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Gonorrhoea: a systematic review of prevalence reporting globally

Jane Whelan^{1*} , Victoria Abbing-Karahagopian^{1*} , Laura Serino²  and Magnus Unemo³ 

Abstract

Background: The World Health Organization (WHO) recommends periodic gonorrhoea prevalence assessments in the general population or proxies thereof (including pregnant women, women attending family planning clinics, military recruits, and men undergoing employment physicals for example) and in population groups at increased risk, including men-who-have-sex-with-men (MSM) and sex workers.

Method: We evaluated reported prevalence data, including estimates from proxy general population samples to reflect the WHO recommendations. We describe the outcomes from the general population country-by-country and extend previous reviews to include MSM, sex workers, and extragenital infections.

Result and conclusion: In our systematic search, 2015 titles were reviewed (January 2010–April 2019) and 174 full-text publications were included. National, population-based prevalence data were identified in only four countries (the United States of America, the United Kingdom, Peru, New Caledonia) and local population-based estimates were reported in areas within five countries (China, South Africa, Brazil, Benin, and Malawi). The remaining studies identified only reported test positivity from non-probability, proxy general population samples. Due to the diversity of the reviewed studies, detailed comparison across studies was not possible. In MSM, data were identified from 64 studies in 25 countries. Rectal infection rates were generally higher than urogenital or pharyngeal infection rates, where extragenital testing was conducted. Data on sex workers were identified from 41 studies in 23 countries; rates in female sex workers were high. Current prevalence monitoring was shown to be highly suboptimal worldwide. Serial prevalence monitoring of critical epidemiological variables, and guidelines to optimize prevalence study conduct and reporting beyond antenatal settings are recommended.

Keywords: global, gonorrhoea, *Neisseria gonorrhoeae*, prevalence, systematic review, men-who-have-sex-with-men, sex workers

Background

Gonorrhoea is a sexually transmitted infection (STI) caused by *Neisseria gonorrhoeae* (the gonococcus). In 2016, an estimated 87 million incident cases occurred among persons aged 15–49 years worldwide with an incidence rate of 20 cases/1000 women and 26/1000 men [1].

Gonorrhoea affects the urogenital tract, oropharynx, rectum, or conjunctiva, and repeat infections are common. Urogenital infections are often asymptomatic, particularly in women, but irrespective of symptoms, gonorrhoea is associated with substantial morbidity. Serious complications and sequelae include pelvic inflammatory disease, chronic pelvic pain, ectopic pregnancy, and infertility in women [2]. Infection during pregnancy is also associated with low birth weight and neonatal conjunctivitis, which can progress to blindness [2, 3]. In men, gonorrhoea can cause epididymitis [2]. Rectal and pharyngeal gonorrhoea cases, mostly asymptomatic, are

* Correspondence: whelanjane@hotmail.com; victoria.x.abbing-karahagopian@gsk.com

¹Clinical and Epidemiology Research and Development, GSK, Amsterdam, The Netherlands

Full list of author information is available at the end of the article



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prevalent in men-who-have-sex-with-men (MSM), but can be common also in women and, particularly pharyngeal infection, in men who have sex only with women [4]. The presence of gonorrhoea is also a co-factor in human immunodeficiency virus (HIV) transmission [5].

Gonorrhoea is substantially underdiagnosed and underreported worldwide [3]. Even in high-income economies with well-established STI surveillance systems, it is estimated that more than half of infections are unidentified or unreported [6, 7]. This underdiagnosis/underreporting is higher in less-resourced settings and settings using syndromic management with limited access to state-of-the-art diagnostics such as nucleic acid amplification tests (NAATs). Though partially explained by the asymptomatic nature of the infection, underreporting is also due to delays in seeking healthcare and inaccessible or inadequate STI testing/treatment in underserved populations or those particularly vulnerable to infection: adolescents and young people, some ethnic and racial groups, communities of lower socioeconomic status, MSM, sex workers, and others [8].

The World Health Organization (WHO)'s global target is a 90% reduction in gonorrhoea cases by 2030 [9]. To monitor progress towards this goal, STI trend monitoring at the national level is recommended. This should include routine prevalence assessments (every two to three years) of bacterial STIs among general populations of men and women (e.g. including pregnant women, women attending family planning clinics, military recruits and men undergoing employment physicals) [3]. Monitoring in high-risk priority populations including MSM and sex workers is also recommended [3, 9].

The WHO reports prevalence estimates of curable non-viral STIs at a global and regional level using epidemic models, while recognizing the small number of prevalence data points that are available to generate reliable estimate [1, 3]. Notably, for key population groups such as MSM and sex workers, who likely contribute substantially to the worldwide infection burden, gonorrhoea prevalence in global estimates is indirectly accounted for [1] and estimates do not reflect rectal and pharyngeal infection.

N. gonorrhoeae is progressively developing antimicrobial resistance (AMR) to all therapeutic antibiotics, and the WHO has issued warnings that untreatable gonorrhoea may be on the horizon [10]. National prevalence estimates are an essential indicator of the state of gonorrhoea and STI control at state level and globally [3]. In this review, we aimed to evaluate global prevalence reporting in the general population, and proxies thereof, on a country-by-country basis, extending previous reviews to report on key population groups of MSM and

female and male sex workers (FSW and MSW), including extragenital as well as urogenital infection.

Methods

Search strategy and selection criteria

We conducted a systematic search of PubMed following PRISMA guidelines (Additional file 1) for papers published from 1 January 2010 to 11 April 2019. We derived a sensitive search strategy requiring at least one medical subject headings (MeSH) term related to a sexually transmitted disease (STD) or gonorrhoea and at least one reference to the keyword 'gonorrhoea' in the title or abstract. We did not specify the population (e.g. MSM, FSW or MSW), as we noted substantial overlap in reporting of risk groups and inclusion of terms such as 'prevalence', 'epidemiology' or 'rate' rendered the search too specific, omitting relevant papers (Additional file 2). Two authors (JW and VAK) independently screened all titles and abstracts against pre-specified inclusion and exclusion criteria (Additional file 3) and agreed on the selection of articles to be obtained as full text. English-language abstracts were reviewed but the full text was translated as necessary, from Portuguese, Spanish, and Chinese, where relevant. The systematic search was supplemented with an online English-language country-by-country search of websites, data repositories and surveillance reports of public health and/or governmental agencies using the country name, and 'gonorr*' or 'sexually transmitted' and 'disease' or 'infection' to identify data sources and provide context to prevalence estimates. We reviewed regional and international health agency data (WHO, European Centre for Disease Prevention and Control [ECDC]) and contacted relevant experts in the field. AMR monitoring, an essential component of gonorrhoea surveillance [10] and worthy of a separate review, was beyond the scope of this search.

Data analysis

The primary outcome (prevalence of gonorrhoea) was defined as the proportion of persons with laboratory-confirmed (culture and/or NAAT positive) gonorrhoea in the population within a specified time. It became apparent early in the literature search that population-based prevalence estimates were very limited and so to address the WHO recommendation to derive estimates from studies which are not necessarily population-based but nevertheless relevant, we defined a post-hoc secondary objective to report test positivity, categorizing these as proxy general population samples. Data were tabulated by population group (classified as 'general population', MSM and sex workers) and summarized per WHO region and country. 'General population' samples were identified according to WHO recommendations, to

