effectiveness by comparing proportions of positive patients treated by historical control/intervention period and by test type, and calculated infectious days averted; (iii) analytical quality by calculating result concordance by test type, and proportion of unsuccessful POC tests.

Findings Between 2016 and 2022, 46,153 POC tests were performed; an increasing mean monthly testing trend was observed in the first four years ($p < 0.0001$). A greater proportion of chlamydia/gonorrhoea positives were treated in intervention compared with historical control periods (≤2 days: 37% vs 22% [RR 1.68; 95% CI 1.12, 2.53]; ≤7 days: 48% vs 30% [RR 1.6; 95% CI 1.10, 2.33]; ≤120 days: 79% vs 54% [RR 1.46; 95% CI 1.10, 1.95]); similarly for trichomonas positives and by test type. POC testing for chlamydia, gonorrhoea and trichomonas averted 4930, 5620 and 7075 infectious days, respectively. Results concordance was high [99.0% (chlamydia), 99.3% (gonorrhoea) and 98.9% (trichomonas)]; unsuccessful POC test proportion was 1.8% for chlamydia/gonorrhoea and 2.1% for trichomonas.

Interpretation Molecular POC testing was successfully integrated into primary care settings as part of a routinely implemented program achieving significant clinical benefits with high analytical quality. In addition to the individual health benefits of earlier treatment, fewer infective days could contribute to reduced transmissions in First Nations communities.

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Research in context

Evidence before this study

To date, the World Health Organisation control strategies for sexually transmissible infections (STIs) have focused on syndromic management, however recently efforts have been made to develop molecular-based point-of-care (POC) tests that can enable etiological diagnosis and address the well-recognised gap in detecting the large proportion of asymptomatic infections. Molecular POC testing for the detection of chlamydia and gonorrhoea has been demonstrated to be feasible and improve time to treatment in few research contexts internationally. In a world first cluster-randomised controlled trial, we demonstrated that molecular POC testing for chlamydia/gonorrhoea conducted by trained clinical staff in remote primary care settings in Australia was acceptable (Natoli et al.; Lafferty et al.), as accurate as laboratory-based testing (Causer et al.) and clinically effective (Guy et al.). Since 2016, molecular POC testing for STI has been scaled up across Australia to address inequities in access to timely diagnosis and treatment for STIs and high burden of sequelae in First Nations populations living in regional and remote Australia. To our knowledge, this program represents the largest such decentralised testing network integrated into primary care globally.

Evaluations of programmatic implementations are important to determine if trial findings are being successfully translated to achieve the expected benefits demonstrated in pilots and research trials. We searched PubMed and Google Scholar on 2 December 2023 to identify evaluations of programmatic implementation of molecular point-of-care (POC) testing for CT/NG and TV from 1 Jan 2014 to 30 November 2023, with no language restrictions. We used the terms *sexually transmitted infection (chlamydia, gonorrhoea, trichomonas), point-of-care test, scaling up, clinical effectiveness and sustainability* to identify papers describing evaluations of programmatic implementation focussing on domains of feasibility, sustainability, effectiveness or impact of molecular POC testing for CT/NG and/or TV. We found no published reports describing evaluations of longer-term or scaled up molecular POC testing programs in primary care settings.

Added value of this study

This paper describes the first evaluation reporting the sustained clinical effectiveness and analytical quality of a multi-year, national molecular POC testing program for STIs integrated into primary care settings. The findings indicate that over a seven-year period of implementation at almost 50 networked clinics, supported by critical infrastructure of training, competency assessment, quality management, connectivity and technical support, significant clinical and public health benefits can be achieved, similar to that observed under conditions of a randomised controlled trial (Guy et al.; Causer et al.). This evaluation is the first to disaggregate clinical effectiveness by sex, highlighting the particularly significant benefit to women, who as a result of receiving faster treatment (compared to if laboratory testing was performed) will lead to fewer reproductive, maternal and neonatal complications of infection including pelvic inflammatory disease, ectopic pregnancy, infertility and poor pregnancy outcomes. In addition, POC testing has the potential to make a substantial public health impact because of fewer onward transmissions and reduced longer-term sequelae at a population level.

Implications of all the available evidence

With strong community leadership, operator training, competency assessment, quality management, connectivity and technical support, molecular STI POC testing can be programmatically implemented with high analytical quality and deliver substantial clinical and public health benefits of more timely treatment for STIs. Increased uptake of this technology in combination with other strategies that enhanced health service access and more timely treatment, may contribute to reductions in the burden of infection and associated morbidities in First Nations communities. In addition, the established network of clinics with POC testing capacity provides a foundation for an expanded program including exploring and benefiting from newer infectious disease assays. Importantly, new advances in POC technology must be accompanied by increased funding for workforce and service provision.

Introduction

Sexually transmissible infections (STIs) remain a major global health problem, having a profound impact on sexual and reproductive health. In 2020, WHO estimated 374 million new infections with one of four STIs: chlamydia (*Chlamydia trachomatis*, CT), gonorrhoea (*Neisseria gonorrhoeae*, NG), syphilis (*Treponema pallidum*) and trichomoniasis (*Trichomonas vaginalis*, TV).[1] These infections are curable but left untreated they can lead to serious complications including pelvic inflammatory disease (PID), ectopic pregnancy, infertility,[2] disseminated gonococcal infection[3,4] and adverse pregnancy and neonatal outcomes including preterm birth, premature rupture of membranes, low birth

weight and neonatal infection.[5,6] Onward transmission to sexual partners and reinfection contributes to high community prevalence in many settings.

