Testing for sexually transmitted infections in the general population of the Rotterdam area

Who goes where?

Denise E. Twisk

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in the General Population of the Rotterdam Area
Who goes where?

Testen op seksueel overdraagbare aandoeningen
in de algemene bevolking van de regio Rotterdam
Wie gaat waar naartoe?

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CHAPTER 1

General introduction

This general introduction provides an overview of sexually transmitted infection (STI) care and current STI testing surveillance and monitoring in the Netherlands. It also briefly discusses various factors that influence STI testing. The general introduction concludes with the aim and the research questions, as well as an outline of the studies in this thesis.

1.1. Sexually transmitted infections (STI)

An STI is an infection caused by a bacterium, virus, or parasite [1-9]. An STI is typically transmitted from person to person through contact involving blood, semen, vaginal fluids and/or other bodily fluids. An STI may not always cause symptoms, and symptoms can also manifest later after infection. Even in the absence of symptoms, an STI can be transmitted to other persons. STIs are common in the general population, partly due to the high frequency of asymptomatic infections. Testing followed by adequate treatment is critical in preventing possible negative health effects and further transmission, and therefore essential for both individual and public health. No treatment, or treatment failure, may lead to short-term or long-term harm to the infected person, including infertility.

1.2. The organisation of STI care in the Netherlands

In the mid-19th century, large-scale STI services emerged in the Netherlands. These services focussed on managing STIs by regularly testing sex workers for STIs [10]. In 1903, STI testing became more accessible for the general population with the opening of the first municipal outpatient STI clinic. This clinic, located in the city of Rotterdam, provided free-of-charge testing and treatment. In the 20 years that followed, a total of 68 municipal clinics were established across the country, with the majority located in the cities of Amsterdam, Rotterdam, and The Hague. After World War II, most of these STI clinics were closed, partly because of a decrease in STI occurrence. In the 1960s and 70s, as STIs resurged, seven hospital-based outpatient STI clinics were established. These clinics were subsidised by the government and provided free-of-charge testing and treatment without the need for a referral by a general practitioner (GP). During the same period, state-subsidised Rutgers clinics provided low-threshold information on sexuality and performed anonymous STI testing and treatment [10, 11]. In the early 2000s, all Rutgers clinics were either closed or continued as an STI clinic [12].

Today, sexual health centres (SHCs, formerly known as STI clinics) and GPs are the primary providers of STI testing and treatment. Specialists in hospitals and online testing services are not extensively performing for STI testing [13-16]. An SHC is coordinated by the Public Health Service, and STI testing and treatment is part of their secondary prevention task [17]. GPs conduct STI tests either upon clients' request or by initiating STI testing when there is an indication to do so. Although a consultation with a GP is covered by compulsory health insurance, the costs of STI tests and prescribed treatment are not always fully reimbursed for those who have not yet met their deduction threshold (minimum 385 euros per year since 2016). SHCs are funded by the government and provide low-threshold, free-of-charge STI testing and care for certain key population groups under the regulation for "Additional Sexual Healthcare" (*regeling Aanvullende Seksuele Gezondheidszorg; ASG*). These key population groups include those notified for an STI, those reporting STI-related symptoms, sex workers, men who have sex with men (MSM), those with a non-western migratory background, those with a sex partner with a non-western migratory background, those under 25 years of age, and victims of sexual violence. In 2015, financial restrictions resulted in stricter prioritisation of key population groups. This implies that individuals at highest risk for an STI, such as those notified for an STI and those with STI-related symptoms, are prioritised above other key population groups.

1.3. STI test policy at SHC and GP

An appointment for a consultation with an STI test (STI consultation) at the SHC is solely on clients' own initiative. Due to limited capacity caused by subsidy restrictions, some SHCs are not able to accommodate everyone that requests an appointment. Individuals that are denied access to STI testing by the SHC are informed that they can obtain STI tests from their GP instead. More recently, they are sometimes also made aware of the possibility of using self-collected sampling through trusted providers or private clinics. To cope with the high demand for testing, some SHCs may offer self-collected sampling for STI testing without the need for an (extensive) face-to-face consultation.

The testing policy for SHC visitors has undergone several changes over the years [18-20]. Until 2011, all SHC visitors were tested for chlamydia, gonorrhoea, syphilis, and HIV, with the option to decline the latter (opt-out). After 2011, this testing policy was no longer applied to visitors under 25 years of age, unless they belonged to another key population group (e.g., MSM, non-western migratory background). Between 2012 and 2014, visitors under 25 years of age were only tested for chlamydia. A positive chlamydia test was followed by a gonorrhoea, syphilis, and HIV test. Since 2015, visitors under 25 years of age are tested for chlamydia and gonorrhoea, and may also be tested for syphilis, HIV and/or hepatitis B if they belong to another key population group as well.

No strict policy applies to GPs, but guidelines for STI consultations recommend proactive risk-based testing of key population groups [21]. GP key population groups largely overlap with those of the SHC. GPs are advised to test heterosexual individuals under 25 years of age for chlamydia and gonorrhoea if they report discharge. Those with casual sexual contacts (i.e., three or more partners in last six months), should also be tested for syphilis, HIV and hepatitis B. For other key population groups – MSM, sex workers, clients of sex workers, those with a non-western migratory background, and individuals who have a partner in any of these groups – it is recommended to test for the "big five" STIs, namely chlamydia, gonorrhoea, syphilis, HIV and hepatitis B. Additionally to proactive risk-based STI testing, GPs are advised to test for HIV based on HIV indicator conditions. HIV indicator conditions are symptoms or medical conditions that indicate a possible HIV infection [22]. Individuals with HIV indicator conditions are likely to first contact their GP. In the Netherlands, GPs are considered easily accessible. Almost everyone is registered with a local GP and 75% contact their GP at least once a year [23]. Therefore, GPs play a crucial role in STI testing for individuals deemed to be at low risk, in addition to key population groups with a higher risk of STI.

1.4. Barriers and facilitators for STI testing

STI testing can be hindered by barriers at patient, provider and system levels. Generally, patient level barriers can be divided into two groups: (1) structural barriers such as proximity to clinic, openings hours, costs of STI testing, and (2) psychosocial barriers such as lack of risk perception, perceived need, lack of knowledge, fear of stigmatisation, and concerns about expertise, confidentially and privacy [24-46]. Some of these barriers can be even greater for HIV testing, for example due to the perception of HIV as a deadly disease rather than a chronic illness, which can increase the fear to test [31, 35]. Provider and system level barriers include time constraints, lack of training, skills and knowledge, difficulty discussing sexual health, but also testing policy restriction (e.g., SHC is only accessible for key population groups) [35, 47, 48].

Reducing barriers and inequalities in STI testing can improve test uptake. STI testing facilitators can help, but many require long-term societal and structural changes. For instance, structural education at schools and public education programmes can help normalise and destigmatise STI testing, empowering individuals to seek testing opportunities [47]. Other barriers may be easier to overcome, such as reducing the distance to testing services with SHC branch locations and outreach activities [49, 50], offering testing as part of other health practices (e.g., checks of new patients at the GP) [30], and using alternative methods like self-sampling [51, 52] and rapid HIV testing [45]. Also, educating healthcare providers, including GPs, can contribute to increasing awareness, confidence, and consideration of STI testing [48].

1.5. National STI surveillance

Public health surveillance and monitoring is an imperative tool for informed decisions and appropriate public health action. At the SHC, STI consultations are thoroughly registered, including extensive information about clients' socio-demographics, sexual behaviour, and STI test results. To facilitate surveillance, information about STI consultations is centrally collected from all 24 SHCs in the Netherlands and managed by the National Institute for Public Health and the Environment (RIVM) in the "SOAP database" [18]. Nationwide, the SHCs perform around 150,000 consultations annually, and annual reports provide stratified overviews of SHC visitors [18]. The proportion of SHC visitors and STI prevalence vary remarkably between groups, even though almost every visitor is considered to be at high risk for STIs [18]. SHC visitor numbers and STI prevalence also differ greatly between SHCs in the Netherlands. Part of this is probably due to differences in populations living in these areas, but also differences in demand and how strict triage is performed.

The RIVM also estimates the number of STI consultations at the GP (circa 300,000 consultations) based on a sentinel primary healthcare database [18]. GPs perform two-thirds of all STI consultations (circa 300,000 consultations at GPs vs. circa 150,000 consultations at SHCs). However, these GP estimates may include consultations where an STI test was not performed, as codes that indicate "fear of STI" in medical records from the GP sentinel database are also counted. Previous research indicated that an STI test is conducted at 83% of the STI consultations at the GP [53]. Detailed information about GP client characteristics such as migratory background is not available due to a lack of standardised registration by the GP. Therefore, more insight into testing at the GP is warranted since SHC visitors generally belong to key population groups with high STI risk and do not necessarily reflect the general population.

1.6. Surveillance of individuals living with HIV

For individuals receiving HIV care at one of the 27 HIV treatments centres in the Netherlands, additional monitoring data is collected by the HIV Monitoring Foundation (Stichting Hiv Monitoring; SHM). Every year on December 1st, World AIDS Day, SHM publishes a scientific report on the major developments in the course of the HIV epidemic and the characteristics of individuals with HIV in the Netherlands [54]. The report also includes results of HIV care continuum modelling, which indicates to what extent the Netherlands is on track in addressing the HIV epidemic. In 2014, the Joint United Nations Programme on HIV/AIDS (UNAIDS) established that by 2030, and later brought forward to 2025, 95% of the individuals with HIV globally should be aware of their HIV status, 95% of those who are aware should be on antiretroviral therapy (ART), and 95% of those on treatment should have suppressed viral loads [55]. According to the most recent estimates, by the end of 2020, 24,000 individuals were living with HIV in the Netherlands [54]. In recent years, significant progress has been made in achieving the 95-95-95 targets of the HIV care continuum, particular for the first two targets. The continuum increased from 88% - 88% - 93% in 2015 to 93% - 94% - 95% in 2020 [54]. As a result, the 95-95-95 targets are almost met nationwide.

1.7. STI testing and surveillance on local level

The studies presented in this thesis primarily focus on the greater Rotterdam area, known as Rotterdam-Rijnmond, which comprises Rotterdam and 14 neighbouring municipalities. Since 2023, the Rotterdam-Rijnmond area consists of 13 municipalities as a result of a municipal reorganisation. The Rotterdam-Rijnmond area is marked by a heterogeneous distribution for various characteristics, such as socio-economic status [56], individuals with a migratory background (varying from 7% to 53% between municipalities) and age (e.g., individuals under 25 years of age range from 23% to 33% between municipalities) [57]. The region contains one SHC situated in the city centre of Rotterdam, which provided circa 13,000 STI consultations annually from 2015 to 2019 [58]. The majority of individuals visiting the SHC in Rotterdam reside within the Rotterdam-Rijnmond area, with 85% living in the area, and 79% of those residing in the Rotterdam municipality [58]. Not all individuals who contact the SHC in Rotterdam are scheduled for an appointment to get tested. The proportion and characteristics of those not receiving an appointment are unknown, but some of these individuals belong to an SHC key population group based on the experience of professionals at the SHC. The number and proportion of individuals who eventually get tested elsewhere, such as at their GP, are also unknown.

Regional estimates of STI consultations at the GP are not available in contrast to national estimates. Regional data can help in understanding local STI care and support policymaking. The ratio of SHC-GP consultations with an STI test can differ from one region to another, and may vary depending on the type of STI [59]. GP laboratory data can be used instead of sentinel networks to understand GP consultations for STI tests and the GP-SHC ratio in STI consultations. Laboratories analyse STI tests conducted by the GP and record the requests and test results. However, client characteristics and information about risk are not available in the laboratory databases. Moreover, GP's standard registration of socio-demographics is limited to sex and age, and information about sexual (risk) behaviour is often absent in electronic medical records. A new approach combining laboratory and population data can be used to gather more information about GP clients' socio-demographic and residential area characteristics.

1.8. Population microdata

Since 1994, Statistics Netherlands (Centraal Bureau voor de Statistiek; CBS) has provided access to longitudinal population data, known as microdata. Microdata contains linkable data at individual, household, company, or address level, using pseudonymised linkage keys. It is derived from various sources, such as the population register and educational registers. Dutch universities and scientific organisations can use this microdata for statistical research under strict conditions [60]. Analyses are conducted within a secured environment, and only analysis results can be exported from this environment after a check on any disclosure risk by Statistics Netherlands.

The availability of population microdata is quite unique, and comparable datasets are only available in Nordic countries [61-64]. Moreover, in addition to the available microdata, researchers can upload external datasets within the secured environment of Statistics Netherlands and enrich them with microdata. For example, GP laboratory STI test data can be uploaded as registered clients' socio-demographics at the GP are limited to sex and age. Combining GP laboratory data with population microdata provides a more in-depth understanding of the characteristics of GP clients, and thereby a more comprehensive picture of individuals tested for an STI in the general population.

1.9. Aims and outline of this thesis

The aim of this thesis is to provide an understanding of STI test provision by the GP and the SHC. This could provide recommendations for revised policies on STI testing and additional testing strategies. We address the following three research questions:

1. To what extent are the general population and specific socio-demographic key population groups tested for STIs/HIV at the GP and the SHC?
2. What are important factors in the utilisation of STI testing services?
3. What is the relative contribution of GP and SHC in STI/HIV testing?

This thesis is divided into three parts.

Part 1 – STI testing in general

Chapter 2 presents a study on the effect of distance on STI testing at the SHC. In **Chapter 3**, we analyse the socio-demographic and residential area characteristics of individuals tested for STIs at the GP and the SHC. STI testing rates of the GP and the SHC are also compared. In **Chapter 4** we assesses the geographical distribution of STI-related risk and STI testing rates to identify areas for improving access to sexual healthcare. **Chapter 3** and **Chapter 4** are based on GP and SHC laboratory data linked to population microdata.

Part 2 – HIV testing

Based on aggregated laboratory and population data, we describe in **Chapter 5** the number of HIV tests performed by GPs and their contribution to HIV testing compared to SHCs in five regions in the Netherlands. This is also stratified by age and sex. **Chapter 6** assesses and compares HIV testing at the GP and the SHC for different socio-demographic population characteristics, and estimates population- and provider-specific HIV incidence. In **Chapter 6**, laboratory data is linked to population microdata. **Chapter 7** describes the development and design of a community-based intervention to promote HIV testing, as well as the results of the conducted pilot.

Part 3 – General discussion and appendices
Chapter 8 provides a general discussion of the main findings of this thesis, based on the research questions stated in the introduction, and concludes with recommendations for practice and further research. The **appendix** contains an English and Dutch summary of this thesis, a brief author biography, and the author's PhD portfolio and list of publications, as well as acknowledgements.

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PART 1

STI testing in general

CHAPTER 2

Distance as explanatory factor for sexual health centre utilization: an urban population-based study in the Netherlands

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Abstract

Background

The central sexual health centre (SHC) in the greater Rotterdam area in the Netherlands helps finding people unaware of their STI/HIV status. We aimed to determine a possible association between SHC utilization and travel distance in this urban and infrastructure-rich area. Insight in area-specific utilization helps adjust outreach policies to enhance STI testing.

Methods

The study population consists of all residents aged 15–45 years in the greater Rotterdam area (2015–17). We linked SHC consultation data from STI tested heterosexual clients to the population registry. The association between SHC utilization and distance was investigated by multilevel modelling, adjusting for sociodemographic and area-specific determinants. The data were also stratified by age (aged<25 years) and migratory background (non-Western), since SHC triage may affect their utilization. We used straight-line distance between postal code area centroid and SHC address as a proxy for travel distance.

Results

We found large area variation in SHC utilization (range: 1.13-48.76 per 1000 residents). Both individual- and area-level determinants determine utilization. Travel distance explained most area variation and was inversely associated with SHC utilization when adjusted for other sociodemographic and area-specific determinants [odds ratio (OR) per kilometre: 0.95; 95% confidence interval (CI): 0.93–0.96]. Similar results were obtained for residents <25 years (OR: 0.95; 95% CI: 0.94–0.96), but not for non-Western residents (OR: 0.99; 95% CI: 0.99–1.00).

Conclusions

Living further away from a central SHC shows a distance decline effect in utilization. We recommend to enhance STI testing by offering STI testing services closer to the population.

Key points

- Geographically, sexual health centre utilization varies widely in the urban and infrastructure-rich region studied.
- The only sexual health centre in the region reaches more remote areas inadequately.
- Travel distance is the most important barrier to sexual health centre utilization.
- STI testing by offering STI testing services closer to the population is recommended.

Introduction

Early diagnosis and adequate treatment are essential in controlling sexually transmitted infections (STIs), including HIV. Easier access to testing services and subsequent treatment can improve health outcomes, and could reduce the risk of STI transmission [1].

In the Netherlands, STI tests and treatment are provided mainly by general practitioners (GPs) and sexual health centres (SHCs). The SHC is restricted to those considered high risk for STI and those who need sexual health advice the most, which is assessed through triage [2]. Those who do not meet at least one triage criterion are advised to visit a GP. Contrary to the GP, SHCs are government funded, enabling tests and treatment free of charge [2]. STI consultations at the GP are free of charge, but STI tests are only free after the 'own risk' of at least 385 Euro of the health insurance is paid [3].

Cost is a barrier for healthcare utilization and testing [4–6]. As the SHC service is completely free of charge, financial barriers should not play a major role in approaching an SHC. There are several other barriers (e.g. service access, perceived needs and social-cultural factors) that undermine utilization and hence, testing [4–12]. This study explores how geographical proximity acts as a barrier to SHC utilization. Various studies have identified geographical proximity as an important structural factor to explain inequalities in geographically accessibility [13–16]. Utilization of a healthcare service, as a proxy for accessibility, appears to decrease with an increasing travel time or distance [13–16]. We could not find any quantitative studies investigating the effect of distance on SHC utilization in western countries.

Based on the hypothesis that larger travel distance is inversely associated with SHC utilization, we conducted a population-based study aiming to determine a possible association between SHC utilization and travel distance in the greater Rotterdam area. Confirmation would provide policy makers with evidence to enhance the (geographical) accessibility to SHC services and thereby increase STI testing and treatment rates.

Methods

Study area and SHC location

This study focuses on the central (and only) SHC of the city of Rotterdam, run by the Municipal Public Health Service. The greater Rotterdam area – the city of Rotterdam and 14 neighbouring municipalities – harbours 1.3 million residents, half of them living in the city. The river Maas divides both the greater Rotterdam area and the city of Rotterdam into a northern and a southern part. The SHC is in the northern part, very close to a bridge connecting both parts, and with a subway and tram station in front of the SHC building.

Data sources and study population

Since equal access to SHC services is pursued, the study population consists of all residents aged 15–45 years in the greater Rotterdam area, obtained from the Dutch population registry (Statistics Netherlands). Each person in this registry has a unique citizen service number (BSN). Due to privacy legislation, the BSN is not collected during SHC consultations. Therefore, we matched each SHC consultation record to an arbitrary, unique resident in the population registry by year of consultation (2015–17), year of birth, sex, grouped migratory background and four-digit postal code (PC). We only selected the first SHC consultation of each attendee that met the following criteria: a heterosexual man or woman living in the greater Rotterdam area, aged 15–45 years, and visiting the SHC for an STI test. We made this choice because: (1) most of the general population is heterosexual, (2) the proportion and residential distribution of men who have sex with men in the general population is unknown, and (3) more than 95% of all SHC heterosexual attendees belong to the age group 15–45 years. Additional data from Statistics Netherlands (degree of urbanization) and the Netherlands Institute for Social Research [socioeconomic status (SES)] were also linked to the dataset by PC.

Outcome variable

The main outcome of interest is access to the SHC, operationalized as 'SHC utilization'. Only residents that match with the SHC consultation database are assumed to have utilized the SHC.

Determinants

Both determinants at individual and PC level are considered (**Supplementary table S1**). The individual determinants include sex, age and grouped migratory background. The main determinant of interest is travel distance to the SHC on PC level. Other PC level determinants include degree of urbanization, SES, ethnic diversity and living in the northern or southern part of the area. Since travel distance (straight-line and road-network) and travel time are highly correlated (r^2>0.9), straight-line travel distance between the centroid of the PC area and SHC address is used as proxy for travel distance. Ethnic diversity is measured by the Herfindahl–Hirschman Index, and can be interpreted as the probability that two randomly selected individuals from the same PC area belong to different migratory background groups. We included living in the northern or southern part of the area as determinant because we assume that the river Maas may serve as natural barrier.

Statistical analyses

Potential selection bias was assessed by comparing selected consultations for SHC attendees that match the population registry to consultations without match. Only records with complete data for all determinants were included in the analysis. Descriptive analysis was performed to describe the study population and those who utilize the SHC, also including the utilization per 1000 residents with 95% confidence intervals (CIs) for the study population and the STI positivity rate with 95% CI among SHC users. The STI positivity rate is the percentage of SHC users with one or more STI diagnoses (i.e. chlamydia, gonorrhoea, infectious syphilis, HIV or infectious hepatitis B), and gives insight into area-specific high risk STI subgroups. For each PC area, we geographically present the degree of urbanization, ethnic diversity and the utilization rate. We also plotted distance against utilization per PC area.

Because of the hierarchical structure of our data – residents located within 183 PC areas in 15 municipalities – we conducted multilevel logistic regression analyses. The top level of the hierarchy (municipality) was not modelled, because the small number of municipalities (n=15) produced unreliable estimates, and because policy implications would most likely target PC areas. First, a null model (Model 0) was constructed. Second, univariable models were computed. Third, a model including travel distance and all individual-level determinants was computed (Model 1) to examine the effect of distance on SHC utilization adjusted for individual-level determinants. The final model (Model 2) included all individual level and PC-level determinants. Determinants' contribution in PC area variance was determined in Model 2 by removing the determinant and comparing the PC variance with the PC variance of Model 2. Each multilevel model was adjusted for year (2015–17). To determine whether the effect of distance differs between subgroups, interaction terms between distance to the SHC and all other determinants were added to Model 2. For interactions with individual-level determinants we included a random slope for determinants at individual level [17].

Model fit was compared using Akaike's information criterion (AIC). Model performance was assessed by the area under the receiver operating characteristics curve (AUC). An AUC value of 1 indicates perfect discriminative ability of the model to classify individuals as (not) visiting the SHC, and 0.5 suggests that the model is equivalent to random guessing. For each model, we also calculated the proportional change in the variance (PCV) with the null model as reference to indicate the explained PC area variance, and the median odds ratio (MOR) to quantify the magnitude of the effect of clustering.

Before the models were constructed, we checked for bivariate Pearson correlation between variables, which ranged from 0.0 to 0.7. No determinants were excluded based on multicollinearity defined by a variance inflation factor (VIF≥10); all variables had a VIF<5.

SHC triage policy affects the utilization rate for triaged groups (aged <25 years and/or having a non-Western migratory background have higher 'priority'). Therefore, we also performed the same analyses separately for residents aged <25 years and for non-Western migratory background. A combined stratification of age and migratory background was not possible, since the number of SHC visitors became too small to reliably estimate differences between PC areas.

All statistical analyses were conducted using SPSS (version 26). *P*-values were 2-sided and *P*<0.05 was considered statistically significant.

Results

Data selection and matching

For each study year, we included over a half million residents, with 1 582 017 records in total. Of the 19 460 SHC consultations that fulfil the study inclusion criteria, 220 (1.1%) records could not be matched to the population registry. There were no significant differences in individual determinants and triage criteria between the matched and non-matched group. In total, 646 records (0.04%) had to be excluded due to unavailability of SES information. This left 1 581 371 residents records with 19 237 SHC consultation record matches for analysis (**table 1**).

Table 1 Profile of the study population[a] (2015-17)

Characteristics	Total population		SHC visitors		Utilization rate per 1000 residents	STI positivity rate SHC visitors[b]
	No.	%	No.	%	rate (95% CI)	rate (95% CI)
Total	1 581 371		19 237		12.2 (12.1–12.2)	21.1 (20.5–21.7)
2015	526 590	33.3	6505	33.8	12.4 (12.3–12.4)	20.4 (19.4–21.3)
2016	526 649	33.3	6203	32.2	11.8 (11.7–11.8)	20.9 (19.9–21.9)
2017	528 132	33.4	6529	33.9	12.4 (12.3–12.5)	22.1 (21.1–23.1)
Sex						
Male	788 641	49.9	8408	43.7	10.7 (10.6–10.7)	21.5 (20.6–22.4)
Female	792 730	50.1	10 829	56.3	13.7 (13.6–13.7)	20.8 (20.1–21.6)
Age						
<25 years	477 768	30.2	13 352	69.4	27.9 (27.9–28.0)	23.0 (22.3–23.8)
≥25 years	1 103 603	69.8	5885	30.6	5.3 (5.3–5.4)	16.8 (15.8–17.7)
Median (IQR)	30	(23–38)	22	(20–26)		
Migratory background						
Native Dutch	862 245	54.5	8910	46.3	10.3 (10.3–10.4)	19.4 (18.6–20.3)
Other Western	133 271	8.4	1600	8.3	12.0 (11.8–12.2)	18.5 (16.7–20.5)
Dutch Antillean	58 318	3.7	1885	9.8	32.3 (31.8–32.8)	25.8 (23.9–27.8)
Surinamese	108 221	6.8	2295	11.9	21.2 (20.9–21.5)	23.1 (21.4–24.9)
Turkish	115 626	7.3	652	3.4	5.6 (5.4–5.9)	18.7 (15.9–21.8)
Moroccan	82 248	5.2	829	4.3	10.1 (9.7–10.4)	22.3 (19.6–25.2)
Other non-Western	104 179	6.6	1269	6.6	12.2 (11.9–12.5)	19.1 (17.1–21.4)
Sub-Sahara African[c]	32 095	2.0	566	2.9	17.6 (16.7–18.5)	19.6 (16.5–23.0)
Cape Verdean	27 857	1.8	972	5.1	34.9 (33.8–35.9)	31.3 (28.4–34.2)
Middle East European	57 311	3.6	259	1.3	4.5 (4.0–5.0)	20.5 (15.9–25.7)
Non-Western migratory background						
No	978 014	61.8	10 393	54.0	10.6 (10.6–10.7)	19.4 (18.6–20.2)
Yes	603 357	38.2	8844	46.0	14.7 (14.6–14.7)	23.2 (22.3–24.0)
Degree of urbanization[d]						
Very high	846 248	53.5	14 757	76.7	17.4 (17.4–17.5)	20.9 (20.2–21.6)
High	432 442	27.3	3289	17.1	7.6 (7.5–7.7)	21.6 (20.3–23.1)
Moderate	192 545	12.2	821	4.3	4.3 (4.1–4.4)	22.0 (19.3–25.0)
Low	72 162	4.6	281	1.5	3.9 (3.5–4.3)	23.1 (18.5–28.3)
Very low	37 974	2.4	89	0.5	2.3 (1.6–3.1)	23.6 (15.7–33.2)

■ **Table 1** Profile of the study population[a] (2015-17) (continued)

Characteristics	Total population		SHC visitors		Utilization rate per 1000 residents	STI positivity rate SHC visitors[b]
	No.	%	No.	%	rate (95% CI)	rate (95% CI)
Socioeconomic status[d]						
High	278 543	17.6	3220	16.7	11.6 (11.5–11.7)	18.7 (17.3–20.0)
Average	711 066	45.0	6734	35.0	9.5 (9.4–9.5)	21.2 (20.3–22.2)
Low	591 762	37.4	9283	48.3	15.7 (15.6–15.7)	21.9 (21.1–22.8)
Travel distance to SHC[d]						
<5km	641 744	40.6	12 832	66.7	20.0 (19.9–20.0)	20.7 (20.0–21.4)
5–10km	586 150	37.1	4779	24.8	8.2 (8.1–8.2)	22.0 (20.9–23.2)
≥10km	353 477	22.4	1626	8.5	4.6 (4.5–4.7)	22.0 (20.0–24.0)
Median (IQR)	6.1	(2.9–9.9)	3.0	(2.1–6.1)		
Northern or southern side of the river Maas[d]						
North	912 135	57.7	13 521	70.3	14.8 (14.8–14.9)	20.1 (19.4–20.8)
South	669 236	42.3	5716	29.7	8.5 (8.5–8.6)	23.6 (22.5–24.7)

Data are presented as N (%) unless otherwise indicated.

95% CI, 95% confidence interval; *IQR*, interquartile range; *km*, kilometres; *no*, number; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

[a] Complete case analysis included 3 years together (2015–17). For persons who utilize the SHC in Rotterdam, we selected for each year only the first record that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15–45 years, tested for any STI).

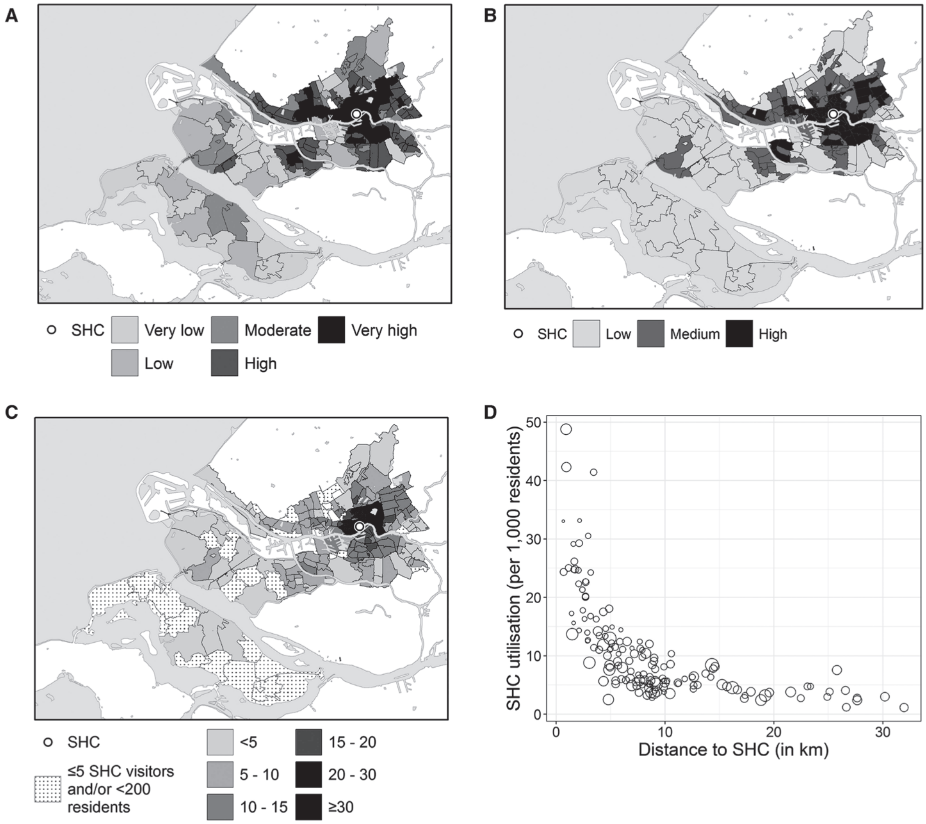
[b] STI positivity rate is the percentage of SHC users with a positive STI test (chlamydia, gonorrhoea, infectious syphilis, HIV or infectious hepatitis B). To identify STI positivity, we considered all SHC records that fulfilled the inclusion criteria for SHC utilization per year.

[c] Sub-Sahara African without Cape Verdean.

[d] Based on four-digit postal code.

Study area and study population

Based on the utilization rate, SHC visitors were more often women, <25 years, non-Western, and living in highly urbanized or low SES areas (**table 1**). The straight-line distance from PC area to the SHC ranged from 0.6 to 41.2 km. In general, SHC utilization decreased with increasing distance to the SHC (**figure 1D and table 1**). PC areas relatively close to the SHC are also the areas with a higher degree of urbanization and a more ethnically diverse population (**figure 1A and B**). The SHC utilization between PC areas ranged from 1.13 to 48.76 per 1000 residents (**figure 1D**).



■ **Figure 1** Degree of urbanization (A), ethnic diversity (B), SHC utilization per 1000 residents (C), and SHC utilization by distance to SHC (D).

km, kilometre; *SHC*, sexual health centre.

[a] Degree of urbanization of each postal code presented in five categories: very low (<500 addresses/km^2), low (500–1000 addresses/km^2), moderate (1000–1500 addresses/km^2), high (1500–2500 addresses/km^2), very high (2500 addresses/km^2).

[b] Level of postal area ethnic diversity ranging from 0 to 1, divided in tertiles; a higher index score reflects more ethnic diversity. The index was based on 10 migratory background groups: native Dutch, other Western residents, Dutch Antillean, Surinamese, Turkish, Moroccans, other non-Western residents, Sub-Sahara African (without Cape Verdean), Cape Verdean and Central and Eastern European.

[c] For SHC utilization per postal code, we selected only the first record that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15–45 years, tested for any STI) for each individual per year (2015–17).

[d] Each dot represents a postal code area. The size of the dots indicate uncertainty; the smaller the dot, the more residents in the postal code area. Postal code areas with 5 SHC visitors and/or <200 residents are excluded.

The data presented in these maps are based on publicly available data from Statistics Netherlands (figure 1A) or data generated in this study (figure 1B–D).

The overall positivity rate was 21.1% (95% CI: 20.5–21.7%) among SHC visitors. In general, the positivity rates for subgroups differed little from this overall positivity rate. The positivity rate was lowest for visitors aged ≥25 years (16.8%) and highest for Cape Verdean visitors (31.3%), which also had the highest utilization rate. We observed a non-significant difference in STI positivity between those living closely and more distant from the SHC (**table 1**).

Multilevel models for SHC utilization

Multilevel logistic models for SHC utilization are presented in **table 2** and **Supplementary table S2**. The null model depicted a statistically significant difference in SHC utilization between PC areas with a PC variance of 0.69 ($P < 0.001$). The univariable model with only travel distance accounted for the highest decrease in PC variance in utilizing the SHC compared to null model; the PC variance decreased with 70.0% (**Supplementary table S2**). After adjusting for travel distance and individual-level determinants (Model 1), the PC variance decreased by 77.5% to 0.15 compared to the null model (**table 2**). Adding other PC area variables to the model (Model 2) explained 87.0% of the PC variance, leaving a MOR of 1.33. In other words, if a resident moved to another PC area with a higher probability of utilizing the SHC, the median increase in their odds of utilizing the SHC would be 1.3-fold.

Table 2 Multilevel logistic models for SHC utilization[a]

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
2015	REF		REF		REF	
2016	0.95	(0.92 - 0.98)	0.94	(0.92 - 0.97)	0.94	(0.92 - 0.97)
2017	0.99	(0.96 - 1.03)	0.99	(0.95 - 1.02)	0.99	(0.95 - 1.02)
Individual level						
Sex						
Male			REF		REF	
Female			1.29	(1.24 - 1.34)	1.29	(1.24 - 1.34)
Age in years						
15-19			0.53	(0.49 - 0.58)	0.53	(0.49 - 0.58)
20-24			REF		REF	
25-29			0.31	(0.28 - 0.34)	0.31	(0.28 - 0.34)
30-34			0.15	(0.13 - 0.17)	0.15	(0.13 - 0.17)
35-39			0.08	(0.07 - 0.09)	0.08	(0.07 - 0.09)
≥40			0.04	(0.03 - 0.05)	0.04	(0.03 - 0.05)
Migratory background						
Native Dutch			REF		REF	
Other western			0.85	(0.69 - 1.04)	0.84	(0.69 - 1.04)
Dutch Antillean			2.08	(1.79 - 2.40)	2.06	(1.79 - 2.40)
Surinamese			1.60	(1.39 - 1.85)	1.59	(1.39 - 1.84)
Turkish			0.38	(0.32 - 0.47)	0.38	(0.32 - 0.46)
Moroccan			0.59	(0.48 - 0.72)	0.58	(0.48 - 0.72)

Table 2 Multilevel logistic models for SHC utilization[a] (continued)

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Other non-western			0.81	(0.67 - 0.98)	0.81	(0.67 - 0.98)
Sub-Sahara African[c]			1.26	(1.05 - 1.51)	1.25	(1.04 - 1.50)
Cape Verdean			2.20	(1.85 - 2.61)	2.18	(1.84 - 2.60)
Central and Eastern European			0.37	(0.30 - 0.46)	0.36	(0.29 - 0.45)
Postal code level						
Degree urbanization						
Very high					REF	
High					0.73	(0.63 - 0.85)
Moderate					0.69	(0.53 - 0.89)
Low					0.70	(0.53 - 0.93)
Very low					0.65	(0.46 - 0.93)
Socioeconomic status						
High					REF	
Average					0.87	(0.73 - 1.03)
Low					0.81	(0.64 - 1.02)
Ethnic diversity						
Low					REF	
Medium					1.37	(1.15 - 1.63)
High					1.81	(1.39 - 2.37)
Travel distance to SHC in km (continuous)			0.92	(0.91-0.93)	0.95	(0.94 - 0.96)
Northern or southern part of river Maas						
North					REF	
South					0.92	(0.84 - 1.01)
Additional information						
Measures of variation		*P*-value		*P*-value		*P*-value
Postal code level variance	0.69	<0.001	0.15	<0.001	0.09	<0.001
PCV (%)	REF[d]		77.5%		87.0%	
MOR	2.20		1.45		1.33	
Model fit and performance						
AIC	199478.9		179223.5		179162.0	
AUC	0.505		0.816		0.819	

AIC, Akaike information criterion; *AUC*, area under the receiver operating characteristics curve; *95% CI*, 95% confidence interval; *km*, kilometres; *MOR*, median odds ratio; *OR*, odds ratio; *PCV*, proportional change in variance; *REF*, reference; *SHC*, sexual health centre.

[a] SHC utilization is defined as at least one SHC visit that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15-45 years, tested for any STI). For each year, we only included the first record that met the inclusion criteria during the study period (2015–17). The model for SHC utilization includes 1 581 371 persons.

[b] Model 0 is a null model in which only levels are defined; this model does not contain any individual or postal code level determinants.

[c] Sub-Sahara African without Cape Verdean.

[d] Reference for Models 1 and 2.

In Model 2, which adjusts for individual and PC determinants, living closer to the SHC was associated with SHC utilization (**table 2**). Each kilometre increase was associated with 5% decrease (OR: 0.95; 95% CI: 0.94–0.96) in the odds of utilizing the SHC. This means that a person has a 20% lower odds of utilizing the SHC (OR: 0.81) when residing at 8.0 km (75th percentile of distance) compared to 4.0 km from the SHC (25th percentile). The ORs of the individual-level variables in Model 2 were similar to the ORs observed in Model 1 (**table 2**).

Each variable included in Model 2 decreased PC area variance, ranging from -0.6% for sex to -31.3% for age and -32.8% for travel distance (**table 3**). Travel distance and ethnic diversity appeared to be the most important PC determinants in PC area variance decrease in Model 2.

Interaction plots are presented in **Supplementary figure S1** and depicted a different effect of distance on SHC utilization by subgroup. Most striking is that individuals with a Cape Verdean, Surinamese, Turkish, Moroccan or other non-Western migratory background living further away from the SHC utilized the SHC more often than their peers living nearby. For all other subgroups, a distance decline effect on SHC utilization was observed, but the slope of the effect differed.

Table 3 Change in postal code variance in SHC utilization[a,b] and AUC upon removing determinant from Model 2

Ranking	Determinant	Level of determinant	% change in PC variance without determinant[c]	AUC
1	Travel distance to SHC in km	Postal code	-32.8%	0.802
2	Age	Individual	-31.3%	0.714
3	Ethnic diversity	Postal code	-16.0%	0.803
4	Degree of urbanization	Postal code	-12.4%	0.818
5	Migratory background	Individual	-4.8%	0.803
6	Socioeconomic status	Postal code	-3.0%	0.819
7	Northern or southern part of river Maas	Postal code	-1.7%	0.819
8	Sex	Individual	-0.6%	0.818

AUC, area under the receiver operating characteristics curve; *km*, kilometre; *PC*, postal code; *SHC*, sexual health centre.

[a] SHC utilization is defined as at least one SHC visit that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15– 45 years, tested for any STI). For each year, we only included the first record that met the inclusion criteria during the study period (2015–17). The model for SHC utilization includes 1 581 371 persons.

[b] Ranked based on contribution to postal code variance.

[c] Complete model (Model 2, table 2) as reference.

Stratified multilevel models for SHC utilization

The same analyses were performed for residents aged <25 years (**Supplementary table S3**) and for residents with a non-Western migratory background (**Supplementary table S4**). Among residents aged <25 years, similar results were observed to the overall results (**table 2**); the OR for distance was 0.95 (95% CI: 0.94–0.96) in the final model, and the VPC and MOR had a similar pattern with a final MOR of 1.33.

The results for non-Western residents differed from the total population and the residents aged <25 years. Univariably (data not shown), distance was statistically significantly associated with SHC utilization (OR: 0.94; 95% CI: 0.93–0.95), which was not the case in the final model for non-Western residents (OR: 0.99; 95% CI: 0.99–1.00). Only age and migratory background were statistically significantly associated in the final model. The PC variance was fully explained for both Models 1 and 2 (PCV=100%), with a corresponding MOR of 1.

Travel distance accounted univariably for the largest decrease in PC variance for both residents aged <25 years and non-Western residents (data not shown). The MOR for the univariable model with travel distance was 1.49 for residents aged <25 years and 1.34 for non-Western residents.

Model fit and performance

Although a relatively small improvement over Model 1, Model 2 had the best model fit with lowest AIC (**table 2**). The AUC improved from 0.505 in the null model to 0.819 in Model 2, reflecting a good discriminative ability of SHC utilization (**table 2**). Age had the largest added value in model performance (**table 3**), since the AUC decreased most when age was removed from Model 2 (AUC=0.714). Distance was the second-best determinant in model performance (AUC=0.802), together with individual migratory background and postal level ethnic diversity (for both AUC=0.803). The discriminative ability of both the final model among residents aged <25 years and non-Western residents was less compared to the overall model, with respectively an AUC of 0.733 and an AUC of 0.775.

Discussion

Our analysis in the greater Rotterdam area confirmed the hypothesis that larger travel distance is inversely associated with SHC utilization. This distance decline is independent of age and migratory background. We found that travel distance accounted for the largest decrease in PC area variance.

The results of our study are consistent with literature, and add to the existing knowledge of the distance decline effect [13–16]. However, these studies do not specifically address SHC utilization and most studies are not in Western infrastructure-rich urban areas, like in the Netherlands. We found the same distance effect for people <25 years, but not for people with a non-Western migratory background.

Possible explanations are related to the provider, the client and area (demographic) characteristics. Triage is probably the most important explanation on the provider side, because prioritization makes SHC consultation generally more accessible for people with a migratory background. Residential location is not an SHC triage criterion, but migratory status is prioritized above the <25 years old criterion because STI positivity is generally higher among people with non-Western background [2,18,19]. Difference in utilization seems unaffected by other triage criteria than age and migratory background; no difference was observed with other prioritized triage criteria, i.e. being notified or having symptoms.

Explanations for the difference in distance effect on client side may be self-selection and (non-)familiarity with the SHC. Those living further away may be more critical on their perceived STI risk, since it takes more effort to visit the SHC. From literature, it is known that a higher risk perception is positively associated with STI testing [11,20–22]. It may be that sexual health care outside standard insured care and free services offered by the SHC are more important for people with a migratory background to counterbalance the distance [23,24]. Previous research showed that more distant healthcare facilities may actually be preferred for stigmatized health conditions [25,26]. It is known that people with a non-Western background perceive more shame and stigma related to STIs than other populations [5,27]. Although in general, we observed a distance decline effect, we found that individuals with a Turkish, Moroccan, Cape Verdean, Surinamese or other non-Western migratory background residing further from the SHC utilize the SHC more often compared to their closer living peers. Also, perceived issues with confidentiality and privacy at the GP may play a role in choosing anonymous STI testing at the SHC [4,28].

Another explanation for the difference in distance effect could be a difference in sociodemographic distribution among PC areas or on non-measured determinants. People with a migratory background may reside further away from the SHC or at places with good public transport access compared to other subpopulations like youngsters, affecting utilization. From additional analysis, we could conclude that migratory groups with a high utilization rate in our study (Antillean, Surinamese or Sub-Sahara African), reside throughout the region without clear 'migrant neighbourhoods'. Turks and Moroccans tend to reside slightly more remotely from the SHC and more clustered.

We were able to explain a substantial proportion of the variance between PC areas. In the overall model, the PC variance in SHC utilization decreased with 87%. Distance explained most decrease in PC variance. Distance also had the second-best added value (together with migratory background and ethnic diversity) in model performance, after age. This finding strongly suggests introducing interventions that decrease the access inequality between areas caused by distance, e.g. a mobile clinic, an additional location, community-based testing in more remote areas or a combination with already existing services. Currently none of these suggested additional interventions are performed in the Rotterdam region, so the feasibility must be investigated. One could also use more internet-based approaches to overcome the physical distance barrier. However, for (digital) illiterate people – which is generally higher among migrants [29] – completely personal consultations are probably always needed [30].

Despite increasing the access by lowering the physical distance, a MOR of 1.33 in the final model still indicates a substantial difference between PC areas in SHC utilization even when other individual and area determinants are similar. This implies that we did not model all (area) determinants explaining geographical differences in utilization.