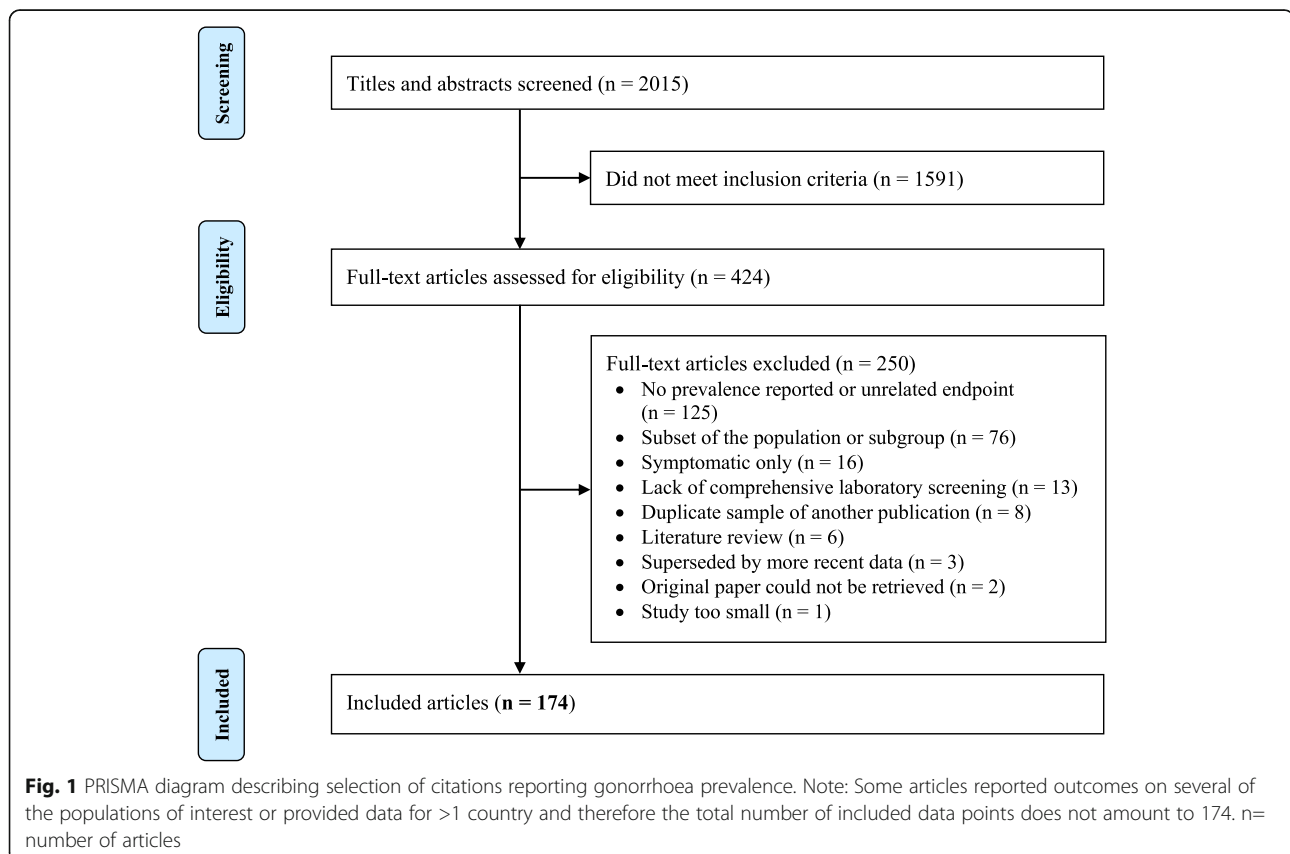
include studies conducted ‘among pregnant women, women attending family planning clinics, male military recruits and men undergoing employment physicals’ [3]. These samples served as proxies for the general population where population-based sampling was not, or could not, be conducted. The point estimates reported were adjusted for diagnostic test performance by applying a standardization factor for urogenital infection as utilized by WHO (Additional file 4) [3, 11]. For rectal and pharyngeal infections, a separate literature review was undertaken to derive sensitivity and specificity values (for culture and/or NAAT) and adjustments were applied in the same manner as for the urogenital samples (Additional file 4). Due to obvious heterogeneity in study populations and study designs, widespread inclusion of non-representative samples and frequent lack of reporting of key parameters to judge the study quality, a quality score was not assigned. Similarly, a meta-analysis could not be conducted as we were limited in our ability to appropriately compare studies directly. We did not calculate a median summary estimate per country because only a small number of countries had three or more available estimates. Instead, guided by the principles of Campbell et al [12], we conducted a narrative synthesis, presenting the prevalence and test positivity estimates reported in the context of the source

population and the type of sampling conducted, rather than directly comparing estimates. General population estimates were considered ‘population-based’ and representative if participants were sampled from a general population sampling frame and some form of random selection was performed. Studies employing other forms of sampling from proxy general population samples are labelled as such. As MSM and sex workers are defined in terms of their sexual behaviour, population-based denominator samples are generally not available. For these groups, screening and/or enhanced testing is frequently recommended irrespective of symptom status (and thus may be more reflective of prevalence). Therefore, studies conducted at STI clinics and at other venues frequented by MSM and sex workers were eligible for inclusion, excepting studies including persons presenting with symptoms, which were excluded to minimize bias. The median sample size and interquartile range were estimated using Excel’s ‘quartile.exc’ function.

Results

Prevalence reporting in the general population

We identified 2015 citations relating to gonorrhoea ‘prevalence’ (Fig. 1), subsequently categorized into (a) the general population or proxy general population groups (men, women, and pregnant women separately),



(b) MSM, and (c) FSW and MSW. Following title and abstract screening, we reviewed 424 full-text publications, of which 174 addressed the primary or secondary objective and were eligible for inclusion, reporting data from the following WHO regions: Africa (n=41), the Western Pacific (n=41), high-income North America that is part of the Region of the Americas (n=25), the Americas excluding high-income North America (n=25), Europe (n=19), South-East Asia (n=18), and the Eastern Mediterranean (n=5). The number of countries where prevalence and/or test positivity estimates were identified from the general population was limited, with data points identified from only 18.0% of countries worldwide (35/194) for women and 9.8% (19/194) for men (Fig. 2). Prevalence of gonorrhoea in the general population by WHO region and country is summarized in Table 1 and test positivity estimates from proxy general population samples in Table 2.

For several countries, we did not identify prevalence or test positivity data. The grey literature search led to one additional estimate [63], but also allowed us to set the prevalence estimates identified in the context of the extent of surveillance otherwise ongoing in the country. To this end, expert consultation led to identification of surveillance data from three international reporting networks (WHO Global, WHO European Regional Office, and ECDC), and national surveillance data or reports from an additional seven countries, the United States of America (USA), Canada, Australia, Singapore, New Zealand, Japan, and the Republic of Korea.

Europe

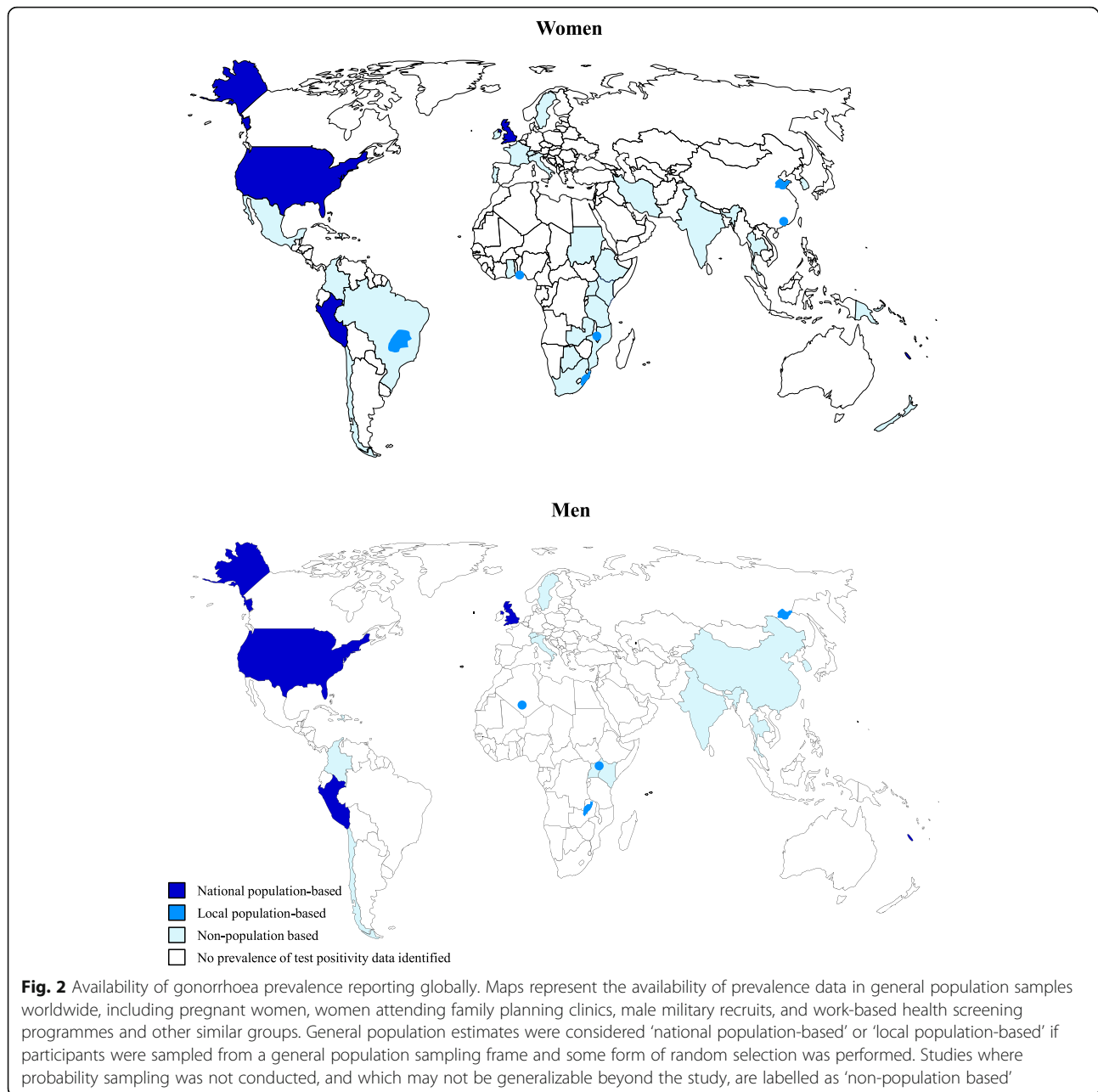
Prevalence data and/or test positivity in general population samples were identified in 13.2% (seven out of 53) of countries in the WHO European region (nine estimates in women, including pregnant women [18, 55–62], and five in men [18, 56–59]) (Tables 1 and 2). We identified only one representative, population-based prevalence study in the United Kingdom (UK) that was of national scope [18]. These data were derived from the National Survey of Sexual Attitudes and Lifestyles (NATSAL) in 2010–2012. A probability sample of 15 162 men and women aged 16–74 years was drawn from the general population. Gonorrhoea testing was conducted for 2665 women and 1885 men and an overall prevalence of <0.1% was recorded (Table 1), higher in women and men aged 20–24 (0.2% and 0.1%, respectively). Data from all other countries represented test positivity data that were drawn from proxy groups of the general population, mainly non-probability samples, drawn from antenatal/obstetric clinics, primary care, community/youth clinics, with one study in a high school setting [56]. The median study sample size was 1004 in all women (interquartile range [IQR]: 220–5337)

