Chlamydia, gonorrhoea, trichomoniasis and syphilis: global prevalence and incidence estimates, 2016

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Objective To generate estimates of the global prevalence and incidence of urogenital infection with chlamydia, gonorrhoea, trichomoniasis and syphilis in women and men, aged 15–49 years, in 2016.

Methods For chlamydia, gonorrhoea and trichomoniasis, we systematically searched for studies conducted between 2009 and 2016 reporting prevalence. We also consulted regional experts. To generate estimates, we used Bayesian meta-analysis. For syphilis, we aggregated the national estimates generated by using Spectrum-STI.

Findings For chlamydia, gonorrhoea and/or trichomoniasis, 130 studies were eligible. For syphilis, the Spectrum-STI database contained 978 data points for the same period. The 2016 global prevalence estimates in women were: chlamydia 3.8% (95% uncertainty interval, UI: 3.3–4.5); gonorrhoea 0.9% (95% UI: 0.7–1.1); trichomoniasis 5.3% (95% UI:4.0–7.2); and syphilis 0.5% (95% UI: 0.4–0.6). In men prevalence estimates were: chlamydia 2.7% (95% UI: 1.9–3.7); gonorrhoea 0.7% (95% UI: 0.5–1.1); trichomoniasis 0.6% (95% UI: 0.4–0.9); and syphilis 0.5% (95% UI: 0.4–0.6). Total estimated incident cases were 376.4 million: 127.2 million (95% UI: 95.1–165.9 million) chlamydia cases; 86.9 million (95% UI: 58.6–123.4 million) gonorrhoea cases; 156.0 million (95% UI: 103.4–231.2 million) trichomoniasis cases; and 6.3 million (95% UI: 5.5–7.1 million) syphilis cases.

Conclusion Global estimates of prevalence and incidence of these four curable sexually transmitted infections remain high. The study highlights the need to expand data collection efforts at country level and provides an initial baseline for monitoring progress of the *World Health Organization global health sector strategy on sexually transmitted infections 2016–202*1.

Abstracts in عربي, 中文, Français, Русский and Español at the end of each article.

Introduction

Sexually transmitted infections are among the most common communicable conditions and affect the health and lives of people worldwide. The World Health Organization (WHO) periodically generates estimates to gauge the global burden of four of the most common curable sexually transmitted infections: chlamydia (etiological agent: *Chlamydia trachomatis*), gonorrhoea (*Neisseria gonorrhoeae*), trichomoniasis (*Trichomonas vaginalis*) and syphilis (*Treponema pallidum*).[1–6] The estimates provide evidence for programme improvement, monitoring and evaluation.

These sexually transmitted infections cause acute urogenital conditions such as cervicitis, urethritis, vaginitis and genital ulceration, and some of the etiological agents also infect the rectum and pharynx. Chlamydia and gonorrhoea can cause serious short- and long-term complications, including pelvic inflammatory disease, ectopic pregnancy, infertility, chronic pelvic pain and arthritis, and they can be transmitted during pregnancy or delivery. Syphilis can cause neurological, cardiovascular and dermatological disease in adults, and stillbirth, neonatal death, premature delivery or severe disability in infants. All four infections are implicated in increasing the risk of human immunodeficiency virus (HIV) acquisition and transmission.[7] Moreover, people with sexually transmitted infections often experience stigma, stereotyping, vulnerability, shame and gender-based violence.[8]

In May 2016, the World Health Assembly adopted the *Global health sector strategy on sexually transmitted infections, 2016–2021*.[9] This strategy includes rapid scale-up of evidence-based interventions and services to end sexually transmitted infections as public health concerns by 2030. The strategy sets targets for reductions in gonorrhoea and syphilis incidence in adults and recommends the establishment of global baseline incidences of sexually transmitted infections by 2018. The primary objectives of this study were to estimate the 2016 global and regional prevalence and incidence of chlamydia, gonorrhoea, trichomoniasis and syphilis in adult women and men.

Methods

Prevalence estimation

Chlamydia, gonorrhoea and trichomoniasis

We generated estimates for these three infections through systematic reviews using the same methods as for the 2012 estimates.[6]

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We searched for articles published between 1 January 2009 and 29 July 2018 in PubMed® without language restrictions. We used PubMed Medical subject heading (MeSH) terms for individual country names combined with: "chlamydia"[MeSH Terms] OR "chlamydia"[All Fields], "gonorrhoea"[All Fields] OR "gonorrhea"[MeSH Terms] OR "gonorrhea"[All Fields], "trichomonas infections"[MeSH Terms] OR ("trichomonas"[All Fields] AND "infections"[All Fields]) OR "trichomonas infections"[All Fields] OR "trichomoniasis"[All Fields]). We also asked WHO regional sexually transmitted infection advisors and other leading experts in the field for additional published and unpublished data.

