27 Zerfu TA, Pinto E, Baye K. Consumption of dairy, fruits and dark green leafy vegetables is associated with lower risk of adverse pregnancy outcomes (APO): a prospective cohort study in rural Ethiopia. *Nutr Diabetes* 2018;8:52.

28 Zheng W, Suzuki K, Tanaka T, et al.; Okinawa Child Health Study Group. Association between maternal smoking during pregnancy and low birthweight: effects by maternal age. *PLoS One* 2016;11:e0146241.

29 Demelash H, Motbainor A, Nigatu D, et al. Risk factors for low birth weight in Bale zone hospitals, South-East Ethiopia: a case–control study. *BMC Pregnancy Childbirth* 2015;15:264.

30 Batra P, Higgins C, Chao SM. Previous adverse infant outcomes as predictors of preconception care use: an analysis of the 2010 and 2012 Los Angeles mommy and baby (LAMB) surveys. *Matern Child Health J* 2016;20:1170–7.

31 Feleke BE, Feleke TE. Pregnant mothers are more anemic than lactating mothers, a comparative cross-sectional study, Bahir Dar, Ethiopia. *BMC Hematol* 2018;18:2.

32 Robichaud MV, Pearl D, Godden S, et al. Systematic early obstetrical assistance at calving: I. Effects on dairy calf stillbirth, vigor, and passive immunity transfer. *J Dairy Sci* 2017;100:691–702.

33 Daglar K, Biberoglu E, Kirbas A, et al. The cellular immunity and oxidative stress markers in early pregnancy loss. *J Maternal Fetal Neonatal Med* 2016;29:1840–3.

34 Cottrell G, Moussiliou A, Luty AJ, et al. Submicroscopic *Plasmodium falciparum* infections are associated with maternal anemia, premature births, and low birth weight. *Clin Infect Dis* 2015;60:1481–8.

35 Collado MC, Cernada M, Neu J, et al. Factors influencing gastrointestinal tract and microbiota immune interaction in preterm infants. *Pediatr Res* 2015;77:726–31.

36 Zivich P, Lapika B, Behets F, Yotebieng M. Implementation of steps 1–9 to successful breastfeeding reduces the frequency of mild and severe episodes of diarrhea and respiratory tract infection among 0–6 month infants in Democratic Republic of Congo. *Matern Child Health J* 2018;22:762–71.

37 Payne S, Quigley MA. Breastfeeding and infant hospitalisation: analysis of the UK 2010 Infant Feeding Survey. *Matern Child Nutr* 2017;13:e12263.

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

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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.

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

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

Characteristics	Total population		SHC visitors		Utilization rate per 1000 residents (95% CI)	STI positivity rate SHC visitors (95% CI)[b]
	No.	%	No.	%		
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)
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]						
<5 km	641 744	40.6	12 832	66.7	20.0 (19.9–20.0)	20.7 (20.0–21.4)
5–10 km	586 150	37.1	4779	24.8	8.2 (8.1–8.2)	22.0 (20.9–23.2)
≥10 km	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.

defined by a variance inflation factor (VIF $\geq$ 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).