Strengths and limitations

Strengths of this study are firstly that this appears to be the first large-scale study linking SHC consultation data to population data to investigate SHC utilization in high-income areas. Secondly, we used multiple data sources for the fullest possible set of determinants. Thirdly, our multilevel approach allows the simultaneous examination of factors at different levels. Therefore, we were able to demonstrate the importance of area level determinants, which is often lacking in studies. Finally, we carefully considered our distance measure. We calculated multiple measures for proximity, which were all highly correlated (r^2>0.9). Other studies also found that straight-line distance is an adequate proxy for road-network distance and travel time in more urban areas [31–34].

The major limitation of the study is that we are not able to quantify the clinical significance of lower utilization rate among more remote areas from the SHC. If residents in these areas have a lower STI risk and are not visiting the SHC, or instead visiting the GP, this is less severe than high STI risk residents not visiting both SHC and GP. Similarly, our finding that STI positivity hardly differs between SHC attendees living close and distant from the SHC whereas the utilization rates do differ, may indicate that distantly living persons with high risk find their way to the SHC. Nevertheless, the low SHC utilization rate in distant areas raises the question whether the reach of the SHC is adequate. To better interpret these results, and to develop an optimal strategy for local STI testing services, the role of the GP should be addressed. Another limitation is that we are unable to completely correct for triage effect. We have no information on triage criteria for all residents, or more specifically, for those who are rejected for an SHC consultation based on triage or limited consultation availability. Insight in the rejected individuals would give more insight in the 'real' SHC accessibility and missed opportunities. We know that almost everyone who attempts to consult the SHC in Rotterdam has at least one triage criterion (unpublished data). We also know that a significant proportion high-risk people are refused due to limited consultation capacity. A final limitation is that we assigned the same distance measure to the SHC for all residents in one PC area. A more individual calculation of distance was not possible because anonymous consultation data only contain four-digit PCs. Nevertheless, several studies have shown that centroid distance is an acceptable proxy measure [35,36].

Conclusion

Distance is a clear barrier for STI testing at the central SHC in the infrastructure-rich urban area of this study. The used research concept is applicable for other geographical areas and health services. Minimizing travel distance, e.g. by using mobile clinics or additional locations in more remote areas, or more internet-based services could reduce area differences in STI testing. Different strategies should be considered for different subgroups.

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Supplementary materials

■ **Supplementary Table S1** Overview of categorization, data source and operationalization per determinant

Determinant	Categories	Data source	Operationalization
Individual level			
Sex	Male; Female	Statistics Netherlands, SHC consultation database	
Age (in years)	15-19; 20-24; 25-29; 30-34; 35-39; ≥40	Statistics Netherlands, SHC consultation database	
Migratory background	Native Dutch; Other western; Dutch Antillean; Surinamese; Turkish; Moroccan; Other non-western; Sub-Sahara African (without Cape Verdean); Cape Verdean; Central and Eastern European	Statistics Netherlands, SHC consultation database	Based on a combination of parental country of birth and the person's own country of birth.
Postal code level			
Travel distance to SHC (in kilometres) and travel time (in minutes)	Continuous	ArcGIS and web route planner(s)	Straight-line travel distance between PC centroid and SHC address.
Degree of urbanization	Very high (≥2500 addresses/km^2) High (1500-2500 addresses/km^2) Moderate (1000-1500 addresses/km^2) Low (500-1000 addresses/km^2) Very low (<500 addresses/km^2)	Statistics Netherlands	
Socioeconomic status	Low (a SES-score less than -1); Average (a score between -1 and +1); High (a score greater than +1)	Netherlands Institute for Social Research	SES was only calculated for four-digit postal with more than 100 households.
Ethnic diversity	In tertiles	Statistics Netherlands	Operationalized as HHI. HHI is based on the percentage of 10 migratory background groups (*see migratory background*).
Northern or southern part of river Maas	North; South	Statistics Netherlands	

HHI, Herfindahl-Hirschman Index; *km*, kilometres; *PC*, postal code; *SES*, socioeconomic status; *SHC*, sexual health centre.

Supplementary Table S2 Univariable multilevel logistic models for SHC utilization[a,b]

Determinant	Postal code level variance[c]	PCV (%)[c]	MOR	AUC
Individual level				
Sex	0.69▼	-0.04	2.20	0.534
Age	0.61▼	-11.18	2.10	0.795
Migratory background	0.69▲	+0.86	2.21	0.596
Postal code level				
Degree of urbanization	0.26▼	-61.88	1.63	0.628
Socioeconomic status	0.54▼	-21.39	2.01	0.564
Ethnic diversity	0.28▼	-59.09	1.66	0.621
Travel distance to SHC in km (continuous)	0.21▼	-70.02	1.54	0.671
Northern or southern part of river Maas	0.56▼	-18.78	1.66	0.567

AUC, area under the receiver operating characteristics curve; *km*, kilometre; *MOR*, median odds ratio; *PCV*, proportional change in variance; *SHC*, sexual health centre.

[a] SHC utilization is defined as at least one SHC visit that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15 to 45 years, tested for any STI). For each year we only included the first record that met the inclusion criteria during the study period (2015-2017). The model for SHC utilization includes 1581371 persons.

[b] Adjusted for year (2015, 2016, 2017).

[c] Null model (Model 0, Table 2) as reference. ▲▼ Postal code level variance higher (▲) or lower (▼) compared to null model.

Supplementary Table S3 Multilevel logistic models for SHC utilization[a] for residents <25 years

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Year						
2015	REF		REF		REF	
2016	0.93	(0.89 - 0.96)	0.93	(0.90 - 0.97)	0.93	(0.90 - 0.97)
2017	0.99	(0.95 - 1.03)	1.00	(0.96 - 1.04)	1.00	(0.96 - 1.04)
Individual level						
Sex						
Male			REF		REF	
Female			1.55	(1.48 - 1.63)	1.55	(1.47 - 1.63)
Age in years						
15-19			0.55	(0.50 - 0.60)	0.55	(0.50 - 0.60)
20-24			REF		REF	
Migratory background						
Native Dutch			REF		REF	
Other western			0.70	(0.55 - 0.91)	0.70	(0.54 - 0.91)
Dutch Antillean			1.55	(1.30 - 1.85)	1.53	(1.29 - 1.83)
Surinamese			1.20	(1.01 - 1.43)	1.20	(1.01 - 1.42)
Turkish			0.27	(0.22 - 0.34)	0.27	(0.22 - 0.33)
Moroccan			0.41	(0.33 - 0.53)	0.41	(0.32 - 0.52)
Other non-western			0.63	(0.51 - 0.78)	0.62	(0.50 - 0.77)
Sub-Sahara African[c]			1.04	(0.84 - 1.28)	1.03	(0.84 - 1.26)
Cape Verdean			1.69	(1.37 - 2.08)	1.67	(1.36 - 2.06)
Central and Eastern European			0.33	(0.25 - 0.42)	0.32	(0.25 - 0.42)
Postal code level						
Degree of urbanization						
Very high					REF	
High					0.69	(0.59 - 0.81)
Moderately high					0.68	(0.52 - 0.88)
Low					0.70	(0.53 - 0.92)
Very low					0.61	(0.42 - 0.90)
Socioeconomic status						
High					REF	
Average					0.82	(0.68 - 0.98)
Low					0.74	(0.58 - 0.95)

Supplementary Table S3 Multilevel logistic models for SHC utilization[a] for residents <25 years (continued)

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Ethnic diversity						
Low diversity					REF	
Medium diversity					1.34	(1.13 - 1.59)
High diversity					1.80	(1.37 - 2.36)
Travel distance to SHC in km (continuous)			0.92	(0.90 - 0.93)	0.95	(0.94 - 0.96)
Northern or southern part of river Maas						
North					REF	
South					0.90	(0.82 - 0.99)
Additional information						
Measures of variation		*P*-value		*P*-value		*P*-value
Postal code level variance	0.62	<0.001	0.16	<0.001	0.09	<0.001
PCV (%)	REF[d]		74.0%		85.2%	
MOR	2.12		1.47		1.33	
Model fit and performance						
AIC	115927.1		111978.5		111917.2	
AUC	0.507		0.726		0.733	

AIC, Akaike Information Criterion; *AUC*, area under the receiver operating characteristics curve; *CI*, confidence interval; *km*, kilometres. *MOR*, median odds ratio; *OR*, odds ratio; *PCV*, proportional change in variance; *REF*, reference; *SHC*, sexual health centre.

[a] SHC utilization is defined as at least one SHC visit that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15 to 24 years, tested for any STI). For each year we only included the first record that met the inclusion criteria during the study period (2015-2017). The model for SHC utilization includes 477768 persons <25 years.

[b] Model 0 is a null model in which only levels are defined; this model does not contain any individual or postal code level determinants.

[c] Sub-Sahara African without Cape Verdean.

[d] Reference for Model 1 and Model 2.

Supplementary Table S4 Multilevel logistic models for SHC utilization[a] for residents with a non-Western migratory background

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Year						
2015	REF		REF		REF	
2016	0.96	(0.92 - 1.00)	0.99	(0.97 - 1.01)	0.99	(0.97 - 1.01)
2017	0.94	(0.89 - 0.99)	0.99	(0.97 - 1.01)	0.99	(0.97 - 1.01)
Individual level						
Sex						
Male			REF		REF	
Female			0.99	(0.97 - 1.01)	0.99	(0.97 - 1.01)
Age in years						
15-19			0.77	(0.74 - 0.80)	0.77	(0.74 - 0.80)
20-24			REF		REF	
25-29			0.74	(0.71 - 0.77)	0.74	(0.71 - 0.77)
30-34			0.64	(0.62 - 0.67)	0.64	(0.62 - 0.67)
35-39			0.61	(0.58 - 0.63)	0.61	(0.59 - 0.63)
≥40			0.58	(0.56 - 0.60)	0.58	(0.56 - 0.61)
Migratory background						
Other western			REF		REF	
Dutch Antillean			1.31	(1.25 - 1.37)	1.31	(1.25 - 1.38)
Surinamese			1.14	(1.09 - 1.20)	1.15	(1.09 - 1.20)
Turkish			0.88	(0.84 - 0.92)	0.88	(0.84 - 0.93)
Moroccan			0.93	(0.89 - 0.98)	0.93	(0.89 - 0.98)
Other non-western			0.98	(0.94 - 1.02)	0.98	(0.94 - 1.03)
Sub-Sahara African[c]			1.08	(1.02 - 1.13)	1.08	(1.02 - 1.14)
Cape Verdean			1.37	(1.27 - 1.47)	1.37	(1.27 - 1.47)
Central and Eastern European			0.89	(0.85 - 0.93)	0.89	(0.84 - 0.93)
Postal code level						
Degree of urbanization						
Very high					REF	
High					0.97	(0.93 - 1.01)
Moderately high					0.95	(0.87 - 1.04)
Low					0.96	(0.88 - 1.06)
Very low					1.02	(0.90 - 1.14)

Supplementary Table S4 Multilevel logistic models for SHC utilization[a] for residents with a non-Western migratory background (continued)

Determinant	Model 0[b]		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Socioeconomic status						
High					REF	
Average					0.98	(0.88 - 1.09)
Low					0.95	(0.83 - 1.08)
Ethnic diversity						
Low diversity					REF	
Medium diversity					1.02	(0.97 - 1.07)
High diversity					1.07	(0.99 - 1.15)
Travel distance to SHC in km (continuous)			0.99	(0.99 - 0.99)	0.99	(0.99 - 1.00)
Northern or southern part of river Maas						
North					REF	
South					0.98	(0.97 - 1.01)
Additional information						
Measures of variation		*P*-value		*P*-value		*P*-value
Postal code level variance	0.21	<0.001	0.00	<0.001	0.00	<0.001
PCV (%)	REF[d]		100.0%		100.0%	
MOR	1.55		1.00		1.00	
Model fit and performance						
AIC	91451.6		82797.6		82778.0	
AUC	0.508		0.774		0.775	

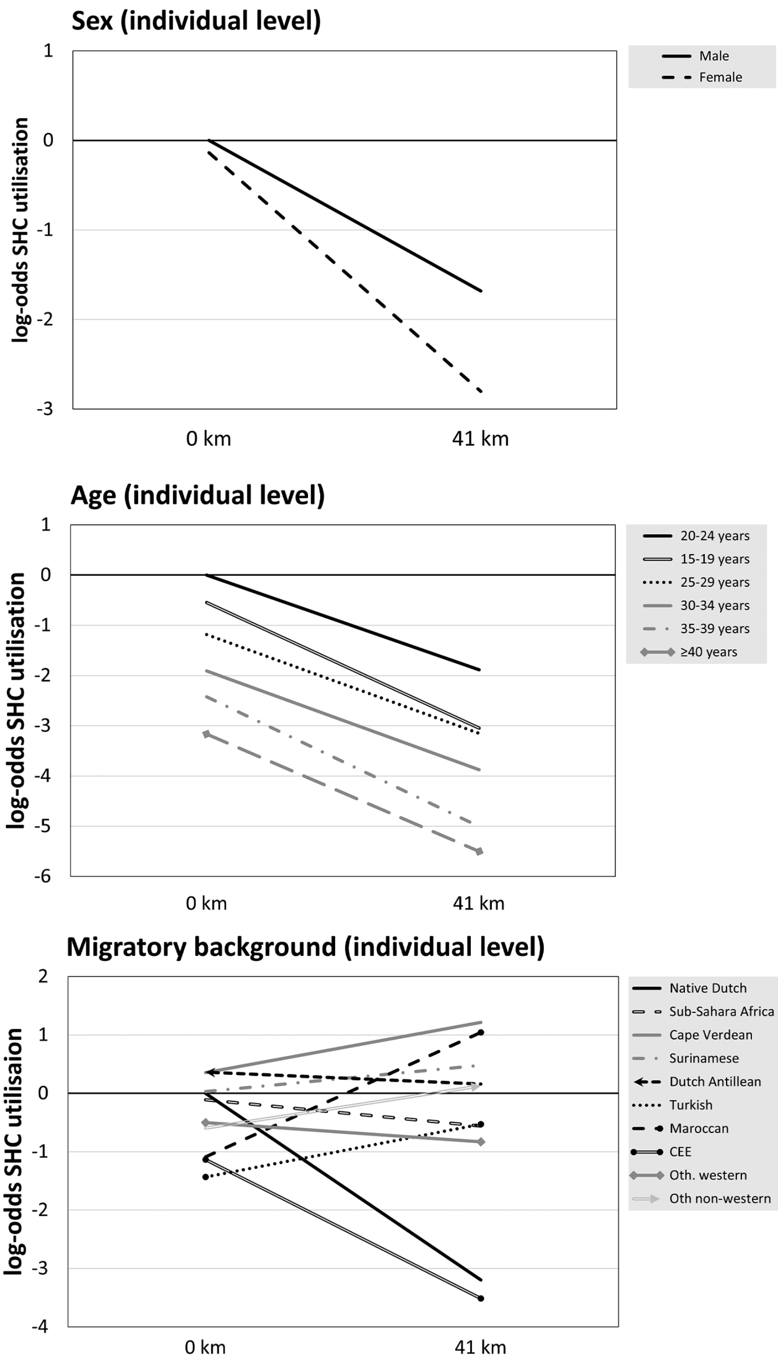
AIC, Akaike Information Criterion; *AUC*, area under the receiver operating characteristics curve; *CI*, confidence interval; km, kilometres. *MOR*, median odds ratio; *OR*, odds ratio; *PCV*, proportional change in variance; *REF*, reference; *SHC*, sexual health centre.

[a] SHC utilization is defined as at least one SHC visit that fulfilled the inclusion criteria (living in the greater Rotterdam area, aged 15 to 45 years, tested for any STI). For each year we only included the first record that met the inclusion criteria during the study period (2015-2017). The model for SHC utilization includes 603357 persons.

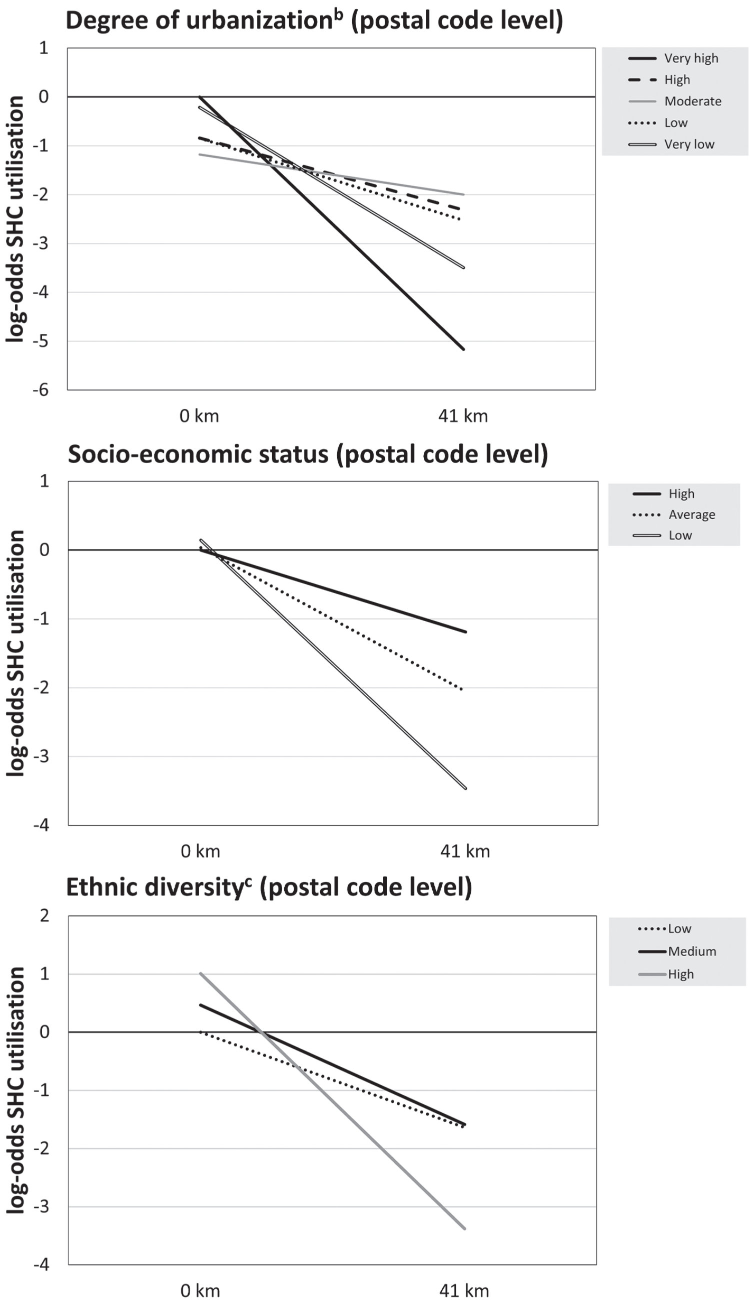
[b] Model 0 is a null model in which only levels are defined; this model does not contain any individual or postal code level determinants.

[c] Sub-Sahara African without Cape Verdean.

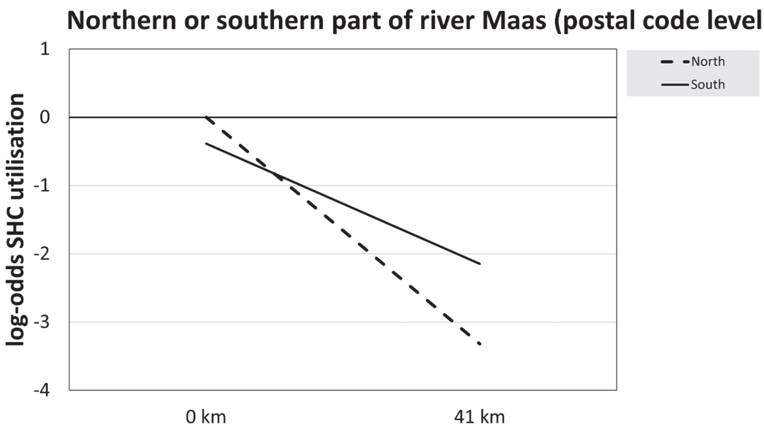
[d] Reference for Model 1 and Model 2.



■ **Supplementary Figure S1** Interaction plot for SHC utilisation versus distance[a] and other individual and postal code area level determinants (part 1)



■ **Supplementary Figure S1** Interaction plot for SHC utilisation versus distance[a] and other individual and postal code area level determinants (part 2)



Supplementary Figure S1 Interaction plot for SHC utilisation versus distance[a] and other individual and postal code area level determinants (part 3)

CEE, Central Eastern European; *km*, kilometre; *SHC*, sexual health centre.

[a] Distance to the SHC defined as straight-line distance between postal code area centroid and SHC address. Distance ranged from 0 to 41 km within the study area.

[b] Degree of urbanisation of each postal code in five categories: very low (<500 addresses/km2), low (500-1000 addresses/km2), moderate (1000-1500 addresses/km2), high (1500-2500 addresses/km2), very high (≥2500 addresses/km2).

[c] Level of postal area ethnic diversity ranging from 0 to 1, divided in tertiles; a higher index score reflects more ethnic diversity. The index was based on 10 migratory background groups: native Dutch, other western residents, Dutch Antillean, Surinamese, Turkish, Moroccans, other non-western residents, Sub-Sahara African (without Cape Verdean), Cape Verdean, and Central and Eastern European.

CHAPTER 3

Testing for sexually transmitted infection: who and where? A data linkage study using population and provider data in the Rotterdam area, the Netherlands

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Abstract

Background
In the Netherlands, insight in sexual transmitted infection (STI) testing and characteristics of those tested by general practitioners (GPs) and sexual health centres (SHC) is limited. This is partly due to lacking registration of socio-demographics at GPs. We aimed to fill this gap by linking different registers.

Methods
Individual STI testing data of GPs and SHC were linked to population register data (aged≥15 years, Rotterdam area, 2015-2019). We reported population-specific STI positivity, proportion STI tested, and GP-SHC testing rate comparison using negative binomial generalised additive models. Factors associated with STI testing were determined by provider using logistic regression analyses with generalised estimating equations.

Results
The proportion STI tested was 2.8% for all residents and up to 9.8% for younger and defined migrant groups. STI positivity differed greatly by subgroup and provider (3.0% to 35.3%). Overall, GPs performed 3 times more STI tests than the SHC. The smallest difference in GP-SHC testing rate was for 20–24-year-olds (SHC key group). Younger age, non-western migratory background, lower household income, living more urbanised and closer to a testing site were associated with STI testing by either GP or SHC. GPs and SHC partly test different groups: GPs test women and lower educated more often, the SHC men and middle/higher educated.

Conclusions
This study highlights GP' important role in STI testing. The GP' role in prevention, diagnosis and treatment of STIs needs continued support and strengthening. Inter-professional exchange and collaboration between GP and SHC is warranted to reach vulnerable groups.

Key messages

- Nearly 3% of the general population was tested for a sexually transmitted infection (STI) (2015-2019).
- Proportion STI tested was up to 9.8% for younger and defined migrant groups.
- General practitioner (GP) test for STIs 3 times more people than the sexual health centre.
- GPs tend to test women and lower educated people more often.
- Collaboration between GP and sexual health centres is warranted to reach vulnerable groups.

Background

Testing followed by adequate treatment and partner notification is a key control strategy for sexually transmitted infections (STI). In the Netherlands, general practitioners (GPs) are important providers of STI testing and treatment due to their accessibility and gatekeeper role to secondary healthcare [1, 2]. GPs perform STI tests upon clients' request or may initiate testing themselves. GPs are advised to perform STI tests based on symptoms or HIV indicator conditions, as well as proactively test key groups such as men who have sex with men, individuals with multiple recent sex partners, and people with a non-western migratory background [3]. STI consultations at the GP are covered by mandatory health insurance, but laboratory tests may incur costs. Most individuals request an STI test at their GP and the remainders usually visit a sexual health centre (SHC) [4]. The SHC is an additional free-of-charge service for key groups with highest STI risk, such as those with STI-related symptoms, having been notified for an STI, men who have sex with men, aged ≤24 years, and with a non-western migratory background [5]. Specialists in hospitals and online testing services have a limited role in STI care in the Netherlands [4, 6, 7].

While GPs are significant providers of STI testing, comprehensive information on the characteristics of those tested is only available for SHC clients. Of all SHC attendees in the Netherlands, 23% is non-Western [8]. The proportion non-western SHC attendees differs largely between SHCs, ranging from 11% to 38% [9], depending on the population living in the area. It is unknown how many people with a non-western background visit their GP for an STI test, because standard registration of socio-demographics are limited to sex and age [10]. Also, information on performed STI consultations and tests are not uniformly registered in GP electronic medical records. Two Dutch studies determined the migratory background of GP clients for STI-related consultations; one by linking a national representative sentinel GP network database to the population register [11], and another by using questionnaires [12]. Woestenberg et al. concluded that GPs were generally consulted more often by people with a migratory background compared to native Dutch [11], but Trienekens et al. found no difference at all [12].

The aim of this study is to gain more insight into the background characteristics of people tested for STIs by linking GP and SHC laboratory data to population register data of the greater Rotterdam area. Because we expected differences in test seeking behaviour by clients and test offering by providers, we also compared GP and SHC tested individuals. Information from this study may improve provision of adequate care by enhancing local STI testing services.

Methods

This cross-sectional data linkage study was conducted in the greater Rotterdam area of the Netherlands, harbouring broadly 1.3 million residents within 15 municipalities, and covering 367 general practices and one SHC [13]. The SHC is conveniently situated with public transport stops in the city centre of Rotterdam.

Data sources, determinants, and outcomes

Non-public population microdata available at the Statistics Netherlands underlie this study (hereafter: population database). All registered residents aged ≥15 years living in the study area between 2015 to 2019 were included. The population database was based on data available on January 1st of each year, and included on individual-level the determinants: sex, date of birth (age), migratory background based on individual's and parents' country of birth, migrants' generation, highest education qualification, and distance to the closest general practice from home address. Level of education was imputed for <60 years-old, above 60 years missingness was assumed not at random due to absence of national registration. We used multiple imputation via chained equations using ten iterations of five multiple imputations. At 4-digit postal code level of residential location, the database included the determinants: degree of urbanisation and median income per household as indicator for area socio-economic status. In addition, we linked straight-line distance from postal code centroid to the SHC [14].

The outcomes in this study were based on STI testing data. We used laboratory data of chlamydia, gonorrhoea and HIV diagnostic tests performed by GP and SHC from 1/1/2015 to 31/12/2019. All anatomical locations were used and HIV tests for antenatal screening were excluded. For each study year we reported dichotomously whether an individual was tested at least once and whether this individual had a positive STI test. GP data was obtained from one laboratory that operates and performs diagnostics for general practices. Depending on the municipality the laboratory performed diagnostics for 12% to 100% of all general practices ('GP data coverage'), with a median coverage of 88% (IQR: 60% - 100%). SHC data was collected from the only SHC in the study area and had a 100% coverage.

Data linkage

The records in the population database included a unique secured pseudonymised identifier based on citizen service number. This identifier was used to link GP and SHC laboratory STI test data to the population database. The identifier in the GP data was also based on the citizen service number, resulting in a 98% match with the population database. At the SHC, a citizen service number is not registered, and therefore, the identifier was based on a combination of gender, date of birth, and postal code. An identifier was only assigned to SHC clients who had a unique match in the population register. In total, 88% of the SHC clients was provided with an identifier and could be matched to the population database. A comparison of SHC registered characteristics for SHC clients with and without a match is presented in **Supplementary Table 1**.

Statistical analysis

Data from one of the 15 municipalities in our study area was excluded for analyses, as GP data coverage was considered too low (12%) for reliable estimates. The GP data coverage of the remaining 14 municipalities was between 60% and 100% (median of 90%). First, we described the socio-demographics and postal area level determinants of individuals tested and not tested for an STI. For tested individuals also the STI positivity (number of diagnoses divided by those tested) was reported. Subsequently, we calculated mean STI testing rates (number of tested individuals per 1,000 residents) at the GP and SHC over studied years. GP and SHC testing rates were compared using generalised additive models with a negative binomial distribution calculating rate ratios (RR) and their 95% confidence intervals (CI). In these models, SHC was used as reference and the log of total number of residents as offset. We corrected the number of tested individuals for incompleteness. The number of tested individuals by SHC was corrected with 100/88, considering the 88% match between SHC and population data. The number of GP-tested individuals was corrected by 100 divided by the municipality-specific GP laboratory data coverage. Last, to quantify the association between determinants and STI testing by the GP and SHC, we performed logistic regression with generalised estimating equations to account for multiple records per person over the included years. All available determinants had an univariable association with a *P*-value<0.05 (**Supplementary Table 2**), and were included in the multivariable regression model. No determinants had to be excluded due to multicollinearity; all determinants had a variance inflation factor below 3, with a mean variance inflation factor of 1.48. The regression analyses were performed without coverage correction. Analyses were conducted with a pooled outcome variable (any chlamydia, gonorrhoea or HIV). The analyses using generalised additive models and the imputation were performed in R version 3.6.3 and the regression analysis with generalised estimating equations in STATA 16.1. Statistical significance level was set at a *P*-value<0.05.

Results

Characteristics tested and not tested

Per year (2015-2019), approximately 1 million residents aged ≥15 years were included. Characteristics of the general population and the STI-tested population are presented in **Table 1**. No difference in characteristics of the general population over the years was observed. Compared to nontested individuals, tested individuals were more often women, younger, non-Dutch, second-generation migrants, and middle-level educated. In addition, they lived in areas with a higher urbanisation level, a lower household income, and nearer to SHC and GP. In total 2.8% of the general population was tested for an STI, but it was higher among for example 20-34-year-olds (6.8%) and people with a non-western background (4.7%), especially for Dutch Antilleans (9.8%), Cape Verdeans (7.3%), Sub-Saharan Africans (5.5%) and Surinamese (5.3%). The highest positivity rate was found for 15–19-year-olds (30.5%) and the lowest positivity for ages above 35 years (**Table 1**).

Table 1 Characteristics of the general population and the population tested for sexually transmitted infections, ≥15 years (2015-2019)

	General population	Not tested[a]	Tested[a]	% positive
	No (%)	No (%)	No (%; row%)	
Total	5107921 (100%)	4966797 (100%)	141124 (100%; 2.8%)	15.4%
2015	1005596 (19.7%)	978806 (19.7%)	26790 (19.0%; 2.7%)	15.3%
2016	1012665 (19.8%)	984897 (19.8%)	27768 (19.7%; 2.7%)	15.1%
2017	1021033 (20.0%)	992858 (20.0%)	28175 (20.0%; 2.8%)	15.4%
2018	1029952 (20.2%)	1000968 (20.2%)	28984 (20.5%; 2.8%)	15.6%
2019	1038675 (20.3%)	1009268 (20.3%)	29407 (20.8%; 2.8%)	15.4%
Mean	1021583	993359	28225 (- ; 2.8%)	15.3%
Individual				
Sex				
Men	2490618 (48.8%)	2433921 (49.0%)	56697 (40.2%; 2.3%)	18.7%
Women	2617303 (51.2%)	2532876 (51.0%)	84427 (59.8%; 3.2%)	13.1%
Age (years)				
15-19	350154 (6.9%)	337865 (6.8%)	12289 (8.7%; 3.5%)	30.5%
20-24	407977 (8.0%)	372957 (7.5%)	35020 (24.8%; 8.6%)	21.7%
25-29	445054 (8.7%)	414395 (8.3%)	30659 (21.7%; 6.9%)	15.0%
30-34	423086 (8.3%)	401952 (8.1%)	21134 (15.0%; 5.0%)	11.2%
35-39	396052 (7.8%)	382217 (7.7%)	13835 (9.8%; 3.5%)	9.2%
40-44	398681 (7.8%)	389089 (7.8%)	9592 (6.8%; 2.4%)	7.6%

■ **Table 1** Characteristics of the general population and the population tested for sexually transmitted infections, ≥15 years (2015-2019) (continued)

	General population	Not tested[a]	Tested[a]	% positive
	No (%)	No (%)	No (%; row%)	
45-49	440438 (8.6%)	433095 (8.7%)	7343 (5.2%; 1.7%)	7.4%
50-54	435597 (8.5%)	430580 (8.7%)	5017 (3.6%; 1.2%)	8.2%
55-59	404668 (7.9%)	401567 (8.1%)	3101 (2.2%; 0.8%)	7.2%
60-64	358974 (7.0%)	357368 (7.2%)	1606 (1.1%; 0.4%)	7.1%
≥65	1047240 (20.5%)	1045712 (21.1%)	1528 (1.1%; 0.1%)	4.6%
Migratory background				
Native Dutch	3260384 (63.8%)	3195373 (64.3%)	65011 (46.1%; 2.0%)	14.2%
Other Western	374454 (7.3%)	363884 (7.3%)	10570 (7.5%; 2.8%)	13.9%
Dutch Antillean	132989 (2.6%)	119958 (2.4%)	13031 (9.2%; 9.8%)	21.2%
Surinamese	305053 (6.0%)	288777 (5.8%)	16276 (11.5%; 5.3%)	16.8%
Turkish	260436 (5.1%)	254279 (5.1%)	6157 (4.4%; 2.4%)	13.0%
Moroccan	189405 (3.7%)	183346 (3.7%)	6059 (4.3%; 3.2%)	15.2%
Other non-Western	266458 (5.2%)	256318 (5.2%)	10140 (7.2%; 3.8%)	13.8%
Sub-Saharan African[b]	57714 (1.1%)	54534 (1.1%)	3180 (2.3%; 5.5%)	13.6%
Cape Verdean	80156 (1.6%)	74323 (1.5%)	5833 (4.1%; 7.3%)	22.1%
Middle and Eastern European	180872 (3.5%)	176005 (3.5%)	4867 (3.4%; 2.7%)	12.6%
Migratory background[c] by generation				
Western (without native Dutch)				
First generation	321663 (57.9%)	313594 (58.1%)	8069 (52.3%; 2.5%)	12.4%
Second generation	233663 (42.1%)	226295 (41.9%)	7368 (47.7%; 3.2%)	14.7%
Non-western				
First generation	838454 (64.9%)	809170 (65.7%)	29284 (48.3%; 3.5%)	13.4%
Second generation	453757 (35.1%)	422365 (34.3%)	31392 (51.7%; 6.9%)	20.5%
Migratory background[c] by age				
Western				
<25 years	489965 (12.8%)	461855 (12.4%)	28110 (34.9%; 5.7%)	21.0%
≥25 years	3325745 (87.2%)	3273407 (87.6%%)	52338 (65.1%; 1.6%)	10.4%
Non-western				
<25 years	268166 (20.8%)	248967 (20.2%)	19199 (31.6%; 7.2%)	28.4%
≥25 years	1024045 (79.2%)	982568 (79.8%)	41477 (68.4%; 4.1%)	11.8%

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Table 1 Characteristics of the general population and the population tested for sexually transmitted infections, ≥15 years (2015-2019) (continued)

	General population	Not tested[a]	Tested[a]	% positive
	No (%)	No (%)	No (%; row%)	
Education level[d]				
Low	1107656 (34.4%)	1070929 (34.6%)	36727 (28.7%; 3.3%)	20.1%
Middle	1294141 (40.1%)	1232518 (39.8%)	61623 (48.2%; 4.8%)	16.3%
High	822707 (25.5%)	793251 (25.6%)	29456 (23.0%; 3.6%)	10.5%
Missing	1883417	1870099	13318	
Education level (imputed)[d,e]				
Low	1420610 (33.0%)	1379793 (33.1%)	40817 (29.1%; 2.9%)	19.0%
Middle	1724767 (40.0%)	1658306 (39.8%)	66461 (47.4%; 3.9%)	15.8%
High	1162096 (27.0%)	1129146 (27.1%)	32950 (23.5%; 2.8%)	10.3%
Missing	800448	799552	696	
Area				
Degree of urbanisation				
Very high (≥2,500 addresses/km^2)	2414666 (47.3%)	2318044 (46.7%)	96622 (68.5%; 4.0%)	15.8%
High (1,500–2,500 addresses/km^2)	1548797 (30.3%)	1518668 (30.6%)	30129 (21.4%; 1.9%)	15.0%
Moderate (500-1,000 addresses/km^2)	690718 (13.5%)	681669 (13.7%)	9049 (6.4%; 1.3%)	14.0%
Low (500-1,000 addresses/km^2)	295389 (5.8%)	291570 (5.9%)	3819 (2.7%; 1.3%)	12.1%
Rural (<500 addresses/km^2)	156723 (3.1%)	155246 (3.1%)	1477 (1.0%; 0.9%)	12.7%
Missing	1628	1600	28	
Median household income				
Highest (>€36,600)	1155750 (22.6%)	1138770 (22.9%)	16980 (12.0%; 1.5%)	12.8%
Upper middle (€28,400-€36,600)	74093 (1.5%)	71867 (1.4%)	2226 (1.6%; 3.0%)	14.6%
Middle (€22,200-€28,400)	1944899 (38.1%)	1900053 (38.3%)	44846 (31.8%; 2.3%)	15.0%
Lower middle (€16,800-€22,200)	1868444 (36.6%)	1794686 (36.1%)	73758 (52.3%; 3.9%)	16.2%
Lowest (<€16,800)	62792 (1.2%)	59510 (1.2%)	3282 (2.3%; 5.2%)	16.5%
Missing	1943	1911	32	
Distance to closest general practice (in km)[f]				
<1	3864777 (75.9%)	3746876 (75.6%)	117901 (84.5%; 3.1%)	15.5%
1-2	1187840 (23.3%)	1166789 (23.6%)	21051 (15.1%; 1.8%)	14.2%
>3	41333 (0.8%)	40797 (0.8%)	536 (0.4%; 1.3%)	14.0%
Missing	13971	12335	1636	

Table 1 Characteristics of the general population and the population tested for sexually transmitted infections, ≥15 years (2015-2019) (continued)

	General population	Not tested[a]	Tested[a]	% positive
	No (%)	No (%)	No (%; row%)	
Distance to SHC (in km)				
<5	1832795 (35.9%)	1752623 (35.3%)	80172 (56.8%; 4.4%)	15.8%
5-10	1955923 (38.3%)	1913886 (38.5%)	42037 (29.8%; 2.1%)	14.6%
>10	1317575 (25.8%)	1298688 (26.2%)	18887 (13.4%; 1.4%)	15.1%
Missing	1628	1600	28	

No, number; *SHC,* sexual health centre; *km*, kilometre.

Data presented as No. and column percentages, unless otherwise indicated. The number of residents tested for an STI is **not** corrected for data incompleteness.

[a] Chlamydia, gonorrhoea or HIV. (Not) tested by a general practitioner and/or sexual health centre.

[b] Without Cape Verdean.

[c] The code was Western if at least one parent was born in another country in Europe (excluding Turkey), North America, Oceania, Indonesia or Japan. The code was non-Western when at least one parent was born in a country in Africa, Latin America or Asia (excluding Indonesia and Japan) or Turkey. First generation included people who were born abroad; second generation included people who were born in the Netherlands.

[d] The International Standard Classification of Education was used as basis. Low: no education, elementary school, pre-vocational secondary education, senior general secondary education (first 3 out of 5 years), pre-university education (first 3 out of 6 years), secondary vocational education level 1. Middle: senior general secondary education (last 2 out of 5 years), pre-university education (last 3 out of 6 years), secondary vocational education level 2-4. High: university of applied sciences, university.

[e] Multiple imputation via chained equations using ten iterations of five multiple imputations. Only imputed for <60 years-old, above 60 years missingness was assumed not at random due to absence of national registration.

[f] Based on address of residential location. Other area characteristics are based on the 4-digit postal code of residential location.

3

Comparing testing rates by GP and SHC

GPs tested around 3 times more individuals compared to the SHC (RR: 3.09, 95%CI: 3.06-3.12, **Table 2**), with a corrected total of 121,856 versus 39,443 tested individuals in the studied years. A small proportion (3.0%) of the tested population was tested by both providers. The GP-SHC ratio differed per subpopulation, but all subpopulations were tested more often by GPs than by the SHC (**Table 2**). The smallest difference in GP-SHC testing rate was observed for age group 20–24 years (RR: 1.28, 95%CI: 1.23-1.33). The GP contribution was greater for women (RR: 4.32, 95%CI: 4.28-4.37) compared to men (RR: 2.05, 95%CI: 2.00-2.09), for people with a migratory background (e.g. RR for Turks: 4.10, 95%CI: 3.96-4.23) compared to native Dutch, and for low-educated people (RR: 3.70, 95%CI: 3.64-3.75) compared to high (RR: 2.99, 95%CI: 2.93-3.05) or middle level educated people (RR: 2.55, 95%CI: 2.55-2.60). Based on area characteristics, the relative number of tests by GP was higher in less urbanised areas, and in areas where people live further away from SHC and GP. A less clear trend was observed for household income, due to the RR for upper middle household income. The STI positivity ranged from 3.0% for ≥65-year-olds to 27.0% for 15–19-year-olds at the GP, and from 14.7% for ≥65-year-olds to 35.3% for 15–19-year-olds at the SHC (**Table 2**).

■ **Table 2** Mean testing rate for sexually transmitted infections, positivity, and comparison between general practitioner and sexual health centre per subpopulation, ≥15 years (2015-2019)

	GP		SHC		STI testing rate GP versus SHC
	Mean STI testing rate[a] (n/1,000)	% positive	Mean STI testing rate[a] (n/1,000)	% positive	RR (95% CI)[b]
Total	23.9	12.3%	7.7	24.5%	3.09 (3.06-3.12)
2015	22.2	12.3%	8.3	22.6%	2.67 (2.64-2.70)
2016	23.3	12.1%	8.1	23.1%	2.87 (2.83-2.90)
2017	23.4	11.8%	8.2	25.5%	2.89 (2.86-2.92)
2018	24.9	12.6%	7.3	25.3%	3.42 (3.39-3.46)
2019	25.4	12.5%	6.8	26.1%	3.72 (3.69-3.76)
Individual					
Sex					
Men	17.6	14.9%	8.6	25.9%	2.05 (2.00-2.09)
Women	29.8	10.8%	6.9	22.8%	4.32 (4.28-4.37)
Age (years)					
15-19	27.0	27.0%	14.3	35.3%	1.89 (1.81-1.97)
20-24	56.4	19.3%	44.1	23.6%	1.28 (1.23-1.33)
25-29	61.9	12.5%	16.6	23.2%	3.74 (3.67-3.80)
30-34	48.1	9.4%	8.2	21.5%	5.90 (5.82-5.99)
35-39	34.4	7.4%	4.8	21.8%	7.10 (6.99-7.21)
40-44	24.1	6.2%	2.9	19.6%	8.27 (8.13-8.41)
45-49	16.7	5.8%	2.0	20.3%	8.33 (8.17-8.49)
50-54	11.2	6.0%	1.7	22.7%	6.53 (6.35-6.70)
55-59	7.4	4.7%	1.1	24.3%	6.60 (6.37-6.82)
60-64	4.3	5.0%	0.6	21.1%	6.69 (6.37-7.00)
≥65	1.4	3.0%	0.2	14.7%	6.25 (5.94-6.56)
Migratory background					
Native Dutch	16.9	11.1%	5.9	22.9%	2.88 (2.84-2.92)
Other Western	23.9	10.9%	7.7	22.1%	3.09 (3.01-3.17)
Dutch Antillean	87.2	17.7%	26.0	31.5%	3.36 (3.27-3.45)
Surinamese	47.0	13.8%	14.0	25.9%	3.35 (3.27-3.43)
Turkish	21.4	10.2%	5.2	24.2%	4.10 (3.96-4.23)
Moroccan	28.1	12.1%	8.1	25.7%	3.48 (3.35-3.61)
Other non-Western	40.9	10.2%	13.2	24.3%	3.09 (3.02-3.17)
Sub-Saharan African[c]	47.7	11.4%	14.8	21.4%	3.22 (3.05-3.40)
Cape Verdean	64.3	18.9%	19.5	31.5%	3.29 (3.16-3.42)
Middle and Eastern European	24.3	9.8%	6.3	23.1%	3.83 (3.68-3.98)

Table 2 Mean testing rate for sexually transmitted infections, positivity, and comparison between general practitioner and sexual health centre per subpopulation, ≥15 years (2015-2019) (continued)

	GP		SHC		STI testing rate GP versus SHC
	Mean STI testing rate[a] (n/1,000)	% positive	Mean STI testing rate[a] (n/1,000)	% positive	RR (95% CI)[b]
Migratory background[d] by age					
Western					
15-24 years	37.6	18.5%	29.4	23.2%	1.28 (1.23-1.33)
≥25 years	15.0	8.2%	2.7	22.2%	5.51 (5.46-5.57)
Non-western					
15-24 years	52.4	25.5%	32.0	31.1%	1.64 (1.57-1.70)
≥25 years	38.4	9.8%	7.2	22.1%	5.33 (5.27-5.39)
Education level[e]					
Low	29.9	16.7%	8.1	32.3%	3.70 (3.64-3.75)
Middle	39.3	13.2%	15.4	23.4%	2.55 (2.51-2.60)
High	30.5	7.6%	10.2	19.3%	2.99 (2.93-3.05)
Education level (imputed)[e,f]					
Low	26.1	15.7%	6.8	31.7%	3.85 (3.79-3.91)
Middle	32.2	12.7%	12.0	23.3%	2.68 (2.64-2.72)
High	24.5	7.3%	7.7	19.6%	3.17 (3.11-3.23)
Area					
Degree of urbanisation					
Very high (≥2,500 addresses/km^2)	33.2	12.3%	12.4	24.5%	2.68 (2.64-2.71)
High (1,500–2,500 addresses/km^2)	18.1	12.4%	4.3	25.1%	4.17 (4.10-4.23)
Moderate (500-1,000 addresses/km^2)	12.4	11.9%	2.7	23.5%	4.63 (4.51-4.74)
Low (500-1,000 addresses/km^2)	12.4	10.5%	2.3	21.1%	5.46 (5.27-5.65)
Rural (<500 addresses/km^2)	9.5	11.4%	1.7	19.1%	5.60 (5.30-5.89)
Median household income					
Highest (>€36.600)	12.6	10.3%	3.6	21.9%	3.53 (3.44-3.61)
Upper middle (€28.400 - €36.600)	21.2	9.8%	12.2	22.8%	1.74 (1.55-1.93)
Middle (€22.200 - €28.400)	20.8	12.2%	6.0	24.2%	3.49 (3.43-3.54)
Lower middle (€16.800-€22.200)	33.4	12.8%	11.7	25.2%	2.86 (2.82-2.90)
Lowest (<€16.800)	44.4	13.4%	15.6	23.8%	2.85 (2.68-3.02)

■ **Table 2** Mean testing rate for sexually transmitted infections, positivity, and comparison between general practitioner and sexual health centre per subpopulation, ≥15 years (2015-2019) (continued)

	GP		SHC		STI testing rate GP versus SHC
	Mean STI testing rate[a] (n/1,000)	% positive	Mean STI testing rate[a] (n/1,000)	% positive	RR (95% CI)[b]
Distance to closest general practice (in km)[g]					
<1	26.0	12.4%	8.7	24.6%	2.98 (2.95-3.02)
1-3	16.6	11.8%	4.1	23.5%	4.04 (3.96-4.11)
>3	13.0	11.6%	2.5	26.6%	5.12 (4.65-5.60)
Distance to SHC (in km)					
<5	35.3	12.1%	14.5	24.4%	2.43 (2.39-2.47)
5-10	20.2	12.2%	4.7	24.4%	4.26 (4.20-4.32)
>10	13.3	13.0%	2.7	25.3%	4.99 (4.90-5.07)

CI, confidence interval; *GP*, general practitioner; *km*, kilometre; *No*, number; *RR*, rate ratio; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

[a] Based on at least one STI test (chlamydia, gonorrhoea or HIV test). Testing rates are corrected for data incompleteness; the number of tests by SHC was corrected with 1/0.88, considering the 88% match between SHC and population data. The number of tests by the GP was corrected by 1/coverage per municipality.