To date, WHO STI control strategies have focused on syndromic management, but in the last few years, substantial efforts have been made to develop molecular-based point-of-care (POC) tests that can enable etiological diagnosis and address the well-recognised gap in detecting the large proportion of asymptomatic infections.[7] While low- and middle-income countries bear the greatest burden of STIs, sub-populations in high income countries experience high rates of STIs including men who have sex with men, people who have experienced gender-based violence, First Nations peoples, undomiciled people, people affected by conflict and civil unrest, and people with disabilities.[8] In Australia, particularly in regional and remote communities, young First Nations people experience some of the highest incidence rates of STIs globally. At any given time, just under half of all young people aged 16–19 years living in remote communities have an STI,[9] with infection rates being considerably higher than among non-Indigenous people.[10] Hospitalisations for PID and ectopic pregnancies are high with a significant proportion attributable to these curable infections,[11,12] with PID being diagnosed more often among those with NG infection.

In regional and remote Australia, there are frequent delays in the diagnosis and treatment of these infections due to substantial physical distance from diagnostic laboratories, constrained health service capacity to locate and recall patients for treatment due to workforce shortages,[13] and a highly mobile young population.[14] A trial of molecular POC testing for CT/NG performed in primary care settings (called TTANGO—Test, Treat ANd GO) demonstrated improvement in uptake and timeliness of treatment,[15] acceptability,[16] concordance with laboratory testing,[17] and was cost-effective.[18] To address inequities in access to diagnostics and timely treatment of STIs, molecular POC testing was subsequently scaled up as part of a translational research program (the Program, TTANGO2) from 2016, with the introduction of TV test in 2018. The Program represents the first large multijurisdictional network of STI molecular POC testing in primary care health services globally. From 2020, the Program continued to expand (TTANGO3) with the addition of testing for respiratory infections.[19] The Program has a strong focus on community leadership and expanding POC testing infrastructure and systems to ensure integration into the health system, in particular to supporting operator training and competency, quality management, and connectivity.[19–21]

Ensuring successful translation from a research trial to programmatic implementation requires close attention to processes and outcomes, as this is often taking place in a broader and less controlled context. Evaluation of translation is critical to ensure program goals and impacts are being achieved, to identify gaps and challenges, and to advocate for policy change and sustainable funding. We hypothesized that the scale-up and programmatic implementation of molecular STI POC testing is a sustainable and effective strategy to improve clinical management and outcomes in regional and remote communities in Australia. In addition to the individual benefits, there are likely to be public health benefits through reduced community transmission. Here we present findings from a comprehensive evaluation of the Program focusing on the clinical effectiveness and analytical quality of testing.

Methods

Population and setting

The Program was implemented for the Australian Government by the Kirby Institute (University of New South Wales) and the Flinders University International Centre for Point-of-Care Testing in partnership with Aboriginal community-controlled health organisations (ACCHOs) and their member health services, government, pathology providers, diagnostic and software developers. Program implementation commenced in January 2016 following on directly from the earlier clinical trial (TTANGO).[15]

Primary care health services and clinics meeting the following criteria were eligible for participation in the Program: located in communities classified as regional, remote or very remote by the Australian Bureau of Statistics; ≥10% combined prevalence of ≥2 STIs (CT, NG and/or TV) in the 15–29 year old age group; >200 patient visits by the 15–29 year-old age group annually; providing care to predominantly First Nations peoples (>50%); support and commitment to take on POC testing (including staff training and competency, participation in quality management and data collection). During the first 4 program years (2016–2019: TTANGO2), 31 clinics (both Aboriginal community-controlled and government controlled) across 4 jurisdictions were enrolled; an additional 18 were enrolled in the following 3 years (2020–2022: TTANGO3).

Clinical network

During the first 4 program years (2016–2019: TTANGO2), 31 clinics across 4 jurisdictions were enrolled (n = 15, 49% in Western Australia; n = 6, 19% in Northern Territory; n = 6, 19% in Queensland and n = 4, 13% in South Australia), with the majority (n = 27, 87%) being remote or very remote and the remainder outer regional; most (n = 24, 77%) were Aboriginal community-controlled health services/clinics. Eleven services had participated in the earlier TTANGO trial. Implementation of POC testing was staggered across clinics, commencing with CT/NG POC testing in January 2016 immediately following completion of the

TTANGO trial to clinics with existing POC testing equipment. TV POC testing was added from early 2018. All TTANGO2 clinics were operational by March 2019. From 2020 onwards, as part of TTANGO3, further scale-up enabled an additional 18 clinics across five jurisdictions to be enrolled and operational by the end of 2022. See Fig. 1. Two clinics (and one mobile outreach service) withdrew from the Program (after >12 operational months) due to insufficient staff and poor device utilization.