To be eligible, studies had to collect most specimens between 2009 and 2016 or be published in 2010 or later if specimen collection dates were not available. Other study inclusion criteria were: sample size of at least 100 individuals; general population (e.g. pregnant women, women at delivery, women attending family planning clinics, men and women selected for participation in demographic and health surveys); and use of an internationally recognized diagnostic test with demonstrated precision using urine, urethral, cervical or vaginal specimens.

To reduce bias in the estimation of general population prevalence, we excluded studies conducted among the following groups: patients seeking care for sexually transmitted infection or urogenital symptoms, women presenting at gynaecology or sexual health clinics with sexually transmitted infection related issues, studies restricted to women with abnormal Papanicolaou test results, remote or indigenous populations, recent immigrant or migrant populations, men who have sex with men and commercial sex workers.

Two investigators independently reviewed all identified studies to verify eligibility. When more than one publication reported on the same population, we retained the publication with the most detailed information. For each included study, we calculated prevalence as the number of individuals with a positive test result divided by the total number tested. We then standardized these values by applying adjustment factors for the accuracy of the laboratory diagnostic test, study location (rural versus urban) and the age of the study population. If the adjustments resulted in a negative value, we replaced the value with 0.1% when doing the meta-analysis. The methods and adjustment factors were identical to those used to generate the 2012 estimates.[6]

We obtained estimates for 10 geographical areas (referred to as estimation regions).[6] Estimates for high-income North America (Canada and United States of America), were based on the latest published United States estimates that used data from multiple sources.[10,11] For the other nine estimation regions, we calculated a summary prevalence estimate by meta-analysis if there were three or more data points.[12] There were sufficient data to generate an estimate for chlamydia in women in all regions, but not for gonorrhoea or trichomoniasis. For regions with insufficient data for gonorrhoea and trichomoniasis, we assumed that prevalence was a multiple of the prevalence of chlamydia. The infection specific multiples were based on those studies that met the 2016 inclusion criteria (available from the data repository).[13] For men, when there were insufficient data for meta-analysis, the prevalence of an infection was assumed to be proportional to the prevalence in women. The male-to-female ratios were infection-specific and were set at the same values as in 2012 estimates.[6]

To reflect the contribution of populations at higher risk of infection (e.g. men who have sex with men and commercial sex workers), who are likely to be under-represented in general population samples, we increased prevalence estimates by 10%, as in the 2012 estimates,[6] for each estimation region, apart from high-income North America.

We performed the meta-analyses using a Bayesian approach with a Markov Chain Monte Carlo algorithm implemented with the software BRrugs in R package (R foundation, Vienna, Austria).[14] For each infection, the software generated 10 000 samples from the posterior distribution for the expected mean prevalence in each estimation region based on the β-binomial model, and used these to calculate the 2.5 and 97.5 uncertainty percentiles.[15] We calculated global and regional prevalence estimates for each infection by weighting each of the 10 000 samples from estimation regions according to population size, using United Nations population data for women and men aged 15–49 years.[16] We present results by WHO region, 2016 World Bank income classification[17] and 2017 sustainable development goal (SDG) region.[18] All analyses were carried out using R statistical software (R foundation).

Syphilis

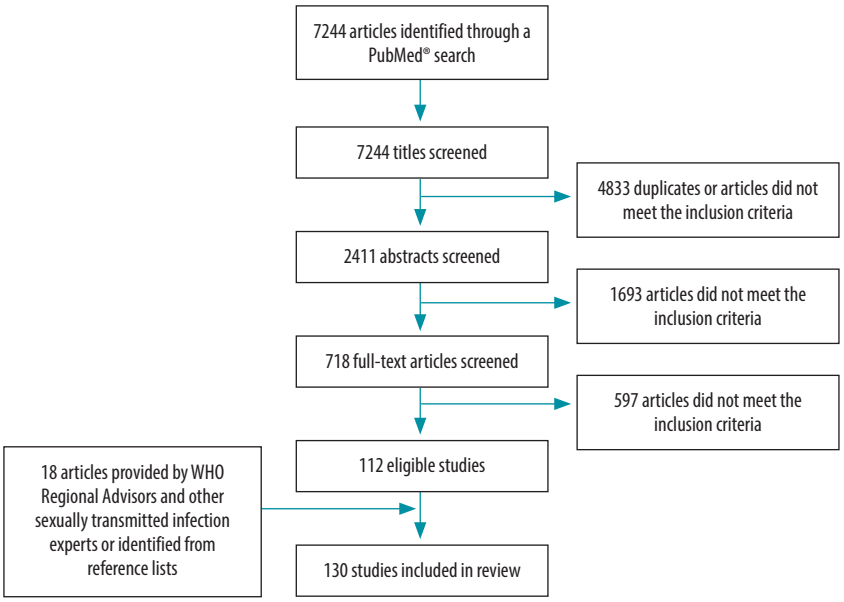
We based syphilis estimates on the WHO's published 2016 maternal prevalence estimates.[19] These estimates were generated by using Spectrum-STI, a statistical trend-fitting model in the publicly available Spectrum suite of health policy planning tools[20] and country specific data from the global Spectrum-STI syphilis database (available from the corresponding author). As in the 2012 estimation,[6] we assumed that the prevalence of syphilis in all women 15–49 years of age in each country was the same as in pregnant women. We then increased the estimate by 10% to reflect the contribution of populations at higher risk. The men to women prevalence ratio of syphilis was set at 1.0 and assumed to have a uniform distribution ± 33% around this value, in agreement with data from a recent global meta-analysis of syphilis.[21]