and 1236 in men (IQR: 802–6620). In all general population studies, NAAT testing conducted on urine (men, women) or genital fluid (women) was most common; confirmation by both NAAT and culture was used in pregnant women in France and Portugal [61, 62]. Data on both sexes were available in only five studies [18, 56–59]. One study reported samples from the urogenital and rectal site in aggregate [57]. All other studies included urogenital infection only.

For countries where no prevalence or test positivity estimate from the general population was identified, some degree of surveillance data was discoverable through the grey literature search. Most European Union (EU)/European Economic Area (EEA) Member States have comprehensive surveillance systems and report a national notification rate annually, except for Germany, Liechtenstein, Austria (not since 2014), and Greece (not since 2017) [85, 86]. Belgium, France, and the Netherlands have sentinel surveillance systems. In countries outside the EU/EEA region (mostly the eastern European region), data were less discoverable. In 2017, countries including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation, Turkmenistan, and Uzbekistan reported gonorrhoea cases to the WHO European Regional Office (M. Dara and G. Kuchukhidze, personal communication, 24 February 2019). Indicators included the absolute number of cases identified, the male to female ratio, and only for Armenia, the proportion of reported MSM among the cases. Prevalence data or comprehensive syndromic and aetiologic case reporting were not otherwise identified in the wider European region.

High-income North America

In the USA, laboratory-confirmed gonorrhoea is mandatorily notifiable and data collection is comprehensive, from diverse clinical settings including STD clinics, laboratories, family planning and school-based clinics, hospitals, emergency rooms, drug treatment centres, correctional facilities, and the military [87]. The most recent estimate of nationwide population prevalence identified was from the National Health and Nutrition Examination Survey (NHANES), a series of cross-sectional, bi-annual household surveys representative in terms of sex, age and race/ethnicity of the USA civilian, non-institutionalized population [19]. Between 1999 and 2008, screening for cervical or urethral gonorrhoea was a study component, and 15 885 persons, aged 14–39 years participated. An extrapolated national prevalence of 0.3% (95% confidence interval [CI]: 0.1%–0.5%) among 14–39-year-olds was estimated, higher in women than in men (Table 1). *N. gonorrhoeae* testing within NHANES stopped at the end of 2008 and, in 2009,



gonorrhoea prevalence and notification rates were at an all-time low in the USA [19].

In terms of non-probability samples, an estimate of prevalence from a sentinel surveillance population of young people at elevated risk for gonorrhoea is provided annually by the Centers for Disease Control and Prevention (CDC), using data from the ‘National Job Training Program’ (NJTP), a nationwide vocational programme for socioeconomically disadvantaged youth aged 16 to 24 years who are considered at risk of STIs [63]. Participants are offered gonorrhoea and chlamydia screening at

programme entry. In 2018, the median state-specific estimated gonorrhoea prevalence for programme entrants aged 16–24 years was 2.2% in women (range 0.4% to 7.6%), and 0.7% in men (range 0.0% to 4.8%) (Table 2) [63].

In the USA, we identified a further seven test positivity estimates from proxy general population samples in women (including one from a chart review of women screened [64], two studies in high schools [65, 66], and four in pregnant women who are routinely tested [67–70]) and three data points in men (the same two

Table 1 Reported population-based prevalence of gonorrhoea in women and men by WHO region and country

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported prevalence	Standardized prevalence
WOMEN										
Africa	Benin	1	Behanzin et al. [13]	2008	Community, Women	Households	Cluster random	1241	0.60%	0.62%
	Malawi	1	Paz-Soldan et al. [14]	2000	Community, Women	Households	Multistage cluster random	758	3.60%	4.13%
	South Africa	1	Francis et al. [15]	2016–2017	Community, Women	Annual household survey	Stratified random	259	1.80%	1.14%
Americas (excluding high-income North America)	Brazil	1	de Lima et al. [16]	2007–2009	Community, Sexually active, Women	Household-based recruitment	Simple random	574	0.70%	0.72%
	Peru ^b	1	Carcamo et al. [17]	2002	Community, Women	Household survey	Cluster random	6439	0.10%	0.00%
Europe	UK ^b	1	Sonnenberg et al. [18]	2010–2012	Community, Women	Natsal-3 respondents	Probability	2665	<0.1%	0.10%
High-income North America	USA ^b	1	Torrone et al. [19]	1999–2008	Community, Women	Household surveys	Multistage probability	..	0.34% ^c	0.37% ^c
Western Pacific	China	2	Huai et al. [20]	2016	Community, Women	General population	Multistage probability	3581	0.14%	0.14%
			Luo et al. [21]	2017	Community, Women	Community-based recruitment	Probability	9207	0.17%	0.18%
	New Caledonia (France) ^p	1	Corsenac et al. [22]	2012	Community, Women	Primary care and public dispensaries	Multistage random	376	3.47%	3.99%
MEN										
Africa	Benin	1	Behanzin et al. [13]	2008	Community, Sexually active, Men	Households	Cluster random	1040	0.30%	0.23%
	Malawi	1	Paz-Soldan et al. [14]	2000	Clinic attendees, Men	Households	Cluster random	469	6.20%	7.94%
	South Africa	1	Francis et al. [15]	2016–2017	Community, Men	Annual household survey	Stratified random	188	1.50%	1.82%
Americas (excluding high-income North America)	Peru ^b	1	Carcamo et al. [17]	2002	Community, Men	Household survey	Cluster random	7486	0.12%	0.02%
Europe	UK ^b	1	Sonnenberg et al. [18]	2010–2012	Community, Men	Natsal-3 respondents	Probability	1885	<0.1%	<0.1%
High-income North America	USA ^b	1	Torrone et al. [19]	1999–2008	Community, men	Household surveys	Multistage probability (0.27% for men and women combined) ^c	.. (0.27% for men and women combined) ^c
Western Pacific	China	1	Huai et al. [20]	2016	Community, Men	General population	Multistage probability	3622	0.03%	0.00%
	New Caledonia (France) ^p	1	Corsenac et al. [22]	2012	Clinic attendees, Men	Primary care and public dispensaries	Multistage random	232	3.45%	4.36%

^aTo aid cross-referencing, study populations were categorized to align with SPECTRUM codes [11].

^bNationally derived samples.

