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Trends in Adult Chlamydia and Gonorrhea Prevalence, Incidence and Urethral Discharge Case Reporting in Morocco over 1995–2015—Estimates Using the Spectrum-Sexually Transmitted Infection Model

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Background: Evolving health priorities and resource constraints mean that countries require data on sexually transmitted infections (STI) trends to inform program planning and resource allocation.

Methods: The Spectrum modeling tool estimated prevalence and incidence of gonorrhea and chlamydia in Morocco's 15- to 49-year-old population, based on prevalence surveys. Incident cases, broken down between symptomatic and asymptomatic, and treated versus untreated, were compared with urethral discharge (UD) case reports, to estimate reporting completeness among treated UD cases.

Results: Gonorrhea prevalence was estimated at 0.37% (95% confidence interval [CI], 0.14–1.0%) in women and 0.32% (0.12–0.87%) in men in 2015; chlamydia prevalences were 3.8% (95% CI, 2.1–6.4%) and 3.0% (95% CI, 1.7–5.1%). Corresponding estimated numbers of new cases in women and men in 2015 were 79,598 (95% CI, 23,918–256,206) and 112,013 (95% CI, 28,700–307,433) for gonorrhea, and 291,908 (95% CI, 161,064–524,270) and 314,032 (95% CI, 186,076–559,133) for chlamydia. Gonorrhea and chlamydia prevalence had declined by an estimated 41% and 27%, respectively, over 1995 to 2015. Prevalence declines probably related to improved STI treatment coverage, and decreasing risk behaviors. Reporting completeness among treated UD cases was estimated at 46% to 77% in 2015. Reported UD cases corresponded to 13% of all estimated (symptomatic and asymptomatic) gonorrhea and chlamydia cases.

Conclusions: STI declines and improvements in treatment coverage are consistent with Morocco's introduction of syndromic management in 2000, scale-up of prevention, and declining human immunodeficiency virus incidence. While gonorrhea is four-fold more common as cause of clinical UD cases than chlamydia, Morocco continues to suffer a large, untreated burden of chlamydia. Reliable monitoring of both STIs requires new periodic surveys and/or novel forms of affordable surveillance beyond high-risk populations.

With evolving health priorities and limited resources, Morocco needs estimates of its burden of sexually transmitted infections (STIs) to inform strategic planning, resource allocation, target setting, and program evaluation. Morocco registers around 400,000 new STI cases through public health clinics every year, but it is estimated that the true burden lies much higher owing to unreported cases.[1] Of reported STI cases, around 15% are urethral discharge (UD) in men, two thirds are cervicitis and vaginitis in women, with smaller numbers of genital ulcers, condylomata,

hepatitis, and other STI in both men and women); 65% are in young adults aged 20 to 40 years.[1]

In 2016, the Spectrum-STI estimation tool was developed to complement the human immunodeficiency virus (HIV) tool and estimate trends in adult prevalence and incidence of STIs at national level, using standard indicator data from routine STI surveillance and population-based surveys. The model is embedded in the Spectrum suite of health program planning tools, anchored on projections of national population sizes over time.[2–4] The Spectrum acquired immune deficiency syndrome (AIDS) Incidence Model is used by over 120 countries to estimate HIV/AIDS burden and associated need for treatment.

Morocco has used the Spectrum-HIV module to annually estimate trends in its HIV/AIDS burden and associated need for ART and prevention services since 2005. In 2016, Morocco was chosen to pilot the Spectrum STI module to inform strategic planning for its STI response, and strengthen its STI surveillance system.[5]

This article collates Morocco's data on chlamydia and gonorrhea prevalence, UD case reports and UD etiologies. Importantly, it presents estimates of the adult prevalence and incidence of gonorrhea and chlamydia in Morocco over 1995 to 2015, using prevalence survey data. Estimated male gonorrhea and chlamydia case numbers were then broken down into numbers symptomatic and asymptomatic to estimate cases with UD, to estimate UD treatment coverage and reporting completeness. We interpret the estimated time trends in STI rates and treatment and reporting patterns in the context of Morocco's recent STI control history and program development and discuss implications for national surveillance and programming.

METHODS

Overview

The Spectrum-STI estimation tool (http://avenirhealth.org/software-spectrum.php) was used to estimate and project the prevalence of gonorrhea and chlamydia in men and women in Morocco's adult population (15–49 years), based on statistical fitting of data from prevalence surveys.[6] Incidence was derived from prevalence by applying assumed average durations of infection. The completeness of UD case reporting was evaluated, relative to the total national UD case load based on estimated gonorrhea and chlamydia incidence.

Data and assumptions used to generate the Morocco estimates were reviewed, discussed, and agreed at 2 technical workshops held in Morocco in May and September 2016. Participants in the workshop included representatives of the Ministry of Health, HIV/AIDS and Maternal and Child Health programs; the central reference laboratory and key partners supporting or implementing the national HIV/STI response.