[b] Comparison of STI testing rate, with SHC as reference.

[c] Without Cape Verdean.

[d] The code was Western if at least one parent was born in another country in Europe (excluding Turkey), North America, Oceania, Indonesia or Japan. The code was non-Western when at least one parent was born in a country in Africa, Latin America or Asia (excluding Indonesia and Japan) or Turkey. First generation included people who were born abroad; second generation included people who were born in the Netherlands.

[e] The International Standard Classification of Education was used as basis. For classification see Table 1.

[f] Multiple imputation via chained equations using ten iterations of five multiple imputations. Only imputed for <60 years-old, above 60 years missingness was assumed not at random due to absence of national registration.

[g] Based on address of residential location. Other area characteristics are based on the 4-digit postal code of residential location.

Determinants associated with being tested

Because the STI testing rate was markedly lowest among people aged >60 years, we restricted our regression analysis to 15–60-year-olds (**Table 3**). Women were more often tested at GP (OR: 1.88, 95%CI: 1.85-1.91), while men were more often tested at the SHC (OR women: 0.85, 95%CI: 0.83-0.88). Overall, 15-19-year-olds and ages over 24 years were tested less often compared to 20–24-year-olds (OR ranged from 0.11 to 0.83). Whereas the odds of being tested at the GP was comparable with the SHC for 15-19-year-olds, the odds declined much stronger at the SHC beyond 24 years. People with a Dutch Antillean (OR: 2.50, 95%CI: 2.43-2.56), Cape Verdean (OR: 2.08, 95%CI: 2.00-2.16), Surinamese (OR: 1.64, 95%CI: 1.60-1.68), and Sub-Saharan African (OR: 1.29, 95%CI: 1.23-1.35) background were tested more often than native Dutch, while for other groups it was comparable or less often. Overall and at the GP, higher educated people were tested less often compared to those with low education (overall: OR=0.88; GP: OR=0.80). This was not the case at the SHC, where middle (OR: 1.42, 95%CI: 1.37-1.47) and higher educated (OR: 1.24, 95%CI: 1.19-1.29) were tested more often compared to low educated. Generally, the larger the distance to SHC, the smaller the odds of being tested (5-10 km: OR=0.80; >10 km: OR=0.65). A less clear trend was observed for distance to the GP. People living in very highly urbanised areas were tested more often by both GP and SHC. No clear association was observed for area-specific household income.

■ **Table 3** Determinants associated with testing for sexually transmitted infections[a] by a general practitioner and/or sexual health centre in residents aged 15-60-years (2015-2019)

	Overall[b]	**GP**	**SHC**
	aOR (95% CI)[c]	aOR (95% CI)[c]	aOR (95% CI)[c]
Individual			
Sex			
Men	REF	REF	REF
Women	1.55 (1.53-1.58)	1.88 (1.85-1.91)	0.85 (0.83-0.88)
Age (years)			
15-19	0.46 (0.45-0.47)	0.50 (0.48-0.51)	0.51 (0.49-0.53)
20-24	REF	REF	REF
25-29	0.83 (0.81-0.84)	1.16 (1.14-1.18)	0.38 (0.37-0.40)
30-34	0.63 (0.62-0.64)	0.94 (0.92-0.97)	0.21 (0.20-0.22)
35-39	0.47 (0.46-0.48)	0.72 (0.70-0.74)	0.14 (0.13-0.15)
40-44	0.33 (0.32-0.34)	0.51 (0.49-0.52)	0.09 (0.08-0.09)
45-49	0.23 (0.23-0.24)	0.35 (0.34-0.37)	0.06 (0.06-0.07)
50-54	0.16 (0.15-0.16)	0.23 (0.22-0.24)	0.05 (0.05-0.06)
55-59	0.11 (0.11-0.12)	0.16 (0.15-0.17)	0.04 (0.03-0.04)
Migratory background			
Native Dutch	REF	REF	REF
Other Western	1.00 (0.97-1.03)	1.02 (0.99-1.06)	0.91 (0.86-0.96)
Dutch Antillean	2.50 (2.43-2.56)	2.70 (2.62-2.78)	1.86 (1.76-1.97)
Surinamese	1.64 (1.60-1.68)	1.72 (1.68-1.77)	1.39 (1.32-1.46)
Turkish	0.57 (0.55-0.59)	0.63 (0.61-0.66)	0.40 (0.37-0.43)
Moroccan	0.73 (0.70-0.76)	0.80 (0.77-0.83)	0.56 (0.52-0.60)
Other non-Western	0.93 (0.90-0.95)	0.96 (0.93-0.99)	0.84 (0.79-0.89)
Sub-Saharan African[d]	1.29 (1.23-1.35)	1.34 (1.27-1.41)	1.12 (1.01-1.24) ▲
Cape Verdean	2.08 (2.00-2.16)	2.21 (2.12-2.30)	1.70 (1.57-1.84)
Middle and Eastern European	0.61 (0.59-0.64)	0.67 (0.64-0.69)	0.49 (0.45-0.54)

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Table 3 Determinants associated with testing for sexually transmitted infections[a] by a general practitioner and/or sexual health centre in residents aged 15-60-years (2015-2019) (continued)

	Overall[b]	GP	SHC
	aOR (95% CI)[c]	aOR (95% CI)[c]	aOR (95% CI)[c]
Education level[e]			
Low	REF	REF	REF
Middle	1.06 (1.05-1.08)	0.97 (0.96-0.99)	1.42 (1.37-1.47)
High	0.88 (0.86-0.90)	0.80 (0.79-0.82)	1.24 (1.19-1.29)
Area			
Degree of urbanisation			
Very high (≥2,500 addresses/km²)	REF	REF	REF
High (1,500–2,500 addresses/km²)	0.79 (0.78-0.81)	0.83 (0.81-0.85)	0.70 (0.67-0.74)
Moderate (500-1,000 addresses/km²)	0.63 (0.60-0.65)	0.66 (0.64-0.69)	0.54 (0.50-0.58)
Low (500-1,000 addresses/km²)	0.67 (0.64-0.71)	0.75 (0.71-0.79)	0.48 (0.43-0.53)
Rural (<500 addresses/km²)	0.49 (0.45-0.53)	0.53 (0.49-0.57)	0.36 (0.30-0.44)
Median household income			
Highest (>€36,600)	REF	REF	REF
Upper middle (€28,400 - €36,600)	1.24 (1.18-1.31)	1.22 (1.14-1.30)	1.17 (1.06-1.28)
Middle (€22,200 - €28,400)	1.17 (1.14-1.20)	1.20 (1.17-1.23)	1.08 (1.02-1.13)
Lower middle (€16,800-€22,200)	1.12 (1.09-1.15)	1.21 (1.17-1.25)	0.91 (0.86-0.97)
Lowest (<€16,800)	1.33 (1.26-1.40)	1.50 (1.42-1.59)	0.97 (0.87-1.07) ▪
Distance to closest general practice (in km)[f]			
<1	REF	REF	REF
1-3	0.91 (0.89-0.93)	0.92 (0.90-0.94)	0.89 (0.85-0.92)
>3	1.17 (1.05-1.31)	1.19 (1.05-1.34)	1.09 (0.83-1.43) ▪
Distance to SHC (in km)			
<5	REF	REF	REF
5-10	0.80 (0.79-0.82)	0.91 (0.89-0.93)	0.56 (0.54-0.59)
>10	0.65 (0.63-0.67)	0.76 (0.74-0.78)	0.41 (0.39-0.44)

CI, confidence interval; *GP*, general practitioner; *km*, kilometre; *No*, number; *aOR*, adjusted odds ratio; *REF*, reference; *SHC*, sexual health centre.

[a] Based on at least one STI test (chlamydia, gonorrhoea or HIV test); 15-60-years-olds (917,131 unique persons with 3,690,479 records).

[b] Tested by a general practitioner and/or sexual health centre.

[c] *P*<0.01 unless otherwise indicated: ▲ *P*<0.05, ▪ not significant.

[d] Without Cape Verdean.

[e] Imputed level of education. For classification see Table 1.

[f] Based on address of residential location. Other area characteristics are based on the 4-digit postal code of residential location.

Discussion

This study linked laboratory STI testing data of GPs and SHC with the Dutch population register to gain insight into the socio-demographics of STI-tested individuals. Nearly 3% of all people were tested for an STI at the GP or SHC, but markedly higher for 20–34-year-olds and defined migrant groups (up to 9.8%). GPs generally test for STI 3 times more often than the SHC. Smaller differences in GP-SHC testing rate were observed for SHC key groups like people under 25 years. With exception of sex and education level, the same individual and area factors were associated with STI testing at the GP or SHC.

This study provides unique information on the STI-tested population in the Netherlands by combining individual level data from the population register with GP and SHC data. Approximately 3% of the general population were tested for an STI at the GP or SHC, which is comparable to the combined percentages of the estimated STI test consultations at the GP (in 2019: 2.1%; 364,500 consultations among 17,407,585 Dutch residents) and at the SHC (in 2019: 0.9%; 150,782/17,407,585) [7]. We observed large differences in proportion tested and testing rate between subpopulations, with the highest rates for Dutch Antilleans. This was also found by Woestenberg et al., but not by Trienekens et al., who studied GP clients' migratory background based on estimates [11] and questionnaires [12], with limitations such as selection bias. Compared to these studies, our register-based method has a lower risk of bias, is more objective, highly applicable, and relatively easy to perform behind a desk.

We consider more detailed data on STI testing at the GP necessary for surveillance and control. Previous studies estimated that 70% of all STI/HIV consultations occur at GPs in the Netherlands [15, 16], but this varies between regions [17]. This is confirmed in our study for the Rotterdam area. That GPs perform most STI consultations is in line with their accessibility and gatekeeper role to secondary healthcare. People are likely to contact their GP first when noticing any symptoms and/or being unaware of having had risk of an STI. Other studies showed that GP clients more often reported symptoms than SHC clients (43% vs. 29%) [7, 12], and that symptoms were more often reported as reason for testing at the GP [6].

Contrary to the GP, SHCs are free-of-charge and considered as additional care. SHC accessibility is limited by strict triage and capacity by governmental finances [5, 18, 19]. The latter is reflected by the increasing contribution of the GP over the studied years, because SHC finances are unchanged since 2015. The effect of SHC triage policy is, for example, reflected in the higher SHC contribution by young people, because <25-year-olds are prioritised. Although people with a non-western background are also prioritised at the SHC, age appears to be more important; testing rates at the SHC hardly differ between western and non-western migrants younger than 25 years. SHC clients are most likely aware of their risk for an STI, are notified by a sex partner, or prefer the SHC above their GP for reasons such as perceived expertise and fear of stigma by visiting a GP in their own neighbourhood. Also, the relatively anonymous and free-of-charge nature of the SHC may be preferable for some groups such as younger people, as people may face out-of-pocket costs when testing at the GP due to health insurance requirements. On the other hand, others may prefer unseen testing by the GP (i.e., a GP visit could be for something other than an STI). For instance, it is known that in Muslim communities cultural sensitives and taboos related to sexuality may prevent individuals from accessing sexual health services and visit their GP instead [20, 21].

At the GP, women, and those with a low education (compared to middle/high education) were more likely to test for an STI. This was not the case at the SHC. Women generally consult healthcare providers more often than men [22]. On the other hand, men are more likely to be tested at the SHC because men who have sex with men are prioritised and are advised to undergo routine STI testing [5]. Because men’s test rate is lower and STI positivity higher than for women at the GP, improvements may be possible. GPs are often not aware of clients’ sexual orientation [23], but when becoming aware through discussing sexual health (e.g., we “routinely discuss sexual health”) and ask about client’s sexual partners (men, women, or both), they could more often initiate an STI test to male clients who have sex with men, in accordance with national GP guidelines [3]. It is also noteworthy that people with a different education level seem to navigate to other healthcare providers. In line with a study by Heijne et al., we found that lower educated were more likely to test at the GP [6]. In addition, low educated people are slightly underrepresented in the STI tested population (28.7% vs. 34.4% in the general population), despite having a relatively high STI positivity rate. This was also observed among Dutch SHC clients [24], but not in combination with GP data. These findings may imply that lower educated are less aware of the SHC or face other barriers accessing them. Moreover, we know that low education level is associated with more risk sexual behaviour and adverse sexual health [25]. Taken together, this highlights the need to prioritise interventions among lower educated, for example by outreach testing in the vicinity of where these groups live. Larger distance to testing sites and living in less urbanised areas are also associated with a lower odd of testing, whereas STI-positivity hardly differs between areas. It may therefore be appropriate to start outreach testing in areas further from the SHC and GP. Additionally, one could choose areas with a higher proportion non-western resident as non-western populations have generally a high STI prevalence [7, 26]. The findings of this study could be integrated into continuing medical education for GPs to underscore their role in STI testing. Additionally, the results could serve as background information to emphasize the importance of discussing sexual health with clients and guideline adherence.

Limitations

There are some limitations to this study. Firstly, we had incomplete GP test data and an incomplete match between SHC data and the population register. In our comparison between GP and SHC we adjusted for this. We possibly over- or underestimated the testing rates, because we did not adjust at a lower level such as patient characteristics or GP practices. Even with these lower-level correction methods, residual bias may still exist due to unmeasured factors affecting testing. We were not able to adjust in our regression analyses, because this was on individual level. However, as our study included a substantial amount of testing data, we expect that findings would be near similar. This is also confirmed by other studies, which found comparable determinants for STI testing [6, 27]. Second, perceived risk, sexual behaviour, reasons to test, and other contextual information are lacking, but these factors often underlie STI testing. Third, the generalisability of our findings may be limited. The greater Rotterdam area, especially the city of Rotterdam, is a high STI prevalence area. Comparison of STI positivity with other countries is challenging due to guideline and population variations [28]. Fourth, we used STI testing data, which is not equal to STI-related consultations. Trienekens et al. reported that for 83% of the STI-related consultation an STI test was requested [12]. Fifth, our pooled STI outcomes are likely driven by chlamydia testing and infections, which is the most recommended STI test by both SHC and GP guidelines, and most frequently diagnosed STI. In practice combined chlamydia and gonorrhoea tests are usually conducted, and syphilis and/or hepatitis B testing is typically performed in conjunction with HIV testing. We aimed to capture all individuals who were tested for an STI by including three of the five "big five" STIs. Finally, we observed high testing rates and positivity in some groups, but we were not able to quantify whether the current test rates are sufficient for these groups.

Conclusions

This study highlights the pivotal role of GPs in STI testing and put GP tested clients in perspective to the SHC-tested clients. The available data indicate that GP and SHC basically test similar population groups, with a tendency for GPs to test women and lower-educated people more often. Given the significant role GPs have in STI testing, it is imperative to provide them with continuous medical education on this topic. Inter-professional exchange of experiences and findings, and collaboration between GP and SHC is warranted to develop strategies to reach vulnerable groups such as low-educated individuals. Outreach activities in less urbanised areas, further away from SHC and GP, and in the vicinity of vulnerable groups, may be an appropriate strategy to better reach, for example, low-educated people.

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Supplementary materials

Supplementary Table 1 Comparison of sexual health centre clients with and without a match to the population register[a] (2015-2019)

	Matched	Not matched	Matched vs. not matched[b]
	No (%)	No (%)	*P*-value
Total	58015 (100.0%)	7691 (100.0%)	
Sex			<0.001
Men	35346 (60.9%)	4894 (63.6%)	
Women	22653 (39.0%)	2689 (35.0%)	
Transgender	16 (0.0%)	108 (1.4%)	
Age			<0.001
Mean age (SD)	28.67 (10.49)	30.36 (10.85)	
Median age	25	27	
Non-western migratory background			<0.001
Yes	22372 (38.6%)	3298 (42.9%)	
No	35643 (61.4%)	4393 (57.1%)	
Migratory background			<0.001
Native Dutch	30714 (53.0%)	3461 (45.0%)	
Other Western	4899 (8.4%)	928 (12.1%)	
Dutch Antillean	4859 (8.4%)	608 (7.9%)	
Surinamese	5622 (9.7%)	517 (6.7%)	
Turkish	1761 (3.0%)	197 (2.6%)	
Moroccan	1968 (3.4%)	319 (4.1%)	
Other non-Western	5387 (9.3%)	1090 (14.2%)	
Cape Verdean	1894 (3.3%)	142 (1.8%)	
Middle and Eastern European	881 (1.5%)	425 (5.5%)	
Education level			<0.001
Low/medium	25164 (43.4%)	3140 (40.8%)	
High	32055 (55.3%)	4194 (54.5%)	
Other/unknown	796 (1.4%)	357 (4.6%)	
Triage criterium			
MSM	19213 (33.1%)	3107 (40.4%)	<0.001
STI-related symptoms	16022 (27.6%)	1704 (22.2%)	<0.001
Notified about STI exposure	12199 (21.0%)	1354 (17.6%)	<0.001
Performing sex work	1464 (2.5%)	796 (10.3%)	<0.001

■ **Supplementary Table 1** Comparison of sexual health centre clients with and without a match to the population register[a] (2015-2019) (continued)

	Matched	**Not matched**	**Matched vs. not matched**[b]
	No (%)	No (%)	*P*-value
STI test and diagnosis			
Tested for Chlamydia	57519 (99.1%)	7625 (99.1%)	0.977
Chlamydia positive	9277 (16.1%)	1023 (13.4%)	<0.001
Tested for Gonorrhoea	57526 (99.2%)	7625 (99.1%)	0.891
Gonorrhoea positive	4177 (7.3%)	533 (7.0%)	0.391
Tested for HIV	38953 (67.1%)	6004 (78.1%)	<0.001
HIV positive	191 (0.3%)	33 (0.4%)	0.158

HIV, human immunodeficiency virus; *MSM*, men who have sex with men; *No*, number; *SD*, standard deviation; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

No. (%) unless otherwise indicated.

[a] Includes all SHC clients and compares SHC registered characteristics. In total 50607/58015 (87.2%) of the match SHC clients lived in the greater Rotterdam area (no age selection).

[b] Based on Chi square test.

■ **Supplementary Table 2** Univariable regression analysis of determinants associated with testing for sexually transmitted infections[a] by a general practitioner and/or sexual health centre in residents aged 15-60-years (2015-2019)

	Overall[b]	**GP**	**SHC**
	OR (95% CI)[c]	OR (95% CI)[c]	OR (95% CI)[c]
Individual			
Sex			
Men	REF	REF	REF
Women	1.54 (1.51-1.56)	1.85 (1.82-1.88)	0.87 (0.84-0.89)
Age (years)			
15-19	0.42 (0.41-0.43)	0.48 (0.46-0.49)	0.38 (0.37-0.40)
20-24	REF	REF	REF
25-29	0.82 (0.81-0.84)	1.14 (1.12-1.16)	0.40 (0.39-0.41)
30-34	0.60 (0.59-0.61)	0.90 (0.88-0.92)	0.20 (0.19-0.21)
35-39	0.43 (0.41-0.44)	0.65 (0.63-0.67)	0.12 (0.12-0.13)
40-44	0.29 (0.28-0.30)	0.45 (0.44-0.46)	0.07 (0.07-0.08)
45-49	0.20 (0.19-0.21)	0.31 (0.30-0.32)	0.05 (0.05-0.05)
50-54	0.14 (0.13-0.14)	0.21 (0.20-0.22)	0.04 (0.04-0.04)
55-59	0.10 (0.09-0.10)	0.15 (0.14-0.15)	0.03 (0.03-0.03)
Migratory background			
Native Dutch	REF	REF	REF
Other Western	1.29 (1.25-1.32)	1.28 (1.24-1.32)	1.29 (1.23-1.36)
Dutch Antillean	3.91 (3.81-4.01)	4.13 (4.01-4.25)	3.20 (3.04-3.37)
Surinamese	2.15 (2.10-2.21)	2.28 (2.22-2.34)	1.83 (1.74-1.91)
Turkish	0.87 (0.84-0.90)	0.95 (0.92-0.99) ▲	0.64 (0.59-0.69)
Moroccan	1.18 (1.14-1.23)	1.25 (1.21-1.30)	0.98 (0.91-1.05) ▪
Other non-Western	1.41 (1.37-1.45)	1.44 (1.39-1.48)	1.34 (1.27-1.41)
Sub-Saharan African[d]	1.95 (1.86-2.05)	2.03 (1.92-2.14)	1.68 (1.52-1.84)
Cape Verdean	3.06 (2.95-3.18)	3.24 (3.11-3.37)	2.57 (2.39-2.77)
Middle and Eastern European	0.98 (0.94-1.02) ▪	1.06 (1.02-1.11)	0.76 (0.70-0.83)
Education level[e]			
Low	REF	REF	REF
Middle	1.27 (1.26-1.29)	1.17 (1.16-1.19)	1.61 (1.56-1.66)
High	0.98 (0.97-1.00) Δ	0.95 (0.93-0.97)	1.06 (1.02-1.10)

■ **Supplementary Table 2** Univariable regression analysis of determinants associated with testing for sexually transmitted infections[a] by a general practitioner and/or sexual health centre in residents aged 15-60-years (2015-2019) (continued)

	Overall[b]	GP	SHC
	OR (95% CI)[c]	OR (95% CI)[c]	OR (95% CI)[c]
Area			
Degree of urbanisation			
Very high (≥2,500 addresses/km^2)	REF	REF	REF
High (1,500–2,500 addresses/km^2)	0.55 (0.54-0.56)	0.60 (0.59-0.61)	0.40 (0.39-0.42)
Moderate (500-1,000 addresses/km^2)	0.36 (0.35-0.37)	0.40 (0.38-0.41)	0.25 (0.23-0.26)
Low (500-1,000 addresses/km^2)	0.37 (0.36-0.39)	0.42 (0.40-0.44)	0.22 (0.20-0.24)
Rural (<500 addresses/km^2)	0.28 (0.26-0.30)	0.32 (0.29-0.34)	0.17 (0.15-0.20)
Median household income			
Highest (>€36,600)	REF	REF	REF
Upper middle (€28,400 - €36,600)	1.82 (1.73-1.92)	1.56 (1.47-1.66)	2.74 (2.50-3.00)
Middle (€22,200 - €28,400)	1.62 (1.59-1.66)	1.62 (1.58-1.66)	1.69 (1.61-1.77)
Lower middle (€16,800-€22,200)	2.43 (2.38-2.48)	2.34 (2.29-2.40)	2.83 (2.71-2.96)
Lowest (<€16,800)	3.06 (2.92-3.22)	3.02 (2.86-3.19)	3.43 (3.12-3.78)
Distance to closest general practice (in km)[f]			
<1	REF	REF	REF
1-3	0.64 (0.63-0.65)	0.67 (0.66-0.68)	0.54 (0.52-0.56)
>3	0.50 (0.45-0.55)	0.53 (0.48-0.60)	0.35 (0.28-0.45)
Distance to SHC (in km)			
<5	REF	REF	REF
5-10	0.57 (0.56-0.58)	0.64 (0.63-0.65)	0.39 (0.38-0.40)
>10	0.39 (0.38-0.40)	0.45 (0.44-0.46)	0.23 (0.22-0.24)

CI, confidence interval; *GP*, general practitioner; *km*, kilometre; *No*, number; *OR*, odds ratio; *REF*, reference; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

[a] Based on at least one STI test (chlamydia, gonorrhoea or HIV test).

[b] Tested by a general practitioner and/or sexual health centre.

[c] *P*<0.01 unless otherwise indicated: ▲ *P*<0.05, Δ *P*<0.1, ▪ not significant.

[d] Without Cape Verdean.

[e] Imputed level of education. Multiple imputation via chained equations using ten iterations of five multiple imputations. The International Standard Classification of Education was used as basis. For classification see Table 1 in the main text.

[f] Based on address of residential location. Other area characteristics are based on the 4-digit postal code of residential location.

3

CHAPTER 4

Area-based comparison of risk factors and testing rates to improve sexual health care access: cross-sectional population-based study in a Dutch multicultural area

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Abstract

Objectives

Areas with high sexually transmitted infection (STI) testing rates may not require additional strategies to improve testing. However, it may be necessary to intervene in areas with elevated STI risk, but with low STI testing rates. We aimed to compare STI-related risk profiles and STI testing rates by geographical area to determine areas for improvement of sexual healthcare access.

Design

Cross-sectional population-based study.

Setting

Greater Rotterdam area, the Netherlands (2015–2019).

Participants

All residents aged 15–45 years. Individual population-based register data were matched with laboratory-based STI testing data of general practitioners (GPs) and the only sexual health centre (SHC).

Outcome

Measures Postal code (PC) area-specific STI riskscores (based on age, migratory background, education level and urbanisation), STI testing rates and STI positivity.

Results

The study area consists of approximately 500 000 residents aged 15–45 years. Strong spatial variation in STI testing, STI positivity and STI risk was observed. PC area testing rate ranged from 5.2 to 114.9 tests per 1000 residents. Three PC clusters were identified based on STI risk and testing rate: (1) high–high; (2) high–low; (3) low, independently of testing rate. Clusters 1 and 2 had comparable STI-related risk and STI positivity, but the testing rate differed greatly (75.8 vs 33.2 per 1000 residents). Multivariable logistic regression analysis with generalised estimating equation was used to compare residents in cluster 1 and cluster 2. Compared with cluster 1, residents in cluster 2 more often did not have a migratory background, lived in less urbanised areas with higher median household income, and more distant from both GP and SHC.

Conclusion

The determinants associated with individuals living in areas with high STI-related risk scores and low testing rates provide leads for improvement of sexual healthcare access. Opportunities for further exploration include GP education, community-based testing and service (re)allocation.

Strengths and limitations of this study

- This is the first study that considers community sexually transmitted infection (STI) risk while examining determinants associated with different area-specific STI testing levels.
- The study design, linking laboratory STI testing data to population microdata, has limited risk of biases and mirrors the real numbers as closely as possible, in contrast to, for example, questionnaires or sentinel databases.
- The use of administrative units to distinguish areas may not differentiate social or health-related characteristics.
- Individual-level STI risk may differ to community-level STI risk. Additionally, the STI risk estimate was based on a limited number of sociodemographic factors available for all residents.
- The current study classified areas with 'low' and 'high' testing rates, but it remains unknown whether the 'high' testing rates are sufficient.

Introduction

Adequate access to sexually transmitted infection (STI) testing services is important as STI testing is the entry point for STI prevention and care and is critical to reduce ongoing transmission and morbidity. Due to healthcare organisation and policy in the Netherlands, general practitioners (GPs) have a pivotal role in provision of sexual healthcare and STI testing. Sexual health centres (SHCs) are important additional providers for key groups [1-4]. STI testing at an SHC is on request and free-of-charge, but only individuals considered as high risk are admitted based on triage (eg, notified for an STI, STI-related complaints, non-western migratory background, <25 years-of-age, men who have sex with men (MSM)). An STI test at the GP is performed on patient request – in principle without risk assessment – and on doctors' reasoning and advice. A consult at the GP is free-of-charge, but laboratory tests may incur costs for people who have not yet met their financial contribution (minimum €385) to compulsory health insurance.

Although GPs are the main STI testing provider, Slurink *et al* found large nationwide differences within the Netherlands [1]. The contribution to STI testing by GPs was much lower in more urban regions, where SHCs play a more prominent role [1]. Even within a smaller area, for example, a metropolitan area, spatial differences in STI testing may occur. No studies have investigated spatial differences in STI testing on such geographical level. Previous studies focussing on spatial distribution in STI levels (operationalised as either incidence, prevalence or the absolute number of cases) showed an uneven distribution, which, among others, was associated with the population living in these areas. It is known that individuals living in an urban geographical 'STI hot spot' are more likely to have an STI [5-8]. This is partly due to the selection of sexual partners nearby one's own residential location [9-

11]. In addition, sociocultural determinants of a specific area may influence spatial clustering of STIs [12,13].

Recognising geographical STI clusters has potential implications, such as more efficient allocation of resources by area-specific interventions. However, in our opinion focussing solely on the spatial distribution of STI risk, without considering the spatial distribution of STI testing, could limit the effectiveness of area-specific strategies aimed to improve testing. Areas with high STI risk together with high STI testing rates may not require additional strategies to improve testing; it might be more effective to intervene in areas with high STI risk but with low STI testing rates. Our study focuses on the greater Rotterdam area which in several respects has a very diverse population. We hypothesised that STI testing rates differ greatly within this area. This study aimed to compare STI-related risk profiles and STI testing rates geographically to determine areas for improvement of access to sexual healthcare. We based STI risk on residents' characteristics and STI testing is defined as the number of residents tested for STI per capita. The study combined population register data with sexual health provider data.

Methods

Study area

This cross-sectional study included Netherlands' second largest city, Rotterdam, and 14 neighbouring municipalities (greater Rotterdam area), with approximately 1.3 million residents [14]. The area had 179 residential administrative postal code (PC) areas ranging in population from 10 to 22 780 (mean 7200 residents) [14]. The population was relatively stable across the study period (2015–2019), and the sociodemographic composition between PC areas was heterogeneous [14]. The area harboured 367 general practices and one central SHC [15]. The number of general practices and SHC staffing were stable over the studied years.

Data sources and determinants

Population data

Non-public population data, with one record per person per year (aged 15–45 years; 2015–2019), was accessed via the Statistics Netherlands. The population database captures the following individual-level determinants: sex, date of birth (age), migratory background based on individual's and parents' country of birth, migrants' generation, education level, distance to the nearest GP practice. Migratory background was encoded according to the Statistics Netherlands' coding scheme. The code was Western if at least one parent was born in another country in Europe (excluding Turkey), North America, Oceania, Indonesia or Japan. The code was non-Western when at least one parent was born in a country in Africa, Latin America or

Asia (excluding Indonesia and Japan) or Turkey [16]. Because level of education was missing for 14% of the records, multiple imputation by chained equations was used to handle missing data. The imputed data sets (n=5 with each 10 iterations) were examined for reasonable imputation by checking whether the SD of the imputed data sets was comparable. The International Standard Classification of Education was used to categorise education level (low, middle, high). At four-digit PC level of residential location, the database also included the determinants: degree of urbanisation (very high: ≥2500 addresses/km^2, high: 1500–2500, moderate: 1000–1500, low: 500–1000 and very low: <500), and median income per household as indicator for area socioeconomic status (highest: >€36 000, upper middle: €28 400–€36 600, middle: €22 200–€28 400, lower middle: €16 800–€22 200, lowest: <€16 800). For each resident also straight-line distance from PC centroid to the SHC in Rotterdam was calculated with ArcGis V.9.3 GIS software (ESRI, Redlands, California) [17].

STI testing data

GP and SHC testing data for *Chlamydia trachomatis* (CT) and *Neisseria gonorrhoea* (NG) for the years 2015 to 2019 were used. GP testing data were obtained from one laboratory. Depending on the municipality (n=15), this laboratory performed diagnostics for 12%–100% of all general practices in the study area ('GP data coverage'). The median GP data coverage was 88% (IQR 60%–100%). SHC data were obtained from the only SHC in the study area. Both in the GP and SHC testing file, one record per person per study year was created. This record stated dichotomously whether the person was tested at least once for CT and/or NG and tested at least once positive per study year. We included all tests, independently of anatomical location.

Outcomes

Individuals tested in the population

For each study year, the population and STI testing data were linked using a unique pseudonymised personal identifier to define whether someone was tested (including test result). This identifier was based on the citizen service number for GP clients. For SHC clients, the identifier was based on a combination of sex, birth data and PC at the time of testing, because no citizen service number is registered at the SHC. In total, 98% of GP clients and 88% of SHC clients could be linked to the population database. As a result of the annual population and STI testing data match, the population records stated whether someone was tested and was tested positive for CT/NG (overall and provider specific) in that year. Population records without GP and/or SHC match were assumed not to have been tested.

Testing rates and positivity by PC area

To provide a stable measure over time and geography, the number of (positive) tests and residents was based on a 5-year cumulative sum (2015–2019). These 5-year cumulatives were also used to calculate STI testing rates and STI positivity percentages (hereafter referred to as STI positivity). STI testing rates – the number of residents CT/NG tested per 1000 residents – were calculated per PC area. To account for incomplete data, we corrected the number of GP tested residents with 100 divided by the municipality-specific GP data coverage. The number of SHC tested residents was corrected with 100/88, considering the 88% match between SHC and population data. STI positivity – the number of residents with a positive test divided by the number of residents tested × 100% – was calculated based on the raw numbers. The number of residents, testing rates and positivity shown hereafter in the main text, tables and figure are based on 5-year cumulative data.

Community STI risk by PC area

We assigned a community STI risk score to PC areas. First, a risk score was calculated for each individual in the population database by summing up the scores for separate factors:

- 15–19 years: 1 point; otherwise: 0 points.
- Very highly urbanised: 3 points; moderately/highly urbanised: 2 points; otherwise: 0 points.
- Low/middle level of education: 2 points; otherwise: 0 points.
- Surinam or Antillean migratory background (former Dutch colonies): 2 points; other non-Western: 1 point; otherwise: 0 points.

The maximum score for an individual was eight points. The scoring was derived from a scoring system previously developed to select individuals with elevated CT risk for CT screening in the Netherlands [18,19]. With this method, the risk is not only based on those who are tested, as is the case for STI positivity. Subsequently, the individual risk score was converted into a community STI risk score for each PC area by adding up the individual risk scores per PC divided by the number of residents in that PC area.

Statistical analysis

PC area-specific testing rates, STI positivity and community STI risk scores were calculated and plotted geographically. We plotted STI risk score against testing rates at the PC level and identified clusters with two-stepped cluster analysis. Three clusters were automatically identified based on the Schwartz's Bayesians inference criterion (**figure 1D**): (1) high risk score with high testing rate (high R-high TR); (2) high risk score with low testing rate (high R-low TR); (3) low risk score, independently of testing rate (low). Multivariable logistic regression with generalised estimating equations (GEE) was performed to compare characteristics of individuals residing in PC areas assigned to cluster 1 (high R-high TR) with individuals from cluster 2 (high R-low TR) and presented in odds ratio (OR) and 95% confidence interval (CI). In the main analyses, STI positivity was not included. We conducted a sensitivity analysis with STI positivity in quartiles (Q1: 0.0%–15.4%, Q2: 15.4%–17.6%, Q3: 17.6%–19.2% and Q4: 19.2%– 30.4%) as an extra determinant. The municipality with GP data coverage of 12% was excluded from all analyses to avoid unreliable estimates. This exclusion involved seven PC areas and 5.1% of all residents. Cluster analysis was performed with SPSS V.25.0, GEE analysis with STATA V.16.1, and all other statistical analyses and geographical plots with R V.3.6.2. Statistical significance level was set at a *P* value <0.05. Areas and population subgroups with less than 10 residents, tests and/or positive cases were not geographically plotted or presented for privacy reasons.

Results

Characteristics of residents

Approximately 500 000 people aged 15–45 years were resident annually in the 14 included municipalities, yielding a total population of 2 508 300 person-years over the 5-year study period. **Table 1** is an overview of the residents' characteristics. Over 50% of the residents lived in very highly urbanised areas and over 40% lived in lower income household areas. Most people lived close to a GP (ie, 77.9% within 1 km) and two-fifths lived within 5 km of the central SHC. The city of Rotterdam, of which 80% is very highly urbanised, harboured almost 60% of the residents. About one-third of the residents in the study area had a non-Western migratory background. Among the people with a non-Western migratory background, about half were first-generation migrants. The age and sex structure were relatively evenly distributed.

Table 1 Characteristics of the population 15-45 years and stratified by cluster,* the greater Rotterdam area, the Netherlands (2015-2019)

	General population	Cluster 1 (high R-high TR)	Cluster 2 (high R-low TR)	Cluster 3 (low)
	n = 2 508 300	n = 1 187 499	n = 1 258 621	n = 62 180
Individual				
Sex				
Male	1 248 716 (49.8%)	593 053 (49.9%)	623 913 (49.6%)	31 750 (51.1%)
Female	1 259 584 (50.2%)	594 446 (50.1%)	634 708 (50.4%)	30 430 (48.9%)
Age (years)				
15-19	350 154 (14.0%)	141 649 (11.9%)	197 269 (15.7%)	11 236 (18.1%)
20-24	407 977 (16.3%)	217 830 (18.3%)	180 888 (14.4%)	9 259 (14.9%)
25-29	445 054 (17.7%)	244 825 (20.6%)	191 273 (15.2%)	8 956 (14.4%)
30-34	423 086 (16.9%)	213 283 (18.0%)	200 833 (16.0%)	8 970 (14.4%)
35-39	396 052 (15.8%)	176 453 (14.9%)	210 089 (16.7%)	9 510 (15.3%)
40 and older	485 977 (19.4%)	193 459 (16.3%)	278 269 (22.1%)	14 249 (22.9%)
Migratory background†				
Western				
Native Dutch	1 342 049 (53.5%)	437 294 (36.8%)	848 917 (67.4%)	55 838 (89.8%)
Middle and Eastern European	129 766 (5.2%)	79 415 (6.7%)	49 104 (3.9%)	1 247 (2.0%)
Other Western	179 235 (7.1%)	99 006 (8.3%)	78 036 (6.2%)	2 193 (3.5%)
Non-Western				
Dutch Antillean	94 700 (3.8%)	63 810 (5.4%)	30 390 (2.4%)	500 (0.8%)
Surinamese	175 116 (7.0%)	114 459 (9.6%)	60 237 (4.8%)	420 (0.7%)
Turkish	177 841 (7.1%)	119 541 (10.1%)	58 012 (4.6%)	288 (0.5%)
Moroccan	134 214 (5.4%)	96 628 (8.1%)	37 382 (3.0%)	204 (0.3%)
Other non-Western	186 370 (7.4%)	115 138 (9.7%)	70 136 (5.6%)	1 096 (1.8%)
Sub-Saharan African‡	43 537 (1.7%)	28 844 (2.4%)	14 381 (1.1%)	312 (0.5%)
Cape Verdean	45 472 (1.8%)	33 364 (2.8%)	12 026 (1.0%)	82 (0.1%)
Migratory background by generation†				
Western (without native Dutch)				
First generation	190 026 (61.5%)	123 842 (69.4%)	64 605 (50.8%)	1 579 (46.0%)
Second generation	118 975 (38.5%)	54 579 (30.6%)	62 535 (49.2%)	1 861 (54.0%)
Non-Western				
First generation	416 557 (48.6%)	280 015 (49.0%)	134 900 (47.7%)	1 642 (56.6%)
Second generation	440 693 (51.4%)	291 769 (51.0%)	147 664 (52.3%)	1 260 (43.4%)
Migratory background by age†				
Western (without native Dutch)				
<25 years	75 244 (24.4%)	46 476 (26.0%)	28 012 (22.0%)	756 (22.0%)
≥25 years	233 757 (75.6%)	131 945 (74.0%)	99 128 (78.0%)	2 684 (78.0%)

Table 1 Characteristics of the population 15-45 years and stratified by cluster,* the greater Rotterdam area, the Netherlands (2015-2019) (continued)

	General population	Cluster 1 (high R-high TR)	Cluster 2 (high R-low TR)	Cluster 3 (low)
	n = 2 508 300	n = 1 187 499	n = 1 258 621	n = 62 180
Non-Western				
<25 years	268 166 (31.3%)	180 395 (31.5%)	86 865 (30.7%)	906 (31.2%)
≥25 years	589 084 (68.7%)	391 389 (68.5%)	195 699 (69.3%)	1 996 (68.8%)
Education level§				
Low	667 506 (26.6%)	328 206 (27.6%)	323 625 (25.7%)	15 675 (25.2%)
Middle	914 301 (36.5%)	430 934 (36.3%)	459 146 (36.5%)	24 221 (39.0%)
High	578 381 (23.1%)	285 120 (24.0%)	283 639 (22.5%)	9 622 (15.5%)
Missing	348 112 (13.9%)	143 239 (12.1%)	192 211 (15.3%)	12 662 (20.4%)
Education level (imputed)§¶				
Low	786 550 (31.4%)	381 717 (32.1%)	385 179 (30.6%)	19 654 (31.6%)
Middle	1 052 806 (42.0%)	483 382 (40.7%)	539 356 (42.9%)	30 068 (48.4%)
High	668 944 (26.7%)	322 400 (27.1%)	334 086 (26.5%)	12 458 (20.0%)
Area				
Degree of urbanisation				
Very highly urbanised (≥2500 addresses/km^2)	1 334 805 (53.2%)	1 082 155 (91.1%)	252 650 (20.1%)	0 (0.0%)
Other (<2500 addresses/km^2)	1 172 938 (46.8%)	105 344 (8.9%)	1 005 971 (79.9%)	61 623 (99.1%)
Missing	557 (0.0%)	0 (0.0%)	0 (0.0%)	557 (0.9%)
Median household income				
Other (≥€22 200)	1 438 463 (57.3%)	289 269 (24.4%)	1 090 417 (86.6%)	58 777 (94.5%)
Lowest/lower middle (<€22 200)	1 069 117 (42.6%)	898 230 (75.6%)	168 124 (13.4%)	2 763 (4.4%)
Missing	720 (0.0%)	0 (0.0%)	80 (0.0%)	640 (1.0%)
Distance to closest general practice (in km)**				
<1	1 953 146 (77.9%)	1 074 116 (90.5%)	847 020 (67.3%)	32 010 (51.5%)
1-3	529 872 (21.1%)	107 365 (9.0%)	404 685 (32.2%)	17 822 (28.7%)
>3	16 209 (0.6%)	62 (0.0%)	4 562 (0.4%)	11 585 (18.6%)
Missing	9 073 (0.4%)	5 956 (0.5%)	2 354 (0.2%)	763 (1.2%)
Distance to SHC (in km)				
<5	1 077 986 (43.0%)	883 470 (74.4%)	191 776 (15.2%)	2 740 (4.4%)
5-10	870 146 (34.7%)	262 175 (22.1%)	602 803 (47.9%)	5 168 (8.3%)
10	559 611 (22.3%)	41 854 (3.5%)	464 042 (36.9%)	53 715 (86.4%)
Missing	557 (0.0%)	0 (0.0%)	0 (0.0%)	557 (0.9%)

■ **Table 1** Characteristics of the population 15-45 years and stratified by cluster,* the greater Rotterdam area, the Netherlands (2015-2019) (continued)

	General population	Cluster 1 (high R-high TR)	Cluster 2 (high R-low TR)	Cluster 3 (low)
	n = 2 508 300	n = 1 187 499	n = 1 258 621	n = 62 180
Other				
No. of PC areas	172	51	100	21
Mean risk score	4.4	4.9	4.0	1.8
No. STI tests per 1 000 residents††	53.1	75.8	33.2	22.6
% STI positive‡‡	17.5%	17.8%	16.9%	13.9%
% STI positive at GP ‡‡	14.5%	14.7%	14.2%	12.7%
% STI positive at SHC ‡‡	24.6%	24.7%	24.4%	19.4%

GP, general practitioner; *km*, kilometre; *No*, number; *PC*, postal code; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

Data presented as No. and column percentages, unless otherwise indicated.