If the standardized estimate was a negative number, the standardized prevalence was reported at 1 case divided by 100 times the sample size [11].

^c15 885 participants aged 14–39 provided a sample. The proportion of men and women participating was not reported separately. The estimate quoted for women (0.34%) is a weighted estimate. The estimate quoted for men is that for both men and women (0.27%) as men were not reported separately. This estimate was not standardized.

..=Not reported. No.=number. UK=United Kingdom. USA=Unites States of America. WHO=World Health Organization.

studies in high schools [65, 66] and one study in college students [81]) that met the inclusion criteria for the secondary objective (Table 2). There was a wide range in study sample size and in estimates reported, reflecting

diversity in study participants and settings, and study population characteristics. Test positivity estimates from non-probability samples from the two studies in high schools were identified: one reported the proportion

positive over almost 8 years (9.0% [3270/36 263] in girls and 4.1% [1588/39 010] in boys) and another yielded a combined estimate of 2.4% in girls and boys (Table 2) [65, 66]. No comparison could be made across studies. Where reported, studies used NAAT testing.

In Canada, no prevalence study or proxy general population study was identified. Gonorrhoea is mandatorily notifiable, and laboratory-confirmed cases are reported to the Public Health Agency of Canada through the Canadian Notifiable Disease Surveillance System. Summary data are published annually by age and sex, and are available online [88], and a detailed surveillance report is produced every five years.

Americas (excluding high-income North America)

Prevalence and/or test positivity estimates from the general population were identified in 18.2% (six out of 33) of countries in this WHO region excluding the USA and Canada (12 estimates in women, including pregnant women [16, 17, 44–53], and four in men [17, 48, 49, 80]) (Tables 1 and 2). One study in Peru could be considered population-based and of national scope. In this study, the substantial sample included 13 925 randomly selected 18–29-year-old men and women who were resident in 24 cities with populations >50 000 people [17]. Additionally, a local population-based study in Brazil, also urban, was conducted using two-stage sampling of households and young women in middle size cities in Central Brazil [16]. The remaining studies were non-probability samples, mainly from community settings including educational facilities, primary healthcare, adolescent health clinics and ANCs. The median study sample size was 399 in women (IQR: 309–1719) and 371 in men (IQR: 180–5749). All studies involved NAAT screening of urine (n=4) [16, 44, 45, 49] and urogenital swab samples (n=7) [17, 46–48, 50, 51, 53] for women (clinical specimen not specified, n=1 [52]), and urine (n=3) [17, 48, 49] for men (clinical specimen not specified, n=1 [80]).

From the grey literature search, we identified only aetiological or syndromic case reporting in adult men through WHO Global AIDS Monitoring (GAM; known as Global AIDS Response Progress Reporting prior to 2015) for other countries in the region [3]. No further prevalence or test positivity data were identified in the region.

Africa

In the WHO African region, prevalence data and/or test positivity estimates from the general population were identified in 25.5% (12 out of 47) of countries (25 estimates in women, including pregnant women [13–15, 23–43], and six in men [13–15, 29, 31, 34]) (Tables 1 and 2). Three of the studies were local population-based,

derived from household samples, and none were of national scope. The first was from the urban centre of Cotonou in Benin, where 2507 subjects aged 15–49 years, from 1070 households sampled from 38 census areas, participated [13]. In Malawi, another estimate was derived from a largely rural population from the eastern lakeside regions of the Mangochi district [14]. Most recently, 1342 young people aged 15–24 years were selected from a ‘health and demographic surveillance site’ sampling frame in rural South Africa [15]. The remaining studies (Table 2) were derived from non-probability samples with diverse recruitment sites, including antenatal clinic (ANC) settings, schools and universities, primary healthcare sites, and community-based recruitment. The median study sample size was 322 in women (IQR: 200–553) and 422 in men (IQR: 351–755). Laboratory confirmation was mainly by NAAT on urogenital swab samples and, to a lesser extent, on urine for women; in four studies [23, 24, 30, 40], Gram stain and/or culture only were used. For men, urine samples were tested by NAAT in all cases where reported.

In the African region, 43% of countries reported to WHO in 2013 having STI surveillance systems in place and 40% had national strategies or plans for preventing and controlling STIs [89], but beyond limited reporting of aetiological surveillance among men and syndromic surveillance in men and women, we did not identify any further prevalence reporting in the region.

Western Pacific

Prevalence data and/or test positivity data from the general population were identified in 22.2% (six out of 27) of countries and territories in the WHO Western Pacific region (11 estimates in women, including pregnant women [20–22, 73–79], and four in men [20, 22, 73, 84]) (Tables 1 and 2). There were three population-based studies. One was of national scope in New Caledonia [22]. It included men and women selected during a national three-stage random sampling of general practice surgeries and public dispensaries, and the sample was then weighted to reflect the general population aged 18–49 years. The other two population-based studies were local in scope and were both in China. In one study from the Shandong province [20], men and women were sampled in a complex multi-stage sampling process based on urban and rural communities within geographic regions. The second study, from Shenzhen City [21], included women only and was designed to be representative of the entire population in the Nanshan District of the city. Beyond these prevalence data, for both men and women, test positivity estimates from non-

Table 2 Reported gonorrhoea test positivity in women and men by WHO region and country

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported test positivity	Standardized estimate
WOMEN										
Africa										
Proxy general population samples										
	Ethiopia	2	Mulu et al. [23]	2013	Clinic attendees, Women	Hospital, multiple clinic types	Simple random	409	1.00%	1.25%
			Tadesse et al. [24]	2014–2015	Ob/Gyn clinic attendees	Mixed attendees	Non-probability	322	0.31%	0.39%
	Ghana	1	Yirenya-Tawiah et al. [25]	2005–2006	Community, Sexually active, Women	Community-based recruitment	Non-probability	191	2.60%	2.05%
	Kenya	4	Jespers et al. [26]	2010–2011	Clinic attendees, Women	Multiple clinic types + community	Non-probability	110	1.00%	0.20%
			Kerubo et al. [27]	2013	Students/young, Women	High school	Non-probability	511	0.59%	0.24%
			Maseke et al. [28]	2014–2015	Students/young, Women	High schools + universities	Non-probability	451	1.55%	1.60%
			Otieno et al. [29]	2007–2009	Community, Women	Community-based recruitment	Non-probability	424	4.70%	3.99%
	Mozambique	1	Menendez et al. [30]	2000	Mixed groups/Unknown, Women	Mixed clinic types + community	Age-stratified	250	13.60%	18.90%
	South Africa	3	Jespers et al. [26]	2010–2011	Clinic attendees, Women	Multiple clinic types + community	Non-probability	109	1.00%	0.20%
			Kaida et al. [31]	2014–2016	Community, Women	Community-based recruitment	Non-probability	198	7.07%	6.42%
			Peters et al. [32]	2011–2012	Community, Women	Primary care centres	Geographic stratification	604	10.00%	10.46%
	Uganda	2	Rassjo et al. [33]	2006	Students/young, Sexually active women	Youth clinic	Non-probability	595	4.50%	3.79%
			Rutherford et al. [34]	2008–2009	Students/young, Sexually active women	University students	Non-probability	280	1.07%	0.69%
During pregnancy										
	Botswana	2	Oforjebe et al. [35]	2015–2016	ANC Survey	ANC	Non-probability	300	1.70%	0.92%
			Wynn et al. [36]	2015–2016	ANC Survey	ANC	Non-probability	200	1.50%	0.72%
	Kenya	2	Masha et al. [37]	2015	ANC Survey	ANC	Non-probability	202	1.00%	1.09%
			Warr et al. [38]	2011–2013	ANC Survey	ANC, HIV negative women	Non-probability	1221	2.00%	1.36%
	Sudan	2	Abdelaziz et al. [39]	2008	ANC Survey	ANC	Non-probability	200	1.80%	2.25%
			Abdelrahim et al. [40]	.	ANC Routine screening	Pregnant women, low socioeconomic status	Non-probability	350	0.00%	0.00%

Table 2 Reported gonorrhoea test positivity in women and men by WHO region and country (Continued)