We generated regional and global estimates by weighting the contribution of each country by the number of women and men aged 15–49 years. Regional and global 95% uncertainty intervals (UIs) were generated using the delta method;[22] uncertainties were assumed to be independent across countries.

Incidence estimation

We calculated incidence estimates for each infection by dividing prevalence by the average duration of infection for all estimation regions except high-income North America where published estimates were used.[10,11] Estimates of the average duration of infection were those used in the 2012 estimation[6] and assumed to have a uniform distribution of ± 33.3% around the average duration. We calculated uncertainty in incidence for a given region, sex and infection at the national level using the delta method;[22] uncertainty in the prevalence estimate was multiplied by uncertainty in the estimated duration of infection. Regional and global uncertainty intervals were generated assuming uncertainties were independent across countries.

Fig. 1. **Flowchart of the selection of studies for estimating the prevalence and incidence of chlamydia, gonorrhoea and trichomoniasis, 2016**



WHO: World Health Organization.
Note: This figure does not include studies from North America; the North American estimates were based on published estimates.[10,11]

Results

Data availability

Chlamydia, gonorrhoea and trichomoniasis

Of the 7244 articles screened, 112 studies met the inclusion criteria for one or more of the three infections (Fig. 1). We identified an additional 18 studies through expert consultations and reviewing reference lists (Nguyen M et al., Hanoi Medical University, Viet Nam, personal communication, 23 March 2018; El Kettani A et al., National Institute of Hygiene, Morocco, personal communication, 2 May 2016; Galdavadze K et al., Disease Control and Public Health, Republic of Georgia; personal communication, 22 August 2017).[23–150] Of these 130 studies, 111 reported data for women only (Table 1; available at: http://www.who.int/bulletin/volumes/96/8/18-228486), three reported data for men only (Table 2; available at: http://www.who.int/bulletin/volumes/96/8/18-228486) and 16 reported data for both women and men (Table 1 and Table 2). Only 34 studies in women and four studies in men provided information on all three infections. The included studies contained 100 data points in women for chlamydia, 64 for gonorrhoea and 69 for trichomoniasis. In men, there were 16 data points for chlamydia, 11 for gonorrhoea and seven for trichomoniasis (Table 3).

For women, a total of 43 (21.0%) of 205 countries, territories and areas had one or more data points for chlamydia, 32 (15.6%) for gonorrhoea and 29 (14.1%) for trichomoniasis. For men, only 15 (7.3%) countries, territories and areas had one or more data points for chlamydia, 10 (4.9%) for gonorrhoea and 7 (3.4%) for trichomoniasis. For women there were sufficient data to generate summary estimates for chlamydia for the nine estimation regions, but not for gonorrhoea or trichomoniasis (Table 4).

Syphilis

As of 2 May 2018, the Spectrum-STI Database contained 1576 data points from surveys conducted since 1990, including 978 from January 2009 to December 2016.[151] In total, 181 (88.3%) of 205 countries, territories and areas had sufficient data to generate a Spectrum STI estimate for 2016. For the remaining 24 countries, territories and areas, we used the median value of the countries with data for the relevant WHO region as the 2016 estimate.

Prevalence and incidence estimates

Table 5 shows prevalence estimates for the WHO regions for 2016. Based on prevalence data from 2009 to 2016, the estimated pooled global prevalence of chlamydia in 15–49-year-old women was 3.8% (95% UI: 3.3–4.5) and in men 2.7% (95% UI: 1.9–3.7), with regional values ranging from 1.5 to 7.0% in women and 1.2 to 4.0% in men. For gonorrhoea, the global estimate was 0.9% (95% UI: 0.7–1.1) in women and 0.7% (95% UI: 0.5–1.1) in men, with regional values in women ranging from 0.3 to 1.9% and from 0.3 to 1.6% in men. The estimates for trichomoniasis were 5.3% (95% UI: 4.0–7.2) in women and 0.6% (95% UI: 0.4–0.9) in men, with regional values ranging from 1.6 to 11.7% in women and from 0.2 to 1.3% in men. For syphilis, the global estimate in both men and women was 0.5% (95% UI: 0.4–0.6) with regional values ranging from 0.1 to 1.6%. The WHO African Region had the highest prevalence for chlamydia in men, gonorrhoea in women and men, trichomoniasis in women and syphilis in men and women. The WHO Region of the Americas had the highest prevalence of chlamydia in women and of trichomoniasis in men.