STI testing and integration in clinical practice

POC testing was integrated into primary care, supported by key infrastructure and support systems including training, competency assessment, quality management, connectivity, and technical support. Briefly, testing was conducted by trained and competent operators (Aboriginal Health Practitioners/Workers and nurses) according to standard operating procedures using the GeneXpert®CT/NG and GeneXpert®TV assays (Cepheid, Sunnyvale CA) on 4-module devices located in the clinic, using urogenital specimens (urine or vaginal/cervical swab). Each clinic participated in a quality management program which included quality control and external quality assurance testing and remote scientific assistance. Connectivity and information technology support was provided to enable return of test results to clinical management systems and the Program management database.[20]

All equipment and consumables were provided free-of-charge to the clinic. Clinics were recommended to conduct POC testing on the same day as specimen collection. Some clinics which routinely conduct annual community STI screens (with a goal to test all eligible young people in their community within a number of weeks) were supported by providing an additional 4-module device to double their testing capacity (8 modules) to facilitate same-day testing. Clinics were encouraged to prioritise STI POC testing among the most at-risk age groups in line with local guidelines which recommend annual screening of individuals aged either 15–29 years or 15–34 years, depending on the region.[22,23] The CT/NG and TV assays were performed using specimens collected as per usual practice for routine laboratory-based STI testing, i.e. self-collected urine or vaginal swab, or clinician-collected cervical swabs. Most services collected urine samples from both men and women, however some preferred self-collected vaginal swabs from women.

Patient management following a POC test (including treatment for the pathogen detected, partner notification, and recall for retesting) was conducted according to local guidelines which recommend the following treatments:

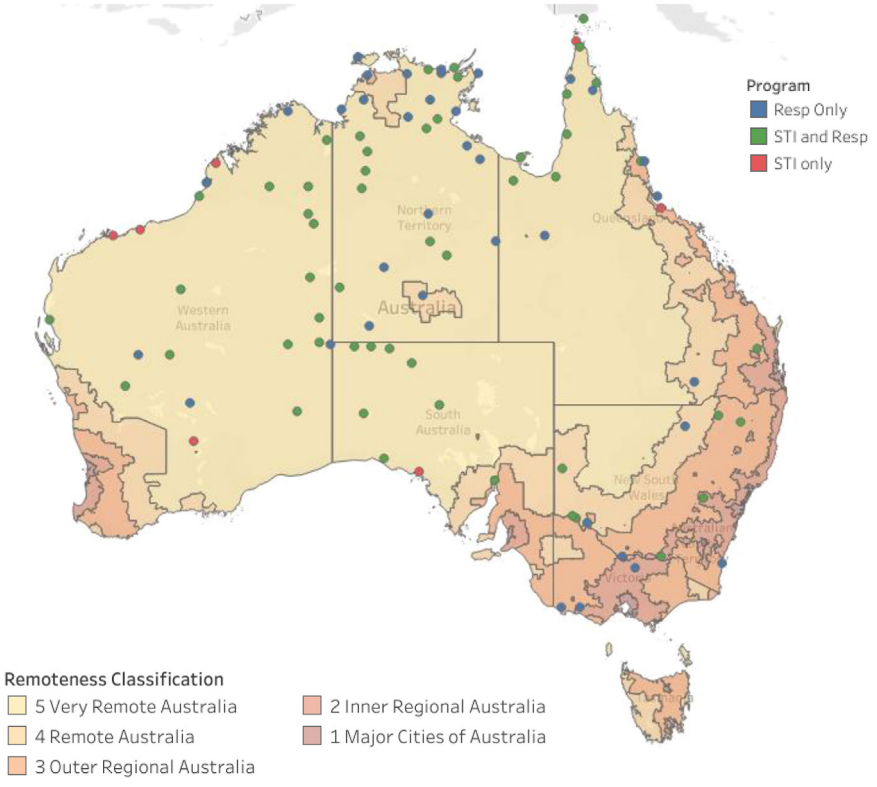


Fig. 1: **Clinical network.**

for CT infection, single oral dose 1 g of azithromycin; for NG infection where NG remains highly susceptible to penicillin, dual therapy comprising single oral dose 1 g of azithromycin plus 3 g of amoxicillin, and 1 g of probenecid; for NG infections where penicillin resistance is widespread, single intramuscular injection 500 g of ceftriaxone; and for TV, single dose of oral metronidazole (2 g).[22,23] According to these guidelines, presumptive treatment was offered to patients whose presentation met syndromic definitions for CT or NG infection, or who were considered at high risk of infection (defined as having had sexual contact with a person with CT, NG or presumptive TV infection).

For patients unable to wait for results, presumptive treatment was offered if their presentation met these syndromic definitions indicative of CT, NG or TV infection. Operators were encouraged to repeat any unsuccessful tests (those which returned a qualitative "no result", "invalid" or "error") with the same or a new sample immediately if possible. As most samples were urines, there was usually adequate volume remaining. Where repeat POC testing was not possible (for example, insufficient remnant specimen or workforce or other operational constraint) or did not provide a valid result, operators were encouraged to send specimens (recollect if necessary) for usual laboratory-based testing, ensuring etiologic diagnosis would be made. Parallel laboratory testing at accredited laboratories, using established nucleic acid amplification technologies, continued to be recommended to maintain the mandatory public health notifiable infections processes; and to ensure provision of samples for NG antimicrobial susceptibility testing.

More detail on the population and setting, testing and clinic integration is provided in the Supplementary Material.

Data collection

We extracted deidentified POC testing and demographic data from the Program POC test database (POC2DOC; Clinical Universe, Adelaide) for all participating clinics from 1 January 2016–31 December 2022. We extracted deidentified, routinely collected clinic-level patient data from patient management systems including demographics, STI testing, and treatment using a tailored, automated extraction software package (GRHANITE™; Melbourne, Victoria; https://www.grhanite.com/technologies), from participating clinics from 1 January 2016 to 1 April 2020. We conducted selective clinical audits to extract treatment information where this information was not available through the automated data extracts. Data were unavailable from 7 of 31 clinics due to limited extraction capacity and incompatible data formats. See Fig. 2.