*Clusters are identified with two-step cluster analysis.

†Migratory background was encoded according to the Statistics Netherlands' coding scheme. Western if at least one parent was born in another country in Europe (excluding Turkey), North America, Oceania, Indonesia or Japan. Non-Western when at least one parent was born in a country in Africa, Latin America or Asia (excluding Indonesia and Japan) or Turkey.

‡Without Cape Verdean.

§The International Standard Classification of Education was used as basis. Low: no education, elementary school, pre-vocational secondary education, senior general secondary education (first 3 out of 5 years), pre-university education (first 3 out of 6 years), secondary vocational education level 1. Middle: senior general secondary education (last 2 out of 5 years), pre-university education (last 3 out of 6 years), secondary vocational education level 2 to 4. High: university of applied sciences, university.

¶Multiple imputation via chained equations (MICE) using ten iterations of five multiple imputations.

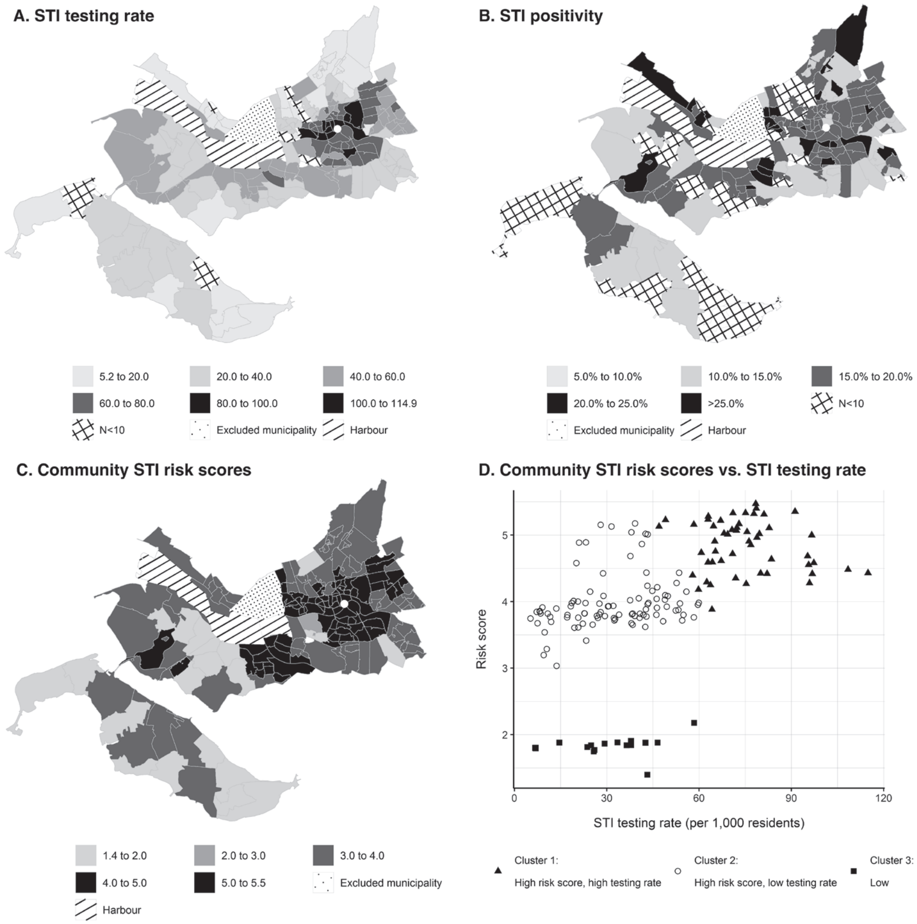
**Based on address of residential location. Other area characteristics are based on the four-digit postal code of residential location.

††No. of STI tests corrected for data coverage.

‡‡Percentage STI positive is based on the performed tests; raw numbers.

Area-specific testing rates, positivity and risk

During the 5-year study period, the median number of tests per PC area was 548 (IQR: 179–1062). The area-specific number of tests per 1000 residents ranged from 5.2 to 114.9. **Figure 1A–C** shows the spatial variation of STI testing, STI positivity and STI risk scores in the study area. The highest testing rates were clustered in the very highly urbanised inner city of Rotterdam (**figure 1A**). This was not found for STI positivity (**figure 1B**). Overall, the positivity was 17.5% (**table 1**). The positivity at the GP (14.5%) was lower than at the SHC (24.6%). The lowest STI risk score was 1.4 and the highest was 5.5. Low-risk scores were mainly confined to suburban areas, while the highest risk scores were in highly urbanised areas (**figure 1C**).



■ **Figure 1** Plots per postal code area, the greater Rotterdam area, the Netherlands (2015–2019). White dot in the geographical plots represents the central sexual health centre. (A) STI testing rate (per 1000 residents). (B) STI positivity (%): residents with a positive test out of number of residents tested. (C) Mean community STI risk scores based on age, migratory background, education level and urbanisation. (D) Mean community STI risk score versus STI testing rate classified in three clusters.

The maps were generated using ggplot in R (version 3.6.2).
STI, sexually transmitted infection.

Characteristics of clusters and associated determinants

The characteristics of residents in the three identified clusters are shown in **table 1** and a cluster plot is shown in **figure 1D**. Areas belonging to cluster 3 (low) were excluded for further analysis (overall risk score of 1.8 and STI positivity of 13.9%), leaving 151 PC areas with a 5-year total of 2 446 120 residents for analysis. Cluster 1 (high R-high TR) consisted of 51 PC areas with 48.5% of these residents. The overall risk score (4.9) and STI positivity (17.8%) in cluster 1 were comparable to cluster 2 (4.0 and 16.9%), but the testing rate was more than two times as high (75.8 vs 33.2 per 1000 residents). Compared with cluster 1 (high R-high TR), cluster 2 (high R-low TR) was characterised by a higher proportion of residents with a western background (77.5% vs 51.8%), a higher proportion of older residents (above 35 years: 38.8% vs 31.2%), less urbanisation, a higher median household income and a greater distance to GP and SHC. This was also found in our multivariable regression analysis identifying factors associated with living in cluster 2 (high R-low TR) compared with cluster 1 (high R-high TR) (**table 2**). Large differences in the strength of the associations were observed, with the strongest associations for area-level characteristics. Weak associations were found for the individual characteristics sex, age and education level. The association was stronger for migratory background. In general, non-Dutch residents lived less often in a high R-low TR area, in particular, Dutch Antilleans (OR: 0.34; 95% CI 0.33 to 0.36) and Surinamese (OR: 0.39; 95% CI 0.38 to 0.40). In a sensitivity analysis with area STI positivity in quartiles (based on those tested) as an extra determinant, all associations remained similar (not shown). STI positivity itself had no clear association with living in a high R-low TR area. Compared with people in quartile 1 areas (STI positivity 0.0%–15.4%), people living in quartile 2 (15.4%–17.6%) and quartile 3 areas (17.6%–19.2%) were less likely to live in a high R-low TR area (OR of 0.61 and 0.65), while people in quartile 4 (19.2%–30.4%) were somewhat more likely to live in these areas (OR: 1.19; 95% CI 1.18 to 1.20).

■ **Table 2** Determinants of individuals in cluster 2 (high R-low TR) compared to individuals in cluster 1 (high R-high TR),* the greater Rotterdam area, the Netherlands (2015-2019)

Determinants	**Univariable**	**Multivariable**
	OR (95% CI)†	OR (95% CI)†
Individual		
Sex		
Men	REF	REF
Women	1.02 (1.01 to 1.03)	0.98 (0.97 to 1.00)
Age (years)		
15-19	1.15 (1.14 to 1.16)	1.06 (1.05 to 1.07)
20-24	REF	REF
25-29	0.98 (0.97 to 0.99)	1.05 (1.04 to 1.06)
30-34	1.12 (1.11 to 1.12)	1.14 (1.12 to 1.15)
35-39	1.28 (1.27 to 1.29)	1.22 (1.21 to 1.24)
40 and older	1.41 (1.40 to 1.42)	1.29 (1.28 to 1.31)
Migratory background‡		
Native Dutch	REF	REF
Middle and East European	0.33 (0.32 to 0.33)	0.87 (0.84 to 0.90)
Other Western	0.36 (0.35 to 0.37)	0.71 (0.69 to 0.73)
Dutch Antillean	0.26 (0.25 to 0.26)	0.34 (0.33 to 0.36)
Surinamese	0.29 (0.28 to 0.30)	0.39 (0.38 to 0.40)
Turkish	0.27 (0.26 to 0.27)	1.07 (1.04 to 1.10)
Moroccan	0.21 (0.20 to 0.22)	0.78 (0.76 to 0.81)
Other non-Western	0.31 (0.30 to 0.32)	0.56 (0.54 to 0.57)
Sub-Saharan African§	0.27 (0.26 to 0.28)	0.51 (0.48 to 0.53)
Cape Verdean	0.20 (0.19 to 0.21)	0.66 (0.63 to 0.70)
Education level (imputed)¶		
Low	REF	REF
Middle	0.99 (0.98 to 0.99)	0.98 (0.97 to 0.98)
High	0.96 (0.95 to 0.97)	1.00 (0.98 to 1.01) ▪
Area		
Degree of urbanisation		
Very high (≥2500 addresses/km²)	REF	REF
Other (<2500 addresses/km²)	20.96 (20.8 to 21.1)	9.03 (8.95 to 9.11)

■ **Table 2** Determinants of individuals in cluster 2 (high R-low TR) compared to individuals in cluster 1 (high R-high TR),* the greater Rotterdam area, the Netherlands (2015-2019) (continued)

Determinants	Univariable	Multivariable
	OR (95% CI)†	OR (95% CI)†
Median household income		
Other (≥€22 200)	REF	REF
Lowest/lower middle (<€22 200)	0.12 (0.11 to 0.12)	0.33 (0.32 to 0.33)
Distance to closest general practice (in km)**		
<1	REF	REF
1 to 3	1.99 (1.97 to 2.00)	0.96 (0.95 to 0.97)
>3	3.13 (2.98 to 3.28)	1.98 (1.77 to 2.23)
Distance to SHC (in km)		
<5	REF	REF
5 to 10	7.14 (7.09 to 7.19)	2.00 (1.98 to 2.02)
>10	29.33 (29.05 to 29.71)	3.51 (3.46 to 3.56)

km, kilometre; *REF*, reference; *SHC*, sexual health centre.

* Clusters are identified with two-step cluster analysis. Cluster 1 (high risk -high testing rate): n=1 187 499; cluster 2 (high risk - low testing rate): n=1 258 621. Individuals in cluster 3 (low) are excluded for this analysis.

† $P<0.01$ unless otherwise indicated: ▪ not significant.

‡ Migratory background was encoded according to the Statistics Netherlands' coding scheme. Western if at least one parent was born in another country in Europe (excluding Turkey), North America, Oceania, Indonesia or Japan. Non-Western when at least one parent was born in a country in Africa, Latin America or Asia (excluding Indonesia and Japan) or Turkey.

§Without Cape Verdean.

¶Multiple imputation via chained equations (MICE) using ten iterations of five multiple imputations. The International Standard Classification of Education was used as basis. Low: no education, elementary school, pre-vocational secondary education, senior general secondary education (first 3 out of 5 years), pre-university education (first 3 out of 6 years), secondary vocational education level 1. Middle: senior general secondary education (last 2 out of 5 years), pre-university education (last 3 out of 6 years), secondary vocational education level 2 to 4. High: university of applied sciences, university.

**Based on address of residential location. Other area characteristics are based on the four-digit postal code of residential location.

Discussion

In this cross-sectional, population-based register study, we found large spatial differences in STI testing, positivity and risk in greater Rotterdam, with the highest rates generally observed in urban areas. We identified three clusters of PC areas based on area-specific risk score and STI testing rates (high R-high TR, high R-low TR, low). Although the community STI risk levels of high R-high TR and high R-low TR areas were similar, the testing rates differed greatly (75.8 vs 33.2 per 1000 residents). Compared with residents from high R-high TR areas, residents from high R-low TR areas had more often a non-migratory background and tended to come from less urbanised, less well-off areas and lived further away from GP and SHC.

We found considerable geographical differences in testing rates, even between areas where the resident populations had comparable STI risk and positivity. For area-specific prevention programmes and to optimize resource allocation, we think it is imperative to account for area-specific STI testing rates. Other studies suggest that areas with elevated STI positivity, cases or key populations ('clusters') might benefit from targeted STI service allocation [20]. A limited number of studies investigated spatial differences in STI testing on population level. A Dutch study found large nationwide differences in STI testing in the general population [1], but no studies investigated differences in STI testing at a smaller geographical level. Although testing rates may not be directly associated with area-specific positivity, it is likely that it drives the relative number of observed cases, for example, as observed by a study on pertussis [21]. Provision of local programmes based on elevated case numbers only may be insufficient, especially when resources are limited. The finding that testing rates differ between areas, despite comparable STI risk levels, seems to indicate that it is appropriate to consider (also) testing rates and to initiate or expand additional interventions in areas with lower test rates.

For insight into appropriate interventions, we were especially interested in differences between areas with comparable community STI risk but that had different testing rates (high 75.8/1000 residents vs low 33.2/1000 residents). Compared with areas with high testing rates, low testing rate areas with comparable risk were less urbanised and residents lived further away from GP and SHC, implying reduced accessibility to testing services. These results correspond with the previous literature [22,23]. In addition to physical accessibility, people living in less urbanised areas may also be less likely to seek sexual healthcare themselves because of barriers such as lack of anonymity, social stigma and privacy concerns [24,25]. Also, healthcare providers in rural areas may contribute to lower testing rates because they are less likely to offer an STI test [26,27]. Educational training, including information about STI testing guidelines and local STI testing practices, could motivate and increase STI test provision by the GP [28-30]. Apart from migratory background, individual factors (sex, age, education level) had a minor effect. This may be explained by relatively small geographical differences for these individual factors within the area.

Strengths and limitations

A major strength of this study is the design, linking all residents with STI testing data from the main sexual healthcare providers within one geographical area, closely mirroring reality. Herewith, we clearly demonstrate a novel and objective method, without recall or registration bias as may be the case with questionnaires or sentinel databases. This design and method can be repeated in other regions or countries with multiple providers and access to population microdata. In addition, this is the first study that considers the underlying STI risk at community level while examining determinants associated with different STI testing levels. We found several factors associated with low testing rate areas such as longer distance to testing sites, which would allow for more targeted local interventions.

Our study also has some limitations. First, the usage of administrative PC units to distinguish areas with different STI testing and risk levels may not exactly differentiate social characteristics or health status. Another level of aggregation may provide a different distribution and the results of the regression analysis might differ. More precise measures, such as street-level addresses, limit the arbitrariness of administrative boundaries but may violate privacy. Therefore, we analysed our data at the smallest possible spatial scale that is relevant for healthcare providers and policymakers in our study area. Our results may not be generalisable to other areas. Second, the identified clusters consist of up to 100 PC areas, which could largely differ in underlying risk, for example, a PC area may be designated as high risk due to a high proportion of youngsters, while another due to a high proportion of migrants. Third, we calculated community STI risk scores, but we realise that this is not the same as individual STI risk and that STI risk depend on more than age, migratory background, education level and urbanisation. We possibly also missed associations with testing or could not account for them because information was not available at population level. Sexual behaviour is, in this respect, probably the most important factor, for example, MSM are advised to test regularly [31]. However, factors such as sexual behaviour, partner selection and sociocultural determinants that are (partly) affected by residential area were indirectly included in the analyses by accounting for area characteristics [9-13,32]. Fourth, we only had GP testing data from one laboratory. Although the estimated data coverage was high and we corrected our aggregated analyses for incomplete data, it is still possible that people tested at GPs that use this laboratory differ from people tested at GPs that use another laboratory for diagnostics. Finally, we suggest that additional interventions should be implemented in low testing rate areas, but it remains unknown whether the current rates are sufficient in high testing rate areas. Additional research is required to fully understand whether people with high STI risk are reached and whether there may be self-selection among higher risk individuals in low testing rate areas. Qualitative research could help to further elucidate this and provide more insight into the underlying reasons for suboptimal testing in our region. Previous research shows that testing is hampered for different reasons, including lack of trust in healthcare providers or authorities, fear of stigma and judgement and underestimating risk [26,33-35]. Some of these barriers may be even greater for certain groups such as migrants and sex workers.

Conclusions

We are confident that our approach provides an objective and practical method to identify characteristics that distinguish areas with high risk and high testing rates from areas with high risk and low testing rates. Although there is substantial literature on STI testing and its associated risk factors, local analyses using data from multiple providers combined with population data may help to target available (financial) resources more efficiently. Population-based estimates of MSM would be a valuable addition to the study design in future research. Further actions could include a proof-of-principle intervention, targeting PC areas with low testing rates, to investigate whether persons with high STI risk can be reached by increasing test volumes in these areas. Interventions that could be considered, to overcome challenges such as long distances to specialised STI care, include opening a local SHC branch location or working with mobile clinics. Additional localised qualitative research can increase understanding of reasons for not visiting (traditional) testing services. Increasing knowledge and awareness about current differences in local STI testing practices through continued medical education can be valuable to motivate GPs, especially in rural areas, to offer STI tests.

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PART 2

HIV testing

CHAPTER 5

Who is providing HIV diagnostic testing? Comparing HIV testing by general practitioners and sexual health centres in five regions in the Netherlands, 2011–2018

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Abstract

Objectives

General practitioners (GPs) and sexual health centres (SHCs) are the main providers of HIV testing and diagnose two- thirds of HIV infections in the Netherlands. We compared regional HIV testing and positivity by GPs versus SHCs to gain insight into strategies to improve HIV testing, to enable timely detection of HIV infections.

Methods

Laboratory data (2011–2018) on HIV testing by GPs and SHCs in five Dutch regions with varying levels of urbanisation were evaluated. Regional HIV testing rates per 10 000 residents ≥15 years (mean over period and annual) were compared between providers using negative binomial generalised additive models and additionally stratified by sex and age (15–29 years, 30–44 years, 45–59 years, ≥60 years). χ^2 tests were used to compare positivity percentage between the two groups of providers.

Results

In the study period, 505 167 HIV tests (GP 36%, SHC 64%) were performed. The highest HIV testing rates were observed in highly urbanised regions, with large regional variations. The HIV testing rates ranged from 28 to 178 per 10 000 residents by GPs and from 30 to 378 per 10 000 by SHCs. Testing rates by GPs were lower than by SHCs in three regions and comparable in two. In all regions, men were tested less by GPs than by SHCs; for women, this varied by region. Among those aged 15–29 years old, GPs' testing rates were lower than SHCs', while this was reversed in older age categories in four out of five regions. The overall mean HIV positivity was 0.4%. In contrast to other regions, positivity in Amsterdam was significantly higher among individuals tested by GPs than by SHCs.

Conclusions

This retrospective observational study shows that besides SHCs, who perform opt-out testing for key groups, GPs play a prominent role in HIV testing, especially in non-key populations, such as women and older individuals. Large regional variation exists, requiring region-specific interventions to improve GPs' HIV testing practices.

Key messages

- General practitioners (GPs) and sexual health centres (SHCs) are the main providers of STI consultations and diagnostics in the Netherlands.
- We found considerable variation in HIV testing by GPs and SHCs between the regions studied.
- HIV testing rates were highest in very highly urbanised regions.
- In this study, GPs' HIV testing rates were lower or comparable with SHCs', while positivity was higher or comparable among the tests performed by GPs.
- Due to the wide accessibility of GPs, opportunities for improved HIV testing strategies predominantly lie with GPs, but regionally tailored interventions are needed.

Introduction

In the Netherlands, a declining trend in annual number of newly diagnosed HIV infections has been observed since 2008 [1]. By the end of 2018, an estimated 23 300 people were living with HIV, of whom a substantial proportion (n=1900, 8%) were estimated to be unaware of their infection [1]. In that same year, about half of newly diagnosed HIV infections were late-stage infections [1]. An important step towards zero new HIV infections is ensuring timely diagnosis and treatment through optimal HIV testing strategies. As the Dutch HIV epidemic is not affecting all regions equally, with clustering in very highly urbanised regions such as the cities of Amsterdam and Rotterdam [2], region-specific tailored approaches for optimised HIV testing and care are warranted.

Nearly 70% of STI consultations are performed by general practitioners (GPs) in the Netherlands [3]. In addition, sexual health centres (SHCs) provide client- initiated STI testing and care for key groups, such as people being notified for an STI, people having STI symptoms, men who have sex with men (MSM), people with a non-Western migratory background and people aged <25 years. GPs and SHCs are therefore the main access points for STI testing and care, but there are important differences in accessibility between GPs and SHCs. The GP is readily accessible for all, while the SHC is only accessible for key groups. GPs usually test for HIV at the request of the patient, and guidelines recommend testing for HIV based on risk assessment and symptoms and in the presence of HIV indicator conditions [4]. The cost of HIV testing by a GP is not covered by health insurance if the obligatory annual deductible (currently €385) has not been reached. In contrast, at the SHC, testing and care are free of charge. Since 2015, SHCs have been offering HIV testing for key groups on an opt-out basis, with the exception of heterosexual attendees <25 years who are tested for HIV on indication only [5]. The number of SHC attendees is limited by financial restrictions imposed by national policy [5].

GPs and SHCs diagnose 36% and 27% of new HIV infections in the Netherlands, respectively, with the remainder being diagnosed in hospitals or other settings such as antenatal care services [1,6]. However, the number of HIV tests performed by GPs and their contribution to HIV testing compared with SHCs in the Netherlands are unknown. Insight into this contribution is needed to identify opportunities for improved HIV testing strategies. Therefore, this study aimed to compare HIV testing and positivity by GPs versus SHCs in five Dutch regions with different levels of urbanisation. We expect that opportunities for improved HIV testing predominantly lie with GPs due to their accessibility in all geographical areas and because HIV testing by SHCs is already done on an opt-out basis in key populations.

Methods

Design and setting

In this retrospective observational study, we used laboratory data (2011–2018) on HIV testing and HIV positivity by healthcare provider (GP or SHC) from five regions in the Netherlands (Amsterdam, Rotterdam, Maastricht, Twente, North Netherlands). The five participating regions accounted for 24% of the total Dutch population of 17.2 million in 2018 [7]. These regions were selected because a collaboration was already established [8], and to provide an overview of HIV testing in settings with varying levels of urbanisation in the Netherlands. As shown in **figure 1**, each region consists of one or more municipalities, varying in level of urbanisation (number of residents per square kilometre, based on 2018 data). The regions ranged from rural (North Netherlands, N-NL: 208 residents/km^2) to very highly urbanised (Amsterdam: 5160 residents/km^2; Rotterdam: 2936 residents/km^2).

Data collection

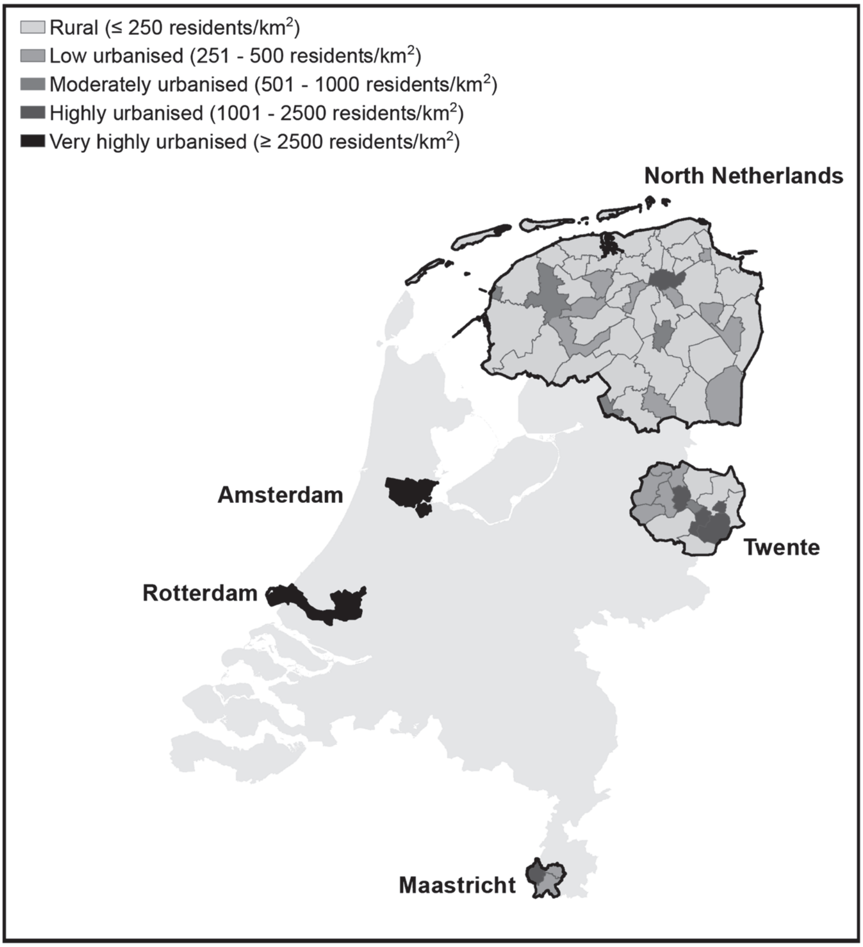
All laboratories performing diagnostics for GPs and SHCs in participating regions were approached for data collection. The annual number of HIV tests performed by GPs and SHCs and the number of positive HIV tests were collected, stratified by sex and age category (15–29, 30–44, 45–59 and ≥60 years). HIV tests as part of antenatal screening were excluded. The aggregated laboratory data were combined with the number of residents and level of urbanisation per region, as publicly available from Statistics Netherlands [9]. Data were included if both the patient's and the healthcare provider's postal code were within the region. For GPs in Amsterdam, the patient's postal code was not available; thus, inclusion was based only on the postal code of the GP. For the N-NL region, all GP laboratory data were included irrespective of postal code. SHC data for N-NL in 2015 were missing as diagnostics for SHCs were performed by a foreign laboratory in that year and could not be retrieved.

Case definition
An HIV test was defined as a serum HIV antibody test, antigen test or a combination test (HIV antibody and p24 antigen). Multiple HIV tests performed within 21 days were counted as one to exclude repeat or confirmation tests. The HIV test result was defined as the result of the last test performed within a 21-day window to exclude possible false positive and false negative test results.

Data coverage
The SHC data coverage was 100%, since laboratory services for SHCs are performed by a single laboratory per region. GPs may contract various diagnostic laboratories. As we were not able to collect data from all laboratories that perform diagnostics for GPs, GP data coverage was estimated by each region to adjust for incomplete data. The estimated GP data coverage ranged from 72% to 92% (**figure 1**).

Statistical analysis

Overall mean and annual HIV testing rates (number of tests per 10000 residents) were calculated for each region and stratified by provider group, sex and age category. We compared HIV testing rates between provider groups with SHC as reference, calculating rate ratios (RR) and their 95% CI. Rates were modelled using generalised additive models (GAM), with the log of total number of residents as offset. Since outcomes were overdispersed, they were modelled assuming a negative binomial distribution. To correct for missing data, HIV testing rates and GAM analyses including GP data were adjusted for regional GP data coverage by multiplying the number of tests with 1/coverage for each region. Overall mean positivity percentages (number of positive tests out of tests performed) were calculated for each region, and compared between providers using χ^2 tests, or Fisher's exact tests when more than 20% of the cells had an expected frequency below five. For all calculations in the region of N-NL, GP and SHC data for 2015 were excluded as SHC data were missing. All analyses were performed using R V.3.6.3. A *P* value <0.05 was considered statistically significant.



Region	Total no. of residents ≥15 years	Population density[2]	Urbanisation[3]	Age distribution (%) 15-29y, 30-44y, 45-59y, ≥60y	GP test data coverage[4]
Netherlands	**14,418,460**	**510**	**Moderately urbanised**	**22.4%, 21.6%, 26.1%, 30.0%**	**NA**
Amsterdam	728,040	5,160	Very highly urbanised	28.2%, 28.6%, 22.8%, 20.4%	91%
Rotterdam	535,290	2,936	Very highly urbanised	26.8%, 25.4%, 23.3%, 24.5%	92%
Maastricht	146,363	967	Moderately urbanised	27.8%, 16.9%, 22.9%, 32.4%	81%
Twente	524,526	422	Low urbanised	22.4%, 20.6%, 25.9%, 31.1%	72%
North Netherlands	1,456,292	208	Rural	22.0%, 19.6%, 26.0%, 32.4%	92%

■ **Figure 1** Urbanisation map of the Netherlands and study region descriptives[1]

[1] Based on 2018. [2] Number of residents per square kilometre. [3] Level of urbanisation by region; each region consists of one or more municipalities. [4] Estimated GP test data coverage to adjust for incomplete HIV test data, as we were not able to collect data from all laboratories that perform diagnostics for GPs.

GP, general practitioner; *NA*, not applicable.

Results

Laboratory data

We analysed 505 167 HIV tests performed by GPs and SHCs from the five included regions from 2011 to 2018 (**supplemental table 1**). GPs and SHCs from the very highly urbanised regions of Amsterdam and Rotterdam performed the largest proportion of tests of the included study regions (59% from Amsterdam and 19% from Rotterdam, respectively). SHCs conducted more tests compared with GPs (323370 (64%) vs 181797 (36%)), with the vast majority of SHC tests done in Amsterdam (65%, 209 610 of 323 370). In total, 2128 HIV tests were positive, 1156 (54%) from SHCs and 972 (46%) from GPs. The largest number of positive HIV tests was reported in Amsterdam (1268, 60%), followed by Rotterdam (508, 24%), N-NL (200, 9%), Twente (117, 6%) and Maastricht (35, 2%).

Mean HIV testing rates

Figure 2 and **table 1** show the overall mean HIV testing rates per 10000 residents by provider per region. The mean HIV testing rates decreased with decreasing level of urbanisation. In three regions with varying levels of urbanization – Amsterdam, Maastricht and Twente – GPs' testing rates were lower than SHCs', with the biggest difference between providers observed in Amsterdam (RR 0.47, 95%CI 0.44 to 0.50). In the very highly urbanised region of Rotterdam and in the rural region of N-NL, mean testing rates were comparable between GPs and SHCs (RR 1.01, 95%CI 0.97 to 1.05 and RR 0.93, 95%CI 0.88 to 0.97, respectively).

In all regions, men were tested less by GPs than by SHCs. This pattern was also observed for women in Amsterdam, Twente and Maastricht, but not in Rotterdam and N-NL. In general, RR increased with increasing patient age categories. In the youngest age category (15–29 years), testing rates by GPs were lower than those by SHCs (RR ranging from 0.24, 95% CI 0.20 to 0.28, to 0.70, 95% CI 0.65 to 0.75), while in the older age categories this was reversed for all regions except Twente.

Table 1 Mean HIV testing rate per 10 000 residents ≥15 years and comparison between GPs and SHCs in five regions in the Netherlands, total and by sex and age category, 2011–2018

	GP*	SHC	GP versus SHC
	Mean HIV testing rate (n/10,000)	Mean HIV testing rate (n/10,000)	RR (95%CI)†
Very highly urbanised regions			
Amsterdam			
Total	178	378	0.47 (0.44 to 0.50)
Men	195	453	0.43 (0.39 to 0.46)
Women	163	306	0.53 (0.49 to 0.57)
15 – 29 years	208	850	0.24 (0.20 to 0.28)
30 – 44 years	268	357	0.75 (0.71 to 0.79)
45 – 59 years	144	143	1.00 (0.94 to 1.07)
≥60 years	43	30	1.42 (1.29 to 1.55)
Rotterdam			
Total	123	122	1.01 (0.97 to 1.05)
Men	124	154	0.81 (0.76 to 0.86)
Women	122	91	1.34 (1.28 to 1.40)
15 – 29 years	209	298	0.70 (0.65 to 0.75)
30 – 44 years	179	122	1.47 (1.40 to 1.54)
45 – 59 years	74	38	1.94 (1.82 to 2.05)
≥60 years	16	8	2.12 (1.87 to 2.37)
Moderately urbanised region			
Maastricht			
Total	83	104	0.80 (0.72 to 0.88)
Men	88	116	0.76 (0.65 to 0.87)
Women	79	93	0.84 (0.73 to 0.96)
15 – 29 years	156	288	0.54 (0.44 to 0.65)
30 – 44 years	140	86	1.62 (1.45 to 1.80)
45 – 59 years	52	42	1.25 (1.02 to 1.47)
≥60 years	13	8	1.67 (1.24 to 2.10)
Low urbanised region			
Twente			
Total	28	50	0.57 (0.50 to 0.64)
Men	29	61	0.48 (0.38 to 0.57)
Women	28	38	0.72 (0.62 to 0.82)
15 – 29 years	48	128	0.38 (0.28 to 0.48)

■ **Table 1** Mean HIV testing rate per 10 000 residents ≥15 years and comparison between GPs and SHCs in five regions in the Netherlands, total and by sex and age category, 2011–2018 (continued)

	GP*	SHC	GP versus SHC
	Mean HIV testing rate (n/10,000)	Mean HIV testing rate (n/10,000)	RR (95%CI)†
30 – 44 years	52	58	0.90 (0.79 to 1.02)
45 – 59 years	20	27	0.73 (0.57 to 0.90)
≥60 years	3	4	0.62 (0.22 to 1.02)
Rural region			
North Netherlands‡			
Total	28	30	0.93 (0.88 to 0.97)
Men	27	32	0.86 (0.79 to 0.92)
Women	29	29	1.00 (0.93 to 1.07)
15 – 29 years	56	91	0.62 (0.55 to 0.68)
30 – 44 years	48	28	1.72 (1.63 to 1.81)
45 – 59 years	18	15	1.22 (1.10 to 1.34)
≥60 years	3	2	1.35 (1.07 to 1.64)

GP, general practitioner; *RR*, rate ratio; *SHC*, sexual health centre.
* GP test data were corrected for estimated HIV test data coverage per region.
† Reference: SHC.
‡ 2015 data were missing for this region and not included in the calculations.

Annual HIV testing rates

Comparing annual HIV testing rates by GPs and SHCs revealed that GPs' rate relative to that of SHCs decreased over time in the very highly urbanised region of Amsterdam and the low urbanised region of Twente (**table 2**). In Amsterdam the RR comparing GP versus SHC decreased most: from 0.72 (95% CI 0.70 to 0.75) in 2011 to 0.40 (95% CI 0.38 to 0.43) in 2018. This decrease was caused by a strong increase in testing by SHCs (HIV testing rate of 314.7 in 2011 to 430.1 per 10 000 residents in 2018). The decrease in RR was observed in all subgroups in Amsterdam and most subgroups in Twente, with the strongest decrease among men and those aged 15–29 years old. In other regions, the RR remained more stable (Rotterdam and Maastricht) or increased over time (N-NL).

■ **Table 2** Annual rate ratios comparing HIV testing rates per 10 000 residents ≥15 years between GPs* and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011–2018

	Amsterdam	Rotterdam	Maastricht	Twente	N-NL
	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†
Total					
2011	0.72 (0.70 to 0.75)	1.03 (0.99 to 1.07)	0.67 (0.59 to 0.74)	0.86 (0.79 to 0.92)	0.64 (0.59 to 0.68)
2012	0.63 (0.60 to 0.66)	0.98 (0.94 to 1.02)	0.97 (0.90 to 1.05)	0.70 (0.63 to 0.76)	0.77 (0.72 to 0.82)
2013	0.50 (0.47 to 0.53)	0.93 (0.89 to 0.97)	0.79 (0.72 to 0.87)	0.50 (0.43 to 0.56)	0.70 (0.65 to 0.75)
2014	0.35 (0.32 to 0.38)	0.94 (0.90 to 0.98)	0.66 (0.58 to 0.74)	0.40 (0.33 to 0.47)	0.57 (0.52 to 0.62)
2015	0.45 (0.42 to 0.48)	1.12 (1.08 to 1.16)	1.02 (0.93 to 1.11)	0.54 (0.46 to 0.62)	NA
2016	0.43 (0.40 to 0.46)	1.05 (1.01 to 1.10)	0.89 (0.80 to 0.98)	0.53 (0.45 to 0.60)	1.45 (1.39 to 1.50)
2017	0.39 (0.36 to 0.42)	0.95 (0.91 to 0.99)	0.77 (0.69 to 0.86)	0.57 (0.50 to 0.64)	1.31 (1.26 to 1.36)
2018	0.40 (0.38 to 0.43)	1.14 (1.10 to 1.18)	0.75 (0.66 to 0.84)	0.56 (0.49 to 0.63)	1.68 (1.63 to 1.74)
Men					
2011	0.67 (0.63 to 0.70)	0.94 (0.89 to 1.00)	0.69 (0.59 to 0.80)	0.78 (0.69 to 0.87)	0.61 (0.54 to 0.68)
2012	0.58 (0.55 to 0.62)	0.84 (0.78 to 0.89)	1.01 (0.90 to 1.12)	0.59 (0.50 to 0.68)	0.70 (0.63 to 0.77)
2013	0.50 (0.46 to 0.54)	0.83 (0.77 to 0.88)	0.83 (0.73 to 0.93)	0.44 (0.35 to 0.53)	0.67 (0.60 to 0.74)
2014	0.39 (0.35 to 0.43)	0.84 (0.78 to 0.89)	0.67 (0.57 to 0.78)	0.37 (0.27 to 0.46)	0.59 (0.52 to 0.65)
2015	0.43 (0.39 to 0.47)	0.82 (0.76 to 0.87)	0.80 (0.69 to 0.92)	0.42 (0.31 to 0.52)	NA
2016	0.37 (0.33 to 0.40)	0.75 (0.70 to 0.80)	0.76 (0.65 to 0.88)	0.43 (0.33 to 0.53)	1.14 (1.07 to 1.21)
2017	0.32 (0.29 to 0.36)	0.69 (0.64 to 0.74)	0.65 (0.54 to 0.77)	0.43 (0.34 to 0.52)	0.96 (0.90 to 1.02)
2018	0.34 (0.31 to 0.38)	0.81 (0.76 to 0.86)	0.65 (0.53 to 0.77)	0.45 (0.36 to 0.54)	1.50 (1.43 to 1.56)
Women					
2011	0.79 (0.75 to 0.83)	1.12 (1.07 to 1.18)	0.65 (0.55 to 0.75)	0.95 (0.86 to 1.04)	0.65 (0.59 to 0.71)
2012	0.68 (0.65 to 0.72)	1.17 (1.11 to 1.22)	0.94 (0.83 to 1.04)	0.84 (0.74 to 0.93)	0.83 (0.77 to 0.90)
2013	0.49 (0.45 to 0.53)	1.06 (1.01 to 1.12)	0.75 (0.65 to 0.86)	0.57 (0.48 to 0.66)	0.72 (0.66 to 0.79)
2014	0.31 (0.27 to 0.35)	1.07 (1.02 to 1.13)	0.65 (0.54 to 0.75)	0.44 (0.33 to 0.54)	0.55 (0.48 to 0.62)
2015	0.49 (0.45 to 0.53)	1.71 (1.65 to 1.78)	1.40 (1.26 to 1.53)	0.79 (0.67 to 0.91)	NA
2016	0.54 (0.50 to 0.58)	1.70 (1.64 to 1.77)	1.10 (0.96 to 1.23)	0.72 (0.60 to 0.83)	1.96 (1.89 to 2.04)
2017	0.52 (0.48 to 0.56)	1.54 (1.48 to 1.60)	0.97 (0.84 to 1.10)	0.88 (0.77 to 0.98)	2.09 (2.01 to 2.16)
2018	0.54 (0.50 to 0.58)	1.94 (1.88 to 2.01)	0.91 (0.77 to 1.05)	0.79 (0.68 to 0.89)	1.99 (1.91 to 2.06)
15 to 29 years					
2011	0.43 (0.39 to 0.46)	0.74 (0.69 to 0.79)	0.50 (0.41 to 0.59)	0.67 (0.59 to 0.76)	0.43 (0.37 to 0.49)
2012	0.35 (0.31 to 0.38)	0.70 (0.65 to 0.75)	0.70 (0.61 to 0.80)	0.47 (0.38 to 0.56)	0.54 (0.47 to 0.60)
2013	0.25 (0.21 to 0.29)	0.63 (0.58 to 0.68)	0.56 (0.47 to 0.66)	0.33 (0.24 to 0.42)	0.44 (0.38 to 0.51)
2014	0.15 (0.10 to 0.19)	0.61 (0.55 to 0.66)	0.45 (0.35 to 0.55)	0.25 (0.15 to 0.36)	0.36 (0.30 to 0.43)
2015	0.21 (0.17 to 0.26)	0.80 (0.74 to 0.85)	0.78 (0.66 to 0.90)	0.38 (0.26 to 0.50)	NA

Table 2 Annual rate ratios comparing HIV testing rates per 10 000 residents ≥15 years between GPs* and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011–2018 (continued)

	Amsterdam	Rotterdam	Maastricht	Twente	N-NL
	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†	RR (95% CI)†
2016	0.22 (0.18 to 0.27)	0.74 (0.68 to 0.80)	0.60 (0.49 to 0.72)	0.36 (0.24 to 0.48)	1.11 (1.04 to 1.18)
2017	0.20 (0.15 to 0.24)	0.67 (0.61 to 0.72)	0.47 (0.35 to 0.59)	0.29 (0.17 to 0.41)	0.99 (0.92 to 1.06)
2018	0.21 (0.17 to 0.25)	0.79 (0.73 to 0.84)	0.35 (0.22 to 0.49)	0.33 (0.21 to 0.44)	1.24 (1.17 to 1.31)
30 to 44 years					
2011	1.17 (1.12 to 1.21)	1.47 (1.41 to 1.54)	1.42 (1.26 to 1.58)	1.22 (1.10 to 1.33)	1.42 (1.33 to 1.51)
2012	1.06 (1.02 to 1.10)	1.45 (1.38 to 1.51)	2.06 (1.88 to 2.23)	1.17 (1.05 to 1.28)	1.66 (1.57 to 1.76)
2013	0.87 (0.83 to 0.91)	1.51 (1.44 to 1.58)	1.85 (1.68 to 2.01)	0.88 (0.77 to 0.99)	1.51 (1.42 to 1.61)
2014	0.66 (0.62 to 0.70)	1.57 (1.50 to 1.65)	1.37 (1.21 to 1.54)	0.76 (0.64 to 0.88)	1.23 (1.14 to 1.32)
2015	0.74 (0.70 to 0.79)	1.51 (1.44 to 1.58)	1.64 (1.46 to 1.81)	0.82 (0.70 to 0.95)	NA
2016	0.65 (0.61 to 0.69)	1.42 (1.35 to 1.48)	1.66 (1.47 to 1.85)	0.77 (0.64 to 0.89)	2.03 (1.94 to 2.12)
2017	0.57 (0.53 to 0.61)	1.30 (1.23 to 1.37)	1.40 (1.23 to 1.57)	0.92 (0.81 to 1.03)	1.78 (1.69 to 1.87)
2018	0.57 (0.53 to 0.60)	1.56 (1.49 to 1.62)	1.76 (1.57 to 1.94)	0.78 (0.67 to 0.89)	2.57 (2.48 to 2.66)
45 to 59 years					
2011	1.43 (1.36 to 1.50)	2.10 (1.97 to 2.22)	1.03 (0.79 to 1.26)	1.12 (0.94 to 1.30)	0.92 (0.79 to 1.05)
2012	1.32 (1.25 to 1.39)	2.12 (2.00 to 2.24)	1.41 (1.21 to 1.61)	0.94 (0.77 to 1.10)	0.91 (0.78 to 1.04)
2013	1.27 (1.20 to 1.34)	2.07 (1.95 to 2.19)	1.12 (0.90 to 1.34)	0.80 (0.63 to 0.97)	1.06 (0.94 to 1.19)
2014	1.10 (1.04 to 1.17)	2.11 (1.99 to 2.24)	1.08 (0.87 to 1.30)	0.51 (0.34 to 0.69)	0.75 (0.63 to 0.87)
2015	1.03 (0.97 to 1.10)	2.06 (1.94 to 2.19)	1.07 (0.85 to 1.29)	0.62 (0.43 to 0.80)	NA
2016	0.83 (0.77 to 0.90)	1.82 (1.70 to 1.93)	1.30 (1.07 to 1.54)	0.64 (0.47 to 0.81)	1.58 (1.47 to 1.70)
2017	0.79 (0.73 to 0.85)	1.60 (1.49 to 1.70)	1.41 (1.17 to 1.64)	0.70 (0.55 to 0.85)	1.54 (1.44 to 1.65)
2018	0.76 (0.71 to 0.82)	1.82 (1.71 to 1.93)	1.73 (1.49 to 1.97)	0.71 (0.56 to 0.86)	1.79 (1.68 to 1.90)
≥60 years					
2011	1.59 (1.44 to 1.75)	2.92 (2.63 to 3.22)	1.80 (1.32 to 2.29)	0.64 (0.13 to 1.15)	0.78 (0.40 to 1.16)
2012	2.01 (1.86 to 2.16)	2.68 (2.40 to 2.96)	1.36 (0.77 to 1.96)	0.71 (0.24 to 1.18)	0.83 (0.44 to 1.21)
2013	1.77 (1.62 to 1.92)	1.85 (1.59 to 2.10)	1.68 (1.18 to 2.18)	NE	0.88 (0.54 to 1.22)
2014	1.68 (1.53 to 1.82)	2.41 (2.14 to 2.68)	1.26 (0.86 to 1.67)	NE	0.59 (0.18 to 0.99)
2015	1.51 (1.37 to 1.64)	1.89 (1.65 to 2.14)	1.58 (1.10 to 2.05)	NE	NA
2016	1.38 (1.26 to 1.51)	1.97 (1.74 to 2.20)	2.01 (1.62 to 2.39)	0.47 (0.05 to 0.89)	1.90 (1.58 to 2.22)
2017	1.18 (1.06 to 1.30)	1.61 (1.39 to 1.83)	1.65 (1.29 to 2.02)	1.19 (0.88 to 1.50)	1.68 (1.45 to 1.90)
2018	1.03 (0.92 to 1.13)	2.31 (2.08 to 2.54)	1.91 (1.54 to 2.28)	0.95 (0.67 to 1.24)	1.92 (1.71 to 2.13)

GP, general practitioner; *NA*, not applicable (data are missing); *NE*, not estimated (n too small for reliable estimates); *N-NL*, North Netherlands; *RR*, rate ratio; *SHC*, sexual health centre.