These prevalence estimates correspond to the totals of 124.3 million cases of chlamydia, 30.6 million cases of gonorrhoea, 110.4 million cases of trichomoniasis and 19.9 million cases of syphilis (available from the data repository).[13]

Using the World Bank classification, high-income countries, territories and areas had the lowest estimated prevalence, and low-income countries, territories and areas had the highest prevalence of gonorrhoea, trichomoniasis and syphilis. For chlamydia, estimated prevalence was highest in upper-middle income countries, territories and areas (Fig. 2). The SDG grouping showed the highest prevalence of all four sexually transmitted infections in Oceania region, that is, Pacific island nations excluding Australia and New Zealand (available from the data repository).[13]

We estimated the global incidence rate for chlamydia in 2016 to be 34 cases per 1000 women (95% UI: 25–45) and 33 per 1000 men (95% UI: 21–48); for gonorrhoea 20 per 1000 women (95%

Table 3. **Number of data points that met the study inclusion criteria for the WHO 2016 prevalence estimates of chlamydia, gonorrhoea and trichomoniasis**

Estimation region	No. of countries, territories and areas	Chlamydia				Gonorrhoea				Trichomoniasis			
		Women		Men		Women		Men		Women		Men	
		No. of data points	No. of countries	No. of data points	No. of countries	No. of data points	No. of countries	No. of data points	No. of countries	No. of data points	No. of countries	No. of data points	No. of countries
Central, eastern and western sub-Saharan Africa	41	16	7	2	2	15	7	2	2	21	9	1	1
Southern sub-Saharan Africa	6	7	4	1	1	6	3	1	1	6	3	1	1
Andean, central, southern and tropical Latin America and Caribbean	42	25	8	2	2	14	6	2	2	16	5	1	1
High-income North America	2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
North Africa and Middle East	20	11	4	1	1	5	2	0	0	5	2	1	1
Australasia and high-income Asia Pacific	6	6	2	2	1	4	1	2	1	3	1	1	1
Western, central and eastern Europe and central Asia	54	19	11	6	6	9	7	2	2	4	3	2	2
Oceania	14	7	3	1	1	7	3	1	1	5	1	0	0
South Asia	5	4	2	0	0	2	1	0	0	3	1	0	0
East Asia and south-east Asia	15	5	2	1	1	2	2	1	1	6	4	0	0
Total	**205**	**100**	**43**	**16**	**15**	**64**	**32**	**11**	**10**	**69**	**29**	**7**	**7**

NA: not applicable; WHO: World Health Organization.
Note: Eight of the 112 studies with data for women had two separate data points (e.g. for different population groups).

Table 4. **Approach used to generate 2016 regional estimates for chlamydia, gonorrhoea and trichomoniasis**

Estimation region	Women			Men		
	Chlamydia	Gonorrhoea	Trichomoniasis	Chlamydia	Gonorrhoea	Trichomoniasis
Central, eastern and western sub-Saharan Africa	Meta-analysis	Meta-analysis	Meta-analysis	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
Southern sub-Saharan Africa	Meta-analysis	Meta-analysis	Meta-analysis	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
Andean, central, southern and tropical Latin America and Caribbean	Meta-analysis	Meta-analysis	Meta-analysis	Special case[a]	Global male-to-female ratio	Global male-to-female ratio
High-income North America[b]	United States estimate for 2012	United States estimate for 2008	United States estimate for 2008	United States estimate for 2012	United States estimate for 2008	United States estimate for 2008
North Africa and Middle East	Meta-analysis	Meta-analysis	Meta-analysis	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
Australasia and high-income Asia Pacific	Meta-analysis	Gonorrhoea to chlamydia ratio	Trichomoniasis to chlamydia ratio	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
Western, central and eastern Europe and central Asia	Meta-analysis	Meta-analysis	Trichomoniasis to chlamydia ratio	Meta-Analysis	Global male-to-female ratio	Global male-to-female ratio
Oceania	Meta-analysis	Meta-analysis	Meta-Analysis	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
South Asia	Meta-analysis	Gonorrhoea to chlamydia ratio	Trichomoniasis to chlamydia ratio[c]	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio
East Asia and south-east Asia	Meta-analysis	Gonorrhoea to chlamydia ratio[d]	Meta-analysis	Global male-to-female ratio	Global male-to-female ratio	Global male-to-female ratio

[a] In consultation with advisors on sexual transmitted infections for the World Health Organization (WHO) Region of the Americas, we decided to use the midpoint between the 2016 estimate generated by applying the global male-to-female ratio (7.5%) and the 2012 estimate for the region (2.1%). We deemed the former to be too high and the latter too low.