Statistical analysis

Using Program POC testing data, we assessed *program implementation* by conducting a trend analysis of mean monthly CT/NG and TV POC testing patterns over time. We selected a cut-off point of April 2020 to coincide with the initiation of a national public health response to the COVID-19 pandemic in Australia and co-implementation of SARS-CoV-2 (and later multiplex respiratory) POC testing utilising the STI POC testing network and infrastructure.[19]

Using clinic-level data, we defined for each clinic an historical control period–all CT/NG and TV tests (laboratory tests) conducted prior to the introduction of POC testing and an intervention period–all CT/NG and TV tests (laboratory ± POC test) conducted following the introduction of POC testing. The date of introduction of POC testing was based on the operational start date at the clinic (i.e., post-installation of POC testing equipment with a trained competent operator available). We assessed clinical effectiveness by comparing the number and proportion of positive tests between: (i) historical control and intervention periods; and (ii) laboratory (parallel control) and POC test type during the intervention period. Statistically significant differences were determined using chi-square tests ($p < 0.05$). We calculated median (and interquartile range; IQR) time to treatment among those with a positive test result (for CT and/or NG and separately for TV), defined as the interval (in days) between the test request and recorded prescription date of the relevant treatment. We categorised time to treatment as: treated on the same day, ≤2 days, ≤7 days or ≤120 days, and compared proportion treated in each time category by historical/intervention periods and by laboratory/POC tests. Treatment greater than 120 days after testing (or no treatment record) was considered as "not treated".

We conducted a cluster-level analysis to evaluate *clinical effectiveness*, including stratification by sex. We estimated the relative risk (RR) based on cluster-level summaries,[24] which were calculated by dividing the number of subjects with the outcome of interest within each cluster by the total number of subjects in each cluster. These cluster-level summaries were used to calculate the corresponding 95% confidence intervals and p-values after accounting for within and between cluster-level variations. We estimated the number of infectious days averted using the difference in median time to treatment between a positive laboratory and POC test (for CT/NG and TV), multiplied by the number of positive POC tests during the intervention period.

We assessed POC test *analytical quality* by calculating test agreement by infection type where both POC test and laboratory results were available for an individual on the same ± one day, and assessed strength by calculating a Kappa statistic.[25] Among the discordant results where cycle threshold data was available (that is, for samples with positive POC test and negative laboratory test), we calculated the median cycle threshold values (and interquartile range) for the POC test results. In addition, we calculated the proportion of tests which were

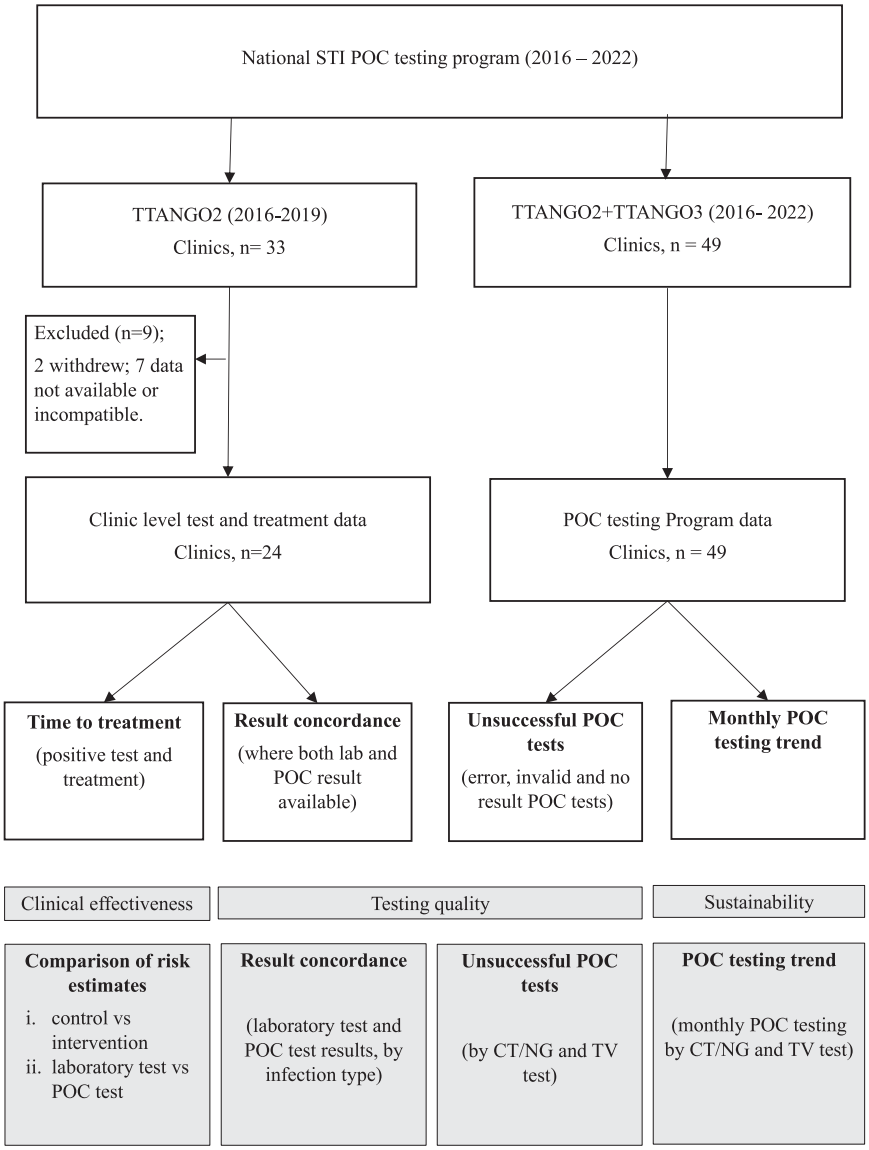


Fig. 2: **Data flow and analysis.**

unsuccessful (i.e. invalid, error or no result) using POC testing data.