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported test positivity	Standardized estimate
	Tanzania	2	Chiduo et al. [41]	2008–2010	ANC Routine screening	ANC	Non-probability	185	1.62%	2.03%
	Zambia	1	Hokororo et al. [42] Chaponda et al. [43]	2012 2013–2014	ANC Survey ANC Survey	ANC, adolescent girls First time attendees	Non-probability Non-probability	403 1083	6.70% 3.14%	7.69% 2.66%
Americas (excluding high-income North America)										
	Proxy general population samples									
	Brazil	3	Piazzetta et al. [44]	..	Students/young, Sexually active women	University students (secondary analysis)	Non-probability	335	2.39%	2.47%
			Pinto et al. [45]	2009	Clinic attendees, Women	Parturient women, national sample	Non-probability	2071	1.00%	1.09%
			Rocha et al. [46]	2010	Community, Women	Primary healthcare	Non-probability	361	1.40%	0.68%
	Chile	2	Conejero et al. [47]	2011	Students/young, Sexually active women	University gynaecology clinic	Non-probability	344	0.00%	0.00%
			Huneus et al. [48]	..	Community, Sexually active, Women	Community adolescent health clinics	Non-probability	115	0.87%	0.07%
	Colombia	1	Paredes et al. [49]	2011	Students/young, Women	High schools	Non-probability	436	0.20%	0.22%
	Haiti	1	Jobe et al. [50]	2012	Clinic attendees, Women	Women's health clinic	Non-probability	104	0.96%	0.18%
	Mexico	1	Casillas-Vega et al. [51]	2013–2014	Ob/Gyn clinic attendees	Gynaecology clinic, first time attendees	Non-probability	662	2.11%	1.34%
	During pregnancy									
	Brazil	1	Silveira et al. [52]	2005–2008	Clinic attendees, Women	Maternity unit, women singleton newborns	Non-probability	2101	1.14%	0.76%
	Haiti	1	Bristow et al. [53]	2015–2016	ANC Survey	ANC	Non-probability	300	2.67%	1.91%
Eastern Mediterranean										
	During pregnancy									
	Iran		Pourabbas et al. [54]	..	Clinic attendees, Women	Maternity unit	Non-probability	239	1.26%	0.49%
Europe										
	Proxy general population samples									
	Ireland	1	Hassan et al. [55]	..	Community, Women	Women attending primary care for cervical screening	Non-probability	236	0.00%	0.00%
	Italy	2	Matteelli et al. [56]	2012–2013	Students/young, Women	High school	Non-probability	1606	0.00%	0.00%
			Salfa et al. [57]	2009–2013	Mixed groups/Unknown, Women	Lab reports from tests at multiple healthcare providers including screening tests	Geographic stratification	40 579	0.1%	0.1%
	Sweden	1	Nolskog et al. [58]	2013–	Students/young,	Youth clinics	Systematic	509	0.00%	0.00%

Table 2 Reported gonorrhoea test positivity in women and men by WHO region and country (Continued)

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported test positivity	Standardized estimate	
	Switzerland	1	Sakem et al. [59]	2009–2010	Mixed groups/Unknown, Women	Laboratory samples including screening programmes	National laboratory database	8009	0.14%	0.00%	
	UK	1	Grech et al. [60]	2014–2015	Clinic attendees, Women	Integrated sexual health service, women >40 years	Systematic	150	0.70%	0.01%	
	During pregnancy										
	France	1	Peuchant et al. [61]	2011	ANC Routine screening	ANC	Non-probability	1004	0.00%	0.00%	
	Portugal	1	Borges-Costa et al. [62]	2006–2008	Clinic attendees, Women	Pregnant adolescents attending obstetric hospital clinic	Non-probability	204	4.90%	4.90%	
High-income America	Proxy general population samples										
	USA	4	CDC (National Job Training Program) [63] Jackson et al. [64] Newbern et al. [65] Nsuami et al. [66]	2009–2010 2003–2010 2003–2005	Community, women Clinic attendees, Women Students/young women Students/young women	National Job Training Program for socioeconomically disadvantaged youth Chart review of women > 25 years screened according to guidelines in Baltimore Participants in Philadelphia high school STI screening programme Participants in New Orleans high school STI screening programme	Non-probability Non-probability sample of consecutive attendees Non-probability Non-probability	.. 658 36 263 1554	2.2% ^b 0.30% 9.00% ^c .. (2.4% for men and women combined) ^a	2.2% ^b 0.00% 9.32% ^c .. (2.4% for men and women combined) ^d	
	During pregnancy										
	USA	4	Akoh et al. [67] Berggren et al. [68] Blatt et al. [69] Waight et al. [70]	2006–2009 2003–2005 2005–2008 2007–2009	ANC Survey ANC Survey Pregnant women, Community Mixed groups/Unknown, Women	Adolescent maternal programme Washington Hospital Center Laboratory results from pregnant women STD diagnoses linked to birth records	Stratified by ethnicity/race Non-probability Database study Database study	158 125 730 796 195 977	3.00% 10.00% 0.63% 1.55% 1.55% 9.77%	3.00% 10.00% 0.63% 1.55% 1.55% 9.77%	
South-East Asia	Proxy general population samples										
	India	1	Krishnan et al. [71]	Not stated	Community, Women	Samples collected during household visits	Non-probability	811	0.00%	0.00%	
	During pregnancy										
	Thailand	1	Asavapiryanont et al. [72]	2006–2007	ANC Survey	Pregnant teenagers	Non-probability	121	1.70%	1.76%	
Western Pacific	Proxy general population samples										
	Korea (Rep. of)	2	Choe et al. [73]	2010	Community, Women	General population health examination centres	Non-probability	805	0.25%	0.26%	

Table 2 Reported gonorrhoea test positivity in women and men by WHO region and country (Continued)

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported test positivity	Standardized estimate	
			Kim et al. [74]	2012	Community, Sexually active, Women	Hospital clinics, health women attending for checkups	Non-probability	799	0.00%	0.00%	
	Papua New Guinea	1	Vallely et al. [75]	2011–2015	Community, Women	Well woman clinic only	Non-probability	614	7.98%	8.17%	
	Solomon Islands	1	Marks et al. [76]	2014	Clinic attendees, Women	Community outpatient clinics	Non-probability	296	5.10%	4.40%	
	During pregnancy										
	New Zealand	1	Ekeroma et al. [77]	2009	ANC Routine screening	Hospital maternity unit	Non-probability	4635	0.22%	0.20%	
	Papua New Guinea	3	Badman et al. [78]	2014	ANC Routine screening	Women at first antenatal visit	Non-probability	125	11.20%	10.65%	
			Vallely et al. [75]	2011–2015	ANC Survey	ANC	Non-probability/non-probability	765	14.20%	15.24%	
			Wangnapi et al. [79]	2011–2012	ANC Survey	ANC	Non-probability	362	9.67%	9.08%	
MEN											
Africa	Kenya	1	Otieno et al. [29]	2007–2009	Community, Sexually active, Men	Community-based recruitment	Non-probability	422	0.00%	0.00%	
	South Africa	1	Kaida et al. [31]	2014–2016	Community, Men	Community-based recruitment	Non-probability	154	1.30%	1.40%	
	Uganda	1	Rutherford et al. [34]	2008–2009	Students/young, Men	University students	Non-probability	360	0.00%	0.00%	
Americas (excluding high-income North America)	Chile	1	Huneus et al. [48]	..	Community, Sexually active, Men	Community adolescent health clinics	Non-probability	171	0.00%	0.00%	
	Colombia	1	Paredes et al. [49]	2011	Students/young, Men	High schools	Non-probability	536	0.00%	0.00%	
	Haiti	1	Downey et al. [80]	2013	Clinic attendees, Men	Men's health clinic	Non-probability	205	0.00%	0.00%	
Europe	Italy	2	Matteilli et al. [56]	2012–2013	Students/young, Men	High school	Non-probability	1112	0.00%	0.00%	
	Sweden	1	Salfa et al. [57]	2009–2013	Mixed groups/Unknown, Men	Lab reports from tests at multiple healthcare providers	Geographic stratification	10 243	2.10%	2.10%	
			Nolskog et al. [58]	2013–2014	Students/young, Men	Youth clinics	Systematic	492	0.20%	0.12%	
	Switzerland	1	Sakem et al. [59]	2009–2010	Mixed groups/Unknown, Men	Laboratory samples incl. screening programmes	National laboratory database	1236	2.10%	1.82%	
High-income North America	USA	4	CDC (National Job Training Program) [63]	2018	Community, Men	National Job Training Program for socioeconomically disadvantaged youth	Non-probability	..	0.7% ^b	0.7% ^b	

Table 2 Reported gonorrhoea test positivity in women and men by WHO region and country (Continued)