[b] Following discussions with the United States Centers for Disease Control and Prevention, we based our estimates on the latest published United States national estimates[21,22] and assumed they remained constant over time and that estimates for 15–39-year-old people could be extrapolated to the 15–49-year age range. We did not apply the adjustments used for other Regions in the WHO estimates process. The figures for the United States were also applied to Canada.

[c] The estimate based on the three available data points was over 4%, considerably higher than the 2012 estimate. Following discussions with regional experts we decided not to use this estimate, but instead to use the trichomoniasis to chlamydia ratio for low and lower middle-income countries, territories and areas.

[d] This estimation region is made up of countries from East Asia and South East Asia. We used the higher and upper-middle income gonorrhoea to chlamydia ratio for East Asia and the low and lower-middle income ratio for South East Asia."

UI: 14–28) and 26 per 1000 men (95% UI: 15–41); for trichomoniasis 40 per 1000 women (95% UI: 27–58) and 42 per 1000 men (95% UI: 23–69); and for syphilis 1.7 per 1000 women (95% UI: 1.4–2.0) and 1.6 per 1000 men (95% UI: 1.3–1.9; Fig. 3). The WHO Region of the Americas had the highest incidence rate for chlamydia and syphilis in both women and men, while the WHO African Region had the highest incidence rates for gonorrhoea and trichomoniasis in women and men. Incidence rates by income category and SDG regions are available from the data repository.[13]

These incidence rates translate globally into 127.2 million (95% UI: 95.1–165.9) new chlamydia cases, 86.9 million (95% UI: 58.6–123.4 million) gonorrhoea cases, 156.0 million (95% UI: 103.4–231.2 million) trichomoniasis cases and 6.3 million (95% UI: 5.5–7.1 million) syphilis cases in women and men aged 15–49 years in 2016. Together, the four infections accounted for 376.4 million new infections in 15–49-year-old people in 2016. Approximately 13.5% (50.8 million) of these infections occurred in low-income countries, territories and areas, 31.4% (118.1 million) in lower middle income, 47.1% (177.3 million) in upper-middle income and 8.0% (30.1 million) in high-income (available from the data repository).[13]

Comparison of estimates

Comparing the 2012 estimates with the estimates presented here shows that more data points were available in women for the 2016 estimates. The number increased from 69 to 100 for chlamydia, 50 to 64 for gonorrhoea and 44 to 69 for trichomoniasis. For men, the number of data points fell from 21 to 16 for chlamydia and from 12 to 11 for gonorrhoea, but increased from one to seven for trichomoniasis. The period of eligibility for both estimates was eight years with an overlap of four years (2009 to 2012); in women 27 data points were included in both estimates for chlamydia, 18 for gonorrhoea and 20 for trichomoniasis. In men, these overlaps were six, five and one, respectively.

Table 5 compares the 2012 and 2016 prevalence estimates for the four infections. For syphilis, two estimates are presented for 2012, the published estimate[6] and the 2012 estimate generated using Spectrum STI and the latest

Table 5. **Comparison of 2012 and 2016 WHO regional prevalence estimates of chlamydia, gonorrhoea, trichomoniasis and syphilis**