Prevalence Estimation

For both STIs, prevalence data from 1985 to 2015 were identified. Inclusion criteria were:

- Study population considered representative of the general adult population. This included pregnant women, women at delivery, women attending family planning clinics, and adults in household surveys. Studies conducted among the following groups were excluded: patients seeking care for an STI or genital symptoms, women with abnormal Papanicolaou smears, women attending gynecology or sexual health clinics, men who have sex with men, commercial female sex workers (FSW), or blood donors.
- Study used an internationally recognized diagnostic test with adequate performance characteristics on urine, urethral, serum or cervicovaginal specimens.

Prevalence data from each study were adjusted for the sensitivity and specificity of diagnostic tests used[7–9]; Supplemental Digital Content (SDC) 1, http://links.lww.com/OLQ/A179. To allow uncertainty analyses, any (test-adjusted) prevalence of zero was imputed to be 1 case divided by 100 times the sample size Supplemental Digital Content (SDC) 2, http://links.lww.com/OLQ/A179. Studies conducted in exclusively rural or urban sites were converted into a national prevalence by applying a rural to urban ratio of 0.9 weighted by the urban/rural population ratios for Morocco,[10] as done in the World Health Organization (WHO)'s 2012 regional STI estimations.[7] Each prevalence data point was adjusted upward by 10% to account for the contribution of higher-risk populations.[7]

The Spectrum-STI module provides the option of using data from other countries to supplement national data. In the current model application, these studies were given a weight of 10%. In addition, the WHO's 2012 regional prevalence estimates for women in the Eastern Mediterranean region were included and assigned a weight of 1%. Despite the small weights, these data additions may help alleviate the absence of data for Morocco for specific years and may account for regional trends not captured sufficiently in the Morocco data.

To allow a trend estimation including all eligible male and female data points combined, each male prevalence was converted into a corresponding female prevalence by applying a fixed male-to-female prevalence ratio, set at 0.86 for gonorrhea and 0.80 for chlamydia (as in the WHO 2012 global and regional estimations[7]). The estimation was done for female prevalence; thereafter, the corresponding male prevalence at each year was generated by applying the same (time-constant) male-to-female prevalence ratios.

National prevalence was estimated over time as a moving average through all adjusted data points, with the weights specified that reflect geographical relevance, with a 95% confidence interval (CI) derived by bootstrapping, using 10,000 replications that considered each study's sample size.[6]

Incidence Estimation

Incidence was derived from the prevalence trend estimates, assuming that the incidence hazard or density (among uninfected people) was constant in each of the consecutive intervals of length 1 year, for t starting from 1995. If the incidence hazard or density, i, and STI episode duration, D, are constant in an interval $(t_0, t_0 + 1)$, then for all t in that interval, the prevalence satisfies the equation:

$$p(t) = \frac{i}{i+r} + \left(p(t_0) - \frac{i}{i+r}\right) \exp(-(i+r)(t-t_0))$$

where $r = 1/D$ (Supplemental Digital Contents (SDC) 3, http://links.lww.com/OLQ/A179 and 4, http://links.lww.com/OLQ/A179).

We solved equation 1 for i piecewise every year, after setting $t = t_0 + 1$, for $t_0 = 1995, 1996, …$ to obtain its time trend, and then calculated the corresponding incidence rate 'IR' *per capita* of national adult population, as: $IR = i(1 - p)$, where p is the prevalence Supplemental Digital Content (SDC) 4, http://links.lww.com/OLQ/A179).

The 95% CIs on incidence bounds reflect both the uncertainty (estimated by bootstrap) in prevalence, and an additional uncertainty on the duration of infection, set at ±50%.

STI Episode Durations

STI episode durations at 2015 were based on WHO estimates of the average duration of infection in the Eastern Mediterranean region, used in the 2005, 2008, and 2012 global and regional estimates Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179[7]: 0.25 years (3 months) for gonorrhea

in men, 0.43 years for gonorrhea in women, 0.84 years for chlamydia in men, and 1.19 years for chlamydia in women (see Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179 for underlying assumptions). These durations were based on the assumption that at 2015, 42% of symptomatic male gonorrhea cases got treated,[7] and 7.2% of chlamydia cases[7,11] Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179.

Knowledge, Attitudes, and Practices (KAP) studies conducted in 2007 and 2013 in youth with UD or vaginal discharge,[12,13] and studies of men in 2001[14] and 2009[15] have documented increases in STI treatment, overall and for public clinics specifically. To reflect this, we assumed that the probability of an infected, symptomatic adult being adequately treated in 1995 was half (eg, in men, 21% for gonorrhea and 3.6% for chlamydia) of what it was in 2015 (in men, 42% for gonorrhea and 7.2% for chlamydia), and that this treatment coverage had increased linearly over time Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179. Based on treatment coverage estimated for each year, the average duration of gonorrhea and chlamydia episodes in each year was calculated, by weighting between the fraction treated and the fraction untreated Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179. The year-specific treatment-weighted durations were then applied to derive annual incidence from annual prevalence.

UD Reporting Completeness

National-level UD case reports over 1995 to 2015 collated by the national STI programme Supplemental Digital Content (SDC) 5, http://links.lww.com/OLQ/A179 were compared to Spectrum-estimated national UD case load, based on estimated gonorrhea and chlamydia incident cases. UD case load was generated by adjusting gonorrhea and chlamydia incidence estimates by the proportion of UD cases due to gonorrhea and chlamydia according to etiological studies Supplemental Digital Content (SDC) 6, http://links.lww.com/OLQ/A179, and proportions of male episodes that are symptomatic and treated Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179.