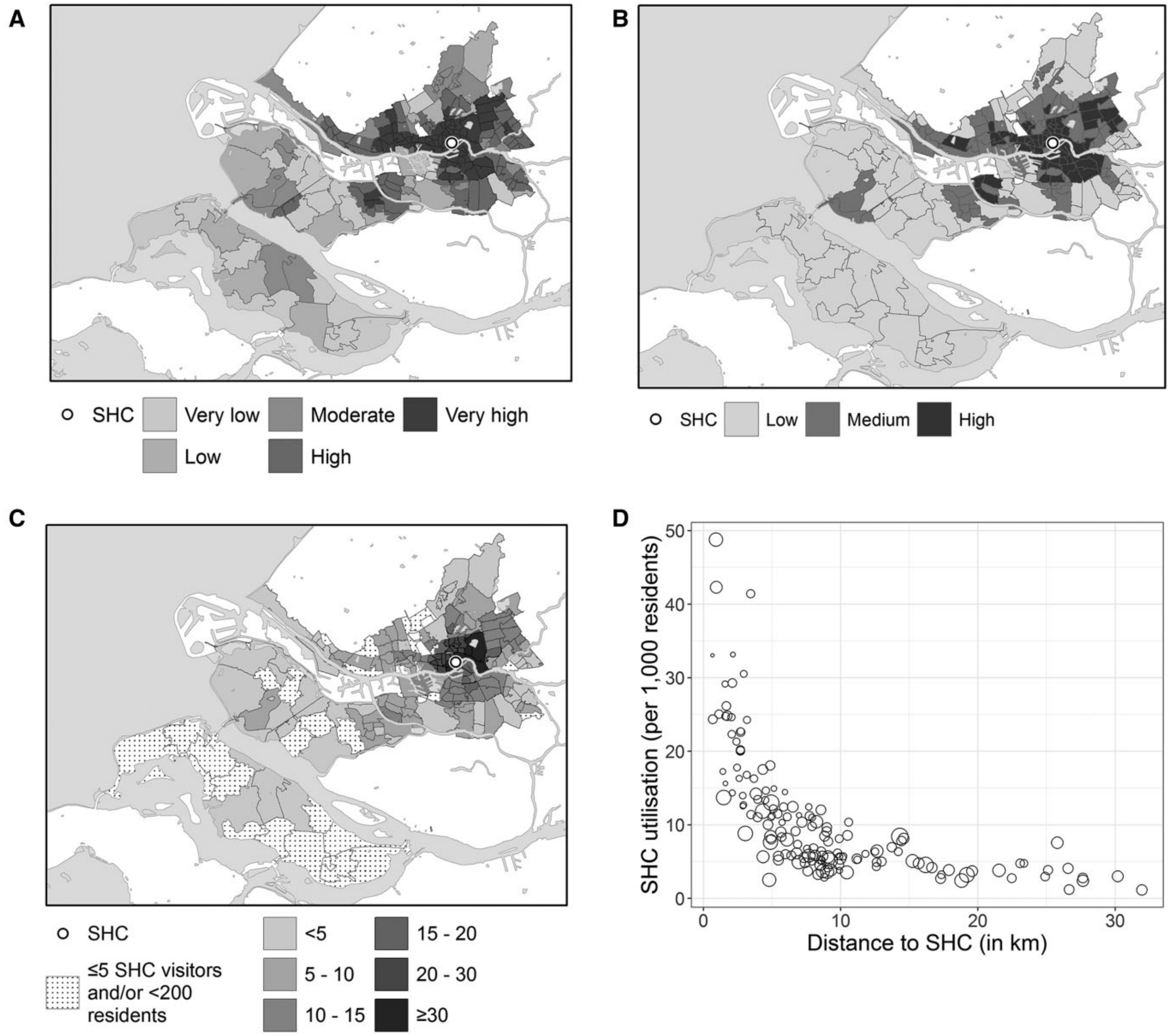

Figure 1 Degree of urbanization (A), ethnic diversity (B), SHC utilization per 1000 residents (C), and SHC utilization by distance to SHC (D). [a] Degree of urbanization of each postal code presented in five categories: very low (<500 addresses/km^2), low (500–1000 addresses/km^2), moderate (1000–1500 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. km, kilometre; SHC, sexual health centre. 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)

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).

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

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)
Year						
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)
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 of 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	199 478.9		179 223.5		179 162.0	
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.

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.

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

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.

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.

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 SCH 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.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Ethical approval

No ethical approval was needed under prevailing laws in the Netherlands as this study is a retrospective observational study using anonymous data only (as stated by the National Central Committee for Human Studies: www.ccmo.nl and in the conduct of good behaviour in research www.federa.org).

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

References

1 Li Z, Purcell DW, Sansom SL, et al. Vital signs: HIV transmission along the continuum of care - United States, 2016. *Morb Mortal Wkly Rep* 2019;68:267–72.

2 The Ministry of Health Welfare and Sport. Public Health Subsidy Schema, 2018. Available at: https://wetten.overheid.nl/BWBR0018743/2018-01-01 (March 2021, date last accessed).

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.

3 The Ministry of Health Welfare and Sport. Health Insurance Decision, 2019. Available at: https://wetten.overheid.nl/BWBR0018492/2019-01-01#Hoofdstuk2_Paragraaf1_Artikel2.4 (March 2021, date last accessed).

4 Denison HJ, Bromhead C, Grainger R, et al. Barriers to sexually transmitted infection testing in New Zealand: a qualitative study. *Aust N Z J Public Health* 2017;41:432–7.

5 Blondell SJ, Kitter B, Griffin MP, Durham J. Barriers and facilitators to HIV testing in migrants in high-income countries: a systematic review. *AIDS Behav* 2015;19:2012–24.

6 Bender SS, Fulbright YK. Content analysis: a review of perceived barriers to sexual and reproductive health services by young people. *Eur J Contracept Reprod Health Care* 2013;18:159–67.

7 Ayehu A, Kassaw T, Hailu G. Level of young people sexual and reproductive health service utilization and its associated factors among young people in Awabel District, Northwest Ethiopia. *PLoS One* 2016;11:e0151613.

8 De Visser RO, O'Neill N. Identifying and understanding barriers to sexually transmissible infection testing among young people. *Sex Health* 2013;10:553–8.

9 Moore EW. Human immunodeficiency virus and chlamydia/gonorrhea testing among heterosexual college students: who is getting tested and why do some not? *J Am Coll Health* 2013;61:196–202.

10 Cassidy C, Bishop A, Steenbeek A, et al. Barriers and enablers to sexual health service use among university students: a qualitative descriptive study using the Theoretical Domains Framework and COM-B model. *BMC Health Serv Res* 2018;18:581.

11 Burns FM, Imrie JY, Nazroo J, et al. Why the(y) wait? Key informant understandings of factors contributing to late presentation and poor utilization of HIV health and social care services by African migrants in Britain. *AIDS Care* 2007;19:102–8.

12 Wang F, Luo W. Assessing spatial and nonspatial factors for healthcare access: towards an integrated approach to defining health professional shortage areas. *Health Place* 2005;11:131–46.