WHO Region, by sex	Estimated prevalence, % (95% UI)							
	Chlamydia		Gonorrhoea		Trichomoniasis		Syphilis	
	2012	2016	2012	2016	2012	2016	2012	2012 (updated)	2016
Women									
African Region	3.7 (2.7–5.2)	5.0 (3.8–6.6)	1.7 (1.2–2.6)	1.9 (1.3–2.7)	11.5 (9.0–14.6)	11.7 (8.6–15.6)	1.8 (1.4–2.5)	1.7 (1.5–1.9)	1.6 (1.2–2.0)
Region of the Americas	7.6 (6.7–8.7)	7.0 (5.8–8.3)	0.8 (0.5–1.1)	0.9 (0.6–1.5)	7.7 (4.3–13.1)	7.7 (5.1–11.5)	0.4 (0.4–0.5)	0.7 (0.6–0.7)	0.9 (0.7–1.1)
South-East Asia Region	1.8 (1.4–2.2)	1.5 (1.0–2.5)	0.4 (0.2–0.5)	0.7 (0.4–1.2)	1.8 (1.1–2.7)	2.5 (1.3–4.9)	0.4 (0.3–0.4)	0.4 (0.2–0.5)	0.2 (0.1–0.4)
European Region	2.2 (1.6–2.9)	3.2 (2.5–4.2)	0.3 (0.2–0.5)	0.3 (0.1–0.6)	1.0 (0.8–1.3)	1.6 (1.1–2.3)	0.2 (0.1–0.4)	0.1 (0.1–0.1)	0.1 (0.0–0.4)
Eastern Mediterranean Region	3.5 (2.4–5.0)	3.8 (2.6–5.4)	0.5 (0.3–0.7)	0.7 (0.5–1.1)	5.9 (4.5–8.0)	4.7 (3.3–6.7)	0.5 (0.4–0.9)	0.6 (0.5–0.8)	0.7 (0.4–1.0)
Western Pacific Region	6.2 (5.1–7.5)	4.3 (3.0–5.9)	1.2 (0.8–1.7)	0.9 (0.5–1.3)	5.5 (3.3–8.9)	5.6 (2.7–10.8)	0.2 (0.2–0.3)	0.3 (0.2–0.4)	0.2 (0.1–0.4)
Global total	4.2 (3.7–4.7)	3.8 (3.3–4.5)	0.8 (0.6–1.0)	0.9 (0.7–1.1)	5.0 (4.0–6.4)	5.3 (4.0–7.2)	0.4 (0.4–0.6)	0.5 (0.5–0.6)	0.5 (0.5–0.6)
Men									
African Region	2.5 (1.7–3.6)	4.0 (2.4–6.1)	0.5 (0.3–0.9)	1.6 (0.9–2.6)	1.2 (0.7–1.7)	1.2 (0.7–1.8)	1.8 (1.1–2.8)	1.7 (1.4–2.0)	1.6 (1.2–2.0)
Region of the Americas	1.8 (1.3–2.6)	3.7 (2.1–5.5)	0.7 (0.4–1.0)	0.8 (0.4–1.3)	1.3 (0.9–2.0)	1.3 (0.9–1.8)	0.4 (0.3–0.6)	0.7 (0.5–0.8)	0.9 (0.7–1.2)
South-East Asia Region	1.3 (0.9–1.8)	1.2 (0.6–2.1)	0.5 (0.3–0.8)	0.6 (0.3–1.1)	0.2 (0.1–0.3)	0.2 (0.1–0.5)	0.4 (0.2–0.5)	0.4 (0.2–0.5)	0.2 (0.2–0.4)
European Region	1.5 (0.9–2.6)	2.2 (1.5–3.0)	0.3 (0.2–0.5)	0.3 (0.1–0.5)	0.1 (0.1–0.2)	0.2 (0.1–0.3)	0.2 (0.1–0.4)	0.1 (0.1–0.2)	0.1 (0.0–0.3)
Eastern Mediterranean Region	2.7 (1.6–4.3)	3.0 (1.7–4.8)	0.4 (0.2–0.6)	0.6 (0.3–1.0)	0.6 (0.4–0.9)	0.5 (0.3–0.7)	0.5 (0.3–0.9)	0.6 (0.5–0.8)	0.7 (0.4–1.0)
Western Pacific Region	5.2 (3.4–7.2)	3.4 (2.0–5.3)	1.0 (0.6–1.7)	0.7 (0.4–1.2)	0.6 (0.3–1.0)	0.6 (0.2–1.1)	0.2 (0.2–0.3)	0.3 (0.2–0.4)	0.2 (0.1–0.4)
Global total	2.7 (2.0–3.6)	2.7 (1.9–3.7)	0.6 (0.4–0.9)	0.7 (0.5–1.1)	0.6 (0.4–0.8)	0.6 (0.4–0.9)	0.5 (0.3–0.7)	0.5 (0.5–0.6)	0.5 (0.4–0.6)

UI: uncertainty interval; WHO: World Health Organization.
Notes: The 2012 estimates are from Newman et al., 2015.[6] For syphilis both the WHO estimate for 2012 and the 2018 updated 2012 estimate using Spectrum STI are shown.[19] For chlamydia, gonorrhoea and trichomoniasis, the study inclusion window for 2016 was samples collected between 2009 and 2016, and for 2012, between 2005 and 2012.

Spectrum data set.[19] For all infections in both women and men, the 2016 global prevalence estimate was within the 95% UI for 2012. At the regional level, the 95% UIs for prevalence overlapped for all four infections in both men and women, apart from gonorrhoea in men in the WHO African Region which was higher in 2016 than in 2012.