The national UD case reports cover adult men over 15 years of age. To compare the model results with these case reports, we assumed the incidence rate in men 50 to 64 years was the same as in men 15 to 49 years.

Sensitivity Analysis

The sensitivity of results to key assumptions were assessed in univariate sensitivity analyses, focusing on prevalence, incidence, and UD reporting completeness at 2015.

RESULTS

Gonorrhea and Chlamydia Prevalence

Three surveys were identified in Morocco that met the study entry criteria. Two surveys, in 1999 and 2011 to 2012, provided data for gonorrhea and chlamydia prevalence, in both ANC and Family Planning women. Additionally, 1 study was included that measured chlamydia only, over 1994 to 1996, in ANC women and male blood donors (Supplemental Digital Content (SDC) 2, http://links.lww.com/OLQ/A179 Fig. 1).

No qualifying data for either gonorrhea or chlamydia were identified from Morocco's geographically bordering countries, but the group of national experts decided to include data from Egypt, considering its presumed similar demographic and sociobehavioral situation. One survey from Egypt, conducted among women attending ANC and family planning clinics in 1999 to 2000, was included for both STIs; additionally, for chlamydia, we included 6 data points from low-risk population surveys conducted over 1985 to 1994 Supplemental Digital Content (SDC) 2, http://links.lww.com/OLQ/A179.

For gonorrhea in women, Spectrum estimated a stable prevalence around 0.6% over 1995 to 1999 followed by slight decline over 1999 to 2011. Corresponding gonorrhea prevalences for men were 0.53% (0.26–0.93%) at 2000 and 0.32% (0.12–0.87%) at 2015.

For chlamydia, Spectrum estimated a slight decline over 1995 to 2011 (the last year with survey data), and stable prevalence thereafter (Fig. 1). Chlamydia prevalences were 4.7% (2.1–6.4%) in women and 4.1% (2.6–6.1%) in men in 2000, and 3.8% (2.1–6.4%) in women and 3.0% (1.7–5.1%) in men in 2015. Over 1995 to 2015, gonorrhea and chlamydia prevalence had declined by 41% and 27%, respectively.

Gonorrhea and Chlamydia Incidence

Figure 2 shows the estimated historic trends in gonorrhea and chlamydia incidence. In 2015, the estimated prevalence estimates corresponded to 79,598 (23,918–256,206) and 112,013 (28,700–307,433) new gonorrhea cases in women and men aged 15 to 49 years, respectively. Corresponding numbers for
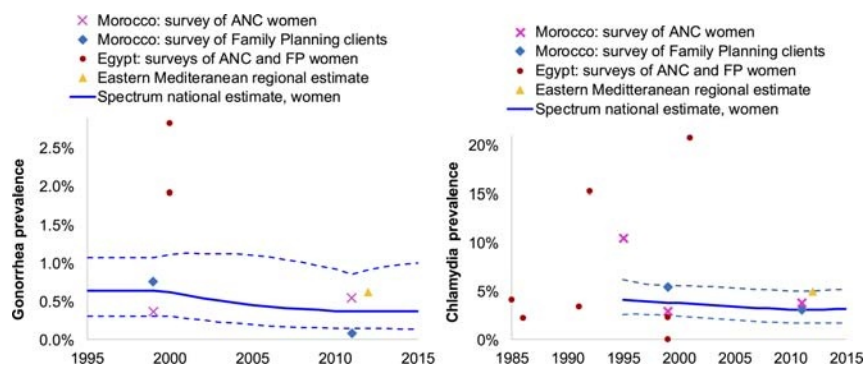
Figure 1. Prevalence of gonorrhea and chlamydia in women 15–49 years in Morocco: Spectrum estimates and underlying data. Data are shown after adjustments for diagnostic test performance, urban/rural differences, and missing high-risk populations, as described in Methods. Regional estimates shown were those also used in the prevalence fitting, at a 1% weight relative to the national data points (see Methods), from WHO for the year 2012.[7] Dashed lines are 95% CIs around the Spectrum estimate. Data and prevalence estimates shown are for women 15 to 49 years.
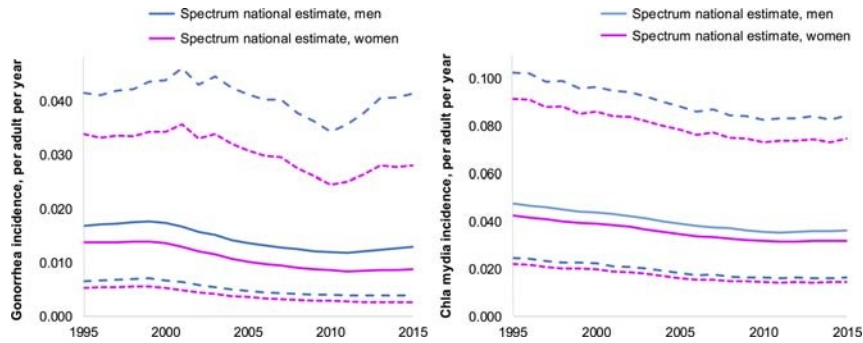
Figure 2. Incidence of gonorrhea and chlamydia cases, per 100,000 adult men or women (15–49 years) in Morocco. Solid lines are best estimates; dotted lines are the 95% CIs. Incidence was based on gonorrhea and chlamydia prevalence estimates from Spectrum simulations, and the assumption that treatment coverage for both gonorrhea and chlamydia in 1995 (21% and 3.6%) had been half that at 2015 (42% and 7.2%), with a linear increase in treatment coverage over 1995–2015 Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179, and corresponding shortening of average episode duration Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179. Dashed lines are 95% Confidence Intervals around the Spectrum estimate.