* GP test data were corrected for estimated HIV test data coverage per region.

† Reference: SHC.

Mean HIV positivity percentage

The overall mean HIV positivity percentage for all provider groups and regions was 0.4%. As shown in **figure 2**, the highest mean positivity percentages were reported in the very highly urbanised regions of Amsterdam (GP 0.7%, SHC 0.3%) and Rotterdam (GP 0.5%, SHC 0.5%), while the lowest positivity percentages were reported in the urbanised area of Maastricht (GP 0.2%, SHC 0.2%). In Amsterdam, the positivity percentages were statistically significantly higher among people tested by GPs compared with those tested by SHCs (*P*<0.001). No statistically significant difference in positivity was found in the other regions.

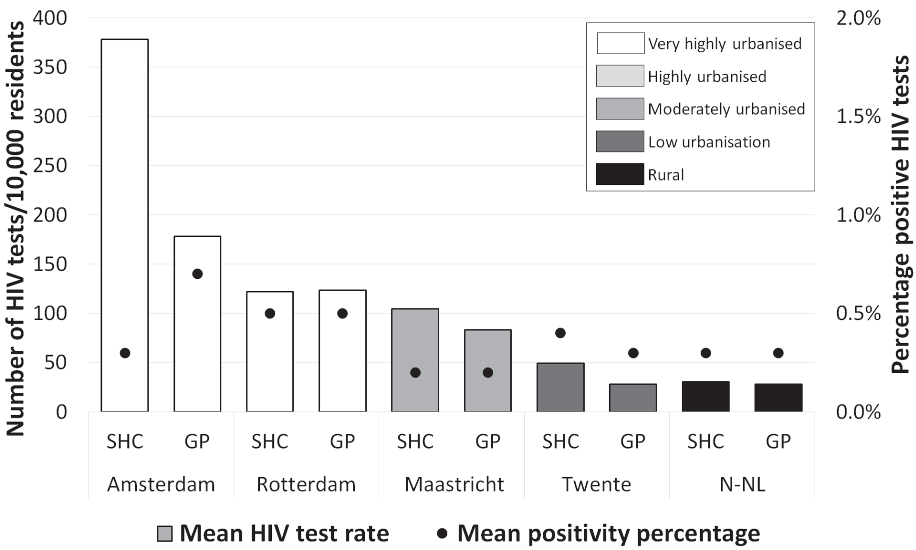


Figure 2 Mean number of HIV tests per 10 000 residents ≥15 years and mean HIV positivity percentage, by provider, in five regions in the Netherlands, 2011–2018

GP test data were corrected for estimated HIV test data coverage per region. Data in 2015 for N-NL are missing and not included in the calculations.

GP, general practitioner; *N-NL*, North Netherlands; *SHC*, sexual health centre.

Discussion

This laboratory-based observational study comparing HIV testing and positivity by GPs and SHCs in five Dutch regions showed considerable regional differences in testing by these providers, while the positivity percentages between GPs and SHCs within regions were generally comparable. The difference between GPs' and SHCs' HIV testing rates largely depended on subgroups by sex and age, with GPs' testing rates being especially lower than SHCs' testing rates in men and those aged 15–29 years old.

Our data show that GPs are an important provider of HIV testing and that they contribute a substantial proportion of positive tests while having lower or comparable testing rates compared with SHCs in all regions. This suggests that, although SHC services are in place as an additional service for key groups for HIV testing, there are valuable opportunities for HIV testing in primary care. This is especially the case among populations that are not typically considered key HIV risk groups in the Netherlands, such as women and older people. However, the GP remains an important HIV test provider among key populations as well. In countries such as the UK, Spain, France, Belgium and the USA, the important role of GPs in optimal HIV testing and earlier diagnosis is increasingly recognised. As GPs are the primary service for (early) detection of disease in general and typically have a wide reach among residents, various interventions to improve HIV testing in this setting have been implemented in these countries [10-13].

The notable regional variation in HIV testing observed in our study is likely due to differences in the level of urbanisation, populations' cultural composition and local policy, as well as patients' and providers' attitudes. Not surprisingly, we observed higher HIV testing rates with higher levels of urbanisation, with the highest testing rates observed in the very highly urbanised regions of Amsterdam and Rotterdam. One explanation for this observation is the fact that key populations for HIV predominantly reside in highly urbanised regions. For example, in the Netherlands, 45% of MSM live in very highly urbanised regions, and over 30% of the residents of these highly urbanised regions are people with a non-Western migratory background [14,15]. Additionally, more HIV testing campaigns are implemented among these communities, likely affecting their HIV awareness and testing behaviour. Healthcare providers in highly urbanised regions might also have higher awareness of HIV testing due to higher HIV prevalence and more focus on sexual healthcare compared with less urbanised regions, where healthcare providers are only incidentally faced with HIV-related concerns. However, although both Amsterdam and Rotterdam have similar levels of urbanisation and population composition, testing rates among both GPs and SHCs are much higher in Amsterdam than in Rotterdam. For SHCs, this discrepancy is largely explained by difference in consultation capacity. In 2018, SHCs in Amsterdam performed over 50 000 STI consultations, while SHCs in Rotterdam performed over 12 000 [16,17]. This difference in capacity is partially historically explained; the SHC in Amsterdam is better known among residents due to its longer existence and there are large regional differences in governmental funding, with the highest proportion allocated to Amsterdam. For GPs, the difference might be explained by higher awareness regarding HIV testing among GPs in Amsterdam: several HIV testing and care campaigns aimed at GPs have been implemented by the HIV Transmission Elimination in Amsterdam (H-TEAM) consortium, which has been working towards zero new HIV infections in the Amsterdam region since 2014, among others. This is reflected in Amsterdam GPs' HIV testing time trends; after an initial decline in testing from 2011 to 2014, testing partially recovered from 2014 onwards [18]. Meanwhile, trends in Rotterdam GPs' HIV testing remained stable from 2011 to 2018.

The results from this study highlight opportunities for improved HIV testing strategies. Since SHCs already offer HIV testing to attendees from key groups on an opt-out basis, GPs' HIV testing strategies have the most room for improvement. Moreover, as GPs perform over twice as many STI consultations compared with SHCs and make 79% of annual STI diagnoses, they are the primary access to sexual healthcare [6,8]. In contrast, the contribution of GPs and SHCs to the annual number of HIV diagnoses is much more equal. This is partly explained by a difference in client population between GPs and SHCs, with only key populations for STI and HIV attending SHCs and because many STI consultations by GPs do not include the performance of an HIV test. Nevertheless, this discrepancy also indicates missed opportunities for HIV testing in the primary care setting. These missed opportunities are the results of previously identified barriers such as time constraints, stigma, financial barriers and low perceived risk, as well as poor adherence to the current guidelines for STI consultations [10,19,20]. In addition, as the Dutch HIV epidemic is shrinking over time, positive test results will become sparser, making a sustained proactive HIV testing strategy by GPs increasingly challenging. The observed regional differences in this study, as well as the underlying differences in policy, barriers and population, should be considered when designing strategies for improved HIV testing. In these strategies, locally targeted approaches to engage GPs are warranted, not only focusing on highly urbanised regions but also engaging lower urbanised regions, where GPs are only incidentally faced with new HIV diagnoses, and the distance to SHCs makes their accessibility more cumbersome [21]. Lessons taken from successful region-specific interventions to improve HIV testing strategies in primary care, such as an educational intervention implemented in Amsterdam by the H-TEAM, could serve as an example [18].

Strengths

This is the first laboratory-based observational study on HIV testing by GPs versus SHCs in the Netherlands, allowing for a novel, objective assessment of the number of HIV tests performed per provider. Previous surveillance on HIV testing in primary care used data from sentinel networks, patient records, questionnaires or interviews [19,22-24]. We compared our laboratory-based GP testing rates with data collected in the Dutch Sentinel General Practice Network from 1988 to 2009 and found large discrepancies in HIV testing between their results from 2009 and our results from 2011 [22]. This discrepancy may be due to registration bias in the sentinel network study, as they used patient records and additional questionnaires completed by GPs. With laboratory data, there is no risk of recall or registration bias, ensuring a more accurate assessment of the contribution of GPs to HIV testing.

Limitations

A limitation of this study is that we used the annual number of tests per healthcare provider, not the annual number of unique patients tested per healthcare provider. As some key groups such as MSM are advised to test for HIV biannually [5], and the SHCs only accommodate key groups while the GPs are widely accessible, it is possible that GPs' testing rates include more unique patients than SHCs'. Second, as we used anonymised aggregated laboratory data, no data on patients' HIV risk factors such as sexual behaviour and migratory background or reason for testing were available. Data on patients' risk factors are available for SHCs and extensively described elsewhere [6], but not for primary care, as they are not routinely registered by GPs. We could therefore not explain differences in GPs' and SHCs' HIV testing based on patient risk factors other than age and sex. Combining risk factors and reasons for consultation with laboratory data could give more insight into indications for HIV testing that are being missed in both settings and pinpoint additional opportunities for improvement. Finally, the results of this study might not be generalisable to all other Western countries due to differences in the organisation of sexual health services and primary care.

Conclusions

Our results show that GPs, in addition to SHCs, play a significant role in HIV testing and HIV diagnoses, but there is large variation between regions. Lessons drawn from regions with the most proactive testing strategies could serve as a basis for broader implementation of optimal testing strategies. However, the observed heterogeneity highlights the need for regionally tailored interventions to improve HIV testing, considering all regional challenges, on our way to zero new HIV infections.

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Supplementary materials

Supplementary Table 1 Crude number[1] of HIV tests and positive tests among patients ≥15 years by GPs and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011-2018

	Amsterdam Number of HIV tests (number positive)		Rotterdam Number of HIV tests (number positive)		Maastricht Number of HIV tests (number positive)		Twente Number of HIV tests (number positive)		N-NL Number of HIV test (number positive)	
	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC
Total										
2011	13,629 (108)	20,676 (107)	6,198 (37)	6,569 (41)	1,126 (2)	2,080 (3)	1,402 (5)	2,275 (9)	3,336 (16)	5,693 (9)
2012	12,655 (85)	22,129 (92)	6,164 (32)	6,830 (34)	1,213 (1)	1,539 (2)	1,249 (6)	2,495 (11)	3,280 (9)	4,610 (10)
2013	10,977 (80)	24,293 (83)	6,046 (31)	7,055 (37)	1,158 (0)	1,808 (1)	1,169 (3)	3,259 (13)	3,203 (8)	4,988 (12)
2014	9,414 (68)	29,774 (88)	5,590 (28)	6,472 (17)	987 (1)	1,847 (5)	893 (3)	3,126 (9)	2,772 (20)	5,296 (19)
2015	10,063 (68)	24,399 (73)	5,681 (32)	5,523 (43)	879 (1)	1,068 (3)	758 (4)	1,949 (10)	2,922 (13)	NA
2016	10,842 (66)	27,757 (84)	5,725 (27)	5,901 (42)	845 (1)	1,170 (1)	836 (6)	2,203 (11)	4,163 (16)	3,131 (1)
2017	10,377 (53)	29,272 (80)	5,748 (31)	6,562 (23)	819 (1)	1,306 (5)	1,035 (1)	2,516 (15)	4,406 (11)	3,664 (14)
2018	11,513 (51)	31,310 (82)	6,150 (30)	5,868 (23)	742 (4)	1,223 (4)	1,065 (1)	2,658 (10)	4,767 (12)	3,076 (30)
Men										
2011	6,651 (81)	10,951 (98)	3,047 (27)	3,512 (37)	541 (2)	963 (3)	683 (5)	1,222 (9)	1,319 (14)	2,339 (9)
2012	6,294 (58)	11,879 (85)	2,970 (27)	3,857 (32)	607 (1)	741 (2)	610 (6)	1,435 (11)	1,316 (6)	2,044 (8)
2013	5,690 (59)	12,475 (77)	2,984 (26)	3,922 (32)	601 (0)	892 (1)	579 (3)	1,822 (13)	1,482 (7)	2,405 (10)
2014	5,251 (59)	14,849 (83)	2,801 (23)	3,645 (17)	488 (1)	894 (5)	473 (3)	1,792 (8)	1,406 (18)	2,609 (16)
2015	5,636 (53)	14,434 (67)	2,748 (30)	3,663 (41)	447 (1)	686 (3)	392 (3)	1,305 (10)	1,463 (9)	NA
2016	5,978 (54)	17,825 (81)	2,771 (23)	4,017 (41)	444 (1)	719 (1)	458 (5)	1,469 (11)	2,062 (16)	1,968 (0)
2017	5,781 (41)	19,639 (76)	2,887 (27)	4,542 (23)	423 (1)	802 (5)	538 (1)	1,728 (15)	2,245 (8)0	2,539 (14)
2018	6,707 (44)	21,552 (79)	3,098 (25)	4,162 (22)	407 (1)	770 (40)	577 (1)	1,795 (9)	2,624 (12)	1,905 (30)

■ **Supplementary Table 1** Crude number[1] of HIV tests and positive tests among patients ≥15 years by GPs and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011-2018 (continued)

	Amsterdam Number of HIV tests (number positive)		Rotterdam Number of HIV tests (number positive)		Maastricht Number of HIV tests (number positive)		Twente Number of HIV tests (number positive)		N-NL Number of HIV test (number positive)	
	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC
Women										
2011	6,978 (27)	9,725 (9)	3,151 (10)	3,057 (4)	585 (0)	1,117 (0)	719 (0)	1,053 (0)	2,017 (2)	3,354 (0)
2012	6,361 (27)	10,250 (7)	3,194 (5)	2,973 (2)	606 (0)	798 (0)	639 (0)	1,060 (0)	1,964 (3)	2,566 (2)
2013	5,287 (21)	11,818 (6)	3,062 (5)	3,133 (5)	557 (0)	916 (0)	590 (0)	1,437 (0)	1,721 (1)	2,583 (2)
2014	4,163 (9)	14,925 (5)	2,789 (5)	2,827 (0)	499 (0)	953 (0)	420 (0)	1,334 (1)	1,366 (2)	2,687 (3)
2015	4,427 (15)	9,965 (6)	2,933 (2)	1,860 (2)	432 (0)	382 (0)	366 (1)	644 (0)	1,459 (4)	NA
2016	4,864 (12)	9,932 (3)	2,954 (4)	1,884 (1)	401 (0)	451 (0)	378 (1)	734 (0)	2,101 (0)	1,163 (1)
2017	4,596 (12)	9,633 (4)	2,861 (4)	2,020 (0)	396 (0)	504 (0)	497 (0)	788 (0)	2,161 (3)	1,125 (0)
2018	4,806 (7)	9,758 (3)	3,052 (5)	1,706 (1)	335 (3)	453 (0)	488 (0)	863 (1)	2,143 (0)	1,171 (0)
15-29 years										
2011	5,094 (25)	13,118 (26)	3,059 (9)	4,485 (21)	660 (0)	1,641 (1)	692 (0)	1,427 (6)	1,661 (4)	4,206 (2)
2012	4,518 (18)	14,363 (27)	3,045 (14)	4,736 (15)	651 (0)	1,141 (0)	528 (0)	1,560 (1)	1,599 (3)	3,239 (4)
2013	3,615 (11)	16,111 (21)	2,854 (8)	4,937 (17)	635 (0)	1,394 (1)	500 (0)	2,127 (0)	1,447 (3)	3,536 (2)
2014	2,704 (10)	20,378 (29)	2,539 (7)	4,540 (7)	506 (0)	1,376 (2)	364 (0)	1,992 (0)	1,215 (2)	3,628 (5)
2015	2,894 (12)	15,055 (31)	2,511 (9)	3,428 (17)	418 (0)	662 (2)	278 (0)	1,016 (4)	1,286 (4)	NA
2016	3,351 (9)	16,453 (35)	2,414 (9)	3,546 (11)	402 (1)	822 (1)	289 (1)	1,123 (7)	1,745 (3)	1,713 (1)
2017	3,007 (5)	16,809 (33)	2,425 (5)	3,950 (12)	341 (0)	893 (2)	265 (0)	1,270 (4)	1,814 (3)	1,993 (3)

Supplementary Table 1 Crude number[1] of HIV tests and positive tests among patients ≥15 years by GPs and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011-2018 (continued)

	Amsterdam Number of HIV tests (number positive)		Rotterdam Number of HIV tests (number positive)		Maastricht Number of HIV tests (number positive)		Twente Number of HIV tests (number positive)		N-NL Number of HIV test (number positive)	
	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC
2018	3,307 (6)	17,197 (32)	2,517 (10)	3,479 (11)	252 (2)	881 (3)	301 (0)	1,276 (4)	1,876 (2)	1,650 (10)
30-44 years										
2011	5,942 (46)	5,604 (61)	2,197 (16)	1,620 (16)	305 (0)	265 (2)	496 (1)	566 (1)	1,211 (5)	929 (4)
2012	5,581 (43)	5,790 (47)	2,143 (13)	1,612 (14)	343 (0)	206 (2)	494 (3)	588 (7)	1,191 (4)	779 (5)
2013	4,876 (34)	6,153 (44)	2,204 (12)	1,589 (11)	347 (0)	232 (0)	468 (1)	737 (8)	1,170 (4)	840 (2)
2014	4,298 (30)	7,176 (39)	2,124 (15)	1,466 (7)	287 (1)	258 (1)	375 (1)	689 (3)	1,067 (9)	943 (5)
2015	4,583 (28)	6,780 (26)	2,179 (18)	1,565 (17)	281 (0)	212 (1)	336 (2)	567 (3)	1,056 (6)	NA
2016	4,768 (22)	8,047 (33)	2,279 (9)	1,747 (20)	244 (0)	181 (0)	352 (3)	639 (2)	1,525 (6)	817 (0)
2017	4,567 (25)	8,838 (32)	2,264 (11)	1,892 (6)	276 (0)	244 (3)	481 (0)	729 (6)	1,531 (3)	935 (7)
2018	5,088 (18)	9,886 (36)	2,489 (10)	1,737 (7)	265 (1)	186 (0)	459 (0)	820 (3)	1,742 (6)	737 (10)
45-59 years										
2011	2,148 (31)	1,650 (19)	778 (11)	403 (3)	123 (2)	148 (0)	196 (3)	243 (2)	419 (6)	495 (3)
2012	2,026 (21)	1,690 (16)	801 (5)	411 (5)	198 (1)	173 (0)	205 (3)	304 (3)	445 (2)	533 (0)
2013	2,016 (31)	1,745 (15)	825 (10)	433 (8)	142 (0)	157 (0)	191 (2)	332 (5)	527 (1)	539 (8)
2014	1,901 (24)	1,893 (19)	756 (5)	389 (3)	149 (0)	170 (1)	141 (1)	381 (3)	455 (7)	660 (7)
2015	2,038 (23)	2,173 (15)	815 (4)	429 (8)	143 (1)	165 (0)	136 (1)	306 (2)	523 (2)	NA
2016	2,105 (27)	2,773 (15)	829 (5)	496 (9)	134 (0)	127 (0)	171 (1)	370 (2)	788 (7)	541 (0)
2017	2,185 (18)	3,056 (15)	859 (14)	585 (5)	139 (1)	122 (0)	223 (1)	440 (4)	859 (4)	605 (4)
2018	2,425 (25)	3,498 (12)	908 (10)	541 (4)	157 (0)	112 (1)	235 (1)	460 (3)	907 (4)	552 (9)

■ **Supplementary Table 1** Crude number[1] of HIV tests and positive tests among patients ≥15 years by GPs and SHCs in five regions in the Netherlands, total and by sex and age categories, 2011-2018 (continued)

	Amsterdam Number of HIV tests (number positive)		**Rotterdam Number of HIV tests (number positive)**		**Maastricht Number of HIV tests (number positive)**		**Twente Number of HIV tests (number positive)**		**N-NL Number of HIV test (number positive)**	
	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC	GPs	SHC
≥60 years										
2011	428 (6)	295 (1)	164 (1)	61 (1)	38 (0)	26 (0)	18 (1)	39 (0)	45 (1)	63 (0)
2012	512 (3)	280 (2)	175 (0)	71 (0)	21 (0)	19 (0)	22 (0)	43 (0)	45 (0)	59 (1)
2013	451 (4)	280 (2)	163 (1)	96 (1)	34 (0)	25 (0)	10 (0)	63 (0)	59 (0)	73 (0)
2014	484 (4)	317 (2)	171 (1)	77 (0)	44 (0)	43 (1)	13 (1)	64 (3)	35 (2)	65 (2)
2015	533 (5)	389 (1)	176 (1)	101 (1)	37 (0)	29 (0)	8 (1)	60 (1)	57 (1)	NA
2016	602 (7)	478 (1)	203 (4)	112 (2)	65 (0)	40 (0)	24 (1)	71 (0)	105 (0)	60 (0)
2017	610 (5)	567 (0)	200 (1)	135 (0)	63 (0)	47 (0)	66 (0)	77 (1)	202 (1)	131 (0)
2018	680 (2)	728 (2)	236 (0)	111 (1)	68 (1)	44 (0)	70 (0)	102 (0)	242 (0)	137 (1)

GP, general practitioner; *NA*, data is missing; *N-NL*, North Netherlands; *SHC*, sexual health centre.

[1] Number of HIV tests by GPs are unadjusted for GPs' HIV test data coverage.

5

CHAPTER 6

High HIV incidence follows high testing rates in the Rotterdam area, the Netherlands: a cross-sectional population-based study

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Abstract

Background

Appropriate access to HIV testing is crucial for detection, linkage to treatment, and prevention. It is likely that HIV testing in less urbanised areas depends more on general practitioners (GPs), as sexual health centres (SHC) are mostly located within urbanised areas. In this cross-sectional study, we aim (1) to assess and compare HIV testing at the GP and SHC, and (2) to assess population- and provider-specific HIV incidence.

Methods

Individual HIV testing data of GPs and SHC were linked to population register data (aged≥15 years, Rotterdam area, 2015-2019). We reported the proportion HIV tested, and compared GP and SHC testing rates with negative binomial generalised additive models. Data on new HIV diagnoses (2015-2019) from the Dutch HIV Monitoring Foundation relative to the population were used to assess HIV incidence.

Results

The overall proportion HIV tested was 1.14% for all residents, ranging from 0.41% for ≥40-year-olds to 4.70% for Antilleans. The GP testing rate was generally higher than the SHC testing rate with an overall rate ratio (RR) of 1.61 (95% CI: 1.56-1.65), but not for 15-24-year-olds (RR: 0.81, 95% CI: 0.74-0.88). Large differences in HIV testing rate (1.36 to 39.47 per 1,000 residents) and GP-SHC ratio (RR: 0.23 to 7.24) by geographical area were observed. The GPs’ contribution in HIV testing was greater for GP in areas further away from the SHC. In general, population groups that are relatively often tested are also the groups with most diagnoses and highest incidence (e.g. men, non-western). The overall incidence was 10.55 per 100,000 residents, but ranged from 3.09 to 24.04 per 100,000 residents for different demographic and area characteristics.

Conclusions

GPs have a more dominant role in HIV testing in less urbanised areas further away from the SHC, and among some population groups (e.g. low educated). For most population groups a relatively high incidence follows relatively high testing rates. Opportunities to improve HIV testing have been found for some subpopulations. Also additional testing, via for example SHC branch locations and outreach activities, is promising.

Introduction

HIV testing is a first step in the HIV care continuum and depends on accessibility to testing sites. Larger distance to and limited availability of testing sites are associated with lower test rates for a sexually transmitted infection (STI) including HIV [1-3]. Other barriers are concerns about privacy, confidentiality, and stigma [4]. These barriers are possibly greater for non-specialised sexual healthcare settings and people living in low urbanised areas [4, 5]. Public sexual health centres (SHC) are often located in urban areas. As a result, STI testing in suburban and rural areas likely depends more on other healthcare providers, like general practitioners (GPs).

In the Netherlands, GPs and SHCs are the main two STI care providers. Approximately two-thirds of STI consultations take place in primary care and the rest at the SHC; a minority uses other settings such as private (self-)care [6, 7]. A study on HIV testing at GP and SHC showed also this 2:1 distribution in the number of HIV tests [8]. GPs test for HIV based on clients' request or on doctors' advice. National GP guidelines advise an HIV test for people belonging to high-risk groups and people with HIV indicator conditions [9, 10]. An HIV test at the GP may incur costs as part of the compulsory financial contribution for health insurance. HIV testing is free and anonymous at the SHC. However, access to SHC is restricted to key populations including those notified for or having symptoms of a STI, men who have sex with men (MSM), people originating from STI/HIV endemic areas, and sex workers [11]. These key populations are offered an HIV test at the SHC. SHC visitors of 25 years and older are tested for HIV according to opt-out principle [11]. In line with previous years, most new HIV diagnoses were at the GP (35%) and SHC (30%) in 2020 [12]. The rest is diagnosed at a hospital (29%) or another location (6%) [12]. Signs or symptoms are likely to underlie HIV testing in hospitals after referral by a GP, who acts as gatekeeper to secondary care in the Netherlands.

In the Netherlands, there are approximately 24,000 people with HIV, of whom around 1,600 remain undiagnosed [12]. Most live in the greater Amsterdam and Rotterdam areas [12]. Compared to Amsterdam, the Rotterdam area has a higher proportion of late-stage infections (CD4 T-cell count <350 cells/mm^3 or AIDS-defining event) at diagnosis [12, 13]. Of people with HIV a broad set of characteristics is centrally registered, but there is limited insight in characteristics of people who test for HIV. This is especially due to limited registration of clients' sociodemographics at the GP, for example migratory background is not registered. Since access to HIV testing is crucial for early HIV detection, more insight is needed into the people being tested and by which provider. Therefore, we firstly aimed to assess and to compare the sociodemographic characteristics of HIV tested individuals at the GP and SHC. Secondly, we aimed to assess the characteristics of people with HIV relative to the general population. Insight in population- and provider specific HIV testing and incidence may further aid local HIV testing strategies. This study focuses on the greater Rotterdam area. We hypothesize large differences in testing, diagnosis, and incidence between subpopulations and by geographical area due to policy and (geographical) differences in access to healthcare providers.

Methods

We performed a cross-sectional study in the greater Rotterdam area. This study area consists of 15 municipalities segmented into 183 four-digit postal code (PC) areas and harbours around 1.3 million residents (Statistics Netherlands, 2022). PC areas were used as geographical study unit.

Data sources

HIV testing and population data

Individual HIV testing laboratory data of GPs and the central SHC were used (2015-2019). HIV tests for antenatal screening were excluded. The GP data included 12% to 100% of all general practices within a municipality, with a median coverage of 88% (interquartile range: 60-100%). SHC data was complete (100% coverage). For each included study year, we stated whether someone was tested for HIV (overall and per provider).

The individual HIV testing data were linked to the population register including all residents within the study area of ≥15 years (2015-2019). Population microdata was obtained from the Statistics Netherlands. GP testing data was linked to the population data using a unique anonymous identifier based on citizen service number (98% match). No citizen service number was available in SHC data. We used pseudonymous surveillance data of the SHC, and match these data on a combination of gender, date of birth and PC to the population data (88% match). For population records with a match with HIV testing data, HIV testing was reported and for the rest not. The municipality with 12% coverage was considered as too low for reliable estimates and therefore excluded. Herewith we excluded around 5% of all residents in the data.

As a result of HIV testing and population data linkage, the study database included on individual level information on HIV testing by provider (yes/no), sex, age, migratory background (based on country of birth of individual and parents), education level (classification based on International Standard Classification of Education), and distance to the closest general practice from home address. Also, information on PC level was available: urbanisation level and median income per household as indicator for area socio-economic status. Additionally, straight-line distance from PC centroid to SHC was linked to the database [2].

HIV data

HIV treatment centres provide care to people with HIV diagnosed at GP, SHC, hospitals and other test settings. Other test settings include a diagnosis abroad, at another location (e.g. antenatal HIV testing, rapid testing at NGO healthcare facility, a self-test, medical examination) or if diagnosis location is unknown. For purpose of HIV monitoring, surveillance, and research, pseudonymised patient data from HIV treatment centres are centrally collected in the ATHENA national HIV cohort at Stichting Hiv Monitoring (SHM; HIV Monitoring Foundation). In contrast to SHM data, which includes people diagnosed at all possible locations, our HIV testing data is limited to diagnoses made at GP and SHC. Therefore, we used SHM data on new HIV diagnoses (2015-2019) of people aged≥15 years living within the study area to assess HIV incidence. Hence, the SHM database includes partly the same individuals as the laboratory HIV testing databases. SHM collects data of all people that receive HIV care in one of the 24 HIV treatments centres in the Netherlands: location of diagnosis, PC at entry of care, the demographics sex, country of birth, age, transmission mode, and clinical and virological data. Based on the PC at entry into care, we enriched the SHM database with publicly available PC level data of Statistics Netherlands and straight-line distance from PC centroid to SHC [2, 14]. This study is limited to 98% of all people with HIV within the study age and area, because we did not receive consent from all HIV treatment centres.

Statistical analysis

We reported the socio-demographic and PC level characteristics of individuals tested for HIV. Subsequently, the mean HIV testing rates (number of HIV tests per 1,000 residents) over the study period were compared between GP and SHC per subpopulation and PC area. The HIV testing rates were corrected for incomplete HIV testing data. SHC numbers were corrected with 100/88, considering the 88% match between SHC and population data. GP numbers were corrected by 100 divided by the municipality-specific GP laboratory data coverage. Numbers and rates were based on 5-year counts (2015-2019) to mitigate analytical problems caused by small numbers of cases per subpopulation or PC area, and to preserve anonymity of the cases. GP and SHC testing rates were compared using generalised additive models (GAM) with a negative binomial distribution calculating rate ratios (RR) and their 95% confidence intervals (CI). In these models, SHC was used as reference and the log of the total number of residents as offset. Finally, we assessed the characteristics of diagnosed individuals – relative to the population – that were available from the population and SHM databases. We did not report on subpopulations or areas with less than 10 cases to maintain anonymity. The minimum of 10 cases applies to both the numerator and denominator. We used R version 3.6.2 for analyses and to create geographical plots.

Results

Characteristics of tested population

Characteristics of the general population and the HIV tested population are presented in **Table 1** and in more detail in **Supplementary Table 1**. The proportion HIV tested was 1.14% for all residents and up to 4.70% for Antilleans. Antilleans were most tested at both GP (2.97%) and SHC (1.86%). Those tested least were older age groups and people from less urbanised areas, at both providers. Over the studied years, the number of residents slightly increased, but the number of tested individuals decreased (**Supplementary Table 1**). This was mainly caused by a decrease in the number of individuals tested by the SHC. In total, 19.96% of the SHC clients were tested more than once within the study period, while this was 5.66% for GP clients.

Comparing GP and SHC testing rate by subpopulation

Overall, the HIV testing rate was 1.61 times higher for GPs than for the SHC (95%CI: 1.56-1.65; **Table 1**). Only individuals <25 years had a lower testing rate at the GP compared to the SHC (RR: 0.81, 95%CI: 0.74-0.88; **Table 1**). This was mainly driven by 20–24-year-olds (RR: 0.74, 95%CI 0.66-0.82) than by 15–19-year-olds (RR: 1.11, 95%CI: 1.97-1.25; **Supplementary Table 1**), and independently of western or non-western background (**Supplementary Table 1**). Despite of large differences in proportion tested, migrant groups did not differ substantially in GP-SHC ratio (RR ranges from 1.38 to 1.77). The test contribution of GPs was greater for low educated (compared to medium/high educated), in less urbanised areas (compared to very high urbanised), in areas with the highest median household income (compared to lower incomes) and in areas where distances to GP and SHC are larger (compared to smaller distances). Over time, the HIV testing rate at the GP increased compared to the SHC; from 1.5 times higher in 2015 (RR: 1.52, 95%CI: 1.43-1.60) to almost 2 times higher in 2019 (RR: 1.96, 95%CI: 1.87-2.04) (**Supplementary Table 1**).

Table 1 Characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1]

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Total	5107921 (100.00%)	58356 (100.00%; 1.14%)	37150 (100.00%; 0.73%)	22394 (100.00%; 0.44%)	1.61 (1.56 - 1.65)
Mean per year	1021584	11671	7430	4479	
Individual					
Sex					
Men	2490618 (48.76%)	30856 (52.88%; 1.24%)	18082 (48.67%; 0.73%)	13516 (60.36%; 0.54%)	1.30 (1.24 - 1.35)
Women	2617303 (51.24%)	27500 (47.12%; 1.05%)	19068 (51.33%; 0.73%)	8878 (39.64%; 0.34%)	2.08 (2.02 - 2.14)
Age (in years)					
15-24	758131 (14.84%)	16117 (27.62%; 2.13%)	7526 (20.26%; 0.99%)	8960 (40.01%; 1.18%)	0.81 (0.74 - 0.88)
25-29	445054 (8.71%)	14222 (24.37%; 3.20%)	8338 (22.44%; 1.87%)	6215 (27.75%; 1.40%)	1.30 (1.22 - 1.37)
30-34	423086 (8.28%)	9378 (16.07%; 2.22%)	6704 (18.05%; 1.58%)	2867 (12.80%; 0.68%)	2.27 (2.17 - 2.36)
35-39	396052 (7.75%)	5964 (10.22%; 1.51%)	4487 (12.08%; 1.13%)	1580 (7.06%; 0.40%)	2.75 (2.62 - 2.87)
≥40	3085598 (60.41%)	12675 (21.72%; 0.41%)	10095 (27.17%; 0.33%)	2772 (12.38%; 0.09%)	3.53 (3.43 - 3.62)
Migratory background					
Native Dutch	3260384 (63.83%)	24559 (42.08%;0.75%)	15828 (42.61%; 0.49%)	9174 (40.97%; 0.28%)	1.67 (1.61 - 1.73)
Western	555326 (10.87%)	6682 (11.45%; 1.20%)	4214 (11.34%; 0.76%)	2595 (11.59%; 0.47%)	1.57 (1.46 - 1.68)
Middle and Eastern European	180872 (3.54%)	1983 (3.40%; 1.10%)	1248 (3.36%; 0.69%)	789 (3.52%; 0.44%)	1.53 (1.34 - 1.73)
Other Western	374454 (7.33%)	4699 (8.05%; 1.25%)	2966 (7.98%; 0.79%)	1806 (8.06%; 0.48%)	1.56 (1.38 - 1.74)
Non-Western	1292211 (25.30%)	27115 (46.46%;2.10%)	17108 (46.05%; 1.32%)	10625 (47.45%; 0.82%)	1.56 (1.50 - 1.61)
Dutch Antillean	132989 (2.60%)	6253 (10.72%; 4.70%)	3956 (10.65%; 2.97%)	2474 (11.05%; 1.86%)	1.55 (1.43 - 1.66)
Surinamese	305053 (5.97%)	7140 (12.24%; 2.34%)	4551 (12.25%; 1.49%)	2762 (12.33%; 0.91%)	1.59 (1.49 - 1.70)
Turkish	260436 (5.10%)	2436 (4.17%; 0.94%)	1581 (4.26%; 0.61%)	900 (4.02%; 0.35%)	1.70 (1.52 - 1.88)
Moroccan	189405 (3.71%)	2518 (4.31%; 1.33%)	1600 (4.31%; 0.84%)	969 (4.33%; 0.51%)	1.59 (1.42 - 1.77)

Table 1 Characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1] (continued)

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Other non-Western	266458 (5.22%)	4770 (8.17%; 1.79%)	2853 (7.68%; 1.07%)	2009 (8.97%; 0.75%)	1.38 (1.25 - 1.51)
Sub-Saharan African[4]	57714 (1.13%)	1640 (2.81%; 2.84%)	1073 (2.89%; 1.86%)	589 (2.63%; 1.02%)	1.77 (1.55 - 1.98)
Cape Verdean	80156 (1.57%)	2358 (4.04%; 2.94%)	1494 (4.02%; 1.86%)	922 (4.12%; 1.15%)	1.56 (1.38 - 1.74)
Education level (imputed)[5,6]					
Low	1420610 (32.98%)	1420610 (27.88%; 1.14%)	11056 (30.06%; 0.78%)	5376 (24.14%; 0.38%)	1.99 (1.92 - 2.07)
Medium	1724767 (40.04%)	1724767 (46.37%; 1.56%)	16451 (44.73%; 0.95%)	10962 (49.22%; 0.64%)	1.45 (1.40 - 1.51)
High	1162096 (26.98%)	1162096 (25.76%; 1.28%)	9269 (25.20%; 0.80%)	5934 (26.64%; 0.51%)	1.51 (1.44 - 1.58)
Missing	800448	482	374	122	
Area					
Municipality					
Municipality of Rotterdam	2657426 (52.03%)	44685 (76.57%; 1.68%)	27971 (75.29%; 1.05%)	17694 (79.01%; 0.67%)	1.52 (1.47 - 1.56)
Surrounding municipalities	2450495 (47.97%)	13671 (23.43%; 0.56%)	9179 (24.71%; 0.37%)	4700 (20.99%; 0.19%)	1.94 (1.86 - 2.02)
Degree of urbanisation					
Very high (≥2,500 addresses/km^2)	2414666 (47.29%)	41598 (71.30%; 1.72%)	25382 (68.34%; 1.05%)	17147 (76.58%; 0.71%)	1.43 (1.38 - 1.47)
Other (<2,500 addresses/km^2)	2691627 (52.71%)	16745 (28.70%; 0.62%)	11759 (31.66%; 0.44%)	5243 (23.42%; 0.19%)	2.20 (2.12 - 2.27)
Missing	1628	13	9	4	
Median household income					
Highest (>€36,600)	1155750 (22.64%)	6304 (10.81%; 0.55%)	4402 (11.85%; 0.38%)	1990 (8.89%; 0.17%)	2.10 (1.98 - 2.21)
Upper middle (€28,400 - €36,600)	74093 (1.45%)	672 (1.15%; 0.91%)	387 (1.04%; 0.52%)	293 (1.31%; 0.40%)	1.24 (0.92 - 1.57)
Other (<€28,200)	3876135 (75.91%)	51365 (88.04%;1.33%)	32351 (87.11%; 0.85%)	20106 (89.80%; 0.52%)	1.56 (1.52 - 1.61)
Missing	1943	15	10	5	

Table 1 Characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1] (continued)

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Distance to closest general practice (in km)[7]					
<1	3864777 (75.87%)	49550 (86.08%; 1.28%)	31336 (85.26%; 0.81%)	19250 (87.58%; 0.50%)	1.57 (1.52 - 1.61)
≥1	1229173 (24.13%)	8012 (13.92%; 0.65%)	5417 (14.74%; 0.44%)	2731 (12.42%; 0.22%)	1.98 (1.88 - 2.08)
Missing	13971	794	397	413	
Distance to SHC (in km)					
<5	1832795 (35.89%)	35399 (60.67%; 1.93%)	21112 (56.84%; 1.15%)	15103 (67.45%; 0.82%)	1.34 (1.29 - 1.39)
5-10	1955923 (38.30%)	16757 (28.72%; 0.86%)	11732 (31.59%; 0.60%)	5312 (23.72%; 0.27%)	2.20 (2.13 - 2.27)
>10	1317575 (25.80%)	6187 (10.60%; 0.47%)	4297 (11.57%; 0.33%)	1975 (8.82%; 0.15%)	2.02 (1.90 - 2.13)
Missing	1628	13	9	4	

CI, confidence interval; *GP*, general practitioner; *km*, kilometre; *No*, number; *RR*, rate ratio; *SHC*, sexual health centre.

1 The data underlying this table are the GP and SHC laboratory data, and the population register data (2015-2019).

2 Proportion tested is based on the raw numbers. The mean HIV testing rates (number of HIV tests per 1,000 residents) are calculated over the study period of 5 year and corrected for data incompleteness. The number of tests by SHC was corrected with 1/0.88, considering the 88% match between SHC and population data. For each municipality, the number of tests by the GP was corrected by 1/coverage (municipality specific). The corrected SHC numbers are on average 13% higher (min. 9% - max. 15%), and the corrected GP numbers on average 9% higher (min. 4% - max. 13%).

3 HIV testing rate comparison, with SHC as reference.

4 Without Cape Verdean.

5 The International Standard Classification of Education was used as basis (European Commission; available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_Standard_Classification_of_Education_(ISCED)#:~:text=ISCED%201%3A%20Primary%20education,Post%2Dsecondary%20non%2Dtertiary%20education).

6 Multiple imputation via chained equations (MICE) using ten iterations of five multiple imputations. Only imputed for <60 years-old, above 60 years missingness was assumed not at random due to absence of national registration.

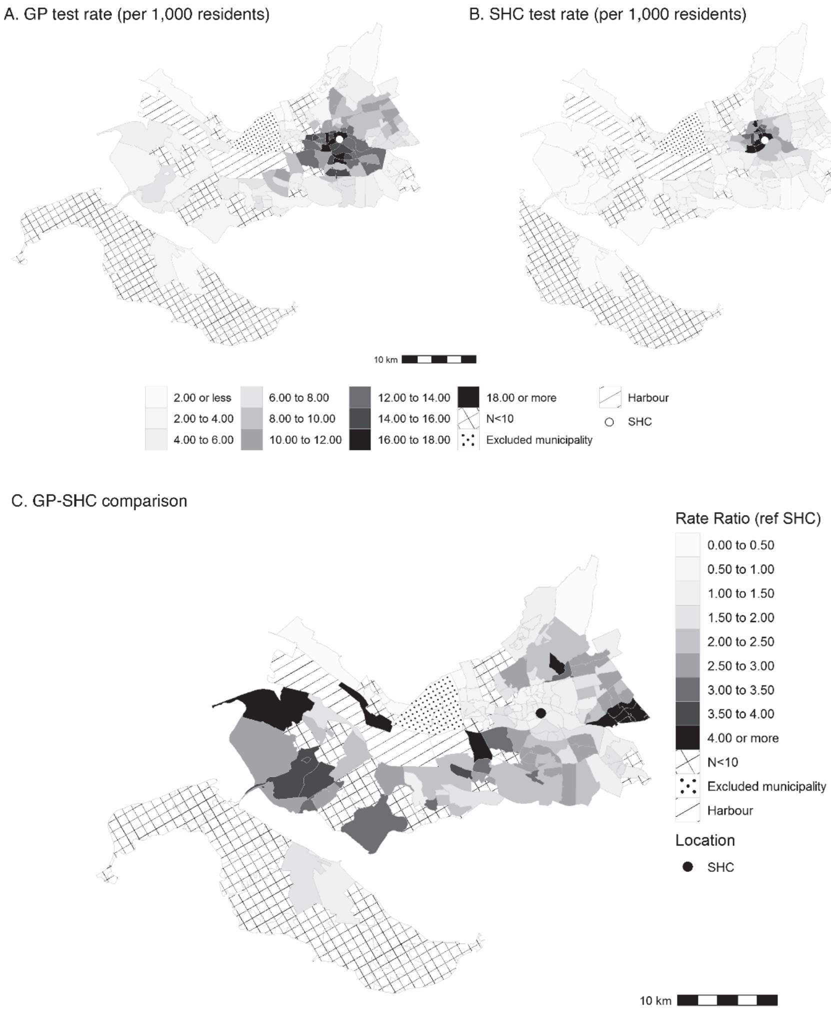
7 Based on address of residential location. Other area characteristics are based on the 4-digit postal code of residential location.