WHO region	Country	No. of data points	Reference	Years reported	Study population ^a	Study setting	Sampling	No. tested	Reported test positivity	Standardized estimate
			Drinkard et al. [81]	2009–2015	Students/young, Men	College health clinics	Database study	5453	0.70%	0.22%
			Newbern et al. [65]	2003–2010	Students/young men	Participants in Philadelphia high school STI screening programme	Non-probability	39 010	4.07% ^c	4.65% ^c
			Nsuami et al. [66]	2003–2005	Students/young men	Participants in New Orleans high school STI screening programme	Non-probability sample of participants	1782	-- (2.4% for men and women combined) ^b	-- (2.4% for men and women combined) ^d
South-East Asia	India	1	Dave et al. [82]	2005	Workers, Men	Migrant workers	Multistage probability	840	0.90%	0.94%
	Thailand	1	Jatapai et al. [83]	2008–2009	Military, Men	Newly inducted military conscripts	Systematic	2123	0.94%	1.04%
Western Pacific	China	1	Zhang et al. [84]	2006	Workers, Men	Miners	Cluster	1773	0.81%	0.81%
	Korea (Rep. of)	1	Choe et al. [73]	2010	Clinic attendees, Men	General population health examination centres	Non-probability	807	0.62%	0.61%

^aTo aid cross-referencing, study populations were categorized to align with SPECTRUM codes [11].

If the standardized estimate was a negative number, the standardized prevalence was reported at 1 case divided by 100 times the sample size [11].

If neither the clinical specimen nor the laboratory test used were specified, the estimate was not standardized [57, 62, 63, 67–70, 84].

If the clinical specimen was specified but not the laboratory test used, or vice versa, the arithmetic mean of the sensitivity and specificity for the laboratory test or for the clinical specimen, respectively, was used instead [27, 34, 52, 59, 80, 81].

^bThe denominator was not reported and estimates were not standardized.

^cPrevalence was reported over an 8-year period.

^dPrevalence proportion for men and women was not reported separately.

--=Not reported. ANC=antenatal clinic. CDC=Centers for Disease Control and Prevention. HIV=human immunodeficiency virus. No.=number. Ob/Gyn=Obstetrics and Gynaecology. Rep.=Republic. STD=sexually transmitted disease. STI=sexually transmitted infection. UK=United Kingdom. USA=United States of America. WHO=World Health Organization.

probability, proxy general population samples were derived from a range of study settings including community settings, primary care, and hospital-based maternity clinics/ANCs. One study was in an occupational group (miners) in men in China [84]. The median study sample size in the region was 765 in women (IQR: 362–3581) and 1290 in men (IQR: 376–4490). In some countries in the region where no data were identified, gonorrhoea is a notifiable infection; routine national surveillance is conducted and opportunistic/risk-based screening and/or testing is recommended for some population groups (Australia, New Zealand, and Singapore) [90–92]. Sentinel surveillance is conducted in the Republic of Korea and in Japan, mostly in urology departments. In both countries, reported cases per sentinel are low and have decreased in recent years [93, 94]. GAM data for men are also notified to WHO from many countries [3], but no further prevalence data were identified in the region.

South-East Asia

Among 11 countries in the WHO South-East Asian region, we did not identify any population-based prevalence estimates. Test positivity data in general population samples were identified from 18.2% (two out of eleven) of countries (two estimates in women, including pregnant women [71, 72], and two in men [82, 83]) (Table 2). Non-probability samples from the general population were community-based in women in India, hospital-based in young pregnant women aged <18 years in Thailand, and in occupational groups in men (migrant workers in India and military conscripts in Thailand). The median study sample size was 466 in women (range: 121–811) and 1482 in men (range: 840–2123).

We did not identify further information on gonorrhoea surveillance in the region, with the exception of GAM data from some countries [3].

Eastern Mediterranean

We identified non-probability samples in 4.8% (one out of 21) of countries in the WHO Eastern Mediterranean region: a single study in a hospital involving pregnant women [54] (Iran, n=239; standardized prevalence: 0.5%) (Table 2). According to the WHO, ten countries surveyed in 2013 reported having an STI surveillance system, four reported conducting aetiological studies, 11 had updated national STI guidelines or recommendations in place and nine had a national strategy or action plan for STI prevention and control [89], but no further estimates were identified in the region.

Prevalence and test positivity reporting in vulnerable population groups

Men-who-have-sex-with-men

Prevalence and/or non-probability test positivity data on gonorrhoea in the MSM population were identified in 64 studies from 25 countries (seven countries in Africa, five in Europe, two in North America, four in the Americas [excluding high-income North America], four in the Western Pacific, and three in South-East Asia) (Fig. 3; Additional file 5) [95–147]. For 56.0% (14 out of 25) of countries, data originated from a single study in an urban setting. In five studies, men testing HIV-positive were excluded at the outset [96, 119, 124, 148, 149]. HIV status was reported in five studies with variable HIV-positivity [98, 100, 103, 115, 127]. Three studies included asymptomatic cases only [120, 131, 150]. Urogenital screening and/or opportunistic testing (predominantly on urine samples) was most often performed. An equal proportion of studies involved recruitment from community settings or STI clinics, but there was diversity in terms of the populations included, including HIV status, which was often not reported. Both rectal and urogenital sampling were reported in 26 studies; rates of rectal infection were higher than urogenital rates in 69.2% (n=18) of these studies (Fig. 3). NAAT testing was reported in 22 of these studies, culture-only testing in two, and culture or NAAT testing in two. Reported rates of pharyngeal testing from 27 studies were mostly (51.9%) between 5.0% and 10.0%, 22.2% were between 1.0% and 5.0%, and 14.8% were >10.0%. Though variable, on average, the standardized estimate of pharyngeal infection was similar to urogenital positivity where reported in the same study.

Sex workers

Data on gonorrhoea prevalence and/or test positivity in MSW, FSW or both were available from 23 countries (Table 3), with 38 studies reporting on FSW and six on MSW. Of 41 unique studies, 14 were conducted in a clinic setting (including STI clinics, genito-urinary clinics and outreach clinics) and 13 at commercial sites (including hotels, brothels, street and residence). The remainder (n=14) were described as community-based or conducted at other mixed locations. Only urogenital testing was performed except for one study in China that also performed pharyngeal testing [184]. Overall, the median study sample size was 655 in women (IQR: 323–2165) and 240 in men (IQR: 113–584). The positivity estimates ranged from 0.0% (MSW in the Republic of Korea) to 29.2% (FSW in Indonesia).

Discussion

Gonorrhoea prevalence monitoring is one of four key components of national STI surveillance programmes that is recommended by WHO to reduce the burden of