Ethics approval

Ethics approvals for TTANGO2 were received from all relevant committees including West Australian Aboriginal Health Information and Ethics Committee (reference#-644, approved 21/07/2015); Western Australia Country Health Service Research Ethics Committee (reference#-2015/13, approved 8/10/2015); Far North Queensland Human Research Ethics Committee (Reference#: HREC/15/QCH/66—986, approved 7/8/2015); Townsville Hospital and Health Service Human Research Ethics Committee (Reference# HREC/18/QTHS/49, approved 23/2/18); Aboriginal Health Research Ethics Committee SA (Reference# 04-15-626, approved 11/8/2015); Kimberley Aboriginal Health Forum Research Sub-committee (reference# 2015—011, approved 12/7/15); Central Australian Human Research Ethics Committee (reference# 16-373, approved 16/5/16); Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (reference# 2016-2610, approved 2/8/16).

Role of funding source

The funder did not play any role in study design, analysis, and interpretation, nor did they have any role in writing the manuscript.

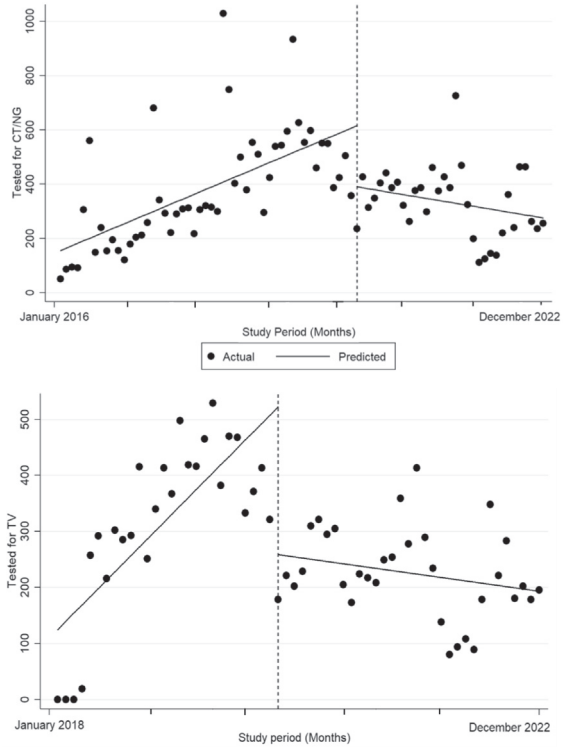
Results

Program implementation

Over the 7-year period, from 2016 to 2022, 46,153 POC tests were performed (30,160 CT/NG; 15,993 TV). From January 2016 to March 2020, the mean number of POC tests conducted per month was 381 (SD 211) for CT/NG [51 months] and 316 (SD 154) for TV [27 months], increasing over time (estimated regression coefficient: 9.02 CT/NG POC tests, $p < 0.0001$ and 14.73 TV POC tests, $p < 0.0001$). From April 2020 to December 2022 (32 months), we observed non-significant decreases in both CT/NG and TV POC tests (estimated regression coefficient: −3.58 CT/NG POC tests, $p = 0.07$ and −2.04 TV POC tests, $p = 0.13$). See Fig. 3.

Clinical effectiveness

Between 2016 and 2019, there were 5205 CT/NG positives: 1988 laboratory tests in the historical control period and 3217 tests (890 POC and 2327 laboratory) in the intervention period (Table 1). There were 4453 TV positives: 3298 laboratory tests in the historical control periods and 1155 tests (283 POC and 872 laboratory) in the intervention period (Supplementary Table S1). Overall, a greater proportion of positives were in women than men (CT/NG: 61.1% vs 38.9%; TV: 85.0% vs 15.0%). Among the 5202 CT and/or NG positive tests, 46.0% were for CT only, 36.7% were for NG only and 17.4% were co-infections. There was a greater proportion of NG positives tests (44.6% vs 33.4%) and lesser



	Mean number observed POC tests per month (tests/months) (SD)	Estimated regression coefficient (95% CI)	p-value
CT/NG POC test period			
January 2016 - March 2020§	381 (19,413/51) (211)	9·02 (5·74, 12·31)	<0·0001
April 2020* – December 2022§§	336 (10,747/32) (128)	-3·58 (-7·51, 0·35)	0·0736
TV POC tests period			
January 2018 - March 2020¶	316 (8,535/27) (154)	14·73 (7·17, 22·29)	<0·0001
April 2020 – December 2022¶¶	226 (7458/32) (79)	-2·04 (-4·70, 0·63)	0·1313

§ 32 clinics; §§ 44 clinics; ¶ 28 clinics; ¶¶ 45 clinics contributing

* Dotted vertical line at April 2020 coincides with date of implementation of national public health response to COVID-19 pandemic in Australia which included restricted community movements, geographical lockdowns, and co-implementation of SARS-COV-2 POC testing utilising existing STI POC testing program device network and infrastructure and ongoing co-implementation during scale-up

Fig. 3: **CT/NG POC patient testing trend (2016–2022) and TV POC patient testing trend (2018–2022) (all sites).**

proportion of CT positive tests (36.9% vs 49.2%) among the POC tests than laboratory tests respectively.