Comparing GP and SHC testing rate by geographical area

We also examined provider-specific HIV testing rates (**Figure 1A and 1B**) and GP-SHC test ratio by PC area (**Figure 1C**). In total 20% of the PC areas had to be excluded due to less than 10 HIV tests at the GP and/or SHC. Large differences in the HIV testing rate were observed for the remaining areas, ranging from 1.36 to 39.47 per 1,000 residents. Stratified by provider, the HIV testing rate per 1,000 residents ranged from 0.25 to 19.23 for GP and from 0.78 to 20.63 for SHC. The highest SHC testing rates were clustered around the SHC location in the northern part of the area (**Figure 1A**). The testing rate at the GP was geographically more widespread compared to the SHC (**Figure 1B**). The GP-SHC ratio ranged from 0.23 (95%CI: 0.00-0.89) to 7.24 (95%CI: 6.82-7.67). The ratio was lowest in the inner-city of Rotterdam where also the SHC is located. The contribution of GPs in HIV testing was greater in more remote areas.

People with HIV and HIV incidence

Of the 539 people diagnosed between 2015 and 2019 in the SHM database, 28.94% was diagnosed at the GP, 28.57% in a hospital, 26.90% at the SHC, 6.10% abroad, 5.40% at another location and for 4.10% setting of diagnosis was unknown. The number of diagnoses and incidence varied largely between different demographic and area characteristics (**Table 2**). However, largely the same patterns were observed between healthcare providers, such as most diagnoses among MSM and people from very urbanised areas. This was not the case for age; hospitals diagnose most people above the age of 40, while other providers diagnose mainly younger people, peaking at the age group 25-29 years. The overall incidence was 10.55 per 100,000 residents (range 3.09 to 24.04). In general, groups that are relatively often tested such as younger age, non-western migratory background, living in urban areas and closely to GP or SHC (**Table 1**), also have a higher number of diagnoses and incidence (**Table 2**).



■ **Figure 1** Provider-specific HIV testing rate and GP-SHC testing rate comparison by postal code area, 2015-2019

GP, general practitioner; *N*, number; *ref*, reference; *SHC*, sexual health centre.

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■ **Table 2** Providers-specific HIV diagnoses and incidence per 100,000 residents, 2015-2019[1]

	Total		GP		SHC		Hospital		Other[2]	
	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence
Total	539	10.55	156	3.05	145	2.84	154	3.01	84	1.64
Individual										
Sex/transmission group										
MSM	349 (68.80%)	14.01	104 (68.90%)	4.18	118 (86.80%)	4.74	74 (53.20%)	2.97	53 (65.40%)	2.13
Heterosexual men and women	158 (31.20%)	3.09	47 (31.10%)	0.92	18 (13.20%)	0.35	65 (46.80%)	1.27	28 (34.60%)	0.55
Missing	32		5		9		15		3	
Age at diagnosis (in years)										
15-24	83 (15.40%)	10.95	19 (12.20%)	2.51	29 (20.00%)	3.83	22 (14.30%)	2.9	13 (15.50%)	1.71
25-29	107 (19.90%)	24.04	29 (18.60%)	6.52	39 (26.90%)	8.76	14 (9.10%)	3.15	25 (29.80%)	5.62
30-34	79 (14.70%)	18.67	26 (16.70%)	6.15	20 (13.80%)	4.73	17 (11.00%)	4.02	16 (19.00%)	3.78
35-39	60 (11.10%)	15.15	12 (7.70%)	3.03	20 (13.80%)	5.05	15 (9.70%)	3.79	13 (15.50%)	3.28
≥40	210 (39.00%)	6.81	70 (44.90%)	2.27	37 (25.50%)	1.20	86 (55.80%)	2.79	17 (20.20%)	0.55
Migratory background										
Native Dutch	267 (49.50%)	8.19	86 (55.10%)	2.64	78 (53.80%)	2.39	81 (52.60%)	2.48	22 (26.20%)	0.67
Western	57 (10.60%)	10.26	14 (9.00%)	2.52	12 (8.30%)	2.16	11 (7.10%)	1.98	20 (23.80%)	3.60
Non-Western	215 (39.90%)	16.64	56 (35.90%)	4.33	55 (37.90%)	4.26	62 (40.30%)	4.80	42 (50.00%)	3.25
Area										
Municipality										
Municipality of Rotterdam	398 (74.10%)	14.98	105 (67.30%)	3.95	120 (82.80%)	4.52	109 (71.20%)	4.10	64 (77.10%)	2.41
Surrounding municipalities	139 (25.90%)	5.67	51 (32.70%)	2.08	25 (17.20%)	1.02	44 (28.80%)	1.80	19 (22.90%)	0.78
Missing	2		0		0		1		1	

Table 2 Providers-specific HIV diagnoses and incidence per 100,000 residents, 2015-2019[1] (continued)

	Total		GP		SHC		Hospital		Other[2]	
	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence
Degree of urbanisation										
Very high (≥2,500 addresses/km²)	403 (75.00%)	16.69	111 (71.20%)	4.6	118 (81.40%)	4.89	112 (73.20%)	4.64	62 (74.70%)	2.57
Other (<2,500 addresses/km²)	134 (25.00%)	4.98	45 (28.80%)	1.67	27 (18.60%)	1.00	41 (26.80%)	1.52	21 (25.30%)	0.78
Missing	2		0		0		1		1	
Median household income										
Highest and upper middle (≥€28,400)	199 (37.10%)	16.18	72 (46.20%)	5.85	36 (24.80%)	2.93	53 (34.90%)	4.31	38 (45.80%)	3.09
Other (<€28,400)	337 (62.90%)	8.69	84 (53.80%)	2.17	109 (75.20%)	2.81	99 (65.10%)	2.55	45 (54.20%)	1.16
Missing	3		0		0		2		1	
Distance to closest general practice (in km)[3]										
<1	489 (91.10%)	12.65	143 (91.70%)	3.70	135 (93.10%)	3.49	-	-	-	-
≥1	48 (8.90%)	3.91	13 (8.30%)	1.06	10 (6.90%)	0.81	-	-	-	-
Missing	2		0		0		1		1	
Distance to SHC (in km)[3]										
<5	292 (54.40%)	15.93	75 (48.10%)	4.09	97 (66.90%)	5.29	-	-	-	-
5-10	188 (35.00%)	9.61	66 (42.30%)	3.37	36 (24.80%)	1.84	-	-	-	-
>10	57 (10.60%)	4.33	15 (9.60%)	1.14	12 (8.30%)	0.91	-	-	-	-
Missing	2		0		0		1		1	

GP, general practitioner; *km*, kilometre; *MSM*; men who have sex with men, *No*, number; *SHC*, sexual health centre.

[1] The data underlying this table are the SHM database which includes all people living with HIV that receive care, and the population register data for incidence estimates (2015-2019).

[2] The provider group Other consists of people diagnosed abroad, diagnosed at another location and diagnosed at an unknown location.

[3] Data for provider group Hospital and Other not shown because of low number of diagnoses by the provider group Other for one distance category (N<10).

Discussion

In this cross-sectional population-based study we found large differences between subpopulations tested for HIV, and testing rates and incidence by subpopulation and geographical area. Generally, the subpopulation-specific HIV testing rate was higher for GPs than for the SHC. However, large differences were observed geographically with areas relatively close to the SHC mainly served by the SHC rather than GPs. HIV incidence was highest for men (MSM), younger age groups, non-western people and people residing in urban areas close to primary healthcare providers. For most population groups a relatively high number of diagnoses and incidence follows relatively high testing rates.

The proportion tested of the general population in the Netherlands within the study period was limited to 1.14%. No other studies reported estimates for this HIV test proportion. This proportion is substantially different compared to the 3% for chlamydia and gonorrhoea testing, which we estimated in a previous study with the same design, timespan, and study area [15]. This discrepancy indicates missed opportunities for HIV testing and provides opportunities for improvement, especially for key populations at the GP. National STI consultation guidelines recommend pre-emptive testing for multiple STIs, including HIV, for key populations and HIV testing in all with a proven STI [9-11]. Previous research also showed that GPs follow these guidelines to a limited extent [16-18].

In addition to an "offer everything" strategy for key populations, HIV testing based on HIV indicator condition is pivotal for the detection of undiagnosed HIV cases. Since 99% of the Dutch population is registered at a general practice and 75% of the population contacts the GP at least once per year, the GP is an important provider in HIV indicator guided testing. HIV testing based on HIV indicator conditions at the GP is – apart from key populations – crucial for people not typically considered at risk for HIV, such as women and heterosexual (older) people [9, 10]. The crucial role of GPs for these groups is also corroborated by our study as we found that people with HIV diagnosed at the GP were more likely to be female, heterosexual males and older compared to the SHC. These findings are in line with a previous nationwide Dutch study [17]. GP educational meetings including reviewing guideline compliance (e.g. "offer everything" strategy for key populations and HIV indicator condition guided testing for all) could increase awareness, confidence, and consideration of HIV testing [19].

In our study we also found opportunities for improved HIV testing for specific groups. Specific activities by the SHC to reach people with a low education, people from less urbanised areas and people living more distant from testing sites may be considered. This was also observed in our study on chlamydia and gonorrhoea testing, in which we additionally found that low education, urbanisation and distance to testing site were independently associated with testing [15]. We observed that these groups were underrepresented within the HIV tested population. Although almost all subpopulations are tested more by the GP than by the SHC, the contribution of the GP in the aforementioned groups is even higher. Possible explanations are that lower educated are unaware of the SHC testing services, and reduced SHC accessibility for people from less urbanised areas, which are usually also the areas further away from the testing sites. Our GP-SHC testing rate comparison by geographical area is in line with the latter: the SHC seems the dominant provider closely to the SHC, while this was the GP in areas further away from the SHC. A branch SHC in less urbanised areas and/or more outreach testing or remote testing may be considered [20]. Outreach activities, for example at community-based organisations, are also likely to reach migrant people better. Migrant people are an important key group for improved HIV testing, as they are more often diagnosed with a late-stage HIV infection [13, 21], and generally face more barriers to test [22-24].

The overall HIV incidence (2015-2019) of 10.55 per 100,000 residents in our study area is more than twice as high as the estimated nationwide incidence (4.3 per 100,000) [12]. Although, the incidence differs largely between subgroups, the observed pattern is in line with our expectations and corresponds with other literature, for example the highest incidence for 25-29 year-olds [25]. We only have information about HIV testing at GP and SHC, but we showed that generally more HIV testing is followed by a relatively high number of diagnoses and incidences. More HIV testing is likely related to easier access to testing services due to priority in policy and guidelines (for younger age groups, men (MSM), and non-western people) and the convenience of proximity (for people living more urban and closer to healthcare providers). A low testing rate was for example observed for people above 40 years, while there were a high number of new HIV cases in this group. A possible explanation is selective testing in both instances. The high number of cases may have been detected by clinical criteria for testing [26]. On the other hand, low testing rates may be due to low-risk perception (patient and provider), low awareness of HIV testing because of low HIV prevalence in non-key populations (provider), and miss preconceptions about sexuality and HIV risk for older people (provider) [26, 27].

Strengths and limitations

The strength of this study is that we linked population and laboratory data of the two main STI test providers. Herewith we ruled out responder, recall and registration biases associated with for example questionnaires [18, 28]. Further, we are the first that provide a unique and comprehensive assessment of characteristics of HIV tested individuals. Our study has some limitations. First, we were not able to include all laboratory testing data of GPs in our study area. To limit the effect of this, we corrected our testing rates and GP-SHC comparison for incomplete data. Second, the current study is limited to GPs and the SHC and has no information about HIV tests performed via other providers or online testing services. However, GPs and SHC are the main STI test providers and additionally GPs have a gatekeeper role in referring to the hospital [6]. Consequently, most opportunities for improving HIV testing are probably at the GP and SHC. Third, the findings in our study may differ to other parts of the country and other countries, and should therefore be generalised with caution. However, our study design can be applied anywhere if population microdata and individual HIV testing data are available. Fourth, the current study lacks detailed information about motives and barriers for HIV testing (e.g. presence of symptoms, notification by sex partner), both from client and provider perspective. Also extra GP client characteristics, for example whether someone is MSM, could provide valuable insight as MSM are advised to test regularly and most newly-diagnosed infections occur among MSM. However, clients' characteristics are not shared with laboratories, only registered to a limited degree in GP electronic medical records and unknown at population level [29]. Fifth, not all people with HIV diagnosed within the study period are included in the SHM data used in this study: 1) 1.1% opt-out to share their data with SHM, 2) we lack consent from all HIV treatment centres (~2% of the cases) and 3) possibly not all people with HIV in care are yet registered at SHM. Although the magnitude of diagnoses and incidence may change when including all cases, we do not expect that the direction of the findings differ as they are in line with previous studies [12, 17, 25]. Finally, for the HIV incidence estimates we were restricted to a limited set of population groups due to small numbers and because of limitations in available information in the SHM database. More accurate and additional insights in individual characteristics of people with HIV might be obtained by extending the number of study years, and by matching the SHM database to population microdata too.

Conclusions

Our findings show that GPs are the main HIV testing provider. They are especially important in less urbanised areas further away from the SHC. As new diagnoses and the proportion of people with HIV still undiagnosed are getting smaller, adherence to guidelines is important (e.g. HIV testing of key populations during STI consultation and HIV indicator guided testing). Educational meetings or other proactive interventions should encourage GPs (and other physicians) to follow test guidelines and share responsivity in the fight against HIV. Additional testing services for example via SHC branch locations and outreach activities are promising to increase (geographical) access and to test people who are usually not tested at the GP and SHC. HIV test providers, policy makers and communities are urged to collaborate to achieve this. Expanding the provision of HIV testing should be monitored to investigate whether it contributes to new diagnoses.

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Supplementary materials

Supplementary Table 1 Additional characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1]

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Total	5107921 (100.00%)	58356 (100.00%; 1.14%)	37150 (100.00%; 0.73%)	22394 (100.00%; 0.44%)	1.61 (1.56 - 1.65)
2015	1005596 (19.69%)	11810 (20.24%; 1.17%)	7348 (19.78%; 0.73%)	4693 (20.96%; 0.47%)	1.52 (1.43 - 1.60)
2016	1012665 (19.83%)	11862 (20.33%; 1.17%)	7343 (19.77%; 0.73%)	4753 (21.22%; 0.47%)	1.50 (1.41 - 1.58)
2017	1021033 (19.99%)	12036 (20.63%; 1.18%)	7370 (19.84%; 0.72%)	4899 (21.88%; 0.48%)	1.46 (1.37 - 1.54)
2018	1029952 (20.16%)	11571 (19.83%; 1.12%)	7514 (20.23%; 0.73%)	4301 (19.21%; 0.42%)	1.69 (1.61 - 1.78)
2019	1038675 (20.33%)	11077 (18.98%; 1.07%)	7575 (20.39%; 0.73%)	3748 (16.74%; 0.36%)	1.96 (1.87 - 2.04)
Individual					
Age (in years)					
15-19	350154 (6.86%)	3602 (6.17%; 1.03%)	1961 (5.28%; 0.56%)	1718 (7.67%; 0.49%)	1.11 (0.97 - 1.25)
20-24	407977 (7.99%)	12515 (21.45%; 3.07%)	5565 (14.98%; 1.36%)	7242 (32.34%; 1.78%)	0.74 (0.66 - 0.82)
25-29	445054 (8.71%)	14222 (24.37%; 3.20%)	8338 (22.44%; 1.87%)	6215 (27.75%; 1.40%)	1.30 (1.22 - 1.37)
30-34	423086 (8.28%)	9378 (16.07%; 2.22%)	6704 (18.05%; 1.58%)	2867 (12.80%; 0.68%)	2.27 (2.17 - 2.36)
35-39	396052 (7.75%)	5964 (10.22%; 1.51%)	4487 (12.08%; 1.13%)	1580 (7.06%; 0.40%)	2.75 (2.62 - 2.87)
40-44	398681 (7.81%)	4115 (7.05%; 1.03%)	3287 (8.85%; 0.82%)	905 (4.04%; 0.23%)	3.52 (3.36 - 3.68)
45-49	440438 (8.62%)	3132 (5.37%; 0.71%)	2534 (6.82%; 0.58%)	643 (2.87%; 0.15%)	3.80 (3.62 - 3.99)
50-54	435597 (8.53%)	2294 (3.93%; 0.53%)	1785 (4.80%; 0.41%)	537 (2.40%; 0.12%)	3.22 (3.01 - 3.42)
55-59	404668 (7.92%)	1537 (2.63%; 0.38%)	1229 (3.31%; 0.30%)	327 (1.46%; 0.08%)	3.65 (3.39 - 3.91)
60-64	358974 (7.03%)	795 (1.36%; 0.22%)	623 (1.68%; 0.17%)	176 (0.79%; 0.05%)	3.40 (3.04 - 3.75)
65-69	332917 (6.52%)	438 (0.75%; 0.13%)	339 (0.91%; 0.10%)	107 (0.48%; 0.03%)	3.08 (2.61 - 3.54)
70-74	259560 (5.08%)	220 (0.38%; 0.08%)	184 (0.50%; 0.07%)	44 (0.20%; 0.02%)	4.21 (3.50 - 4.92)
≥75	454763 (8.90%)	144 (0.25%; 0.03%)	114 (0.31%; 0.03%)	33 (0.15%; 0.01%)	3.35 (2.53 - 4.18)

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■ **Supplementary Table 1** Additional characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1] (continued)

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Migratory background by age					
Western					
<25 years	489965 (12.84%)	8090 (25.90%; 1.65%)	3778 (18.85%; 0.77%)	4451 (37.82%; 0.91%)	0.82 (0.73 - 0.92)
≥25 years	3325745 (87.16%)	23151 (74.10%; 0.70%)	16264 (81.15%; 0.49%)	7318 (62.18%; 0.22%)	2.15 (2.09 - 2.22)
Non-Western					
<25 years	268166 (20.75%)	8027 (29.60%; 2.99%)	3748 (21.91%; 1.40%)	4509 (42.44%; 1.68%)	0.81 (0.71 - 0.90)
≥25 years	1024045 (79.25%)	19088 (70.40%; 1.86%)	13360 (78.09%; 1.30%)	6116 (57.56%; 0.60%)	2.11 (2.04 - 2.18)
Education level[4]					
Low	1107656 (34.35%)	1107656 (27.38%; 1.30%)	9746 (29.75%; 0.88%)	4882 (23.52%; 0.44%)	1.94 (1.86 - 2.02)
Medium	1294141 (40.13%)	1294141 (47.17%; 1.91%)	14924 (45.56%; 1.15%)	10353 (49.87%; 0.80%)	1.40 (1.34 - 1.45)
High	822707 (25.51%)	822707 (25.45%; 1.62%)	8088 (24.69%; 0.98%)	5525 (26.61%; 0.67%)	1.41 (1.34 - 1.49)
Missing	1883417	5932	4392	1634	
Area					
Degree of urbanisation					
Very high (≥2500 addresses/km^2)	2414666 (47.29%)	41598 (71.30%; 1.72%)	25382 (68.34%; 1.05%)	17147 (76.58%; 0.71%)	1.43 (1.38 - 1.47)
High (1500-2500 addresses/km^2)	1548797 (30.33%)	12013 (20.59%; 0.78%)	8418 (22.66%; 0.54%)	3805 (16.99%; 0.25%)	2.18 (2.10 - 2.27)
Moderate (1000-1500 addresses/km^2)	690718 (13.53%)	2968 (5.09%; 0.43%)	2043 (5.50%; 0.30%)	956 (4.27%; 0.14%)	2.11 (1.94 - 2.27)
Low (500-1000 addresses/km^2)	295389 (5.78%)	1288 (2.21%; 0.44%)	971 (2.61%; 0.33%)	329 (1.47%; 0.11%)	2.72 (2.45 - 2.99)

Supplementary Table 1 Additional characteristics of general and HIV tested population, and GP-SHC comparison of HIV testing rates, 2015-2019[1] (continued)

	General population	Tested[2]	Tested by GP[2]	Tested by SHC[2]	Mean HIV testing rates GP vs. SHC[2]
	No (%)	No (%; row%)	No (%; row%)	No (%; row%)	RR (95% CI)[3]
Rural (<500 addresses/km^2)	156723 (3.07%)	476 (0.82%; 0.30%)	327 (0.88%; 0.21%)	153 (0.68%; 0.10%)	2.01 (1.60 - 2.42)
Missing	1628	13	9	4	
Median household income					
Highest (>€36,600)	1155750 (22.64%)	6304 (10.81%; 0.55%)	4402 (11.85%; 0.38%)	1990 (8.89%; 0.17%)	2.10 (1.98 - 2.21)
Upper middle (€28,400 - €36,600)	74093 (1.45%)	672 (1.15%; 0.91%)	387 (1.04%; 0.52%)	293 (1.31%; 0.40%)	1.24 (0.92 - 1.57)
Middle (€22,200 - €28,400)	1944899 (38.09%)	17985 (30.83%; 0.92%)	11690 (31.48%; 0.60%)	6650 (29.70%; 0.34%)	1.73 (1.66 - 1.80)
Lower middle (€16,800-€22,200)	1868444 (36.59%)	31996 (54.84%; 1.71%)	19834 (53.40%; 1.06%)	12848 (57.39%; 0.69%)	1.49 (1.44 - 1.54)
Lowest (<€16,800)	62792 (1.23%)	1384 (2.37%; 2.20%)	827 (2.23%; 1.32%)	608 (2.72%; 0.97%)	1.30 (1.08 - 1.53)
Missing	1943	15	10	5	

CI, confidence interval; *GP*, general practitioner; *km*, kilometre; *No*, number; *RR*, rate ratio; *SHC*, sexual health centre; *STI*, sexually transmitted infection.

[1] The data underlying this table are the GP and SHC laboratory data, and the population register data (2015-2019).

[2] Proportion tested is based on the raw numbers. The mean HIV testing rates (number of HIV tests per 1,000 residents) are calculated over the study period of 5 year and corrected for data incompleteness. The number of tests by SHC was corrected with 1/0.88, considering the 88% match between SHC and population data. For each municipality, the number of tests by the GP was corrected by 1/coverage (municipality specific). The corrected SHC numbers are on average 13% higher (min. 9% - max. 15%), and the corrected GP numbers on average 9% higher (min. 4% - max. 13%).

[3] Comparison of HIV testing rate, with SHC as reference.

[4] The International Standard Classification of Education was used as basis (European Commission; available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_Standard_Classification_of_Education_(ISCED)#:~:text=ISCED%201%3A%20Primary%20education,Post%2Dsecondary%20non%2Dtertiary%20education).

Supplementary Table 2 Providers-specific HIV diagnoses and incidence per 100,000 residents by year, 2015-2019[1]

	Total		GP		SHC		Hospital		Other[2]	
	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence	No. (%)	Incidence
Total	539	10.55	156	3.05	145	2.84	154	3.01	84	1.64
2015	134 (24.90%)	13.33	39 (25.00%)	3.88	40 (27.60%)	3.98	32 (20.80%)	3.18	23 (27.40%)	2.29
2016	116 (21.50%)	11.45	26 (16.70%)	2.57	34 (23.40%)	3.36	32 (20.80%)	3.16	24 (28.60%)	2.37
2017	115 (21.30%)	11.26	38 (24.40%)	3.72	26 (17.90%)	2.55	37 (24.00%)	3.62	14 (16.70%)	1.37
2018	81 (15.00%)	7.86	24 (15.40%)	2.33	26 (17.90%)	2.52	18 (11.70%)	1.75	13 (15.50%)	1.26
2019	93 (17.30%)	8.95	29 (18.60%)	2.79	19 (13.10%)	1.83	35 (22.70%)	3.37	10 (11.90%)	0.96

GP, general practitioner; *No*, number; *SHC*, sexual health centre.

[1] The data underlying this table are the SHM database which includes all people living with HIV that receive care, and the population register data for incidence estimates (2015-2019).

[2] The provider group Other consists of people diagnosed abroad, diagnosed at another location and diagnosed at an unknown location.

CHAPTER 7

Community-based HIV testing through a general health check event in a high HIV prevalent multicultural area in Rotterdam, the Netherlands: a pilot study on feasibility and acceptance

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Pilot Feasibility Stud 2023;9(1):101

Abstract

Background
HIV testing is crucial for finding the remaining cases in a declining HIV epidemic in the Netherlands; providing HIV testing in non-traditional settings may be warranted. We conducted a pilot study to determine the feasibility and acceptability of a community-based HIV testing (CBHT) approach with general health checks to improve HIV test uptake.

Methods
CBHT's main conditions were low-threshold, free-of-charge, general health check, and HIV education. We interviewed 6 community leaders, 25 residents, and 12 professionals/volunteers from local organizations to outline these main conditions. Walk-in test events were piloted at community organizations, providing HIV testing along with body mass index (BMI), blood pressure, blood glucose screening, and HIV education (October 2019 to February 2020). Demographics, HIV testing history, risk perception, and sexual contact were collected via questionnaires. To evaluate the pilots' feasibility and acceptance, we utilized the RE-AIM framework and predefined goals, incorporating quantitative data from the test events and qualitative input from participants, organizations, and staff.

Results
A total of 140 individuals participated (74% women, 85% non-Western, median age 49 years old). The number of participants during the seven 4-h test events ranged from 10 to 31. We tested 134 participants for HIV, and one was found positive (positivity 0.75%). Almost 90% of the participants were never tested or>1 year ago, and 90% perceived no HIV risk. One-third of the participants had one or more abnormal test results on BMI, blood pressure, or blood glucose. The pilot was well-rated and accepted by all parties. The staff had concerns about waiting time, language problems, and privacy. Participants hardly indicated these concerns.

Conclusions
This CBHT approach is feasible, acceptable, and well-suited for testing not (recently) tested individuals and detecting new cases. Besides reducing HIV-associated stigma and increasing HIV test acceptance, offering multiple health tests may be appropriate as we frequently observed multiple health problems. Whether this laborious approach is sustainable in the micro-elimination of HIV and should be deployed on a large scale is questionable. CBHT like ours may be suitable as a supplement to more sustainable and cost-effective methods, e.g., proactive HIV testing by general practitioners and partner notification.

Key messages regarding feasibility

- **What uncertainties existed regarding the feasibility?**
  HIV testing continues to be a key strategy in case finding. Providing HIV testing in non-traditional settings may be warranted in the micro-elimination of HIV in the Netherlands. There are limited studies on community-based HIV testing and multi-disease testing approaches in high-income countries, like the Netherlands.
- **What are the key feasibility findings?**
  Offering a rapid HIV test combined with other health tests at community organizations was feasible, acceptable, and well-rated by participants, stakeholders, and staff. The approach was effective in testing not (recently) tested persons and detecting new cases.
- **What are the implications of the feasibility findings for the design of the main study?**
  The results of this study inform how to design and conduct community-based HIV testing with a multi-disease approach. However, it is unclear whether this laborious approach outweighs finding the last fraction of unidentified HIV cases, and whether it should be conducted on a large scale.

Background

Over the last decade, significant efforts have been made to tackle the global HIV epidemic, especially after the introduction of the UNAIDS 90-90-90 targets [1]. The UNAIDS targets have been recently revised to 95-95-95 by 2025 [2]. The Netherlands nearly achieved the 95-95-95 targets in 2019; 93% of people living with HIV (PLHIV) are aware of their HIV status, 93% of those diagnosed are on antiretroviral therapy, and 96% of those under treatment have viral suppression [3]. However, there are large regional differences in the Dutch HIV epidemic, with nearly half of all PLHIV residing in one of the four largest cities of the Netherlands, including Amsterdam and Rotterdam [3].

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With the declining HIV epidemic in the Netherlands, we currently enter the phase of micro-elimination of HIV. A geographically targeted approach may be warranted and more effective as HIV prevalence varies greatly across the country, even within regions and cities [4]. While focusing on more regional approaches, HIV testing continues to be a key strategy. Many barriers undermine HIV testing uptake at the individual (e.g., low-risk perception, fear of disease, discrimination and judgment, limited knowledge), healthcare provider (e.g., no proactive testing, unease to discuss HIV/sexual behavior, fear of discriminating, insufficient time) and at health service (e.g. location, waiting time, costs) levels [5-7]. To overcome these barriers, other approaches are introduced to increase HIV testing. Outreach community-based HIV testing (CBHT) is seen as an acceptable and effective strategy to overcome most provider and health service level barriers, and thereby reach populations not accessing healthcare settings and/or populations that have not recently or never tested before [8]. However, individual barriers like fear of stigma could still affect CBHT participation. Integration of HIV testing into a broader service delivery with less stigmatized non-communicable diseases (e.g. hypertension screening) could normalize HIV testing and thus reduce stigma and increase HIV test uptake [9, 10].

In contrast to several low- and middle-income countries, CBHT interventions combining HIV testing with other general health tests are infrequently documented for high-income countries [8, 11-13]. To our knowledge, the Netherlands limits outreach activities on HIV testing to occasional events and mostly targets high risk groups, for example, around World AIDS Day [14, 15]. The Public Health Service (PHS) of Rotterdam aimed to assess the feasibility and acceptability of an intervention to improve HIV test uptake in the general population by offering an HIV test combined with more general health tests in a community setting in the city of Rotterdam, the Netherlands. To evaluate the feasibility and acceptance, we utilized the RE-AIM framework that describes the reach, effectiveness, adaptation, implementation, and maintenance of the pilot [16].

Methods

Study design

This pilot study employed an observational cross-sectional design. For the evaluation we applied the RE-AIM framework with both quantitative and qualitative data.

Input stakeholders

We conducted a pilot CBHT intervention (hereafter: test event) with a community participatory approach to improve HIV testing uptake. First, we selected an intervention area (neighborhood) in Rotterdam that ranked as highest on HIV prevalence (6.6 per 1000 residents) and proportion of residents with a non-western migratory background (66.0%), an important key population in the Netherlands [3, 17, 18]. Second, individual semi-structured interviews were conducted with community leaders ($N = 6$), residents ($N = 25$), and professionals and volunteers from local organizations ($N = 12$) from the selected area to solicit advice on the design and implementation of the test events. Stakeholders were recruited through snowball sampling (i.e., recruiting within stakeholders' social networks). Interviews were transcribed verbatim. Barriers and facilitators for HIV testing were identified via inductive qualitative content analysis. The stakeholders' recommendation to improve HIV testing uptake included the following:

1. Combine HIV testing with more general health tests to overcome HIV-related taboo/stigma.

2. Create a low-threshold setting by offering free-of-charge anonymous rapid HIV tests at non-medical locations that residents already visit and link up with existing activities, which ensures relatively little effort for residents and an opportunity to test unseen.
3. Include HIV education since knowledge was estimated as low.

Based on these suggestions, a general health check test event was designed (HIV test, body mass index (BMI), blood pressure (BP), and blood glucose (BG)). We conducted a trial run before the pilot launch. This pre-testing took place in the week before World AIDS Day 2018. No major adjustments were necessary.

Procedures

Seven 4-h walk-in test events were held at three community organizations (October 2019 to February 2020): once at a boxing school, three times at a community center, and three times at a community support organization where mainly women with a migratory background come to socialize.

Test events were announced by community leaders (e.g., word of mouth, social media, and community organizations' website), via the PHS website and social media, and by posters and leaflets in the neighborhood among others at locations of interviewed community organizations. If walk-in was considered as low, passers-by and people present at nearby organizations were actively invited.

Each eligible person (≥18 years) that walked in was informed about the test event and procedure. Those who declined to participate were asked for their reason (non-participants). Participants filled out an informed consent form. The test event was organized in three different stops. First, a questionnaire was administered orally and anonymously by a researcher with questions about sociodemographics, HIV testing behavior, HIV risk perception, and sexual contact. In addition, we asked women if they had children and the children's years of birth. Women with pregnancy after 2003 have most likely been tested for HIV as part of a national HIV screening program [19]. At the second stop, BMI was computed with weight and height measures, and BP was checked. The last stop included BG measurement and HIV testing via a finger-prick blood sample. We used the INSTI™ HIV1/HIV2 Rapid Antibody test (Biolytical TM, Laboratories Inc., Richmond, BC, Canada), which yields the HIV test result within 1 min. A sexual health nurse of the PHS performed the HIV test, communicated the HIV test result, and provided counseling. Participants received a record of their test results including links to reliable health websites and were given verbal health advice. If results on BMI, BP, or BG fell outside the recommended guidelines, and participants were not yet aware of this, they received a letter for their general practitioner (GP) [20-22]. A positive rapid HIV test was followed by a consultation at the PHS within 24 h. After rapid laboratory confirmation of the HIV infection, the participant received counseling and was referred to specialized HIV care according to regular procedures. All services were provided free of charge and anonymously. Before the start and in between stops, waiting time could be filled with an educational true or false game with facts and myths about HIV. The game was led by a health educator or a peer living with HIV, who would then discuss the answers with the participants. The peer was also present for counseling after a positive rapid HIV test.

Evaluation

To guide our evaluation, we utilized the RE-AIM framework. To examine *Reach*, the demographic characteristics of the study population are described and compared to the target population, i.e., the residents within the selected geographical area. The study population is also described in terms of their health and HIV testing history, as this reflects the value of targeting this population, and whether they might benefit from health checks. Predefined quantitative goals were assessed to determine whether the pilot had the ability to reach the preferred population. **Table 1** gives an overview of these goals and the rationale behind the goals. The proportion of non-participants and the reason for non-participation are provided as well. The outcome *Effectiveness* is embodied by the uptake of HIV testing by participants at the test events. Indicators of acceptability, and perceived usefulness of the intervention design (e.g. actively offered, part of general health check), are also included. For *Adaption*, the willingness to participate and engagement of community organizations was used as indicators. The focus of *Implementation* is on the key successes and challenges of the test events, based on feedback from participants, community leaders and staff involved in events. The staff and community leaders' experiences with the test events are also explored. *Maintenance* is operationalized as the value and willingness to continue the pilot according to community leaders and staff.

For the RE-AIM dimensions and indicators, we used the following quantitative and qualitative data sources:

1. Quantitative data collected during the test events, such as questionnaires from participants and health results from participants (*Reach, Effectiveness*)
2. A short smiley rated questionnaire among participants (not good, neutral, good, very good), evaluating different aspects of the program, including location, waiting time, staff, provided information, the combination HIV test with other health tests, general atmosphere, and privacy (*Effectiveness, Implementation*)
3. Interviews with the community leader on location about the experiences of the test event (*Reach, Effectiveness, Adoption, Implementation, Maintenance*)
4. Questionnaires among staff about experiences and whether the events had been performed as intended (*Reach, Effectiveness, Adoption, Implementation, Maintenance*)

5. One closing focus group discussion (FGD) with the key staff. All evaluation questionnaires and interviews served as input for the FGD (*Reach, Effectiveness, Adoption, Implementation, Maintenance*)

Table 1 Overview of predefined quantitative goals regarding the preferred population and the goal rationale

No	Goal	Goal rationale
1	Minimum of 25 persons per test event	Number of participants during the pre-test (*N* = 25) and estimated capacity to include in all stops in 4 h
2	No selective reach	Sociodemographics of participants reflects the area's composition based on sex, age and migratory background [18]
3	70% first-time HIV testers	▪ Two national representative studies from the Netherlands and Britain that reported 16-25% was tested at least once for HIV (i.e., 75-84% never tested) [23,24] ▪ We downscaled the proportion first-time testers to 70%, because our pilot was conducted in a highly urbanized area that harbors a relatively high proportion of non-western residents, which is associated with higher proportions of people who have been tested at least once [23,24]
4	80% not recently tested for HIV (i.e., >12 months)	Two national representative studies from the Netherlands and Britain that reported 14-23% of the population was tested in the last year (i.e., 77-86% not recently tested) [23,24]
5	HIV positivity of 0.33-0.66%	Comparable to area's HIV positivity (0.33-0.66%) [17]

Data analysis

Quantitative data included participant questionnaires (*N* = 140), health results (*N* = 138), and participant smiley ratings (*N* = 115). These data were anonymously registered and analyzed using SPSS (version 26). All data were categorical, and age was condensed into four categories standardly used by Statistics Netherlands. Due to the small number of participants, detailed subgroup analysis could not be performed (e.g., by sex and migratory background). Qualitative data were collected from staff questionnaires (*N* = 29), interviewer field notes from interviews with community leaders (*N* = 7), and one FGD with staff. Key themes were extracted from the free text responses in questionnaires and interviewer field notes through document analysis using an inductive process. The FGD was transcribed verbatim, and themes were identified using content analysis.

Ethics statement

The Medical Ethics Committee of the Erasmus Medical Center, Rotterdam, the Netherlands, decided that this study did not require Institutional Review Board approval (MEC-2019-0431). All participants signed written informed consent after they were made clear that participation in this study was voluntary and anonymous and that they could refuse or discontinue their participation at any time.

Results

A total of 178 persons were registered as either participants (*n* = 140; 78.7%) or non-participants (*n* = 38; 21.3%) during seven 4 h walk-in test events at three community organizations between October 2019 and February 2020. Not every participant answered all questions in the questionnaire and did all health tests, due to language barriers or time constraints by the participant.

Reach

Participants' sociodemographics

The number of participants per event ranged from 10 to 31. Based on the number of participants during the pre-test, we aimed for a minimum of 25 persons per test event. This was only achieved at two of the seven test events (**Table 2**).

■ **Table 2** Achievement of predefined goals

No	Goal	Goal achievement
1	Minimum of 25 persons per test event	Partially achieved: 2 out of the 7 test events had ≥25 participants (26 and 31 participants), the remaining test events had 19 participants (3 times), 16 participants or 10 participants
2	No selective reach	Not achieved (Table 3)
3	70% first-time HIV testers[a]	Not achieved: ▪ Not corrected: 65.4% (*n* = 83/127) ▪ Corrected[b]: 52.8% (*n* = 67/127)
4	80% not recently tested for HIV (i.e., >12 months)[c]	Achieved: ▪ Not corrected: 80.0% (*n* = 28/35)[d] ▪ Corrected[b]: 87.3% (*n* = 48/55)[d]
5	HIV positivity of 0.33-0.66%	Achieved: 0.75%; 95% CI: 0.02-4.09% (*n* = 1/134)

CI, confidence interval.

[a] Among all participants tested for HIV at the test events, and that had information on HIV testing history

[b] We asked women if they had children and the children's years of birth to correct for national HIV screening among pregnant women (pregnancy after 2003). Women who had a child after 2003 but did not report being tested for HIV were reclassified into the tested group

[c] Among all participants previously tested for HIV, and that had information on HIV testing history

[d] 5 participants were excluded for whom the duration since their last HIV tests was unknown

The sociodemographics of the 140 participants are presented in Table 3. The most common non-Western migratory backgrounds were Moroccan (*n* = 43/119, 36.1%), Sub-Sahara African (*n* = 23/119, 19.3%), Surinamese (*n* = 22/119, 18.5%), and Turkish (*n* = 19/119, 16.0%). The participants were not representative of the residents within the selected geographical area. Participants were more often women, non-Western, and middle-aged (**Table 3**).

Table 3 Sociodemographic characteristics of participants and neighborhood residents

	Participants	**Residents**[a]
	N (%)	N (%)
Total (min, max)	140 (10 - 31)	9445
Gender		
Men	36 (25.7%)	4745 (50.2%)
Women	104 (74.3%)	4700 (49.8%)
Migratory background[b]		
Dutch/Western	21 (15.0%)	4040 (42.8%)
Non-Western	119 (85.0%)	5405 (57.2%)
Age[c]		
18 - 24 years	13 (9.3%)	1395 (17.0%)
25 - 44 years	46 (32.9%)	3055 (37.2%)
45 - 64 years	58 (41.4%)	2354 (28.7%)
65 years and older	23 (16.4%)	1400 (17.1%)
Median (IQR)	49 (37 – 60)	NA
Mean (min, max)	48 (18 – 81)	NA
Level of education		
None	21 (15.0%)	NA
Low	44 (31.4%)	NA
Middle	32 (22.9%)	NA
High	14 (10.0%)	NA
Others/unknown	29 (20.7%)	NA
Sexual contact		
Heterosexual	100 (98.0%)	NA
MSM	2 (2.0%)	NA
No answer/missing	38	NA

IQR, interquartile range; *max*, maximum; *min*, minimum; *MSM*, men who have sex with men; *NA*, not available.
Numbers and percentages unless stated otherwise.

[a] Based on all residents in the selected intervention area (2019); no age selection was possible.

[b] Based on participants' and partners' country of birth.

[c] Due to the standard classification of age groups used by Statistics Netherlands, no age selection was possible for residents, only 5-years age groups were available. N (%) in the resident column reflects the age group 15 to 24 year.

HIV testing history and perceived risk

Figure 1 shows the HIV testing history by subgroup, and Table 2 shows whether the predefined goals regarding first-time tested and recent tested are achieved. After correction for pregnancy screening, 52.8% (*n* = 67/127) of the participants were not previously tested. The proportion never tested was highest among people with a non-Western migratory background, people aged ≤24 years and people ≥65 years

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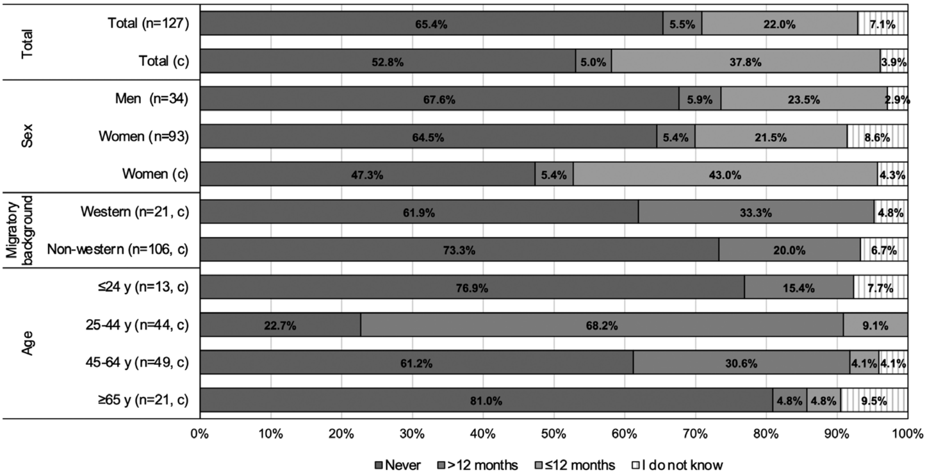
(**Fig. 1**). Among those tested before, this was >12 months ago for 87.3% (n = 48/55). The most recent HIV test was performed mostly at the GP (29.4%), where the most frequently cited reason was medical complaints (42.2%). Nearly one quarter (23.5%) of the participants had their most recent test at the obstetrician in relation to pregnancy.



■ **Fig. 1** HIV testing history, by sex, migratory background, and age group (N = 127)

Based on all participants tested for HIV during the test events that had information on HIV testing history.
Rows with (c) are corrected for national HIV screening among pregnant women (pregnancy after 2003).
y, year

In general, participants perceived themselves as not at risk for HIV: 57.4% (n = 66/115) indicated no HIV risk and 33.0% (n = 38/115) a very small risk. The rest (9.6%, n = 11/115) indicated that they did not know their risk. Future HIV risk was perceived comparably: 53.4% (n = 62/116) indicated no risk, and 31.9% (n = 37/116) a very small risk. Slightly more than one in ten (n = 17/116) indicated that they did not know their HIV risk in the future (*You never know what will happen in the future*).

Health results

Table 4 shows the number of participants per health test and the proportion with an abnormal result. Overall, approximately one-third had at least one result that required a referral to their GP, of which many were not previously aware of the health problem. Specifically, more than half of the participants were unaware of their abnormal BP, while two-fifths were unaware of their abnormal BG levels, and one-third were unaware of their abnormal BMI.

■ **Table 4** Number of participants per health test and the proportion with an abnormal test result

	Participants	Abnormal test result[a]	Unaware of abnormal test result in advance
	n/*N* (%)	n/*N* (%)	n/*N* (%)
Body Mass Index	135/140 (96.4%)	55/135 (40.7%)	19/55 (34.6%)
Blood pressure	138 /140 (98.6%)	45/138 (32.6%)	24/45 (53.3%)
Blood glucose	137/140 (97.9%)	17/133[b] (12.8%)	7/17 (41.2%)
HIV	134/140 (95.7%)	1/134 (0.75%)	1/1 (100.0%)

[a] Fell outside recommended ranges in national guidelines. The denominator varies per health test due to participants' time constraints and language barrier

[b] Test result not registered for 4 tested individuals.

The non-HIV tests were offered merely to improve the acceptability and uptake of HIV testing; hence, these results are not reported in detail here. The one HIV-positive case was a heterosexual woman with a non-Western migratory background. As a result, our pilot had a HIV positivity of 0.75% (95% confidence interval: 0.02-4.09%), by which the predefined goal of positivity is achieved.