chlamydia were 291,908 (161,064–524,270) in women and 314,032 (186,076–559,133) in men (Table 1).

Gonorrhea's estimated case incidence rate declined from 1690 per 100,000 person-years in 1995 to 1290 per 100,000 in 2015 in men, and from 1370 to 870 per 100,000 in women (Fig. 2A). Over this period, estimated chlamydia incidence decreased from 4760 to 3610/1000,000 in men, and from 4250 to 3200 per 100,000 in women. Incidence rates were higher in men than in women, despite higher prevalence of both STIs in women—reflecting the longer duration of infection in women.

UD Case Reporting Completeness, in 2015

Using the male gonorrhea incidence estimates for 2015 and the assumptions detailed in Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179, the projected number of gonorrheal UD cases in 15- to 64-year-old men was 90,441, of whom 58,876 sought treatment (Table 2). For chlamydia, Spectrum estimated 43,579 symptomatic cases in men 15 to 64 years in 2015, of whom 28,327 were treated.

In 2015, a total of 71,999 UD cases were reported in adult men Supplemental Digital Content (SDC) 5, http://links.lww.com/OLQ/A179. If gonorrhea accounts for 63% of UD cases (,[15] Supplemental Digital Content (SDC) 6, http://links.lww.com/OLQ/A179) then the total estimated number of UD cases treated (from gonorrhea and other STIs) was 93,609, which suggests that the UD reporting completeness was 77% among cases treated in clinics.

Doing a corresponding analysis starting from the etiological fraction of chlamydia, with chlamydia accounting for 18% of

clinical UD cases[15] then the total estimated number of UD cases treated would be 153,934, in which case the UD cases actually reported covered 46% of UD cases treated.

These estimates indicate that reporting completeness among clinically treated UD cases is quite high; however, the reported UD cases represented only 13% of all male gonorrhea and chlamydia cases in 2015, due to the large number of asymptomatic and untreated cases, especially of chlamydia (Fig. 3).

Reporting Completeness, Treatment Coverage, and Case Incidence over 1995–2015

Figure 3 shows estimated time trends in incident cases in men. Comparing reported UD cases with estimated incident cases over 1995 to 2015, UD reporting completeness increased from 46% to 77% among treated cases when based on gonorrhea incidence estimates; or from 41% to 46% when based on chlamydia incidence estimates. The trends suggest a marked improvement in treatment coverage and reporting completeness around 1999 to 2002, coinciding with Morocco's implementation of the syndromic STI treatment approach in 2000.[16]

The total number of new gonorrhea cases in men in 1995 and 2015 were similar, reflecting a slight decline in incidence rate balanced by population growth. Within this total, the numbers of asymptomatic and not treated cases, and of symptomatic treated but not reported cases, were stable over time; in contrast, the number of symptomatic, treated and reported cases increased over 3-fold (Fig. 3A). For chlamydia, there was slight increase in the total cases over 1995 to 2015, reflecting population growth and a modest

TABLE 1. Spectrum-Estimated Prevalence and Incidence Rate (per 100,000 Person-Years) of Gonorrhea and Chlamydia, in Women and Men 15 to 49 Years, Morocco at 2015

STI	Metric	Women		Men	
		Point Estimate	95% CI	Point Estimate	95% CI
Gonorrhea	Prevalence	0.37%	0.14–1.0%	0.32%	0.12–0.87%
	Incidence rate per 100,000 total adult population	870	260–2800	1290	387–4149
	New incident cases, 15–49 y	79,598	23,918–256,206	112,013	28,700–307,433
Chlamydia	Prevalence	3.8%	2.1–6.4%	3.0%	1.7–5.1%
	Incidence rate per 100 000 total adult population	3200	1800–5700	3610	2140–6400
	New incident cases, 15–49 y	291,908	161,064–524,270	314,032	186,076–559,131

TABLE 2. Incident Cases of Gonorrhea, Chlamydia and UD, and the Subset Who Are Treated and Reported, in Men 15 to 64 Years in Morocco, 2015