The median age of those with a CT/NG positive test was 22 years [interquartile range (IQR):18–28] and for a TV positive test was 27 years [IQR: 20–38]. While there was no difference by age group for CT/NG, there was a higher proportion of TV POC than laboratory test positives (Table 1, Supplementary Tables S1 and S2).

The median time to treatment following a positive CT/NG POC test and laboratory test was one day (IQR: 0–3) and 11 days (IQR: 0–65), respectively. A greater proportion of those testing positive for CT and/or NG in the intervention period were treated compared to the control period in all time categories (≤2 days: 37% vs 22% [RR 1.68; 95% CI: 1.12, 2.53]; ≤7 days: 48% vs 30% [RR 1.6; 95% CI: 1.10, 2.33]; <120 days: 54% vs 79% [RR 1.46; 95% CI: 1.10, 1.95]) (Table 2). During the intervention period, a greater difference in the proportion treated was observed following a positive POC test compared with a laboratory test (≤2 days: 61% vs 31% [RR 1.97; 95% CI: 1.48, 2.62]; ≤7 days: 64% vs 40% [RR 2.06; 95% CI: 1.24, 2.18]). This difference was greatest in women (≤2 days: 61% vs 26% [RR 2.20; 95% CI: 1.67, 3.30]; ≤7 days: 70% vs 38% [RR 2.35; 95% CI: 1.40, 2.43]); in men this difference was smaller and non-significant (Supplementary Table S3).

The median time to treatment following a positive TV POC test and laboratory test was 2 days (IQR: 0–14) and 27 days (IQR: 8–228), respectively. Similar to treatment following a positive CT/NG test, a greater proportion of patients were treated following a positive TV test in the intervention compared with the control period (≤2 days: 19% vs 8% [RR 2.38; 95% CI: 1.25, 4.50]; ≤7 days: 29% vs 16% [RR 1.81; 95% CI: 1.16, 2.83]) and following a POC test compared with a laboratory test during the intervention period (≤2 days: 32% vs 10% [RR 3.2; 95% CI: 1.63, 6.29]; ≤7 days: 45% vs 20% [RR 2.25; 95% CI: 1.41, 3.58]). See Supplementary Tables (S4 and S5).

Based on the difference in median time to treatment following a positive POC test compared with a laboratory test for CT (10 days), NG (10 days) and TV (25 days), 4930, 5620 and 7075 infectious days, respectively, were averted by POC testing during the first four Program years.

Analytical quality

The overall diagnostic agreement between POC test and laboratory test results was 99.0% for CT (4071/4111; k = 0.94, 95% CI 0.92–0.96), 99.3% for NG (4082/4110; k = 0.95, 95% CI 0.94–0.97) and 98.9% for TV (2344/2371; k = 0.95, 95% CI 0.93–0.97) (Table 3). Among the discordant results with available cycle threshold values (only POC test positive/laboratory test negative), the median cycle threshold value was 37.1 for CT (range: 33.1–41.2; n = 23), 349 for NG (33.6–40.2; n = 20) and 31.9 for TV (27.2–36.7; n = 2). There was no discernible pattern of discordance associated with study sites or test year. Cycle thresholds were not available for discordant results positive by laboratory testing but negative by POC test.

Evaluation Period[c]		Control	Intervention		Intervention		
CT/NG	All	Lab test only	Lab test +/− POC test	p value	Lab test only	POC test	p value
Overall	5205	1988	3217		2327	890	
Sex				<0.0001			<0.0001
Male	2020 (38.9%)	730 (36.7%)	1290 (40.3%)		889 (38.2%)	401 (45.9%)	
Female	3168 (61.1%)	1258 (63.3%)	1910 (59.7%)		1437 (61.8%)	473 (54.1%)	
Age[a]							
Mean (SD)	24.0 (8.4)	24.0 (8.4)	24.1 (8.3)	0.67[b]	24.1 (8.4)	24.0 (8.1)	0.78[b]
Age group				0.46			0.44
15–29 years	4099 (79.2%)	1585 (79.7%)	2514 (78.9%)		1843 (79.2%)	671 (77.9%)	
≥30 years	1077 (20.8%)	403 (20.3%)	674 (21.1%)		484 (20.8%)	190 (22.1%)	
Test result				0.72			<0.0001
CT positive only	2393 (46.0%)	919 (46.2%)	1474 (45.8%)		1146 (49.2%)	328 (36.9%)	
NG positive only	1908 (36.7%)	734 (36.9%)	1174 (36.5%)		777 (33.4%)	397 (44.6%)	
CT and NG positive	904 (17.4%)	335 (16.9%)	569 (17.7%)		404 (17.4%)	165 (18.5%)	
Clinic				<0.0001			<0.0001
Remote or very remote	4517 (86.8%)	1628 (81.9%)	2889 (89.8%)		2046 (87.9%)	843 (94.7%)	
Regional	688 (13.2%)	360 (18.1%)	328 (10.2%)		281 (12.1%)	47 (5.3%)	

Data are n (%) and mean (SD). Category totals vary due to missing values. The % overall missing for sex was 0.35% and for age was 0.33%. [a]Overall median age is 22 [interquartile range (IQR) 18–28] years; no difference was found in the median age between control and intervention groups (p > 0.05), or between lab test and point-of-care (POC) test (p > 0.05). [b]p-value is from the t-test. [c]Evaluation Period: Control, laboratory testing only available; Intervention, laboratory testing and POC testing available.