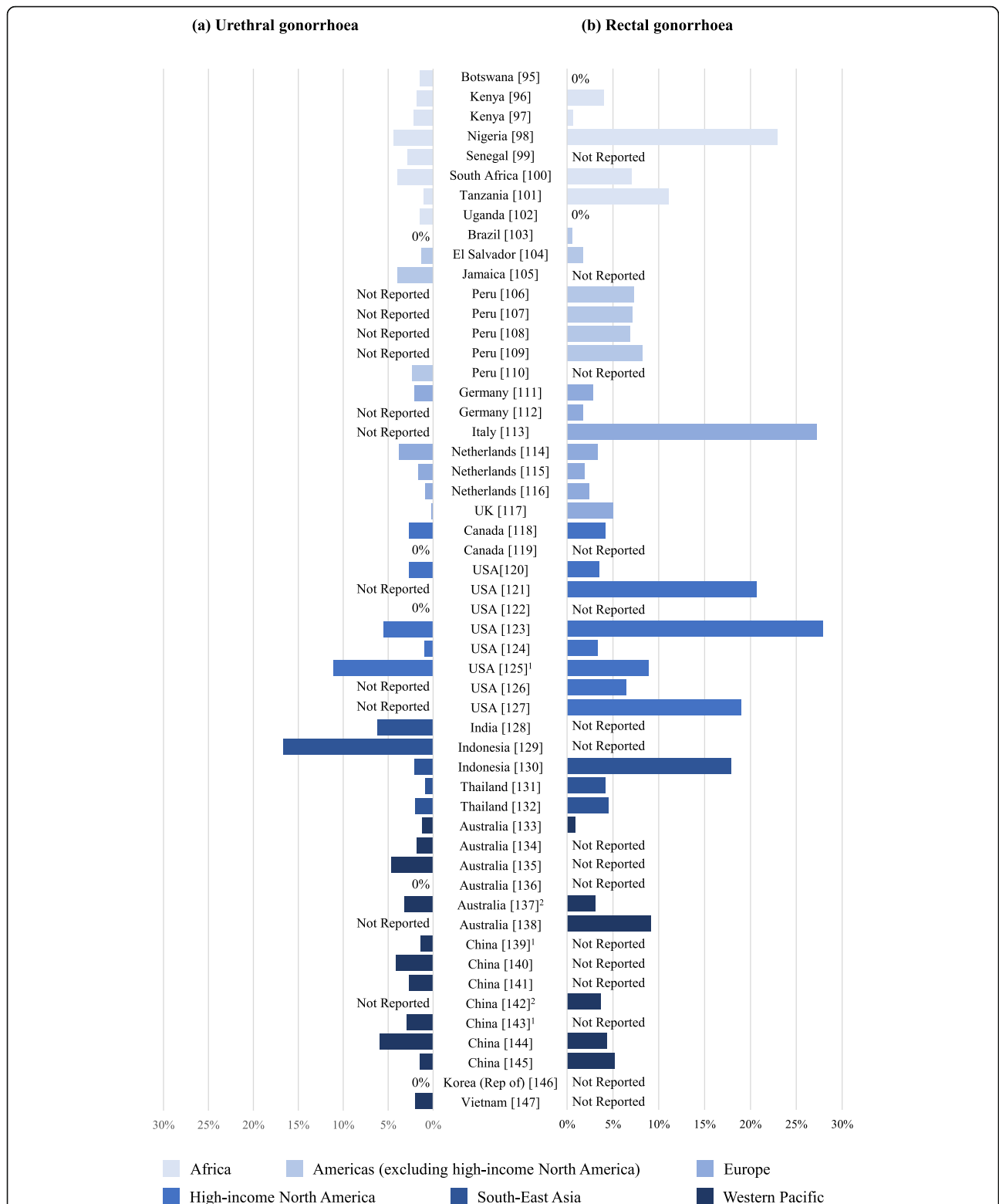


Fig. 3 Reported prevalence and/or test positivity of urethral (a) and/or rectal (b) gonorrhoea-positive cases in men-who-have-sex-with-men. ¹Prevalence rates for urethral gonorrhoea could not be standardized. ²Prevalence rates for rectal gonorrhoea could not be standardized

Table 3 Reported gonorrhoea prevalence and/or test positivity in sex workers, by WHO region and country

WHO region	Country	No. of data points	Reference	Years reported	Study setting ^a	No. tested	Reported prevalence and/or test positivity	Standardized estimate	
WOMEN									
Africa	Benin	1	Behanzin et al. [151]	2008	Clinic setting	1082	6.20%	5.53%	
	Botswana	1	Merrigan et al. [152]	2012	Community-based or other mixed locations	947	10.50%	10.86%	
	Cote d'Ivoire	1	Vuylsteke et al. [153]	2007 and 2009	Clinic setting	1110	5.10%	4.40%	
	Ethiopia	1	Tadele et al. [154]	2017	Clinic setting	338	3.30%	4.13%	
	Guinea	1	Aho et al. [155]	2005–2006	Clinic setting	223	9.00%	8.40%	
	Kenya	1	Izulla et al. [156]	2009–2010	Clinic setting	2933	3.07%	3.84%	
	Rwanda		2	Braunstein et al. [157]	2006–2007	Clinic setting	397	11.60%	11.06%
				Jaspers et al. [26]	2010–2011	Community-based or other mixed locations	30 ^b	7.00%	6.35%
Uganda	1	Vandepitte et al. [158]	2008–2009	Community-based or other mixed locations	1025	13.00%	12.49%		
Americas (excluding high-income North America)	Guatemala	1	Sabido et al. [159]	2008–2009	Commercial site	494	0.80%	0.83%	
	Honduras	1	Tinajeros et al. [160]	2006–2008	Community-based or other mixed locations	950	2.30%	1.54%	
	Mexico	1	Bazzi et al. [161]	2010–2013	Community-based or other mixed locations	212	0.94%	0.98%	
	Peru	1	Carcamo et al. [17]	2002	Commercial site	4263	1.62%	1.25%	
Eastern Mediterranean	Iran	2	Kazerooni et al. [162]	2010	Community-based or other mixed locations	278	1.43%	1.79%	
			Nasirian et al. [163]	2013–2014	Community-based or other mixed locations	99 ^b	9.09%	8.49%	
	Pakistan	1	Khan et al. [164]	2007	Commercial site	730	7.50%	6.86%	
	Tunisia ^c	1	Znazen et al. [165]	2007	Clinic setting	188	3.72%	4.66%	
			Znazen et al. [165]	2007	Clinic setting	188	11.17%	10.62%	
Europe	UK	1	Mc Grath-Lone et al. [166]	2011	Clinic setting	2534	2.70%	1.95%	
South-East Asia	Bangladesh	2	Haseen et al. [167]	2006–2007	Commercial site	1013	2.20%	2.27%	
			Khanam et al. [168]	2014	Commercial site	700	5.40%	4.71%	
	India	2	Das et al. [169]	2008–2008	Clinic setting	417	14.20%	13.72%	

Table 3 Reported gonorrhoea prevalence and/or test positivity in sex workers, by WHO region and country (Continued)

WHO region	Country	No. of data points	Reference	Years reported	Study setting ^a	No. tested	Reported prevalence and/or test positivity	Standardized estimate
			Hemalatha et al. [170]	2005–2006	Community-based or other mixed locations	3223	1.99%	2.05%
	Indonesia	5	Bollen et al. [171]	2008–2009	Clinic setting	580	29.31%	29.19%
			Majid et al. [172]	2006–2007	Commercial site	4324	24.60%	24.37%
			Mawu et al. [173]	2008	Commercial site	217	10.60%	10.03%
			Silitonga et al. [174]	1997–2002	Clinic setting	3073	16.69%	20.88%
			Tanudyaya et al. [175]	2005	Community-based or other mixed locations	2500	28.60%	28.46%
Western Pacific	Cambodia	1	Couture et al. [176]	2007–2008	Community-based or other mixed locations	160	7.80%	8.06%
	China	9	Chen et al. [177]	2009	Commercial site	3099	5.91%	5.23%
			Guo et al. [178]	2010–2011	Community-based or other mixed locations	609	2.30%	1.54%
			Jin et al. [179]	2008	Commercial site	568	8.30%	7.68%
			Luo et al. [180]	2009–2012	Commercial site	2053	8.00%	7.37%
			Remis et al. [181]	2009	Commercial site	750	3.50%	3.62%
			Tang et al. [182]	2009	Commercial site	849	5.42%	4.73%
			Wong et al. [183]	2007	Clinic setting	503	1.79%	1.01%
			Wong et al. [184]	2012–2013	Community-based or other mixed locations	340	0.90%	0.93%
			Zhu et al. [185]	2007	Commercial site	488	1.84%	1.06%
MEN								
Africa	Cote d'Ivoire	1	Vuylsteke et al. [186]	2007–2008	Clinic setting	96 ^b	12.80%	11.75%
Americas (excluding high-income North America)	Mexico	2	Bazzi et al. [161]	2010–2013	Community-based or other mixed locations	212 ^d	1.42%	1.54%
			Galarraaga et al. [187]	..	Clinic setting	267	2.26%	2.53%
Europe	UK	1	Mc Grath-Lone et al. [166]	2011	Clinic setting	447	17.40% ^e	16.33%
Western Pacific	Korea (Rep. of)	1	Jung et al. [146]	2008	Community-based or other mixed locations	118	0.00%	0.01%
	Vietnam	1	Goldsamt et al. [188]	2014–2016	Community-based or other mixed locations	995	10.45%	9.41%

^aClinic settings included STI clinics, genito-urinary clinics and outreach clinics. Commercial sites included hotels, brothels, street and other residences. The remainder were community-based or conducted at other mixed locations, or the location was not specified.

If the standardized estimate was a negative number, the standardized prevalence was reported at 1 case divided by 100 times the sample size [11].

If the clinical specimen was specified but not the laboratory test used, or vice versa, the arithmetic mean of the sensitivity and specificity for the laboratory test or for the clinical specimen, respectively, was used instead [17].

^bGiven the rarity of data, this study was included despite a sample size of <100.