	Gonorrhea	Chlamydia	Comment and Source
New incident cases: point estimate	141,314	396,177	Spectrum-STI estimate, extending
New incident cases: 95% CI	42,462–454,850	178,010–925,533	the case incidence rate estimated for 15–49 years to men 50–64 years
Gonorrhea or chlamydia cases developing UD/symptoms	90,441	43,579	Assuming 64% of male gonorrhea [7] and 11% of male chlamydia cases [11] develop symptoms
UD cases due to gonorrhea or chlamydia, who got treated in a clinic	58,786	28,327	Assuming 65% of gonorrheal and chlamydial UD cases seek and get treatment ([7] and Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179)
Estimation of reporting completeness, based on:	Gonorrhea incidence estimate:	Chlamydia incidence estimate:	
UD cases (any etiology)	144,014	242,895	Calculated by dividing the STI cases or UD cases
UD cases treated (any etiology)	93,609	153,934	(rows 4 and 5 above) by 63% of UD due to gonorrhea, or by 18% due to chlamydia, from Morocco 2009 etiology study among STI clinic patients ([15] and Supplemental Digital Content (SDC) 6, http://links.lww.com/OLQ/A179).
Actual UD case reports	71,999		National STI program
UD reporting completeness, among cases treated in clinics	77%	46%	Calculated as: 77% = 71,999/93,609; 46% = 71,999/153,934
Reporting completeness, UD cases reported relative to all gonorrhea + chlamydia cases (asymptomatic + symptomatic)	13%		Calculated as: 13% = 71,999/537,491

decline in incidence rate (Fig. 3B), and the number of cases that were symptomatic, treated, and reported more than doubled.

Sensitivity Analysis

Changes to the assumptions used to estimate prevalence trends, in terms of the weights attached to data from neighboring countries, and to the annual dilution factor used in the moving-average trend estimation,[17] had a greater effect on prevalence estimates for gonorrhea than for chlamydia (Table 3). The implied UD reporting completeness changed in the opposite direction of changes in the prevalence and incidence estimate for gonorrhea (within a range of 59–91%). UD reporting completeness did not change much (range, 41–49%) when compared with estimated chlamydia rates under varying assumptions.

Gonorrhea prevalence was slightly sensitive to the weight given to data from Egypt, whose prevalence survey at 1999 to 2000 had measured higher prevalence than both Moroccan surveys. When excluding the Egypt data, gonorrhea prevalence at 2015 would be 0.27% instead of 0.32%; in this case national UD reporting completeness would have been 48% to 91%.
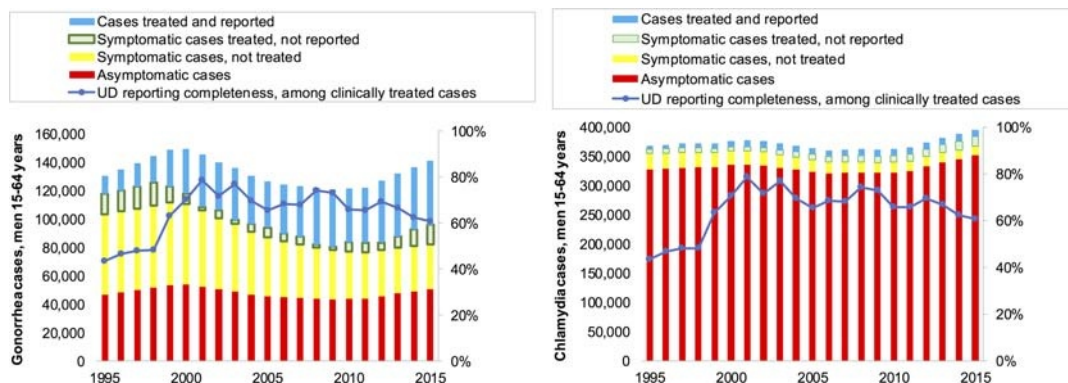
Figure 3. Spectrum-estimated incident gonorrhea and chlamydia cases, in men 15 to 64 years, by treatment and reporting status, Morocco. Reporting completeness among UD cases treated in clinics shown, is the average of the reporting completeness estimates calculated relative to gonorrhea incidence, and the completeness relative to chlamydia incidence, as shown for year 2015 in Table 2.

TABLE 3. Sensitivity Analysis—Effect of Varying (Selected) Assumptions and Values, on National STI Estimates for Men in Morocco, at 2015

| Parameters | Default Value | Alternative Assumption | | Gonorrhea Prevalence, Men | Chlamydia Prevalence, Men | Incidence per 100,000 Men 15–49 Years | | UD reporting Completeness, Relative to Spectrum-Estimated Incidence of: | |
		Lower	Upper			Gonorrhea	Chlamydia	Gonorrhea	Chlamydia
Default, best estimates				0.32%	3.0%	1290	3,610	77%	46%
Weight of neighboring country (Egypt) prevalence surveys, relative to national prevalence studies	10%	0%		0.27%	2.85%	1088	3,430	91%	48%
	10%		30%	0.36%	2.84%	1451	3,417	68%	49%
Annual dilution factor in moving average trend estimation	20%	0%		0.42%	3.4%	1693	4.091	59%	41%
	20%		40%	0.32%	3.0%	1290	3,610	77%	46%
Gonorrhea and chlamydia incidence rate in men 50–64 y	Same as 15–49 y	0	NA	As default	As default	1290	3,610	97%	58%
% of UD cases treated at 2015 (and linearly corresponding changes for years 1995–2014)	65% (7)	46% (13)	NA	As default	As default	1090	3,540	91%	47%
% Of male chlamydia cases that are symptomatic	11%	NA	54% [7]	As default	As default	1290	4,970	77%	7%