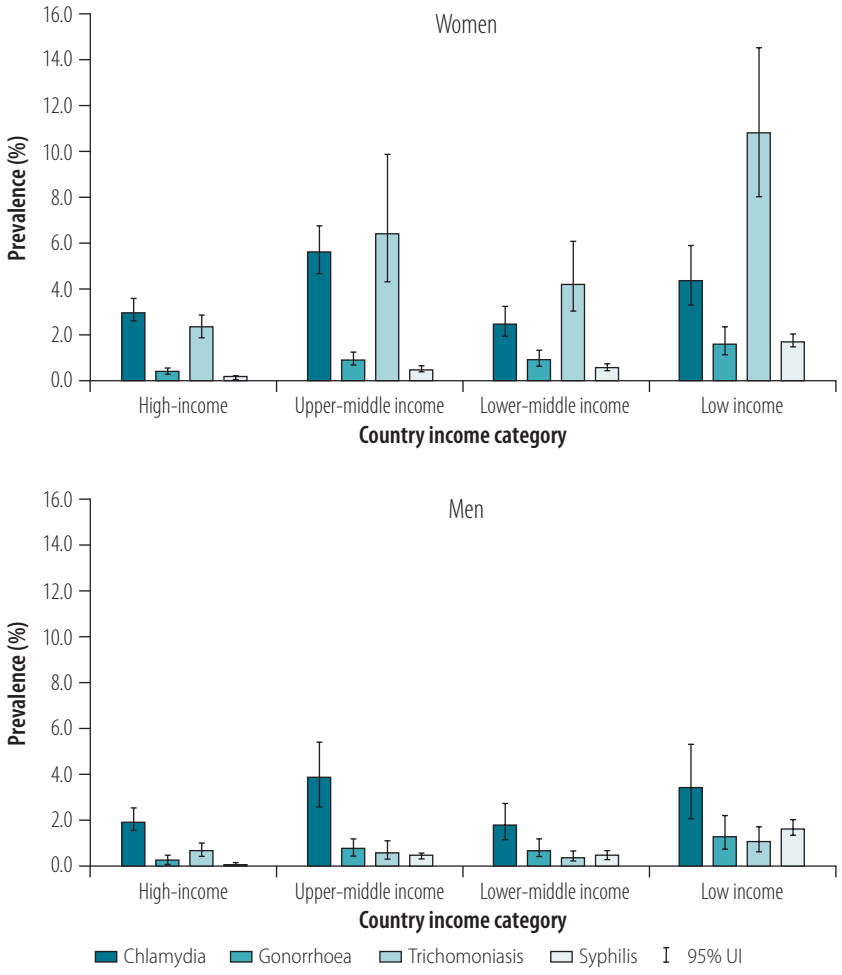
Discussion

We estimated a global total of 376.4 million new curable urogenital infections with chlamydia, gonorrhoea, trichomoniasis and syphilis in 15–49-year-old women and men in 2016. This estimate corresponds to an average of just over 1 million new infections each day. The number of individuals infected, however, is smaller as repeat infections and co-infections are common.[152]

The estimates of prevalence and incidence in 2016 were similar to those in 2012, both globally and by region, showing that sexually transmitted infections are persistently endemic worldwide. Grouping countries, territories and areas according to SDG regions revealed that the prevalence and incidence of all four sexually transmitted infections, in both women and men, were highest in the Oceania Region. The small island states in this SDG region are part of the WHO Western Pacific Region, which is dominated by China (owing to its population size). Therefore, the levels of sexually transmitted infections and need for infection control in these island states are masked when viewing the estimates only by WHO Region. When using the World Bank classification of countries, the prevalence of gonorrhoea, trichomoniasis and syphilis were highest in low-income countries, territories and areas. The prevalence of chlamydia was highest in the upper middle-income countries, territories and areas, partly due to high estimates in some Latin American countries. Further research is needed to determine whether these estimates reflect methodological factors or differences in *C. trachomatis* transmission.

The 2016 estimates for chlamydia, gonorrhoea and trichomoniasis were based on a systematic review of the literature complemented by outreach to experts using the same methods as in 2012. The aim was to reduce bias and insure comprehensiveness in the

Fig. 2. **Prevalence estimates of chlamydia, gonorrhoea, trichomoniasis and syphilis in adults, by World Bank classification, 2016**



UI: uncertainty interval.
Notes: We defined adults as 15–49 years of age and used year 2016 income classification from the World Bank.[17]

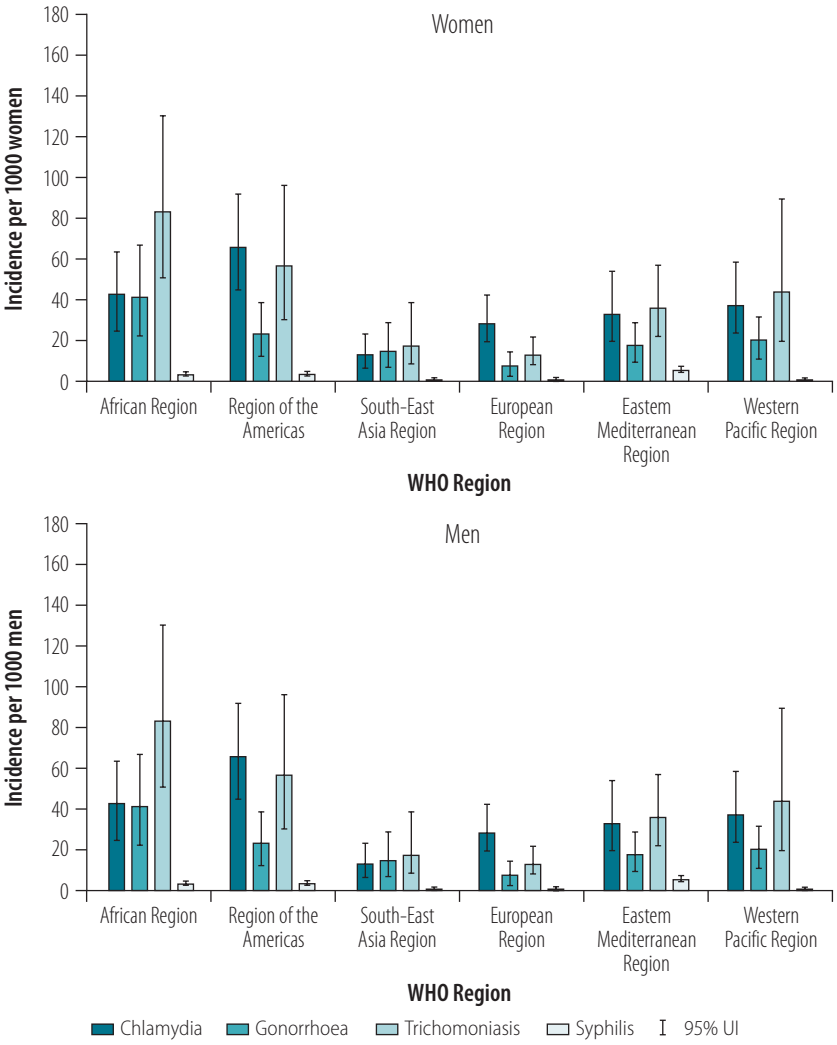
search for data.[19] For syphilis, the use of national estimates generated by a statistical model improves on the 2012 method by making use of historical trend data. The similarity between the published 2012 syphilis estimates and Spectrum STI generated estimates for 2012 provides reassurance about the validity of comparing the 2016 and 2012 estimates.