^cIn this study, two separate estimates were generated in the same population – 188 participants were tested by culture and the same 188 participants by NAAT.

^dMen included in this study are non-commercial, intimate partners of female sex workers.

^eThis is a period prevalence, defined as the proportion of individuals tested for a sexually transmitted infection in 2011 who experienced an episode of that infection.

---=Not reported. NAAT=nucleic acid amplification test. No=number. UK=United Kingdom. WHO=World Health Organization.

gonorrhoea infections by 90% between 2018 and 2030 (in addition to case reporting, assessment of the aetiology of STI syndromes, and monitoring of antimicrobial resistance) [9]. WHO recommends prevalence assessments in the general population every two to three years, and in key populations such as MSM and sex workers [3, 9]. From our review, it is clear that substantive prevalence data among representative samples of the general population were seriously lacking on a worldwide basis. We identified national population-based data from only four countries (USA [19], UK [18], Peru [17], and New Caledonia [22]), all pre-dating 2013. Recent local population-based data were identified from China [20, 21] (2016 and 2017) and South Africa [15] (2018), but otherwise samples used for local population-based estimates were collected more than 10 years ago (Brazil, Benin, and Malawi [13, 14, 16]). The majority of the remaining test positivity estimates were derived from non-probability samples from groups that might be considered proxies of the general population, as proposed by WHO [3].

Based on our findings, most studies were conducted in single centres or discrete geographic regions or populations. We excluded STI clinic settings to avoid overestimating the prevalence in general population samples. As estimates (mainly from proxy general population groups) tended to be high, albeit with wide variation in the magnitude and precision of the estimate, it is highly likely that the risk profile of proxy populations was also higher than that of the general population. Even within groups, representativeness may not always have been similar (e.g. military conscripts residing in barracks versus those living at home). The median study sample size in the Americas (excluding high-income North America), Africa and the Eastern Mediterranean was <500 in both men and women, which further limits generalizability beyond the study population in question. Where national data were available to comment (e.g. USA), estimates from non-probability samples in defined younger populations [63, 65, 66] were higher than nationwide population-based estimates [19] or estimates from older populations [64], further highlighting the need for continued nationally representative population sampling. Diagnostic testing used varied widely and the sensitivity and specificity of these are an essential factor,

contributing to differences in reported estimates. We standardized estimates for differences in laboratory methods (NAAT versus culture) and clinical specimens (urine or urogenital samples) where reported [3, 11]. For consistency, we also adjusted for NAAT versus culture on rectal and pharyngeal samples, based on reported sensitivities and specificities in the literature and using a similar standardization procedure, to allow for within-study comparison. The specimen and test were not always reported, but NAAT-based testing was most common.

For most countries, no prevalence estimate or test positivity estimate from general population groups was identified. It was clear from our online (English) grey literature search, that surveillance is ongoing more widely, as we retrieved surveillance reports from online national and international data repositories, syndromic surveillance reports in some countries, and intermittent summaries of laboratory surveillance in others. Generally, the quality and quantity of data identified were highly variable and often neither timely nor contemporaneous. In the absence of prevalence data, low case rates reported in some settings likely reflect limited testing and restricted availability of appropriate laboratory diagnostics rather than actual infection rates. In many African countries, for example, prevalence reports (where available) and syndromic surveillance suggest that the very limited aetiological reporting substantially underestimates the true infection burden.

Heterogenous data in MSM were available for only 12.9% (25 out of 194) of countries, mainly single-centre studies in urban, community-based or STI clinic settings. Most studies performed testing at the urogenital site. Where both urogenital and extragenital testing were conducted, rates at rectal sites were typically higher. However, for modern NAATs no evidence-based consensus exists regarding sensitivity and specificity correction factors when using other diagnostic methods or different NAATs for urogenital and especially extragenital infections. International evidence-based consensus regarding these corrections is imperative to develop. Rates among FSW were often many multiples higher than general population estimates in women, in countries where data in both populations were available. Due to the dearth of data on sex workers in some regions, we

erred on the side of inclusivity, including small studies of <100 from Iran for example, where no data were otherwise available.

Our review had limitations. There were undoubtedly data from studies not discoverable on PubMed. For example, a systematic review from China, which documented STI risk among MSM [189], included studies that we could not access through the library systems available to us. Systematic reviews on a regional basis with good local knowledge, including in setting and language, would be a valuable addition. For many countries, only one or two data points were identified. Limited data and marked heterogeneity between studies prohibited us from conducting a meta-analysis or reporting median estimates. Reporting of proportion testing positive was very diverse in terms of variables reported, degree of stratification by demographic and other factors (e.g. HIV status), details regarding diagnostic tests, and anatomic site, often with statistics omitted where data had clearly been collected. With improved reporting from diverse populations, novel methods for synthesizing diverse data may therefore be required.

Conclusions

Gonorrhoea prevalence is a core indicator to properly inform gonorrhoea management and control programmes, international and national guidelines, and policy documents. Gonorrhoea prevalence monitoring and reporting is suboptimal or absent in most countries. Many countries and regions have seen substantial increases in notification rates of gonorrhoea in recent years [63, 85]. In the absence of serial prevalence data, however, it is difficult to disentangle how much of this reflects a true increase in the burden of gonorrhoea or some degree of improved awareness among groups at increased risk (in particular MSM), more consistent screening and/or testing, increased availability and use of NAATs, and improved (electronic) reporting. Irrespectively, among key populations such as MSM and sex workers, there is a substantial burden of infection where data are available. To inform STI control programmes at the national and regional level, and to inform innovative epidemiologic modelling initiatives such as SPECTRUM [11] and the Global Burden of Disease [190] that attempt to quantify and model the global burden, significantly more data of higher quality are required. There is an urgent need for more resources for researchers to design, conduct and report prevalence studies in a more consistent, standardized, and quality-assured way. Within countries, serial prevalence monitoring at intervals, including assessment and reporting of a minimum set of epidemiological variables, should be considered. Our review showed the need for more testing at extragenital sites, particularly, but not exclusively, among the MSM

population. WHO currently provides guidance on the assessment of gonorrhoea and chlamydia prevalence among pregnant women at ANCs [191]. This guidance could be extended beyond the ANC setting. Consistent adherence to study reporting guidelines (e.g. adapted STROBE checklists [192] or equivalent), for all researchers is also advised.

Abbreviations

AMR: Antimicrobial resistance; ANC: Antenatal clinic; CDC: Centers for Disease Control and Prevention; CI: Confidence interval; ECDC: European Centre for Disease Prevention and Control; EEA: European Economic Area; EU: European Union; FSW: Female sex workers; GAM: Global AIDS Monitoring; HIV: Human immunodeficiency virus; IQR: Interquartile range; MeSH: Medical subject headings; MSM: Men-who-have-sex-with-men; MSW: Male sex workers; NAATs: Nucleic acid amplification tests; NATSAL: National Survey of Sexual Attitudes and Lifestyles; NHANES: National Health and Nutrition Examination Survey; NJTP: National Job Training Program; STD: Sexually transmitted disease; STI: Sexually transmitted infection; UK: United Kingdom; USA: United States of America; WHO: World Health Organization

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12879-021-06381-4>.

Additional file 1. PRISMA checklist.

Additional file 2. Literature search strategy.

Additional file 3. Inclusion and exclusion criteria.

Additional file 4. Standardizations adopted for urogenital, rectal and pharyngeal laboratory tests.

Additional file 5. Reported gonorrhoea prevalence and/or test positivity in men-who-have-sex-with-men, by WHO region, country, and anatomic site.

Additional file 6. Dataset supporting the output of the literature search.

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Authors' contributions

JW supervised this work. JW, VAK, LS and MU contributed to the conceptualization, investigation, methodology, validation, and visualization of this work. JW, VAK, LS and MU participated in the development and the review of the manuscript and approved the final submitted version.

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Availability of data and materials

The dataset supporting the conclusions of this article is included within the article and its additional file (Additional file 6).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

VAK, LS and JW are employed by the GSK group of companies. JW and LS hold shares as part of their remuneration. MU declares no financial interests. None of the authors declare non-financial interests.

Author details

¹Clinical and Epidemiology Research and Development, GSK, Amsterdam, The Netherlands. ²Clinical and Epidemiology Research and Development, GSK, Siena, Italy. ³WHO Collaborating Centre for Gonorrhoea and other STIs, Department of Laboratory Medicine, Microbiology, Faculty of Medicine and Health, Örebro University, Örebro, Sweden.

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