Assuming no incidence in men 15 to 64 years, or assuming lower proportions of UD cases to be treated, increased reporting completeness estimates (to 47–97%), whereas assuming a higher proportion of male chlamydia episodes to be symptomatic, 54% as in WHO's regional estimation,[7] instead of the default assumed 11% implied a much lower estimated reporting completeness (of 7%, instead of 46%) when evaluated relative to estimated chlamydial UD cases.

DISCUSSION

Trend estimations through Spectrum-STI model applied to prevalence survey data indicated prevalence declines in chlamydia and especially in gonorrhea over 1995 to 2015 in Morocco. Estimates are more certain (narrower 95% CIs) for chlamydia than for gonorrhea, as for chlamydia, there were more data points. For both STIs, the uncertainty in STI prevalence and incidence increased after 2012, because no national surveys were conducted post-2012. Chlamydia was estimated to be around 5-fold more prevalent than gonorrhea, in line with the 2012 WHO regional estimates,[7] although for both STIs, Morocco's estimated prevalence in 2012 was below the WHO's estimate for the Eastern Mediterranean region as a whole[7] (Fig. 1).

The estimated decreasing prevalence and incidence for gonorrhea is in keeping with data from women consulting with vaginal discharge and/or lower abdominal pain, where gonorrhea prevalence fell from 4.8% in 1996 in Agadir, Marrakech and Tanger[18,19] to 1.0% in 2007 in Agadir, Rabat/Salé, and Tanger.[20] In these study populations, in contrast, chlamydia did not decline, with 5.3% infected in 1996 and 5.6% in 2007.

These declines are furthermore in line with Spectrum-STI prevalence trend estimates for adult syphilis,[6,21] and the reported declines in HIV incidence (after a peak at 2002–2004) in Morocco.[5,22–24] These trends coincide with expansion of the HIV/STI response and services in Morocco over the last 2 decades, including for FSW.[25] Commercial sex networks play the leading role in HIV transmission in Morocco[23,26] and also probably drive gonorrhea and chlamydia transmission. Morocco is a pioneer in the Eastern Mediterranean region in adapting its HIV/STI response to where needs are, and in implementing programs targeted at different at-risk populations.[25] Nongovernmental organizations with the support and collaboration of national authorities have scaled-up HIV counseling and testing services, with particular uptake by FSWs in the main cities since 2012,[27] as well as the free distribution of condoms.[28] About half of FSWs report condom use during last sex act across recent surveys,[22–26] an increase from year 2003,[28] highlighting the progress of HIV/STI response since earlier years.

The declines in gonorrhea and chlamydia prevalence are likely attributable to a combination of factors associated with the expanded HIV/STI response: improved treatment coverage, improved reporting of cases treated, and a fall in sexual risk behaviours (eg, nonuse of condoms during commercial sex), possibly in part thanks to testing and counselling services for HIV.

Comparison of the actual number of reported UD cases in men and estimated incident cases suggests that treatment coverage of symptomatic gonorrhea and chlamydia cases may have doubled from 1995 to 2015 and reporting completeness may have improved from 41–46% to 46–77%.

The triangulation of comparative trends in both STIs and their determinants suggests there was a major improvement in clinical STI services around the year 2000. This concords with changes in national policy and data from Morocco's KAP studies, which suggest an improvement in treatment coverage since 2001.[12–15] In 2000, Morocco adopted the syndromic treatment approach and standardized its protocols,[16] thereby facilitating better planning of drug and diagnostic needs and possibly improving patient access. More recent improvements may be linked to the introduction of obligatory health insurance in 2004, although officially STI treatment has been free in the public sector ever since 1995.

The estimates of reporting completeness seem to be consistent with Morocco's earlier independent estimate of reporting completeness, in the year 1999: in men and women combined, a

total of 276,750 cases (of any STI) were notified, whereas for that year, 600,000 cases were estimated,[16,29] implying a 46% reporting completeness. Our slightly higher UD reporting completeness estimate (56–70% in 1999) may reflect that, due to higher treatment coverage in men than in women,[30] reporting completeness will typically be higher for men than for women and men combined.

For 2015, the estimated 46% to 77% reporting completeness among treated UD cases would seem reasonable, given that since 2006 Morocco's Ministry of Health and its provincial offices actively chase health facilities in case of missing or late notification reports. However, this national-level completeness may have to be interpreted in light of possible UD overreporting by some health facilities in attempts to justify procurement of medications.

Limitations

The biggest challenge to model-based estimates are the quantity, representativeness and bias of data available. Notably, differences in prevalence between studies may reflect true trends or methodological sources of bias.