13 Hiscock R, Pearce J, Blakely T, Witten K. Is neighborhood access to health care provision associated with individual-level utilization and satisfaction? *Health Serv Res* 2008;43:2183–200.

14 Kelly C, Hulme C, Farragher T, Clarke G. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. *BMJ Open* 2016;6:e013059.

15 Sanz-Barbero B, Otero Garcia L, Blasco Hernandez T. The effect of distance on the use of emergency hospital services in a Spanish region with high population dispersion: a multilevel analysis. *Med Care* 2012;50:27–34.

16 Bergeron P, Courteau J, Vanasse A. Proximity and emergency department use: multilevel analysis using administrative data from patients with cardiovascular risk factors. *Can Fam Physician* 2015;61:e391–7.

17 Heisig JP, Schaeffer M. Why you should always include a random slope for the lower-level variable involved in a cross-level interaction. *Eur Sociol Rev* 2019;35:258–79.

18 Visser M, van Aar F, Op de Coul ELM, et al. *Sexually Transmitted Infections in The Netherlands in 2017*. Bilthoven: National Institute for Public Health and the Environment, 2018.

19 National Institute for Public Health and the Environment. Draaiboek Consult seksuele gezondheid [Script Consult sexual health]. Bilthoven, the Netherlands, 2017.

20 Clifton S, Mercer CH, Sonnenberg P, et al. STI risk perception in the British population and how it relates to sexual behaviour and STI healthcare use: findings from a cross-sectional survey (Natsal-3). *EClinicalMedicine* 2018;2:29–36.

21 Ajayi AI, Abioye AO, Adeniyi OV, Akpan W. Concerns about contracting HIV, knowing partners' HIV sero-status and discussion of HIV/STI with sexual partners as determinants of uptake of HIV testing. *J Biosoc Sci* 2019;51:549–61.

22 Ajayi AI, Mudefi E, Adeniyi OV, Goon DT. Achieving the first of the Joint United Nations Programme on HIV/AIDS (UNAIDS) 90-90-90 targets: understanding the influence of HIV risk perceptions, knowing one's partner's status and discussion of HIV/sexually transmitted infections with a sexual partner on uptake of HIV testing. *Int Health* 2019;11:425–31.

23 Thomas F, Aggleton P, Anderson J. "If I cannot access services, then there is no reason for me to test": the impacts of health service charges on HIV testing and treatment amongst migrants in England. *AIDS Care* 2010;22:526–31.

24 Klein J, von dem Knesebeck O. Inequalities in health care utilization among migrants and non-migrants in Germany: a systematic review. *Int J Equity Health* 2018;17:160.

25 Pearson M. What does distance matter? Leprosy control in West Nepal. *Soc Sci Med* 1988;26:25–36.

26 Nanfuka EK, Kyaddondo D, Ssali SN, Asingwire N. Paying to normalize life: monetary and psychosocial costs of realizing a normal life in the context of free antiretroviral therapy services in Uganda. *J Int Assoc Provid AIDS Care* 2019;18:2325958219859654.

27 Rade DA, Crawford G, Lobo R, et al. Sexual health help-seeking behavior among migrants from Sub-Saharan Africa and South East Asia living in high income countries: a systematic review. *Int J Environ Res Public Health* 2018;15:1311.

28 Biggs K, Walsh J. Why not the GP? Client preferences for sexually transmissible infection testing in Western Sydney. *Sex Health* 2015;12:463–4.

29 Bijlsma I, Van den Brakel J, Van der Velden R, Allen J. Estimating literacy levels at a detailed regional level: an application using Dutch data. *J Off Stat* 2020;36:251–74.

30 Estcourt C. PL09 Digital sexual health: what we know and what we need to know for effective services [Conference Presenation STI & HIV 2021, Amsterdam]. *Sex Transm Infect* 2021;97 (Suppl. 1):A2.4–A3.

31 Boscoe FP, Henry KA, Zdeb MS. A Nationwide Comparison of Driving Distance Versus Straight-Line Distance to Hospitals. *Prof Geogr* 2012;64:10.

32 Apparicio P, Abdelmajid M, Riva M, Shearmur R. Comparing alternative approaches to measuring the geographical accessibility of urban health services: distance types and aggregation-error issues. *Int J Health Geogr* 2008;7:7.

33 Jordan H, Roderick P, Martin D, Barnett S. Distance, rurality and the need for care: access to health services in South West England. *Int J Health Geogr* 2004;3:21.

34 Fone DL, Christie S, Lester N. Comparison of perceived and modelled geographical access to accident and emergency departments: a cross-sectional analysis from the Caerphilly Health and Social Needs Study. *Int J Health Geogr* 2006;5:16.

35 Bliss RL, Katz JN, Wright EA, Losina E. Estimating proximity to care: are straight line and zipcode centroid distances acceptable proxy measures? *Med Care* 2012;50:99–106.

36 Jones SG, Ashby AJ, Momin SR, Naidoo A. Spatial implications associated with using Euclidean distance measurements and geographic centroid imputation in health care research. *Health Serv Res* 2010;45:316–27.