Table 1: **Patient and clinic characteristics of positive *Chlamydia trachomatis* (CT) and/or *Neisseria gonorrhoeae* (NG) tests, by program period (historical control vs intervention) and test type (laboratory vs POC).**

CT/NG positive	Control period	Intervention period			Intervention period			
	Control: P_0	Intervention: P_1	Risk Ratio[a] = P_1/P_0 (95% CI)	p-value	Lab test: P_0	POC test: P_1	Risk Ratio = P_1/P_0 (95% CI)	p-value
Number of clusters	23	23						
Treated same day								
Overall % (n)	29% (577/1988)	40% (1274/3217)			30% (696/2327)	65% (579/891)		
Mean of cluster % (SD[§])	21% (18%)	35% (19%)	1.67 (1.10, 2.54)	0.005	27% (16%)	60% (29%)	2.22 (1.61, 3.07)	0.0041
Treated ≤2 days								
Overall % (n)	30% (588/1988)	41% (1330/3217)			31% (721/2327)	68% (609/891)		
Mean of cluster % (SD[§])	22% (18%)	37% (19%)	1.68 (1.12, 2.53)	0.004	31% (15%)	61% (28%)	1.97 (1.48, 2.62)	0.005
Treated ≤7 days								
Overall % (n)	39% (785/1988)	51% (1648/3217)			41% (953/2327)	78% (695/890)		
Mean of cluster % (SD[§])	30% (24%)	48% (20%)	1.60 (1.10, 2.33)	0.003	39% (17%)	64% (32%)	1.64 (1.24, 2.18)	0.02
Treated ≤120 days								
Overall % (n)	76% (1514/1988)	80% (2568/3217)			77% (1781/2327)	88% (787/890)		
Mean of cluster % (SD[§])	54% (37%)	79% (20%)	1.46 (1.10, 1.95)	0.004	73% (25%)	80% (29%)	1.10 (0.89, 1.36)	0.3845

SD, standard deviation; Control, only laboratory-based testing available (before introduction of POCT); Intervention, both POC testing and laboratory testing available. [a]Based on cluster-level summaries.

Table 2: **Time to treatment for *positive CT/NG* patient tests by historical control vs intervention period; laboratory vs POC test (intervention period).**

During the period January 2016–December 2022, there were 655 (3.1%) unsuccessful CT/NG POC patient tests conducted, generating either 'invalid' (n = 326), 'error' (n = 229) or 'no result' (n = 100) output. Among these, 325 (49.6%) were retested, with 287 (88.3%) producing a valid test result on repeat. There were 295 unsuccessful patient TV POC tests (73 'invalid'; 165 'error'; 57 'no result'); 121 (41.0%) were retested with 113 (93.4%) successfully generating a valid result. The overall rate of unsuccessful tests, considering retesting, was 1.8% for CT/NG POC testing and 2.1% for TV POC testing.

Discussion

This evaluation is the first to assess the implementation, clinical effectiveness, and analytical quality of a multi-year, national molecular STI POC testing program with comprehensive operator training and competency and ongoing technical support, integrated into primary health clinics providing care to First Nations peoples. Our findings demonstrate that molecular STI POC testing can be successfully scaled up as part of a routine program while maintaining high test quality and significant clinical effectiveness, with the greatest benefit being observed in women. The impact achieved closely approximates findings observed under trial conditions.[15]

The clinical effectiveness demonstrated by comparing historical control and intervention periods reflects the real-world effectiveness of POC testing, recognising limited uptake of POC testing in settings where laboratory testing is available. While theoretically POC testing should enable same day treatment, in

POC test	Laboratory test				Kappa statistic, (95% CI), p-value[25]
	Negative	Positive	Total	% agreement	
Chlamydia (CT)				99.0%	0.94 (0.92–0.96) p < 0.0001
Negative	3726	17	3743		
Positive	23	345	368		
Total	3749	362	4111		
Gonorrhoea (NG)				99.3%	0.95 (0.94–0.97) p < 0.0001
Negative	3773	8	3781		
Positive	20	309	329		
Total	3793	317	4110		
Trichomonas (TV)				98.9%	0.95 (0.93–0.97) p < 0.0001
Negative	2046	25	2071		
Positive	2	298	300		
Total	2048	323	2371		

CI, Confidence intervals.

Table 3: **POC and laboratory test result concordance by infection type.**

practice this will depend on a variety of clinic and patient factors including testing integration and patient ability to wait for results. Even in a trial context, immediate treatment was not completely feasible.[15] Our findings highlight the benefit in women, with more than double the proportion treated in ≤2 days for CT/NG and almost three times the proportion treated for TV in the same timeframe. The absence of an observed difference in men might be explained by their more likely symptomatic presentation and subsequent presumptive treatment.

The proportions treated following a positive TV POC test were two to three-fold higher than for a laboratory test; however, the proportions treated in each time category were lower than those observed for CT/NG. A possible explanation is that TV may be considered a nuisance infection, with a reluctance to treat infections detected during pregnancy. Preliminary qualitative work exploring perceptions around TV testing, including TV POC testing, suggests that while TV is generally considered by many clinicians as important to diagnose and treat, some clinicians remain sceptical.[26]

In addition to the individual benefits of more timely diagnosis and treatment including reduced adverse reproductive and pregnancy outcomes, POC tests resulted in a 11-fold (CT/NG) and 12.5-fold (TV) reduction in median number of days of infectivity (inferred from the differences in the median time to treatment). This difference could translate to a lower reproductive rate in the community for these STIs, which could result in a decline in the incidence, and prevalence if a sufficiently high testing coverage were achieved. In remote Australia, where over 40% of hospital admissions for PID among young Aboriginal women are attributable to a current NG and/or CT infection,[11] strategies such as POC testing to improve time to treatment and potentially improve recognition of PID could have a major reproductive health impact.