In addition, incidence estimates depend on treatment coverage and the assumed durations of—treated and untreated—infection, for which there is a lack of empirical longitudinal data. Assumed proportions of episodes that become symptomatic were calibrated on earlier WHO estimates for the entire Eastern Mediterranean region,[7] not on Morocco-specific data. The proportion of symptomatic episodes that are treated was also taken from a regional-level WHO assumption, although the 65% was in line with data from Morocco's KAP studies (see Supplemental Digital Content (SDC) 3, http://links.lww.com/OLQ/A179).

The estimated reporting completeness also depended on UD etiology distributions. Three studies were identified in Morocco, but how representative they are is hard to tell because they were from selected sites and had small samples Supplemental Digital Content (SDC) 6, http://links.lww.com/OLQ/A179.

Implications for Surveillance, and Programmatic Response

There is a lack of recent population based prevalence data for both chlamydia and gonorrhea in women and no good data in men. To improve trend estimation, Morocco would benefit from one or more population-based prevalence surveys that collect data on multiple STIs in men and women in both urban and rural areas. Securing funding for such surveys is challenging given broader health and surveillance prioritizations. Screening and treatment programs for chlamydia in adolescents, as recommended in the WHO's global STI strategy 2016 to 2021[31] may yield useful data, but is as yet not implemented in Morocco.

Stable annual UD case numbers, reflecting improving treatment coverage and reasonably good UD reporting completeness, obscure recent declines in rates of nonulcerative STIs in Morocco, which are encouraging and for which the program can take credit. Also, although gonorrhea is the predominant cause of UD cases seen in clinics, at population level the prevalence, incidence and case numbers are much higher for chlamydia, and chlamydia has declined less than gonorrhea. Still large numbers of chlamydia cases are not being treated, firstly because many chlamydia infections in both men and women do not cause symptoms, and second, because over half of symptomatic chlamydia-infected adults (in our best estimates) do not seek or access treatment.

As other countries, Morocco has seen resistance of *Neisseria gonorrhoeae* against two of the common first-line drugs, ciprofloxacin and tetracycline, rising to high levels between 2001[14] and 2009.[15] It is hoped, but remains to be confirmed by ongoing surveillance of gonorrhea rates (in conjunction with drug resistance surveillance and etiology monitoring), that the switch in first-line treatment (from ciprofloxacin to ceftriaxone) will contribute to maintaining the recent gonorrhea prevalence decline.

CONCLUSIONS

Model-based estimations based on prevalence surveys suggests that gonorrhea and chlamydia have declined in Morocco, due to improved treatment coverage and a reduction in risk behaviours. These findings highlight the pioneering role of Morocco within the Eastern Mediterranean region in changing policies and rolling out effective national HIV/STI programs. These results, and the wide CIs around many of the estimates, argue for improved data input though periodic prevalence surveys, within and possibly beyond key populations. Our findings also highlight a largely hidden burden of untreated chlamydia, that merits intensification of control efforts beyond routine clinical services. There is a need for increased screening in primary care settings, among key populations, within antenatal care, and youth health care settings, such as school-based clinics. New diagnostic and delivery approaches and affordable rapid point-of-care tests[31] should facilitate clinic-based and non–clinic-based screening expansion, thus improving treatment coverage and surveillance and reducing disease burden.

REFERENCES

1. Royaume du Maroc Programme National de lutte contre les IST/SIDA Direction de l'épidémiologie et des luttes contre les maladies du Ministère de la Santé. Le plan stratégique national de lutte contre le Sida (2012–2016). Rabat2012 4 April.
2. Stover J, Brown T, Marston M. Updates to the Spectrum/Estimation and Projection Package (EPP) model to estimate HIV trends for adults and children. Sex Transm Infect 2012; 88(Suppl 2):i11–i16.
3. Stover J, Johnson P, Zaba B, et al. The Spectrum projection package: improvements in estimating mortality, ART needs, PMTCT impact and uncertainty bounds. Sex Transm Infect 2008; 84(Suppl 1):i24–i30.
4. Stover J, McKinnon R, Winfrey B. Spectrum: a model platform for linking maternal and child survival interventions with AIDS, family planning and demographic projections. Int J Epidemiol 2010; 39: i7–i10.
5. Ministère de la Santé du Maroc. Estimations Nationales VIH/sida 2016: Rapport National 2016 sur la Mise en oeuvre de la declaration politique sur le VIH/SID Rabat2016.
6. Korenromp EL, Mahiané G, Rowley J, et al. Estimating prevalence trends in adult gonorrhoea and syphilis in low- and middle-income countries with the Spectrum-STI model: results for Zimbabwe and Morocco from 1995 to 2016. Sex Transm Infect :2017.
7. Newman L, Rowley J, Vander Hoorn S, et al. Global estimates of the prevalence and incidence of four curable sexually transmitted infections in 2012 based on systematic review and global reporting. PLoS One 2015; 10:e0143304.
8. Chico RM, Mayaud P, Ariti C, et al. Prevalence of malaria and sexually transmitted and reproductive tract infections in pregnancy in sub-Saharan Africa: a systematic review. JAMA 2012; 307:2079–2086.
9. Orroth KK, Korenromp EL, White RG, et al. Comparison of STD prevalences in the Mwanza, Rakai, and Masaka trial populations: the role of selection bias and diagnostic errors. Sex Transm Infect 2003; 79:98–105.
10. World Population Prospects: the 2015 revision [database on the Internet]2015. Available from: http://esa.un.org/unpd/wpp/.
11. Korenromp EL, Sudaryo MK, de Vlas SJ, et al. What proportion of episodes of gonorrhoea and chlamydia becomes symptomatic? Int J STD AIDS 2002; 13:91–101.
12. Ministère de la santé du Maroc. Etude sur les comportements, attitudes et pratiques des jeunes en matière de VIH-sida. Rabat2007.
13. Ministère de la santé du Maroc. Etude sur les comportements, attitudes et pratiques des jeunes en matière de VIH-sida. Rabat2013.