Non-participants

Thirty-eight persons (16 men and 22 women) did not participate after receiving information about the test event. Almost 40% (*n* = 15/38) reported a practical reason for not participating (i.e., other appointments, work/internship). Around 20% (*n* = 9/38) recently visited a doctor, but not specially for HIV. The rest mentioned various reasons for non-response (e.g., scared of blood, taped hands due to boxing lessons, “not interested”).

Effectiveness

Participation and reason for HIV testing

Out of the 140 participants of the test events, 134 (95.7%) opted for an HIV test. The remaining participants who did not receive an HIV test cited time constraints or there was a language barrier that prevented the staff from adequately explaining the information about HIV testing. Almost 90% (*n* = 111/127) of the participants had not undergone an HIV test either in the past 12 months (*n* = 28/111) or ever before (*n* = 83/111).

When participants were asked for their reason to test for HIV during the test event, 88.6% (*n* = 124/140) gave at least one reason. Most frequently mentioned reasons were to be certain (47.6%), no special reason (24.2%), because it is free-of-charge (16.9%), and because multiple tests were offered (15.3%). Participants also indicated the convenience of the test event: *At the GP you only test if you are ill, here you just enter, and you can test. This is nice and easier.*

Acceptability of HIV testing

All participants expressed willingness to undergo HIV testing. Moreover, participants reported a higher likelihood of undergoing an HIV tests when initiated by their GP (72.2%, $n = 84/118$), as opposed to them having to request it themselves (38.1%, $n = 45/118$). The majority of participants (73.8%) indicated that they would prefer to receive a reason from their GP for recommending the HIV test, but they would still undergo the test regardless (*He doesn't just ask, He probably has a good reason*). More than half (54.7%) of the participants suggested that HIV testing should always be free-of-charge, like at the test events.

Stigma reduction and increasing knowledge

The staff and community leaders observed that participants engaged in open conversations about HIV and health in general. They suggested that such discussions may contribute to reducing the stigma and taboo associated with HIV. The staff and community leaders reported that test events contributed to increased knowledge and openness, and helped reduce HIV-related stigma by normalization and taboo reduction. This was facilitated by the game provided during waiting time. One community leader said: *A lot of people did not know what HIV was, but because of today they know*. This was further supported by the participants themselves. One participant reported: *I didn't know about HIV, but now I do*, while another noted that: *When people talk more about it [HIV], taboo decreases. This [test event] also helps!*. Additionally, both the staff and community leaders mentioned that the presence of a CBHT in general, positively contributed to the attitudes and knowledge about HIV/PLHIV.

Adoption

Establishing and maintaining contact with community organizations required frequent communication, persistence, and the importance of finding the right person. The most effective approach to establishing contact with the organizations was through in-person visits, rather than e-mail or telephone communication. This informal and personal interaction also facilitated the development of a network and trust by the organization.

The involvement of the community leaders and professionals of local organizations was essential for the successful adoption of the test events. Community leaders and professionals from local organizations gave advice about the design and implementation of the test events. This process created local support for the test events. A wide range of local organizations were interviewed, e.g. healthcare organizations, various types of community support organizations, organizations facilitating social gatherings or courses, and sports facilities. Although some interviewed organizations were surprised about the topic of HIV, they were all willing to cooperate by opening up their location for the test events and/or by promoting the events through hanging posters, distributing flyers, and via their social media platforms. Test event locations were chosen based on features, such as having separate rooms or the possibility to place the test bus in front of the location, as well as the population visiting these organizations (e.g., diverse group, young people). The initial plan was to involve local health professionals as well, such as general partitioners or district nurses. However, we did not succeed to involve them in the test events, because of their lack of time and commitment to other priorities.

The facilities at the test events at the community center and support organization were rated as sufficient by the staff. The boxing school was found to be inadequate in terms of providing sufficient privacy and workspace that met professional standards, as the pre-arranged spaces were occupied by athletes. In addition, young people did not participate as they only stayed for their training. Staff questionnaires and interviews with community leaders were among others used to evaluate which people were reached during the pilot. This guided the planning of future test events, including reaching out to involved and new organizations serving different population groups than those already reached. Test events to reach other population groups, including men and youngsters, via a barbershop and a youth organization, were canceled due to the COVID-19 pandemic.

Implementation

Planning and execution

The test events were extensively planned. Whenever possible, the date and time of the test events were scheduled to coincide with other events taking place at the location, ensuring that the target group would be present. The test events were generally carried out as planned. The high level of flexibility of the staff ensured that any problems that arose on the day of the test event were resolved swiftly (e.g., last-minute changes to rooms due to them being occupied by other events). The significance of having multiple test events at a single community organization was recognized as it promoted better collaboration between the organization and staff, and facilitated the planning of future test events. Moreover, the test bus helped in raising awareness among local residents about the test events. Additionally, the staff indicated that maintaining a consistent team composition throughout the test events was advantageous for fostering interaction, cooperation and contact with the community (leaders) and residents.

One of the major challenges was the labor-intensive nature of the approach, particularly during the preparation phase. This involved searching for benevolent organizations and individuals for the needs assessments, conducting the needs assessment, maintaining communication with stakeholders, developing materials (e.g., questionnaires, posters and leaflets), and checking suitable locations. Another challenge was managing waiting times during the test events. Waiting time was the lowest scored item by participants, with 3.5% (n = 4/116) rating it as not good and 13% (n = 15/116) as neutral. The staff was also critical about the waiting time when a high volume of concurrent walk-ins resulted in longer than desired waiting times. Language barrier was the main challenge mentioned by the staff, particularly during the questionnaire administration, and to a lesser extent, during other stops. The staff expressed concerns that the lack of understanding could have negatively affected the comprehension of the procedure and the reliability of the participants' answers. In cases where the staff felt the participants' understanding was low, (hypothetical) questions were sometimes skipped. In some instances, participants translated for each other, which staff felt compromised privacy. However, in general, participants did not express concerns about language barriers and privacy, even when the staff attempted to intervene to improve privacy (for example, when a surveyed participant expressed a desire for other participants to stay).

Recruitment was also a challenge. Both the staff and community leaders were dissatisfied with the overrepresentation of Moroccan and Turkish women above 40 years. One community leader explained: *Men did not want to participate because the location was predominately occupied with women and this scared the men*. However, a relatively homogenous population was also considered as beneficial, as participants had in-depth discussions on health and HIV with each other and the staff.

Experiences and feedback

Over 80% of the participants rated the various aspects of the pilot as (very) good. Furthermore, they were appreciative of the provided actions in their community: *I am happy. This event came here out of nowhere! And happy with the test results!* Community leaders also expressed high satisfaction with the program and the attention to "their people". Both the staff and community leaders emphasized that the pilot's core elements (within the community, general health check, and free-of-charge) helped to reach first-time testers and did not encounter stigma-related issues to HIV testing. In addition, community leaders and participants were positive about the game and indicated they learned new information. The staff indicated that participants who played the game before the first stop at the test event were better informed about HIV.

The involvement of community leaders was considered valuable, especially in recruiting participants. Although it was indicated as labor-intensive by the staff, continuous contact with the community leaders, and repeated presence at locations, created a network and trust, which benefited the execution of the test events. Community leaders appreciated the contact and involvement, especially during the input phase. None of the community leaders found that the preparation and execution of the test events (time) demanding. Community leaders did feel responsible for recruitment.

Maintenance

All community organizations that provided their location for the test events were willing to facilitate in future test events. Participants also indicated that they wanted to participate again in the future (*continue with this initiative*). During the test events, some participants called family and friends and urged them to come and test. Several participants wrote that there should be more test events, with one participant explaining: *people go to the doctor too late*. Despite the success and perceived usefulness of the test events for the residents, the staff expressed hesitancy to continue due to the labor-intensive, and therefore costly, nature of the events. Nonetheless, the staff acknowledged the value of a wide range of health tests, including HIV testing. A collaboration with other health programs and/or improve HIV testing at GP was seen as more sustainable.

Discussion

This study showed the pilot CBHT intervention, a combination of an HIV test with other health checks, to be feasible and acceptable. While not all predefined goals were achieved, the pilot was well-rated by all parties involved and successfully reached many first-time and not recently tested individuals with low perceived HIV risk. We found one positive HIV participant (HIV positivity of 0.75%).

The developed CBHT intervention met most recommendations of the stakeholders, and was considered as low-threshold due to its features such as decentralization, anonymity, and free-of-charge rapid HIV testing. This is supported by other studies [25-29]. Participants did not report any doubts about HIV testing, which seems to underpin the low-threshold setting. Non-participants mainly cited practical reasons for not participating (e.g. other appointment, work). Another stakeholder recommendation was to increase HIV knowledge. Although not quantitatively measured, the educational game was well received and may have positively impacted knowledge and attitudes about HIV/PLWH. Both increasing knowledge about HIV and combining HIV testing with other non-stigmatized health tests can help to normalize and reduce stigma related to HIV and HIV testing [9, 30-37]. No instances of HIV-related stigma were observed by the staff and the community leaders during the test events.

CBHT can increase the likelihood of reaching and testing key populations, particularly, in areas where they are concentrated. This suggests that more geographically targeted approaches may be effective in improving HIV testing uptake

[3, 4, 29]. In the Netherlands, people with a non-Western migratory background are an important key population for HIV, alongside men who have sex with men (MSM) [3, 18]. To target this population, we selected an area with a relatively high HIV prevalence and a relatively large proportion of people with a non-Western migratory background. Although the participants' sociodemographics did not reflect the neighborhood's demographics, we were able to reach an even larger proportion of non-Western participants, one of which tested HIV positive. This woman, like most of the participants, perceived low risk for HIV and would probably not have tested until symptoms appeared, potentially leading to delayed diagnosis, and further spread of HIV. Compared to MSM, people with a non-Western background in the Netherlands have a higher proportion of late-stage HIV infections and undiagnosed HIV [3], making this population especially important in finding the last cases in this phase of the HIV epidemic. The high proportion of late-stage HIV infections among non-Western people also may indicate that they may not be adequately reached by regular healthcare services such as the GP and SHC, the two main providers of HIV tests in the Netherlands. CBHT approaches like ours can effectively reach individuals with low-estimated risk and first-time testers, especially those who are not likely to utilize other healthcare services [6, 8]. We were able to reach a significant proportion of first-time testers (52.3%) and not recently tested for HIV (87.3%). However, CBHT is usually not conducted on a frequent, regular and widespread basis, and is costly. Therefore, improving proactive HIV testing at regular healthcare services seems more practical and sustainable [28]. This was also indicated by the staff in our study.

Our study observed HIV test opportunities at the GP; 71.2% of the participants would be willing to test for HIV if their GP offered the test, compared to only 38.1% who would request a test themselves. Although most participants indicated a preference for a reason for the HIV test recommendation from their GP, we indirectly found that people accept an HIV test if it is offered as none of the participants declined the HIV test, even without any prior advice. This highlights the importance of HIV testing being offered proactively. However, it is known that GPs currently adhere insufficiently to HIV testing guidelines, even during STI consultations with high-risk patients [38-40]. Guideline adherence will be even more difficult if a patient does not belong to known key populations or if they consider themselves not at risk. Our study identified one participant who tested positive for HIV and was not notified by her partner. This exemplifies that partner notification is another effective method for timely detection of new HIV infections, though its implementation is currently insufficient [40, 41].

We showed that the performed pilot was generally well-received and feasible to conduct, with some important lessons learned. First, this approach is very labor intensive, and therefore costly, particularly in the preparatory phase (e.g., find benevolent organizations, investment in and stay in contact with stakeholders, need assessment, material development, prior visits to check the locations at the planned day/time). However, investing in this phase was indicated as crucial for the success of the intervention and can partly be compensated by increasing the number of test events. Second, active involvement of local community organizations and staffs' repeated presence was found essential for tailoring interventions for community needs, for location usage, and for recruitment, but also to build trust and social cohesion. The involved organizations felt that their voices were heard and that they had a sense of shared responsibility in the recruitment and execution processes. Third, evaluation among all involved parties is valuable for gaining insight into potential in-between adjustments. Our study found that major concerns expressed by the test team (e.g., language problems and privacy), were not shared by most participants. Finally, the general health check also provides opportunities for collaboration with other health organizations in the neighborhood. Collaboration could reduce costs and provide benefits for specialized health advice. However, establishing these collaborations can be challenging, as health professionals that we approached did not want to corporate either because of lack of time or other priorities.

Limitations

Our study had several limitations. First, the results may not be generalizable as this is a pilot project with a small sample size from a specific geographical area. In addition, the composition of the participants is affected by the organizations where we performed the test events and the day and time of the events. While we used different locations, days, and parts of the day, we predominantly reached middle-aged women. The staff suggested other solutions, such as connecting test events to other activities (e.g., sports), and using a more diverse group of community recruiters. Attempts to reach more men and youngsters via a barbershop and a youth organization, both of which had expressed willingness to participate, were canceled due to the COVID-19 pandemic. Second, we did not collect detailed HIV risk factor information from participants, making it difficult to assess the underlying HIV risk. Our aim was to offer testing at the community risk level as opposed to the individual risk level. Moreover, adding questions about HIV risk would have increased the barrier to participate; staff was concerned that it could jeopardize privacy and further increase the already time-consuming questionnaire. Third, systematic collection of non-response was not always possible due to the multiple tasks of the test team members and the walk-in setting. Finally, the questionnaire was orally administrated in Dutch or with an improvised translation into English. If there was still a language barrier, simplified additional explanation was given or participants translated for each other. This may have affected the reliability of the questionnaire answers. Additionally, not all questions were answered by all participants. The staff members proposed different solutions to address language barriers, such as multilingual staff or a telephone interpreter. However, not all staff preferred these options, as there was a diverse range of languages spoken by the participants, and using a telephone interpreter was conceived as unfeasible.

Conclusions

Offering decentralized anonymous free-of-charge rapid HIV testing in combination with other more general health tests was feasible, accepted, and effective to test not (recently) tested persons. The approach appeared to positively impact attitudes and knowledge about HIV/PLHIV according to the staff and community leaders. However, there were some concerns about the labor-intensive nature of this approach, and whether it is worth the investment to find the last unidentified HIV cases. As we observed multiple health problems among the participants, collaborations with other health programs and professionals could help to reduce costs, share expertise, and further normalize and destigmatize HIV (testing). However, in the phase of micro-elimination of HIV, CBHT may be a suitable supplement to more sustainable and cost-effective methods, e.g., proactive HIV testing by GPs and partner notification.

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PART 3

General discussion and appendices

CHAPTER 8

General discussion

The aim of the studies presented in this thesis is to provide a better understanding of sexually transmitted infection (STI) test provision by the general practitioner (GP) and sexual health centre (SHC). Based on these insights, recommendations can be made for existing policies on STI testing, as well as whether additional testing strategies are necessary. This chapter discusses the main findings in the context of the three research questions formulated in the general introduction (**Chapter 1**). The chapter concludes with recommendations and suggestions for further practice and research, and as well as an overall conclusion.

8.1 A more comprehensive picture of STI testing

GPs and SHCs are the primary providers for sexual healthcare and STI testing. While the SHC has a complete and thorough nationwide registration of STI consultations, there is limited insight into individuals tested for STIs at the GP due to lack of monitoring data and limited registration of clients' characteristics. To obtain a more comprehensive picture of individuals tested for an STI in the general population, it is essential to have insight into those who are tested at GPs as well as SHCs. To achieve this, we combined GP and SHC laboratory data with population data.

Research question 1

To what extent are the general population and specific socio-demographic key population groups tested for STIs/HIV at the GP and the SHC?

Based on laboratory data from the GP and the SHC, combined with population data, we found that 2.8% of the population had been tested for an STI at least once within the five-year study period. Specifically, for HIV, the proportion was 1.1%. We observed large differences in the proportion of individuals tested for STIs between subpopulations. The highest STI testing proportions were found among individuals under 25 years of age (6.5% for STIs in general and 2.1% for HIV) and those with a non-western migratory background (4.7% for STIs in general and 2.1% for HIV). An overview of the proportion of individuals undergoing testing for STIs in general or HIV in the general population is summarised in **Figure 1**.

Using SHC and GP administrative laboratory data is a more accurate method to gain insight into individuals tested for an STI on the population-level compared to questionnaires and sentinel surveillance networks [1, 2]. Questionnaires may suffer from various biases such as selection bias (overrepresentation of those interested in sexual health), socially desirable answers (e.g., respondents saying they have been tested when they have not), or memory bias (forgetting if or for which STI they were tested). These biases may have contributed to the large difference in the reported STI test proportion between our laboratory-based studies and previous conducted survey studies [1, 3]. A nationwide representative survey reported that in the past 12 months, 5% of the men and 7% of the women were tested for an STI

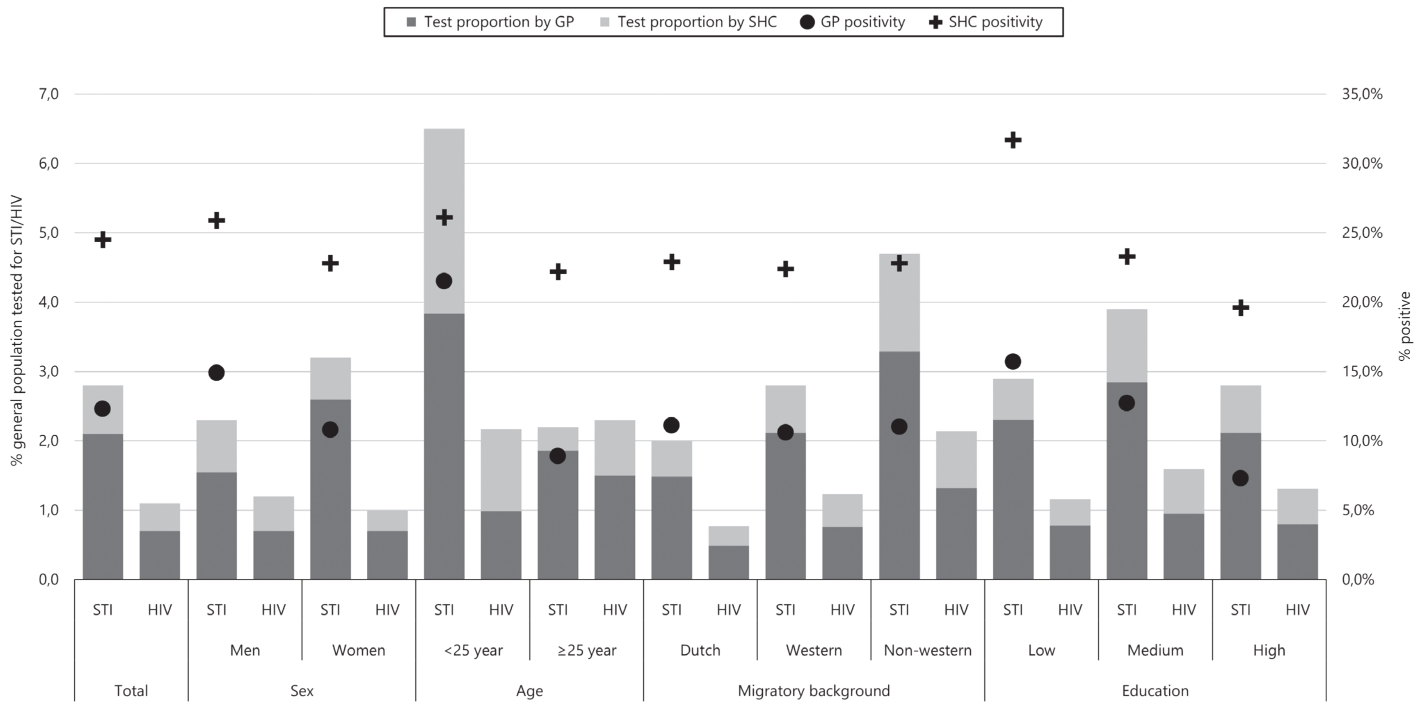
[1]. A regional public health monitor survey (*Gezondheidsmonitor*), which covers the same study area as our laboratory-based studies, reported that 9.4% of 18-23 year-olds and 6.5% of 24-64 year-olds were tested for an STI in the previous year [3]. In contrast, we found that 2.8% of the general population tested for an STI within five years (**Chapter 3**), which differed greatly from these nationwide and regional survey studies. Also, the proportion of the general population tested for HIV found in our study (1.1%, **Chapter 6**), was significantly lower than the proportion reported in the national survey study (3.0%).

Our results for STI testing in general aligned more closely with the estimations from the National Institute for Public Health and the Environment (RIVM) [2]. The RIVM reported that there were approximately 150,000 STI consultations annually at SHCs between 2015 and 2019. In addition, based on sentinel primary healthcare data, they estimated that the annual number of STI consultations at the GP was around 300,000. Combining these SHC and GP figures, and comparing it to the population of the Netherlands during the same period, indicated that 2.6% of the general population was tested for an STI.

The overall findings suggest that combining GP sentinel network data with SHC surveillance data provides a reasonably accurate estimate of the proportion in the general population tested for STIs, but survey data tend to substantially overestimate this proportion. A major drawback of the current GP sentinel network data is the lack of population-specific information, as GP standard registration of socio-demographics is limited to sex and age. Furthermore, STI-specific estimates, such as an estimation of HIV tests, are also missing. To obtain such insight through sentinel network data, professionals would need to collect more patient characteristics, which increases their registration burden. Therefore, the use of routinely collected laboratory data in combination with population data, as applied in our studies, appears to be a more practical and efficient approach.

In addition to our main finding on the proportion of individuals tested for STIs/HIV, there are three points to highlight from our studies:

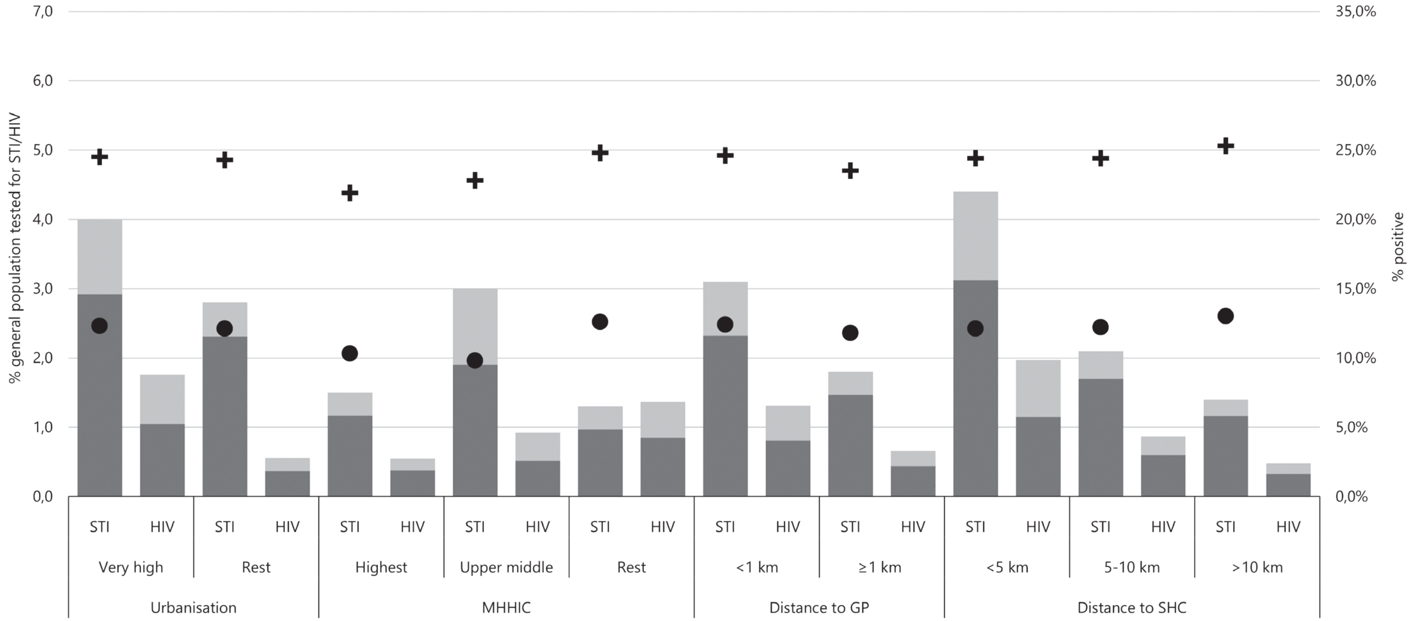
1. The impact of policy, as certain key population groups targeted by triage policies were tested more frequently than others (**section 8.1.1**)
2. Only 40% of the individuals who underwent STI testing was also tested for HIV, also among key population groups (**section 8.1.2**)
3. STI/HIV positivity (i.e., the percentage positive tests among performed tests) in relation to testing (**section 8.1.3**)



■ **Figure 1** Proportion of general population tested for an STI, STI positivity and GP-SHC ratio in the greater Rotterdam area

Positivity was defined as a positive test result among those tested.

GP, general practitioner; *HIV*, human immunodeficiency virus; *MHHIC*, median household income; *SHC*, sexual health centre; *STI*, sexually transmitted infection, *km*, kilometre.



■ **Figure 1** Proportion of general population tested for an STI, STI positivity and GP-SHC ratio in the greater Rotterdam area (continued)

Positivity was defined as a positive test result among those tested.
GP, general practitioner; *HIV*, human immunodeficiency virus; *MHHIC*, median household income; *SHC*, sexual health centre; *STI*, sexually transmitted infection, *km*, kilometre.

8.1.1 The impact of policy

Many SHCs in the Netherlands are facing challenges in meeting the demand for their services. The capacity of SHCs is often determined by financial restrictions, and triage policies are in place to prioritise key population groups with the highest risk for an STI [4, 5]. SHC key population groups identified for testing include individuals with a non-western migratory background and those who are under 25 years old [4]. GPs are also advised in their STI guidelines to test these individuals [6]. Our studies in **Chapter 3** (STIs in general) and **Chapter 6** (HIV specifically) have shown that the proportion of STI/HIV testing is much higher among these prioritised groups compared to the overall population. This finding is a strong indication that triage policies, particularly the policy implemented by SHCs, play a significant role in the accessibility of STI care and consequently increase testing rates in populations that are prioritised. It is important to note that based on the studies in this thesis, we still do not know whether the current testing rates are sufficient.

8.1.2 Discrepancy between STI and HIV testing for key population groups

A comparison of the proportion of individuals tested for STIs in general (**Chapter 3**) and HIV (**Chapter 6**) at the population-level showed a large discrepancy. The proportion of individuals tested for HIV was overall around 60% lower than the proportion of individuals tested for STIs in general for almost all subpopulations studied (1.1% for HIV vs. 2.8% for STIs in general). This discrepancy may be attributed to current test policies in the Netherlands. Guidelines recommend HIV testing only for key population groups at GPs and SHCs, with additional indicator condition guided HIV testing at GPs [4, 6, 7]. This means that individuals with a non-western migratory background – one of the key population groups – should be tested for HIV. However, **Chapter 3** and **Chapter 6** taken together provide indications that these guidelines are not being followed. Depending on the origin, only 30% (other non-western) to 44% (Sub-Sahara African) of non-western individuals tested for an STI are also tested for HIV at the GP. At the SHC, this ranges from 65% (other non-western) to 82% (Antillean). Our findings are consistent with another Dutch study that used GP sentinel primary healthcare data and additionally collected clients' background characteristics, reporting that only 29% of the clients originating from STI-endemic country were tested for HIV during an STI consultation [8]. Not performing an HIV test for key population groups during an STI consultation indicates missed opportunities for HIV testing, particularly at the GP, which can hamper (early) diagnosis and treatment, and potentially lead to further transmission.

8.1.3 STI/HIV positivity in relation to testing

We were able to evaluate STI positivity in the context of population-level STI test estimates (**Chapter 3**) and identified that the population groups with higher STI positivity do not always have the highest test rates. The largest discrepancy in ranked testing proportions and positivity percentages was observed among 15-19-year-olds (**Chapter 3**). Only 3.5% of the general population in this age group is tested, yet 30.5% of those tested were positive. The relatively low testing rate among 15-19-year-olds may be due to a limited proportion of sexually active individuals. A large-scale representative survey study among 12 to 25 year-olds in the Netherlands showed that at the age of 18.6 half had engaged sexual intercourse [9]. Among the sexually active 15-19-year-olds, the positivity may be relatively high due to more risky sexual behaviour, which is associated with earlier sexual debut [10] and less knowledge about sexual and reproductive health [1, 9, 11]. Lack of knowledge about sexual health – for example about when and where to test – and feelings of shame and stigma surrounding STI testing can hinder testing [12-14]. Whether the current low testing rate is sufficient, given the high STI positivity among youngsters, remains unknown based on our studies. However, the high STI positivity in the light of limited knowledge suggests that visibility and awareness of sexual health (care) may need to be improved for younger individuals, particularly since they often do not navigate to reliable sources for sexual health information such as sense.info (which provides help and advice about sex, STI (testing), pregnancy, contraception, and sexuality) [9]. Offering STI tests in different ways also can increase accessibility and lower certain barriers to testing (e.g., online (video) consultations, (home) self-collected samples, or testing at locations where people reside or spend their free time). In **Chapter 3** we also identified other groups with considerable differences between low testing and high positivity: those with a lower educational level (3.3% tested and 20.1% positive) and men (2.3% tested and 18.7% positive). For individuals with a lower educational level, the gap between testing and positivity is greater at the SHC than at the GP, suggesting that low-educated individuals may find GPs more accessible than SHCs. In **section 8.2.2** the effect of low educational level is discussed in more detail.

8.2 Factors associated with utilisation of STI testing services

A deeper understanding of individuals who receive STI testing at the GP also allows us to investigate characteristics that may be associated with STI testing. The design and data sources used in our studies, which include all residents in a certain age range within the greater Rotterdam area, offered a comprehensive overview of factors associated with STI test utilisation in the real-world setting.

Research question 2

What are important factors in the utilisation of STI testing services?

All the individual socio-demographics and area characteristics studied influenced the utilisation of STI testing at the GP and SHC. Generally, the same characteristics were associated with STI testing at both providers, but with some exceptions. Women and lower educated individuals were more likely to be tested at the GP, while men and medium/higher educated individuals were more likely to be tested at the SHC. Individual socio-demographic characteristics were more important than area characteristics, with age having the strongest association with STI testing. The effect of sex on STI test utilisation at the SHC varied between our studies (women more tested vs. men more tested), likely due to a difference in age ranges between the studies. In general, particularly through the contribution of the GP, women were more often tested for an STI. The effect of a person's migratory background on STI test utilisation was mixed, with some backgrounds being tested more often (e.g., Antillean) and other being tested less often (e.g., Turkish) than native Dutch. Utilisation of STI testing services diminished with reduced urbanisation, but area-level SES showed mixed results for the SHC and the GP. The effect of distance to the SHC was clear; larger distances were associated with less STI test utilisation, while the effect of distance to the GP varied. The distance to the SHC explained most area variance in SHC utilisation. Additionally, residing in a highly ethnic diverse area was associated with higher SHC utilisation, and the Maas river acted as barrier for SHC utilisation. Spatial differences in utilisation for an STI test were not related to STI positivity and STI related risk.

As described earlier, guidelines and policies have impact on the utilisation of GP and SHC for an STI test. According to guidelines and policies, indications for an STI test include age (<25 years), migratory background (non-western) and sexual contact (MSM) [4, 6]. Our studies also reflected this, as younger age and non-western migratory background were strong predictors for STI test utilisation. Overall, we found that a non-western migratory background was associated with STI testing. Upon further specifying non-western, it was found that not every non-western background was associated with STI testing to the same extent, and that individuals with a Turkish, Moroccan, and Middle and Eastern European background were tested less frequently than the comparison group of native Dutch. This finding is consistent with another Dutch study [15]. The wide variation in STI testing rates between migrant groups may indicate differences in their STI testing needs. However, since current STI testing guidelines do not differentiate between different non-western migrant groups, it can be inferred that access to STI testing needs improvement. Furthermore, our data suggests that different migrant groups may benefit from different interventions to enhance their access to STI testing services. This may also be applicable to individuals with different levels of education, as we found that education plays a role in STI test utilisation, but its effect differs between GP and SHC. **Section 8.2.2** further elaborates on education level.

We found mixed results for sex in relation to STI testing utilisation between our studies, in contrast to age and migratory background. The upper limit of age differed between our studies (**Chapter 2** and **Chapter 3**) which likely affected the sex results. In **Chapter 2** we studied SHC clients of up to a maximum age of 45 years and found that women were more often tested than men. Women generally have a higher risk perception, which is associated with healthcare usage, in addition to their general higher health seeking behaviour [16, 17]. However, in **Chapter 3**, where maximum age was expanded to 60 years, women at the SHC were less often tested for STIs than men. This shift in the sex results is likely explained due to a higher proportion of MSM visitors above 45 years. Furthermore, at the GP, which is the largest STI test provider, women were 1.9 times more likely to test than men (**Chapter 3**). These findings suggest that heterosexual men under 45 years of age, and probably particularly those under 25, may benefit from improved and targeted STI testing.

In addition to individual sociodemographic characteristics, our studies have shown that area-level characteristics are also important factors associated with STI testing utilisation (**Chapter 2** and **Chapter 3**). We found that individuals living in less urbanised areas (compared to highly urbanised areas) and in areas further away from SHC and GP (compared to closer to testing services) were associated with lower odds of being tested for an STI (**Chapter 2** and **Chapter 3**). We consider "physical" area-level characteristics, such as proximity to testing services and geographical barriers like the Maas river, as relevant for testing interventions to reduce STI testing inequities. For instance, individuals living on the southern riverside of the Maas were found to visit the SHC less frequently compared to those living on the northern side, even with comparable socio-demographics and distance to the SHC (**Chapter 2**). The fact that the SHC is conveniently located at the northern foot of the Erasmus bridge, with a metro and tram stop located directly in front that connects north and south, seems irrelevant. Moreover, STI positivity between different categories of area characteristics were comparable (maximum of 3.7% difference) (**Chapter 3**).

In addition to "physical" characteristics, "social" area characteristics, such as socio-economic status (**Chapter 2** and **Chapter 3**) and ethnic diversity (**Chapter 2**) of areas, were also found to be associated with SHC utilisation. Therefore, an intervention to improve STI testing could, for example, target individuals in the urban southern part of Rotterdam, which has a higher proportion of less well-off households and/or ethnic minorities. Adding an STI testing opportunity conveniently located close to their homes seems important to investigate. The importance of proximity was also highlighted in our pilot study aimed at promoting HIV testing in the general population through community-based HIV testing (**Chapter 7**).

In the following section, we highlight three factors that are associated with STI testing utilisation and have not been extensively described before:

1. Access to an STI testing service (**section 8.2.1**)
2. Education level (**section 8.2.2**)
3. Geographical area-specific STI-related risk (**section 8.2.3**)

8.2.1 Access to an STI testing service matters

A considerable body of evidence on healthcare access has accumulated in recent decades. It has been established that greater distance to healthcare is associated with lower uptake, especially in low-middle income countries [18]. Although less studied in high-income countries, literature on a diverse range of health topics has indicated that healthcare access appears to decrease with an increasing travel time or distance [19-26]. No studies investigated the effect of distance on sexual healthcare utilisation. In a study conducted in Vancouver, distance was more often mentioned as barrier to STI testing by individuals visiting an STI clinic than those using online STI testing service without visiting a healthcare provider [27]. Even though the infrastructure in Vancouver differs from the Netherlands, and distances are generally much greater than in the Netherlands, these results indicate that making testing more convenient, either with self-collection at home or testing locations close to home, can significantly lower barriers to testing.

Sexual healthcare access can vary even within the Netherlands, highlighting the importance of conducting local analysis to understand the effect of distance on healthcare utilisation and to tailor policies to improve access. In **Chapter 2**, we investigated the effect of distance on SHC utilisation in the greater Rotterdam area. Consistent with other studies on distance decay effect, we found that increasing travel distance was strongly associated with reduced SHC utilisation. Specifically, an increase in travel distances from 1 to 15 km led to a reduction of more than 80% in the frequency of contacts. Furthermore, travel distance was the main explanatory determinant for the differences in SHC utilisation between geographic areas (**Chapter 2**). The distance decay effect to SHC remained also after including GP data (**Chapter 3** and **Chapter 4**), and even when the STI positivity and STI-related risk of an area were relatively high (**Chapter 4**). The latter is discussed in more detail in **section 8.2.3**.

Previous literature and our findings suggest that non-traditional testing, such as outreach testing and approaches like online testing services with self-collected samples, could be effective in overcoming the distance barrier to testing. Offering supplementary non-traditional testing can be vital in reaching certain key population groups, such as MSM, migrants and youngsters, and individuals that are never tested before [28]. Expanding testing opportunities not only increases testing uptake, but also helps identify undiagnosed infections which is especially important for HIV [28]. This is also emphasised in **Chapter 7**. **Chapter 7** describes an area-based pilot intervention aimed at promoting HIV testing in the general population. The pilot included test events at community organisations in an area with relatively high incidence of HIV and a relatively large proportion of residents with a non-western migratory background. Non-western migrants are an important key population group for HIV in the Netherlands due to the relatively high proportion of late-stage HIV infections and undiagnosed HIV among them [29, 30]. A substantial proportion of the participants at these test events were never or not recently tested for HIV and had a non-western migratory background.

Area-based testing, taking into account the area's socio-demographic composition and involving members of the community organisation, can reach a population that may not be reached via traditional settings. Also combining STI testing with other health programmes can extend the reach of testing individuals who may not otherwise seek out for STI testing (**Chapter 7**). One possible reason for this is that a combination of health checks or programmes helps to normalise and reduce stigma surrounding STI testing [31-33]. Moreover, vulnerable groups often face health disparities across multiple levels. This was highlighted by our findings in **Chapter 7**; a considerable proportion of participants had abnormal test results for BMI, blood pressure or blood glucose. Combined testing services can be provided in outreach settings, but also in healthcare settings such as at the GP when other tests are performed.

In addition to "going to the people", community involvement may contribute to reaching and testing an important key population group for HIV who were not (recently) tested (**Chapter 7**). There is a growing interest and increased emphasis on involving the community in research and implementation [34]. Community involvement can occur on various levels (e.g., inform, consult, involve, collaborate, empower) and through different methods (e.g., interviewing, brainstorming, workshop) [34, 35]. In our area-based HIV testing pilot study, community members were involved in the design and planning of the intervention. We identified facilitators, barriers and key elements for HIV testing based on interviews with key figures, residents, and healthcare organisations. These elements were considered while developing the test events, and it is likely that this contributed to the positive outcome of our pilot; HIV test provision combined with general health checks was accepted and well-rated by participants. We also brainstormed with interviewees about the possible set-up of test events, and more practical matters such as test locations, days, and times. Key figures assisted with recruitment and logistics during test events. After each test event, the main key figure present was questioned about his or her experience. In both the design phase and evaluation phase, one of the main facilitators for HIV testing mentioned was a test location within their neighbourhood, even though the selected intervention area was relatively close to several GPs and the central SHC. This finding highlights the importance of testing close to home in a location where people feel comfortable. Testing strategies should preferably consider local barriers and preferences.

Despite the fact that HIV test events, as described in **Chapter 7**, can reach individuals who are typically not tested, this labour-intensive approach may be more suitable as a supplement to more sustainable and cost-effective methods like partner notification for identifying remaining undiagnosed HIV cases in a declining epidemic. The pilot study highlighted that partner notification may not always be carried out adequately. Among the 134 participants who underwent HIV testing at the pilot, one heterosexual women with a non-western migratory background and low perceived risk tested positive (positivity of 0.75%). Upon further investigation, it was revealed that she was not notified by her partner about HIV. It is likely that she would have only visited the GP after symptoms surfaced.

8.2.2 Education level

Individuals with a lower level of education, individuals with a non-western migratory background, and others with a low socio-economic status are often considered vulnerable groups concerning sexual health. The national action plan for STIs, HIV and sexual health 2017-2022 also emphasises the need for specific attention towards these groups to ensure low-threshold access to sexual healthcare [36]. We found that the proportion of low-educated individuals among those tested for STIs was slightly lower than in the general population (28.7% vs. 34.4%), despite having a relatively high STI positivity rate (**Chapter 3**). This is in line with another study based on data from all SHCs in the Netherlands [37]. While low-educated individuals utilise the SHC for STI testing less frequently than those with other educational levels, we observed an opposite trend at the GP. Lower-educated individuals more frequently visit the GP for an STI test than higher-educated individuals do. A Dutch study based on national representative survey data found similar results [38]. These findings suggest that vulnerable groups such as low-educated individuals may have difficulty accessing the SHC. A possible explanation is that higher-educated individuals may more frequently navigate the triage process by mentioning indications that are considered higher priority, thereby reducing the opportunity for an appointment for those with lower education levels. Additionally, lower-educated individuals may also be less aware of the SHC or face other barriers in accessing them.

The lower STI testing rate among lower-educated individuals, combined with the high STI positivity, highlights the need for additional strategies by the SHC to reach this vulnerable population. The action plan for STIs, HIV and sexual health, already suggested that hard-to-reach groups require tailored and innovative methods to reach them [36]. However, it should be noted that structural efforts by the SHC to invest in hard-to-reach populations may be challenging due to limited (financial) capacity. Recently, a policy vision regarding sexual health has been published, again emphasizing the importance of low-threshold access to good care, information, and facilities [39]. The policy vision is a follow-up to the national action plan in which the government pledged to further promote, protect, and better map sexual health in the Netherlands. Nevertheless, there is no commitment to increase funds for the

SHC capacity, limiting the possibilities of implementing additional strategies, such as reaching out to lower-educated individuals outside the SHC.

8.2.3 Geographical area-specific STI risk and testing

The occurrence of STI varies greatly across different geographical areas, as also observed in our studies. For instance, our study found that the overall HIV incidence in the Rotterdam area (10.55 per 100,000 residents) was more than twice as high as the estimated nationwide incidence (4.3 per 100,000 residents), and large differences were also observed within the area (**Chapter 6**). The heterogeneity in STI occurrence highlights that STI testing interventions can also target specific geographical areas rather than individual (e.g., education level) and area characteristics (e.g., distance to service). Previous studies have emphasised the importance of residential area in STI positivity [40-43], and suggested that areas with high STI positivity, cases or key population groups (i.e., "clusters") may benefit from STI service allocation [44]. Additionally, we found strong heterogeneity in STI testing rates between geographical areas, even in areas with comparable STI risk and positivity in the underlying population (**Chapter 4**). This suggests that it is appropriate to (also) consider testing rates, and start or expand interventions in areas with lower test rates.

In **Chapter 4** we computed postal code area-specific STI testing rates and risk scores. The STI testing rate was defined as the number of residents tested for STI per capita, and the STI risk was determined based on residents' socio-demographic characteristics (age, education, migratory background and urbanisation). These characteristics were available for all residents, and not just for those who were tested. The risk scores were derived from a previously developed system used to select individuals at an evaluated risk for chlamydia in the Netherlands [45]. Based on the risk scores and STI testing rate, we observed three clusters of postal code areas: (1) high risk score with high testing rate, (2) high risk score with low testing rate, and (3) low. The postal code areas classified as low, with both a relatively low testing rate and risk score, were mainly located in suburban areas. We were particularly interested in population differences in areas with comparable high community STI risk (cluster 1 and 2), but different testing rates. The overall STI testing rate for postal code areas classified as high testing rate was 75.8 per 1,000 residents, while this was only 33.2 per 1,000 residents for low testing rate areas. Low testing rate areas were less urbanised and further away from GPs and the SHC, which implies lower access to testing services. These findings correspond with previous literature [46, 47]. Except from migratory background, other individual factors (sex, age, education level) hardly differed between areas with comparable community STI risk but a different testing rate. This may be explained by the diversity in demographic structure of sex, age, education level and migratory background between postal code areas

[48]. In contrast to sex, age and education level, the demographic structure of migratory background varies more between postal code areas.

The community risk scores in our study (**Chapter 4**) were based solely on socio-demographic characteristics that were available for all residents. It is possible that other factors not measured on population-level or not available for all residents could also affect STI testing and risk. For instance, the distribution of MSM is unquestionably an important factor for STI risk and testing on geographical level. As shown by other studies, the distribution of MSM is likely heterogeneously distributed over the area [49-52]. MSM are disproportionality affected by STIs and are advised to get tested twice a year [4]. MSM using HIV-Pre-Exposure Prophylaxis (PrEP) are even recommended to get tested four times a year [4, 53], although the most recent PrEP guideline of 2022 allows less frequent testing based on individual risk [54]. Our studies, with exception of **Chapter 5**, include only one record per person per year and therefore multiple STI tests did not result in higher STI testing rates. However, MSM are more likely to be part of the tested group. It is estimated that 61% of MSM get tested at least once per year in the Netherlands [55]. Previous estimates of MSM population in the Netherlands range from 2.0% to 3.5% of the total male population [56, 57], but there are no publicly available local estimates on size and geographical distribution of MSM. The regional public health monitor survey (*Gezondheidsmonitor*) estimated the proportion of MSM to be 4.8% of total male population in Rotterdam, with a variation of 1.4% to 8.4% between geographical units within the city (personal communication between Gea Schouten and Denise Twisk, unpublished data). Unfortunately, no estimates of the MSM population for surrounding municipalities of Rotterdam were available.