The almost perfect agreement between POC and laboratory tests observed provides reassuring evidence of continued excellent analytical performance in the hands of trained and competent clinic staff. These findings are consistent with those previously observed.[17] The unsuccessful test rate, including operator and device-related errors, remained very low across the Program (~2%). Reasons for "invalid", "error" and "no results" outputs may be multifactorial. However, in general where operator-related issues were identified (usually an "invalid") such as insufficient sample volume added to the test cartridge, additional training was provided. Device-related or power-supply issues (usually an "error" or "no result") were often outside the control of the operator or Program. Following investigation, devices were repaired or replaced if needed. Universal power supply devices were supplied to all sites to minimise the disruption caused by power outages or fluctuations mid-testing.

After four years of increased use of STI POC testing, we observed a drop in testing from April 2020, which can be attributed to shifting of clinical priorities, repurposing POC testing equipment for SARS-CoV-2 community lockdowns/border restrictions to and changes in health seeking behaviours, with similar reductions observed in most preventative health areas.[27] The COVID-19 pandemic exacerbated already limited workforce capacity in remote health services and clinics.[13] Despite these challenges, testing remained stable though end of 2022 which should be considered as a positive achievement by ACCHOs.

Despite POC testing being highly acceptable to patients and staff[15,16] and all program elements provided free-of-charge, just over a quarter of all positive tests in the intervention period were POC tests. Barriers to POC testing uptake are strongly related to the high staff turnover, substantial workload and competing clinical priorities.[28] High staff turnover remains a considerable challenge incurring higher direct costs for service provision and likely contributes to sub-optimal continuity of care, compromised health outcomes and poorer levels of staff safety.[13] The current Program relies on existing clinical staff taking on the additional responsibility of POC testing with no dedicated financial compensation. To maximise uptake, new workforce strategies are urgently needed including dedicated workforce funding and training First Nations community workers, akin to peer workers.[20,29]

Staff confidence to conduct POC tests has also been identified as a barrier.[28] Busy staff or staff who are lacking confidence may have preferred to send a sample for a laboratory test, rather than conducting a POC test and waiting the 60–90 minutes for the result. With the development of future strategies to support reporting and NG resistance surveillance, parallel laboratory testing will no longer be routinely recommended. These include optimising digital connectivity systems to enable and ensure the delivery of mandatory notifications for STI for public health surveillance and working with clinics and pathology providers to support pathways to ensure NG positive specimens continue to be sent for usual culture and antimicrobial sensitivity testing. This change may have a beneficial impact on STI POC test uptake as would a test with a more rapid time to result (<30 min).

A major strength of our study design is the use of historical and parallel control periods, which was made possible by staggered implementation and long-term retrospective data, minimising the risk of any specific external factors prior to POC testing that could have influenced the observed improved time-to-treatment. The risk of bias from uncontrolled confounders was minimized by the design of our analytical approach and the naturally staggered programmatic implementation. Limitations include the absence of clinic level testing data from 7 clinics. While these clinics were

predominantly from one jurisdiction, we believe it is unlikely these missing data would have changed our results as these clinics were similar to others providing data in terms of geographic remoteness, clinic governance, burden of infection and population served (as these were criteria for site participation). It is possible that for some clinics included in our analyses, treatment information was missing (e.g. not recorded or unable to be extracted). While the impact of this was not expected to be different by test type or control period, the impact of these missing data was mitigated by conducting selective clinical audits to manually review patient records to identify treatments.

This program was implemented to address the recognised inequities in access to diagnosis and treatment for STIs and burden of sequelae in First Nations populations living in regional and remote Australia and recognises the essential role diagnostics play in a well-functioning and high-quality health system.[30] Increased uptake of this technology, in combination with other strategies that enhance health service access and more timely treatment following a positive POC test, may contribute to reductions in the disproportionate burden of infection and associated-morbidities in these communities. To maximise both the individual and public health benefits of molecular STI POC testing through further scale-up and enhanced uptake of molecular POC testing will require sustainable funding which recognises not only the consumable costs but also costs associated with clinic workforce, new workforce models (including non-clinical staff) and optimisation of the implementation infrastructure including training, quality assurance and connectivity. Streamlining program integration will also be important to reduce barriers to uptake, improve workflow and generate economic efficiencies.

Our findings are broadly generalisable to other marginalised populations in other high-income countries and while likely too costly for wide-scale implementation in low- and middle-income countries, it clearly demonstrates the importance of strong community leadership and ensuring robust POC test systems to support integration into the health system.

Contributors

All authors contributed to the conceptualisation and/or implementation of the program and its evaluation. LMC, KS, AS, HW and RG led the design of the evaluation. LMC, AS and HW collected, cleaned, validated and analysed the data. LMC, AS and RG prepared the original draft with all authors contributing to the review and editing of final version submitted.

LMC, KS, HW, AS, and RG confirm that they had full access to all the data in the study. All authors accept responsibility for the submission of this manuscript for publication.

Data sharing statement

Data sharing is at the discretion of the data custodians and will be considered upon request.

Editor note

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Declaration of interests

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101110.

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