14. Alami K, Aït Mbarek N, Akrim M, et al. Urethral discharge in Morocco: prevalence of microorganisms and susceptibility of gonococcos. East Mediterr Health J 2002; 8:794–804.

15. Hançali A, Ndowa F, Bellaji B, et al. Antimicrobial resistance monitoring in *Neisseria gonorrhoeae* and strategic use of funds from the Global Fund to set up a systematic Moroccan gonococcal antimicrobial surveillance programme. Sex Transm Infect 2013; 89(Suppl 4): iv24–iv27.

16. Programme national de lutte contre les IST/SIDA, Ministère de la santé du Maroc Direction de l'Epidemiologie et de Lutte contre les Maladies. La prise en charge syndromique des infections sexuellement transmissibles.Guide du prestataire. Rabat1999.

17. Korenromp EL, Hamilton M, Sanders R, et al. Impact of malaria interventions on child health in endemic African settings: comparison and alignment between LiST and Spectrum-Malaria model. BMC Public Health 2017; Supplement.

18. Ryan CA, Manhart L. Les maladies sexuellement transmissibles au Maroc, prévalence des infections, évaluation de risque et arbre de décision de traitement. Rapport final: AIDSCAP Université de Washington, 1997.

19. Ryan CA, Zidouh A, Manhart LE, et al. Reproductive tract infections in primary healthcare, family planning, and dermatovenereology clinics: evaluation of syndromic management in Morocco. Sex Transm Infect 1998; 74(Suppl 1):S95–S105.

20. Royaume du Maroc Programme National de lutte contre les IST/SIDA Direction de l'épidémiologie et des luttes contres les maladies du ministère de la santé. Etude de prévalence des IST chez les femmes qui consultent pour pertes vaginales et/ou douleurs du bas ventre. Rabat2008 June.

21. Bennani A, El Rhilani H, El Kettani A, et al. The prevalence and incidence of active syphilis in Morocco, 1995–2016: model-based estimation and implications for STI surveillance. PLoS One conditionally accepted.

22. Mumtaz G, Hilmi N, Zidouh A, et al. National and Souss Massa Draa HIV Modes of Transmission analysis in Morocco 2008. Rabat: Kingdom of Morocco Ministry of Health Department of Epidemiology and Disease Control National STI/AIDS Programme, Weill Cornell Medical College in Qatar, ONUSIDA, 2010.

23. Mumtaz GR, Kouyoumjian SP, Hilmi N, et al. The distribution of new HIV infections by mode of exposure in Morocco. Sex Transm Infect 2013; 89(Suppl 3):iii49–iii56.

24. Kouyoumjian SP, Haddad P, El Rhilani H, et al. National and Souss Massa Draa HIV Modes of Transmission analysis in Morocco 2013. Rabat: Kingdom of Morocco Ministry of Health Department of Epidemiology and Disease Control National STI/AIDS Programme, Weill Cornell Medical College in Qatar, Qatar Foundation, ONUSIDA, 2014.

25. Kouyoumjian SP, Mumtaz GR, Hilmi N, et al. The epidemiology of HIV infection in Morocco: systematic review and data synthesis. Int J STD AIDS 2013; 24:507–516.

26. Bennani A, Latifi A, El Kettani A, et al. National and Souss Massa Draa: HIV modes of transmission analysis in Morocco 2013: Morocco Ministry of Health & Joint United Nations Programme on HIV/AIDS; 2014.

27. El-Rhilani H. National VCT Database. Rabat, Morocco: UNAIDS Morocco Office, 2010.

28. Royaume du Maroc Programme National de lutte contre les IST/SIDA Direction de l'épidémiologie et des luttes contres les maladies du Ministère de la Santé. Mise en oeuvre de la déclaration d'engagement sur le VIH/sida: Rapport national 2010. Rabat2010.

29. Elharti E, Zidouh A, Mengad R, et al. Monitoring HIV through sentinel surveillance in Morocco. East Mediterr Health J 2002; 8:141–149.

30. Manhart LE, Dialmy A, Ryan CA, et al. Sexually transmitted diseases in Morocco: gender influences on prevention and health care seeking behavior. Soc Sci Med 2000; 50:1369–1383.

31. World Health Organization. Global health sector strategy on sexually transmitted infections 2016–2021. Towards ending STIs. Report. Geneva2016 June. Report No.: WHO/RHR/16.09.