The study has limitations. First, limited prevalence data were available, despite an eight-year time window for data inclusion. Estimates for a given infection and region are therefore extrapolated from a small number of data points and ratios were used to generate estimates for some regions. For men, the lack of data was particularly striking. For syphilis, most data were from pregnant women, which might not reflect all women aged 15–49 years, or men. Second, the source studies include people in different age groups and used a range of diagnostic tests, so adjustment factors were applied to standardize measures across studies. Third, owing to the absence of empirical studies, incidence estimates were derived from the relationship between prevalence and duration of infection, and data on the average duration of infection for each of the four infections are also limited. Finally, because only studies among the general population were used, the prevalence and incidence in areas where key populations contribute disproportionately to sexually transmitted infection epidemics may have been underestimated despite the applied correction factor. These limitations have been discussed previously in detail.[6]

This study has implications for sexually transmitted infection programming and research. The quantity and quality of prevalence and incidence studies for sexually transmitted infections in representative samples of the general population, for both women and men, need improvement. Identifying opportunities to integrate data collection with clinical care platforms, such as HIV, adolescent, maternal, family planning and immunization is crucial. The recently developed WHO protocol for assessing the prevalence of sexually transmitted infections in antenatal care settings[153] provides a framework and consistent methods that can be adapted for women and men. Comparing data across studies requires better understanding of the performance characteristics of diagnostic tests, and implications for estimates of the average duration of infection for each infection. The processes for producing future prevalence estimates could be made timelier and more efficient through continually updated systematic reviews,[154] as well as technological solutions that automate searching of databases and facilitate high quality updates of reviews.

The global estimates of prevalence and incidence of four curable sexually transmitted infections are important in the broader global context, highlighting a continuing public health challenge. Prevalence and incidence data play an important role in the design and evaluation of programmes and interventions for sexually transmitted infections and in interpreting changes in HIV epidemiology. The global threat of antimicrobial resistance, particularly the emergence of *N. gonorrhoeae* resistance to the few remaining antimicrobials recommended for treatment, further highlights the importance of investing in monitoring prevalence and incidence.[155] Estimates of prevalence and incidence are essential for calculations of the burden of disease due to sexually transmitted infections, which are needed to advocate for funding to support sexually transmitted infection programmes. These burden estimates can also be used to promote innovation for point-of-care diagnostics, new therapeutics, vaccines and microbicides. The WHO Global Health Sector

Fig. 3. **Incidence rate estimates for chlamydia, gonorrhoea, trichomoniasis and syphilis in adults, by WHO Region, 2016**



UI: uncertainty interval, WHO: World Health Organization.
Note: We defined adults as 15–49 years of age.

Strategy on Sexually Transmitted Infections sets a target of 90% reductions in the incidence of gonorrhoea and of syphilis, globally, between 2018 and 2030.[9] Major scale-ups of prevention, testing, treatment and partner services will be required to achieve these goals. The estimates generated in this paper, despite their limitations, provide an initial baseline for monitoring progress towards these ambitious targets. ■

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ملخص

الكلاميديا، والسيلان، وداء المشعرات، والزهري: تقديرات الانتشار والإصابة العالمية، 2016

الغرض وضع تقديرات للانتشار والإصابة العالمية لعدوى الجهاز الكلاميديا 3.8% (فاصل عدم الثقة 95%: 3.3 إلى 4.5)،