8.3 The contribution of GP and SHC in STI/HIV testing

As described in **section 8.2**, generally the same characteristics were associated with STI testing at the GP and the SHC. In this section we describe the relative contribution of GP and SHC in STI/HIV testing within population groups and whether this contribution shifts between subpopulations. For example, the contribution of GPs may be greater in areas located further away from the SHC. In addition, such GP-SHC comparisons may indicate whether some population groups prefer one provider over the other for STI testing. **Figure 1** also presents the ratio between GP and SHC in STI/HIV testing.

Research question 3

What is the relative contribution of GP and SHC in STI/HIV testing?

We observed that STI testing was primarily conducted by GPs, but that the difference in testing rates between GPs and SHCs varied across population groups. The SHC key population group under the age of 25 had the smallest difference in STI testing rates between GPs and SHCs. Although migrant groups – also a key population group – differed in the proportion tested, the GP-SHC ratio did not differ significantly between migrant groups. The relative contribution of the GP was greatest for older age groups, those with lower levels of education, in less urbanised areas, and in areas further from the city centre of Rotterdam, where the SHC is located. This finding was found for both for STIs in general and for HIV. In addition to differences in GP-SHC ratios between population groups, there were also substantial variations between geographical areas.

In general, GPs performed the most STI/HIV tests (**Chapter 5**) or tested the most individuals (**Chapter 3** and **Chapter 6**) in the Rotterdam area. These findings are in line with our expectations. The nationwide estimated ratio between STI consultations at GP and SHC has been stable in recent years, with GPs performing two-thirds of the STI consultations [2]. However, our studies have shown significant variation in STI testing rates between GPs and SHCs for different population groups and STIs (**Chapter 3**, **Chapter 5**, and **Chapter 6**), and geographical areas (**Chapter 5** and **Chapter 6**). In **sections 8.3.1 through 8.3.3** we further elaborate on these main, and other notable, findings:

1. GPs play a larger role in providing STI testing for hard-to-reach populations and for non-key population groups (**section 8.3.1**)
2. GPs are the main test providers for STI testing, but the GP-SHC ratio is smaller for HIV compared to STIs in general (**section 8.3.2**)
3. There are differences in GP-SHC testing ratios by geographical area (**section 8.3.3**)

8.3.1 A larger role for the GP for hard-to-reach populations and non-key population groups

We showed that GPs test more individuals than SHCs. Additionally, there are indications that access to and client-seeking behaviour for STI testing vary across different population groups, as demonstrated by the significant differences in GP-SHC testing ratios across population groups (**Chapter 3**, **Chapter 5**, and **Chapter 6**). For most subpopulations, the contribution of the GP is higher than that of the SHC in STI testing, such as for individuals living further away from an SHC and vulnerable groups such as those with a lower educational level. This may be due to the familiarity, preference, and accessibility of GP services. However, the SHC must be keen to strengthen the accessibility for these groups, often described as "hard-to-reach" by the SHC. This need is further reinforced by comparing STI testing rate and STI positivity. The disparity between STI testing rates and STI positivity seems lower for the GP than for the SHC among all studied populations. For instance, among individuals with a lower educational level, 2.3% were tested at the GP with a positivity rate of 15.7%, while only 0.6% were tested at the SHC with a positivity rate of 31.7%. This suggests that people seem to find GP services more accessible than SHCs. Whether the total testing rate and accessibility is sufficient remains unanswered. Possible strategies to address the lower STI testing rate and/or the relatively low contribution by the SHC for certain groups and areas, could include, for example, outreach activities and online video consultations by the SHC with self-sampling at home. These efforts are essential not only for STI testing access, but also for access to "sense consultations" provided by the SHC. Sense consultations are consultations for more generic questions about topics such as sex, sexuality, gender identity, STI prevention, and contraception. Prioritising individuals under 25 years of age at the SHC is also specifically intended to serve youngsters with sense consultations. Topics discussed during sense consultations are most likely not or less extensively discussed at the GP due to time constraints and other barriers [58-62]. In addition to possible extra efforts by the SHCs, GPs must recognise that they play a pivotal role in STI testing non-key population groups such as women and individuals from older age groups, and individuals with low self-estimated STI risk.

8.3.2 Testing ratio between GP and SHC smaller for HIV than STIs in general

We found that for STIs in general, GPs test three times as many individuals as the SHC (**Chapter 3**), while for HIV specifically, this ratio is around one and a half times (**Chapter 6**). This trend was also observed for subpopulations studied. There could be several explanations for this finding. Firstly, offering an HIV test may pose greater barriers for GPs than SHC professionals. Previous studies have identified several barriers to optimal HIV testing in primary care, such as discomfort in offering HIV tests, fear of offending or stigmatising patients, decreasing HIV prevalence leading to less motivation to test for HIV, financial burden for patients for laboratory costs, and time constraints [63-65]. These barriers are likely less prevalent among SHC professionals, whose primary task is STI/HIV testing and who provide free-of-charge services. Secondly, GPs may be more likely to request a chlamydia test, for example in the presence of urogenital complaints or in the case of new sexual partner, as opposed to an HIV test. GPs are also recommended to test for HIV based on indicator conditions. However, this testing strategy is often insufficiently implemented, resulting in missed opportunities for HIV diagnosis [66-68]. Thirdly, the difference in client composition, and associated STI policies and guidelines could be a significant factor. GP clients include individuals with both low and high STI risk, while SHC clients consist primarily of high-risk individuals. SHCs are required to test all clients, except for those under 25 years of age who do not belong to another key population group, for HIV. The GP is also recommended to test individuals considered high-risk, but they may not always be aware of a patient's high-risk status.

8.3.3 Geographical differences in the GP-SHC testing ratio

Large regional and local geographical differences in STI/HIV testing, positivity, and GP-SHC ratio show the significance of (detailed) local analysis. In **Chapter 5**, we investigated and compared HIV testing and positivity in five Dutch regions with different levels of urbanisation. We found a large regional variation in the number of HIV tests per 10,000 residents and positivity percentages. The highest HIV test rates and positivity were found in highly urbanised regions compared with more rural areas. We also found that HIV testing rates by GPs were lower than those by the SHC in in three out of the five regions, and a similar GP-SHC ratio in the remaining two regions. There was no clear association between GP-SHC ratio in HIV testing and level of urbanisation. For instance, areas with the similar level of urbanisation, like Amsterdam and Rotterdam, had significantly different HIV testing rates and GP-SHC testing ratios. The SHC tested twice as many individuals as the GP in Amsterdam, while there was no difference between the two providers in Rotterdam. The positivity percentages were comparable between GP and SHC in all studied regions, expect for Amsterdam, where the positivity was higher among individuals tested by the GP. **Chapter 5** included the city of Rotterdam as one of the study regions. In **Chapter 6** we zoomed in further on the greater Rotterdam area, which consists of the city of Rotterdam and 14 neighbouring municipalities. Even within this relatively small geographical area, we observed large differences in HIV testing between subareas. Areas that were in close proximity to the SHC had a higher proportion of HIV testing conducted by the SHC, while GPs had a higher contribution in more remote areas. These nationwide and local variations between areas – even with similar area-characteristics – demonstrate the importance of local analysis for informed local policy decision-making and interventions to improve STI/HIV testing.

8.4 Implications for practice

The studies in this thesis were initiated to find out whether there are indications to adapt the current STI testing policy or whether additional STI testing interventions are required. Based upon this thesis and recent literature we have several recommendations to improve the current practice and policy of STI testing.

1. Expand STI testing via non-traditional test settings and facilitate remote testing possibilities

Expanding STI testing through non-traditional test settings and remote testing options is a primary recommendation to improve access to STI testing. Non-traditional test settings include mobile clinics, community-based testing and neighbourhood-orientated (“wijkgericht”) testing. This can be done in conjunction with other (existing) health programmes, which could, for example, lower costs, normalise STI testing, and improve access to sexual healthcare. Another valuable strategy to increase testing uptake and frequency is to use home-based sampling kits that are analysed at a certified laboratory. These kits are usually initiated by professional healthcare providers. To ensure accurate results and linkage to care, caution should be taken to avoid low-quality rapid test kits purchased online for at-home use that provide an instant test result.

2. Improve STI testing via traditional test settings and collaboration between GP and SHC

Another critical recommendation is to improve STI testing through traditional test settings. Educational training for GPs that includes information about STI/HIV testing guidelines, and that provides up-to-date audit feedback and details about local clusters and local-specific population groups can increase awareness, adherence to testing guidelines, and motivate adequate testing practices. STI/HIV testing as part of a clinical consultation for another reason, or based on HIV indicator conditions, may circumnavigate the perception that STI testing is not a priority or underestimated risk. In addition, GPs are not always aware of patients' high-risk status. GPs could also offer STI/HIV testing for new patients. The SHC should increase its familiarity and offer specific activities to certain groups such as low-educated individuals, individuals from less urbanised areas, and individuals living further from testing sites. Collaboration, with an exchange of experiences and findings between GPs and SHCs, is also essential to reach vulnerable groups.

3. Establish a connection with the (surrounding of) a target group

To enhance access for specific populations, such those with lower levels of education, a collaborative approach involving organisations that work with the target group is essential. Such organisations can provide valuable insight into the potential barriers that may prevent these groups from seeking services. Interventions should be tailored accordingly. Moreover, involving these organisations in the development and implementation of interventions can help build trust within the target group and establish a vulnerable bridge to reach them. This is increasingly recognised by policymakers, but structural adaption of STI testing to certain populations is still limited. Funding agencies should acknowledge the significance of community involvement, recognising that it can be labour-intensive and requires a long-term commitment. The same approach should be considered for interventions targeting a geographical area. Cooperation with organisations already present in the area can help provide better insight into the unique needs of the resident community.

4. Improve partner notification and testing

Partner notification is an effective method for identifying individuals with the highest risk, and ensuring that an individual receives timely treatment and care. Partner notification is key for the last mile of the HIV epidemic, but also important for other STIs. Offering low-threshold self-sampling tests through partners could be an effective way to improve testing. To support partner notification, healthcare providers should be regularly reminded of the importance of partner notification and testing through continued training. Additionally, providers should provide appropriate support and resources to patients to help them inform their partners. Electronic patient records could be equipped with a pop-up window that alerts healthcare professionals to discuss partner notification when a patient is diagnosed with an STI. This pop-up could also include the link to partnerwaarschuwing.nl, which can be used to arrange (anonymous) partner notification after diagnosis. The usage of this website among Dutch GPs is currently limited [69]. Patients themselves may also benefit from tips and tricks, or example videos on how to effectively notify their partners, which can be made available through healthcare providers or online.

5. A single one-fits-all intervention is unlikely to be effective: a combination of interventions is needed

A one-fits-all intervention is unlikely to be effective in addressing the challenges associated with STI testing. Rather, a combination of interventions is needed. A multi-faceted approach may include a range of interventions such as public awareness campaigns about the importance of testing, offering different testing options, educating GPs on HIV indicator-guided testing, offering HIV tests alongside other STI tests, and implementing partner notification. A blend of these interventions can help to overcome obstacles to STI testing experienced by different populations, including those related to stigma, accessibility, and preference.

8.5 Implication for (future) research

1. Use and combine data sources

SHCs maintain comprehensive registrations of STI tests and diagnoses, yet SHCs alone do not offer a complete picture of STI testing in the Netherlands. Considering GP data is crucial in obtaining a more reliable and accurate number of STI tests and diagnoses. Initial indications of the number of STI tests and diagnoses can be obtained through aggregated GP laboratory data. Alternatively, individual-level data with limited available client characteristics at the laboratory can also be used. For a more detailed understanding of client background characteristics, combining GP laboratory data with population register (microdata) can provide valuable insight. The combination of laboratory data with population data can also alleviate extra registration burden required for more detailed patient information when working with sentinel network data. Laboratory-based data combined with population data provides comparable overall results to sentinel network data. Obtaining GP patients details on a nationwide level is probably not feasible due to the time-consuming nature and the need to collaborate with many laboratories.

2. The used research concepts are applicable for other geographical areas and health services

The research concepts utilised in this thesis are not limited to the specific geographical area and health services under investigation. They can be applied to other regions and healthcare settings as well.

3. Map the numbers on local level and share results with local health professionals

Simple visualisation techniques, such as maps, can be an effective tool to communicate key information from research to health professionals. Mapping the numbers of STIs at a detailed geographical level, such as postal code area, and sharing these results with local health professionals can be a helpful step in improving STI testing. It is important to recognise that each region has its unique challenges and populations, as well as patients' and providers' attitudes regarding STI testing. Therefore, sharing research results with local health professionals can help inform their decision-making processes and improve their understanding of the local context. The research findings could also be included in trainings or other initiatives for professionals.

4. Evaluation of expanding STI testing services

Conducting both implementation and impact evaluation is essential to predict the effectiveness of expanding STI testing services. The evaluation should focus on determining the added value of the expanded services, including whether it reaches "new" groups of individuals. It is also crucial to gather feedback from both users and providers to understand their experiences and perceptions. A multi-perspective evaluation approach is needed to identify any discrepancies between the groups. The findings from evaluations should be used to inform the continued development of the programme, and facilitate interim adjustments to better serve the needs of the community.

5. Register non-participants at STI testing interventions

For researchers conducting an STI testing intervention, it is important to also collect information on individuals who do not participate. Understanding the characteristics and reasons behind non-participation can provide valuable insight that can be used to tailor interventions and better meet the needs of the community.

8.6 Conclusion

In conclusion, the studies presented in this thesis contribute to new insights, while also strengthening existing knowledge about (sexual) healthcare access. The local character of the studies provides evidence to support the need for increased (geographical) STI testing access. Nationwide and regional differences in testing and occurrence of STIs emphasise the importance of local analysis. The used research concepts are applicable to other regions and settings as well. Possible activities to increase local STI testing access and decrease differences between areas in STI testing include using mobile clinics, additional branch locations in remote areas, or internet-based services with self-sampling tests. Moreover, GPs' knowledge about sexual health and STI test provision should be continuously updated as they play a major role in STI care. GP educational meetings should also emphasise adherence to testing guidelines. Different strategies should be considered for different subgroups, since one-fits-all interventions are unlikely to be effective. Interventions should preferably be tailored based on input from key populations to increase the effectiveness and acceptability. It is important to acknowledge that a combination of interventions is likely to be needed, and interventions may vary between STIs in general and HIV. In summary, this thesis provides valuable insights into the STI testing landscape in the Rotterdam area and suggests interventions to inform policymakers, healthcare providers, and researchers working in the field of (sexual) health to improve the quality of and access to services.

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APPENDICES

Summary
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Summary

Chapter 1 of this thesis provides an overview on how sexually transmitted infection (STI) care is organised in the Netherlands, including a description of STI policies at the main STI test providers, general practitioners (GPs) and sexual health centres (SHCs). It also describes STI/HIV surveillance and the possibilities of using population microdata.

Part 1 – STI testing in general

In **Chapter 2** we investigated geographical variation in SHC utilisation and factors associated with SHC utilisation for clients aged 15 to 45 years in the greater Rotterdam area. We were especially interested in the effect of travel distance on SHC utilisation. The results revealed a substantial variation in SHC utilisation throughout the area, ranging from 1.13 to 48.76 per 1,000 residents. A substantial proportion of the variance in utilisation between areas was explained by factors included in the analyses. Travel distance accounted for the largest decrease in area variance and was inversely associated with utilisation. The results provided local insights into SHC accessibility.

The aim of **Chapter 3** was to provide more insight into which individuals underwent STI testing at the GP and the SHC in the general population of the greater Rotterdam area. It also aimed to explore factors associated with STI testing and compare the relative contribution of GP and SHC in testing across population groups. This was achieved by linking individual-level laboratory STI testing data from both GPs and the SHC to population register data (microdata). The findings indicated that nearly 3% of the general population underwent STI testing within the five-year study period (2015-2019). Large disparities in testing proportions were observed between population groups, reaching up to 9.8% for younger and defined migrant groups. The STI positivity, which refers to the percentage of positive tests, varied greatly among subgroups and providers, ranging from 3.0% to 35.5% among individuals who were tested. GPs tested three times more individuals than the SHC for an STI, and their contribution was even higher for certain stratified groups, such as older age groups, less urbanised areas, and further distance from the SHC. Generally the same population groups were tested by GPs and the SHC, although GPs tend to test women and lower educated individuals more often than the SHC. The results in this study underline the important role of GPs in STI testing and could be integrated into continuing medical education for GPs to emphasise their role, and stress the importance of discussing sexual health and guideline adherence. In addition, inter-professional collaboration and SHC outreach activities in vulnerable areas, may improve access to STI testing for underserved populations.

In **Chapter 4** we presented the spatial distribution of STI testing, community STI-related risk profiles and STI positivity to determine characteristics of areas that need improved access to sexual health care in the greater Rotterdam area. STI testing and positivity were based on laboratory data from the GP and SHC, and STI risk on residents' socio-demographic characteristics. Based on area-specific STI risk and STI testing rates, three clusters of areas were identified: (1) high risk score with high testing rate (high R-high TR), (2) high risk score with low testing rate, and (high R-low TR), (3) low testing rate, independent of risk (low). Although STI risk levels of high R-high TR and high R-low TR areas were similar, the testing rate differed greatly (75.5 vs 33.3 per 1,000 residents). We were especially interested in differences between these areas to determine appropriate interventions. A comparison of characteristics of residents in high R-low TR areas to residents in high R-high TR, revealed that residents high R-low TR had more often no migratory background, and tended to come from less urbanised, less well-off areas, and lived further away from the GP and the SHC. The methodology employed in this study provided a pragmatic and relatively unbiased means of identifying areas with high STI risk, but low rates of testing. Proof-of-principle interventions, such as mobile clinics or SHC branch locations, could help to identify methods to increase testing among individuals who are currently not (sufficiently) tested. The involvement of GPs in areas with low testing rates could also further enhance testing and expand its coverage.

Part 2 – HIV testing

The study in **Chapter 5** was initiated to expand our understanding of HIV testing practices among GPs, and how this relates to HIV testing at the SHC. While extensive data on HIV testing is available at the SHCs, which offer opt-out testing to certain key groups, there is limited information on GP testing practices. The study compared HIV testing by GPs and SHC in five different regions in the Netherlands with varying levels of urbanisation (2011-2018): Amsterdam, Rotterdam, Maastricht, Twente and North Netherlands. Large regional variation in the annual number of HIV tests per 100,000 residents was found, with higher rates in highly urbanised regions compared to more rural areas. The GP testing rate was lower or comparable to the SHC testing rate in every region. The study also found large discrepancies in GP-SHC ratio of HIV testing between regions. For instance, in Amsterdam, the GP contribution was only half that of SHC, while in Rotterdam, both GP and SHC testing rates were similar. The HIV positivity percentages were the highest in highly urbanised areas. In general, the positivity percentages of GP and SHC were comparable, except for Amsterdam, where the positivity percentage of GP testing was higher than that of the SHC. Although Rotterdam and Amsterdam are the first and second-largest cities of the Netherlands with diverse populations, they differed significantly in terms of HIV testing and positivity rates. This heterogeneity highlights the need for regionally tailored interventions to improve HIV testing.

In **Chapter 6** we delved deeper into HIV testing in the greater Rotterdam area, and provided more detailed information about characteristics of individuals tested for HIV by linking laboratory HIV testing data to population microdata. The study showed that 1.1% of all residents in the greater Rotterdam area was tested for HIV, with GPs testing 1.6 times more frequently than the SHC. The GP-SHC ratio differed considerably across population groups and area characteristics. The contribution of the GP was 1.1 to 4.2 times greater than the SHC, with exception to 20- to 24-year-olds, who are a typical SHC key population. Individuals with lower educational level, those living in less urbanised areas, and those residing farther from testing sites were more likely to be tested by GPs. An additional analysis with data from Stichting Hiv Monitoring data (SHM; HIV Monitoring Foundation) revealed that population groups that were relatively often tested also had the highest number of HIV diagnoses and incidence. The overall HIV incidence was 10.55 per 100,000 residents, but ranged from 3.09 (heterosexual men and women) to 24.04 (25–29-year-olds) across different demographic and area characteristics. This study emphasises the importance of adherence to STI testing guidelines, and that additional testing services could increase access to testing for underserved populations.

In **Chapter 7** the development, design, acceptability and feasibility of a community-based HIV testing (CBHT) approach to improve HIV test uptake were described. With the HIV epidemic in the Netherlands declining and only a small number of undiagnosed individuals living with HIV, alternative methods to improve testing may be considered. We performed a feasibility study that built on existing literature and CBHT approaches. Instead of targeting specific key groups, we focused on the general population in an area with a relatively high prevalence of HIV and high proportion of migrant residents in the city centre of Rotterdam. A community participatory approach was used, with localised input from over 40 stakeholders including community leaders, residents, professionals, and volunteers of local organisations. The CBHT design included not only HIV testing, but also BMI, blood pressure and blood glucose screening via test events at multiple community organisations. The approach successfully reached individuals with a low perceived HIV risk that were never or not recently tested. The participants' HIV positivity (0.75%) exceeded the neighbourhoods' HIV positivity. Evaluation among participants, stakeholders, and staff showed that the approach was acceptable, feasible and well-rated by all parties. However, implementation on a larger scale is deemed unlikely due to the significant labour required. It may be valuable as a supplement to more sustainable and cost-effective methods like proactive HIV testing by GPs and partner notification. The insights gained from stakeholders and during the intervention (development) can be valuable for future community-based STI testing interventions.

Part 3 – General discussion

Chapter 8 gives a general discussion of all chapters, including concluding remarks and future implications for practice and research. We conclude that our approach of combining laboratory data from GPs and the SHC with population register data provided a comprehensive view of STI/HIV testing in the general population of the greater Rotterdam area in the Netherlands. Our method – combining laboratory data with population data – also allowed for the investigation of factors associated with STI/HIV testing for all residents, not just those who visited an STI test provider. Furthermore, we found that GPs and the SHC largely test the same population groups, with generally a greater contribution from the GP, particularly for certain groups. We also identified missed opportunities for HIV testing during STI consultations for key populations, emphasising the importance of adhering to testing guidelines. Local analyses are crucial, as significant differences were observed in STI/HIV testing between regions and within the greater Rotterdam region itself. The results in this thesis offer guidance for implementing localised strategies to increase access to STI/HIV testing, such as additional testing strategies in areas and population groups with low testing rates. To improve access and acceptance of STI/HIV testing, we recommend enhancing STI testing in traditional settings and expanding STI testing opportunities through non-traditional means.

Samenvatting

Hoofdstuk 1 van dit proefschrift biedt een overzicht van hoe het testen en de zorg voor seksueel overdraagbare infecties (soa's) is georganiseerd in Nederland. Ook het soa-testbeleid bij de belangrijkste soa-testaanbieders, huisartsen en centra voor seksuele gezondheid (CSG's), wordt beschreven, evenals de soa/hiv-surveillance en de mogelijkheden van bevolkingsmicrodata.

Deel 1 – Soa-testen in het algemeen

In **hoofdstuk 2** hebben we de geografische variatie in het gebruik van het CSG in Rotterdam onderzocht, evenals factoren die hiermee verband houden. Dit onderzoek richtte zich op CSG-cliënten van 15 tot 45 jaar, woonachtig in de regio Rotterdam. We waren voornamelijk geïnteresseerd in het effect van reisafstand op het bezoeken van het CSG. Er waren grote geografische verschillen CSG-bezoek tussen verschillende postcodegebieden, variërend van 1,13 tot 48,76 per 1000 inwoners. Een aanzienlijk deel van deze variantie tussen gebieden kon worden verklaard door factoren die in de analyses waren opgenomen. Reisafstand verklaarde het grootste deel van de gebiedsvariatie: het CSG werd minder vaak bezocht als personen verder moesten reizen. De resultaten in deze studie hebben inzicht gegeven in de toegankelijkheid van het CSG op lokaal niveau.

In **hoofdstuk 3** is gefocust op de algemene bevolking van Rotterdam-Rijnmond. Het doel was om inzicht te krijgen in de personen die getest zijn op een soa bij de huisarts of bij het CSG. We hebben ook factoren onderzocht die van invloed zijn op het laten testen op soa's, en het testaandeel van huisartsen en het CSG vergeleken voor verschillende bevolkingsgroepen. Hiervoor hebben we individuele laboratoriumgegevens van soa-testen die zijn uitgevoerd bij huisartsen en het CSG gekoppeld aan bevolkingsregistergegevens (microdata). Uit het onderzoek bleek dat 3% van de algemene bevolking een soa-test had ondergaan tijdens de onderzoeksperiode (2015-2019). Er zijn aanzienlijke verschillen gevonden in testpercentages tussen bevolkingsgroepen, waarbij het percentage opliep tot 9,8% voor jongere en specifieke migrantengroepen. De soa-positiviteit, oftewel het percentage positieve testen, varieerde sterk tussen subgroepen en aanbieders: van 3,0% tot 35,5% bij de geteste personen. Huisartsen testten drie keer meer personen op soa's dan het CSG. Het testaandeel van huisartsen was onder andere groter in oudere leeftijdsgroepen, minder verstedelijkte gebieden en gebieden die verder van het CSG liggen. Verder bleek dat huisartsen en het CSG grotendeels dezelfde bevolkingsgroepen testten, maar dat huisartsen vaker vrouwen en personen met een lager opleidingsniveau testten dan het CSG. De resultaten van dit onderzoek benadrukken de belangrijke rol van huisartsen bij het uitvoeren van soa-testen. Deze bevindingen kunnen worden geïntegreerd in medische educatie voor huisartsen, om hen beter te informeren over (de grootte van) hun rol, het belang van het bespreken van seksuele gezondheid en het volgen van richtlijnen. Daarnaast kunnen interprofessionele samenwerkingen en CSG outreach-activiteiten in kwetsbare gebieden de toegang tot soa-testen voor onderbediende populaties verbeteren.

In **hoofdstuk 4** hebben we de geografische verdeling van soa-testen, het soa-risico en de soa-positiviteit gepresenteerd voor de regio Rotterdam-Rijnmond. Het doel hiervan was het identificeren van kenmerken van gebieden die verbeterde toegang tot seksuele gezondheidszorg nodig hebben. De gegevens over soa-testen en positiviteit waren gebaseerd op laboratoriumgegevens van huisartsen en het CSG. Het soa-risico was gebaseerd op sociaal-demografische kenmerken van inwoners (leeftijd, opleiding, migratieachtergrond en het al dan niet woonachtig zijn in een verstedelijk gebied). Op basis van de gebiedsspecifieke soa-risicoscore en testratio (aantal inwoners getest per 1.000 inwoners) zijn gebieden in drie clusters ingedeeld: (1) hoge risicoscore en hoge testratio ("hoge R-hoge TR"), (2) hoge risicoscore en lage testratio ("hoge R-lage TR"), en (3) lage testratio, onafhankelijk van de risicoscore ("laag"). Hoewel de soa-risiconiveaus van "hoge R-hoge TR" en "hoge R-lage TR" gebieden vergelijkbaar waren, was er een aanzienlijk verschil in testratio (75,5 versus 33,3 per 1.000 inwoners). Onze specifieke interesse lag bij het onderzoeken van de verschillen tussen deze gebieden om passende interventies te kunnen bepalen. Door een vergelijking te maken van de kenmerken van inwoners in "hoge R-lage TR" gebieden met die van "hoge R-hoge TR" gebieden, vonden we dat inwoners van "hoge R-lage TR" gebieden vaker geen migratieachtergrond hadden, afkomstig waren uit minder verstedelijkte en minder welvarende gebieden, en dat zij verder weg woonden van een huisarts en het CSG. De methodologie die in dit onderzoek is gebruikt, biedt een pragmatische en relatief onbevooroordeelde benadering om gebieden met een hoog soa-risico maar met een lage testratio te identificeren. Interventies zoals mobiele klinieken of satellietlocaties van het CSG kunnen helpen om soa-testen toegankelijker te maken voor personen die momenteel niet (voldoende) worden getest. Ook kan de betrokkenheid van huisartsen in gebieden met lage soa-testratios bijdragen aan het verbeteren en het vergroten van het testaanbod.

Deel 2 – Hiv-testen

Het onderzoek dat is beschreven in **hoofdstuk 5** had als doel het begrip van hiv-testpraktijken bij huisartsen te vergroten en inzicht te geven in hoe huisartsen en het CSG zich tot elkaar verhouden wat betreft hiv-testen. Er zijn gedetailleerde gegevens beschikbaar over wie er wordt getest op hiv bij CSG's, die opt-out hiv-testen aanbieden aan bepaalde doelgroepen. Voor huisartsen is er echter beperkt inzicht in de hiv-testpraktijken. In het onderzoek vergeleken we het aantal hiv-testen en het aandeel positieve testen tussen huisartsen en CSG's in vijf verschillende regio's in

Nederland met verschillende niveaus van verstedelijking (2011-2018): Amsterdam, Rotterdam, Maastricht, Twente en Noord-Nederland. Er was een grote regionale variatie in het jaarlijkse aantal hiv-testen per 100.000 inwoners. Het merendeel van de testen werd uitgevoerd in de sterk stedelijke regio's in vergelijking met meer landelijke gebieden. In de onderzochte regio's was de testratio van huisartsen lager of vergelijkbaar met de testratio van het CSG, maar er waren grote verschillen in de huisarts-CSG verhouding tussen de regio's. Zo was in Amsterdam de bijdrage van huisartsen slechts de helft van die van het CSG, terwijl in Rotterdam de testratio van huisartsen vergelijkbaar was met dat van het CSG. Het percentage positieve testen (hiv-positiviteit) was het hoogst in sterk verstedelijkte gebieden. Over het algemeen was de hiv-positiviteit bij huisartsen en CSG's vergelijkbaar, met uitzondering van Amsterdam waar de hiv-positiviteit bij de huisarts hoger was dan dat bij het CSG. Hoewel Rotterdam en Amsterdam de twee grootste steden van Nederland zijn, en beide steden gekenmerkt worden door een grote diversiteit aan bevolkingsgroepen, waren er aanzienlijke verschillen wat betreft hiv-testen en hiv-positiviteit. Deze heterogeniteit benadrukt de noodzaak van regionaal afgestemde interventies om het testen op hiv te verbeteren.

In **hoofdstuk 6** zijn we dieper ingegaan op hiv-testen in Rotterdam-Rijnmond en hebben we meer inzicht gekregen in de kenmerken van op hiv geteste personen, door laboratoriumgegevens van hiv-testen te koppelen aan bevolkingsmicrodata. Uit de studie bleek dat 1,1% van alle inwoners in Rotterdam-Rijnmond was getest op hiv, waarbij huisartsen 1,6 keer vaker testten dan het CSG. De huisarts-CSG testverhouding verschilde aanzienlijk tussen bevolkingsgroepen en gebiedskenmerken. De bijdrage van huisartsen was 1,1 tot 4,2 keer groter dan die van het CSG, met uitzondering van de leeftijdsgroep van 20- tot 24-jarigen, die een belangrijke doelgroep van het CSG zijn. Personen met een lager opleidingsniveau, personen die in minder verstedelijkte gebieden wonen en personen die verder van testlocaties wonen, werden vaker getest door huisartsen. Een aanvullende analyse met gegevens van Stichting Hiv Monitoring (SHM) toonde aan dat bevolkingsgroepen die relatief vaak werden getest, ook het hoogste aantal hiv-diagnoses en incidentie hadden. De totale hiv-incidentie in het onderzoeksgebied was 10,55 per 100,000 inwoners, maar varieerde van 3,09 (heteroseksuele mannen en vrouwen) tot 24,04 (25-29-jarigen) voor verschillende demografische en gebiedskarakteristieken. De bevindingen in deze studie benadrukken het belang van het naleven van soa-testrichtlijnen, en laten zien dat extra testmogelijkheden de toegang tot testen kunnen vergroten voor bepaalde groepen.

In **hoofdstuk 7** is de ontwikkeling, het ontwerp, de acceptatie en de haalbaarheid van een pilot-interventie in de populatie beschreven met als doel het gebruik van hiv-testen te verbeteren. Gezien de afnemende hiv-epidemie in Nederland en het feit dat nog maar een klein aantal personen leeft met niet-gediagnosticeerde hiv, zijn er wellicht alternatieve methoden nodig om testen te verbeteren. We voerden een pilot-interventie uit die voortbouwde op bestaande literatuur en andere hiv-test initiatieven. In plaats van ons te richten op specifieke risicogroepen, richtten we ons op de algemene bevolking in een gebied met een relatief hoge hiv-prevalentie en een hoge proportie personen met een migratieachtergrond in het centrum van Rotterdam. Meer dan 40 stakeholders, waaronder sleutelfiguren, bewoners, professionals en vrijwilligers van lokale organisaties leverden input voor het ontwerp van de pilot-interventie. De ontworpen pilot-interventie bestond uit testevenementen waarbij niet alleen een hiv-test werd aangeboden, maar ook metingen van BMI, bloeddruk en bloedglucose. De testevenementen zijn gehouden bij verschillende organisaties in de wijk. De pilot-interventie bereikte personen met een lage risicoperceptie en personen die nooit of niet recentelijk getest waren. De hiv-positiviteit onder de deelnemers (0,75%) was hoger dan de hiv-positiviteit in de wijk waar de testevenementen zijn gehouden. Evaluatie onder deelnemers, stakeholders, en medewerkers toonde aan dat pilot-interventie geaccepteerd werd, haalbaar was en goed beoordeeld werd door alle betrokken partijen. Het was echter een arbeidsintensief proces, waardoor grootschalige implementatie niet waarschijnlijk is. Wel kan de onderzochte aanpak een waardevolle aanvulling zijn op meer duurzame en kosteneffectieve methoden zoals proactief hiv-testen door huisartsen en partnernotificatie. De inzichten die verkregen zijn op basis van de stakeholdergesprekken en tijdens de interventie(ontwikkeling) kunnen waardevol zijn voor toekomstige soa-test interventies in de populatie.

Deel 3 – Algemene discussie

In **hoofdstuk 8** bespreken we de bevindingen uit de onderzoeken die zijn beschreven in dit proefschrift, en presenteren we een algemene conclusie en implicaties voor praktijk en onderzoek. We concluderen dat onze aanpak, waarbij we laboratoriumgegevens van huisartsen en het CSG combineren met bevolkingsregistergegevens, een beter inzicht heeft gegeven in het testen op soa/hiv in de algemene bevolking van Rotterdam-Rijnmond. Door het combineren van laboratoriumgegevens met bevolkingsgegevens hebben we ook kunnen onderzoeken welke factoren verband houden met het testen op soa/hiv bij alle inwoners, en niet alleen degenen die zich hebben laten testen. Bovendien hebben we ontdekt dat huisartsen en het CSG grotendeels dezelfde bevolkingsgroepen testen, waarbij de huisarts over het algemeen een grotere rol heeft, vooral voor bepaalde groepen. We hebben ook gemiste kansen geïdentificeerd voor hiv-testen tijdens soa-consulten voor sleutelpopulaties. Dit benadrukt het belang van het naleven van testrichtlijnen. Lokale analyses zijn cruciaal, aangezien grote verschillen zijn waargenomen in het testen op soa/hiv tussen verschillende regio's en binnen Rotterdam-Rijnmond zelf. De bevindingen in dit proefschrift kunnen worden gebruikt voor lokale strategieën om de toegang tot het testen op soa's/hiv te vergroten, zoals aanvullende teststrategieën in gebieden en bevolkingsgroepen met een lage testratio. Om de toegang en acceptatie van soa/hiv-testen te verbeteren, raden we aan om het testen bij traditionele zorgaanbieders te versterken en meer mogelijkheden te bieden voor soa-testen via niet-traditionele routes.

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About the author

Denise Eline Twisk was born in December 1991 in Delft (the Netherlands). At the age of 4 years she moved to the green town of Heiloo with her parents and younger sister Nancy. After graduating from secondary education at Bonhoeffer College in Castricum, she studied Health and Life Sciences at the Vrije Universiteit (VU) in Amsterdam. She received her Bachelor's degree in 2015 and subsequently pursued her Master's degree in Health Sciences specialisation Infectious Diseases and Public Health at the same university (2016). During her Bachelor and Masters she did two research internships on sexual health and STI/HIV. The results of both internships were published in an international peer-reviewed journal.

Her professional career started as junior researcher at Rutgers, expertise centre for sexual and reproductive health and rights, in Utrecht. She worked on two large studies about sexual health in the Netherlands (*Seks onder je 25ᵉ* and *Monitor Seksuele Gezondheid*). In December 2017, she was offered a job at the Public Health Service Rotterdam-Rijnmond (GGD Rotterdam-Rijnmond) and started her PhD project, of which the results are described in this thesis. The PhD was supervised by prof. dr. Jan Hendrik Richardus, dr. Hannelore Götz, and dr. Abraham Meima. After finishing her PhD project in December 2022, she continued as researcher for the Sexual Health Department of the GGD Rotterdam-Rijnmond.

Denise lives with Sven in Utrecht.

PhD portfolio

Name PhD candidate	Denise Eline Twisk
University	Erasmus University Rotterdam, the Netherlands
Faculty	Erasmus MC
Department	Public Health
PhD period	2017 - 2022
Promotor	Prof. dr. J.H. Richardus
Co-promotors	Dr. H.M. Götz
	Dr. A. Meima

	Year	Workload (ECTS)
PhD training		
Course Meeting and Presentation Skills in English, the Square Mile	2017	1.5
Workshop Scientific Integrity, Graduate School, Erasmus MC	2019	0.3
Workshop EndNote, Medical Library, Erasmus MC	2019	0.2
Course Scientific Writing, MolMed, Erasmus MC	2019	2.0
Course Effective Ownership and Communication (basis), Schoonderwoerd	2020	1.5
Course Effective Ownership and Communication (follow-up), Schoonderwoerd	2021	0.3
Course Begin R, RIVM	2021	0.3
Course R, Municipality of Rotterdam	2021	0.5
Clinical Epidemiology, NIHES, Erasmus MC	2022	3.0
Course Perfect Chart, De perfecte grafiek	2022	0.9
Conferences and (poster) presentations		
Annual meeting of the Dutch Epidemiology Society (WEON), Wageningen, the Netherlands (poster presentation)	2017	0.5
Annual STI expert meeting, Bilthoven, the Netherlands (oral presentation in 2019 and 2021)	2018 – 2021	2.2
Annual STI*HIV*Sex conference, Amsterdam, the Netherlands	2017 – 2022	1.3
International AIDS Conference, Amsterdam, the Netherlands	2018	1.5
STI & HIV 2019 World Congres (23rd ISSTR & 20th IUSTI), Vancouver, Canada (poster presentation)	2019	2.0
The Netherlands Conference on HIV pathogenesis, Epidemiology, Prevention and Treatment (NCHIV), Amsterdam, the Netherlands (oral presentation)	2020	0.8
STI & HIV 2021 World Congres (24th ISSTDR & 21st IUSTI), Amsterdam, the Netherlands (2 poster presentations and 1 oral presentation)	2021	3.0

Research meetings, RIVM	2018 – 2022	1.0
Research meetings, Municipality of Rotterdam	2018 – 2022	1.0
Attended seminars, workshops, and other events		
Data Protection Regulation for Public Health Services, MedLaw	2017	0.3
Microdata in Public Health, Statistics Netherlands	2018	0.3
Various science and research events, Municipality of Rotterdam	2018, 2019, 2021	1.5
PhD day, Erasmus MC	2018	0.3
The Netherlands to zero HIV infections, Soa Aids Nederland	2019, 2020	0.6
Research meetings, RIVM	2018 – 2022	2.0
Research meetings, Municipality of Rotterdam	2018 – 2022	2.5
Organised workshops and teaching activities		
Workshops		
STI*HIV*Sex conference	2018, 2019	2.0
Symposium Rotterdam-Rijnmond AIDSVRIJ2030	2018	1.0
Supervision		
Master thesis student Management, Policy Analysis and Entrepreneurship in Health & Life Sciences, Vrije Universiteit Amsterdam	2020	3.0
Several groups of students visiting the Public Health Service for career perspective, bachelor Health & Life Sciences, Vrije Universiteit Amsterdam	2019-2021	0.5
Grants and awards		
(Co-)acquired research grants		
Small grant Aidsfonds “Map the numbers” (granted €10.000)	2019	
Small grant Aidsfonds “HIV testing in Oude Westen” (granted €10.000)	2019	
Awards		
First price oral presentation, STI & HIV 2021 World Congres	2021	
Other activities		
Conducting Data Protection Impact Assessment		
Various data requests (e.g., Statistics Netherlands, laboratory)		

List of publications

This thesis

Denise E Twisk, Abraham Meima, Jan Hendrik Richardus, Hannelore M Götz. Testing for sexually transmitted infection: who and where? A data linkage study using population and provider data in the Rotterdam area, the Netherlands. *Fam Pract.* 2023;cmad079 *(online ahead of print)*.

Denise E Twisk, Anita Watzeels, Hannelore M Götz. Community-based HIV testing through a general health check event in a high HIV prevalent multicultural area in Rotterdam, the Netherlands: a pilot study on feasibility and acceptance. *Pilot Feasibility Stud.* 2023;9(1):101.

Denise E Twisk, Abraham Meima, Jan Hendrik Richardus, Hannelore M Götz. Area-based comparison of risk factors and testing rates to improve sexual health care access: cross-sectional population-based study in a Dutch multicultural area. *BMJ Open.* 2023;13(5):e069000.

Saskia J Bogers*, **Denise E Twisk***, Loes M Beckers, Hannelore M Götz, Abraham Meima, Michelle Kroone, Elske Hoornenborg, Alewijn Ott, Marleen N Luning-Koster, Nicole HTM Dukers-Muijrers, Christian JPA Hoebe, Carolina JG Kampman, Froukje Bosma, Maarten F Schim van der Loeff, Suzanne E Geerlings, Jan EAM van Bergen. Who is providing HIV diagnostic testing? Comparing HIV testing by general practitioners and sexual health centres in five regions in the Netherlands, 2011-2018. *Sex Transm Infect.* 2022;98(4):262-68.

**These authors contributed equally to this work*

Denise E Twisk, Abraham Meima, Daan Nieboer, Jan Hendrik Richardus, Hannelore M Götz, Distance as explanatory factor for sexual health centre utilization: an urban population-based study in the Netherlands. *Eur J Public Health.* 2021;31(6):1241-48.

Submitted for publication

Denise E Twisk, Abraham Meima, Jan Hendrik Richardus, Ard van Sighem, Casper Rokx, Jan G den Hollander, Hannelore M Götz. High HIV incidence follows high testing rates in the Rotterdam area, the Netherlands: a cross-sectional population-based study. *Under review.*

Ohter publications

Saskia J Bogers*, **Denise E Twisk***, Hannelore M Götz, Jan EAM van Bergen. Op weg naar 0 nieuwe hiv-infecties door proactief testen. *Huisarts en Wetenschap.* 2022;65(4):24-27.

**These authors contributed equally to this work*

Denise E Twisk, Marianne AB van der Sande, Arne van Eeden, Daniëlle AM Heideman, Fiona RM van der Klis, Henry JC de Vries, Maarten F Schim van der Loeff. Detection of incident anal high-risk Human Papillomavirus DNA in men who have sex with men: incidence or reactivation? *J Infect Dis.* 2018;218(7):1018-1026.

Hanneke de Graaf, Sanne Nikkelen, Marieke van den Borne, **Denise Twisk**, Suzanne Meijer. Sex under the age of 25 in 2017: the sexual health of young people in the Netherlands. *Ned Tijdschr Geneeskd*. 2018;162;pii:D2734.

Denise E Twisk, Ivo K Joore, Jan EAM van Bergen. Improving early HIV diagnosis, treatment and care in Europe with healthcare provider specific HIV indicator list and audits. *Sex Transm Infect.* 2017;93(8):582.

Denise Twisk, Marianne Cense, Afiah Vijlbrief, Hanneke Felten, Michelle Emmen (2017). Literatuurstudie Genderdiversiteit. Utrecht, Nederland: Rutgers & Movisie.

Denise Twisk & Suzanne Meijer (2017). Soa en hiv. In: De Graaf H & Meijer S (red.), *Seks onder je 25e: seksuele gezondheid van jongeren in Nederland anno 2017* (pp. 111-133).

Denise Twisk & Marieke van den Borne (2017). Seksuele grensoverschrijding. In: De Graaf H & Meijer S (red.), *Seks onder je 25e: seksuele gezondheid van jongeren in Nederland anno 2017* (pp. 135-148).

Denise Twisk & Hanneke de Graaf (2017) Soa en hiv. In: De Graaf H & Wijsen C (red.), *Seksuele gezondheid in Nederland 2017* (pp. 75-87).

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Denise Twisk & Ciel Wijsen (2017). Landelijke abortusregistratie 2015. Utrecht, Nederland: Rutgers.

Ivo K Joore, **Denise E Twisk**, Ann M Vanrolleghem, Maria de Ridder, Suzanne E Geerlings, Jan EAM van Bergen, Ingrid V van den Broek. The need to scale up HIV indicator condition-guided testing for early case finding: a case control study in primary care. *BMC Fam Pract*. 2016;17(1):161.