**Supplementary Digital Contents, accompanying Morocco NG/CT/UD paper in submission to Sex. Transm. Dis. journal,**

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*Version 22 April 2017*

**SDC 1. Sensitivities and specificities assumed for diagnostic tests of chlamydia and gonorrhea, used to adjust observed prevalences before time trend estimation**

| **Specimen** | **Sex** | **Test** | **Sensitivity %, gonorrhea** | **Sensitivity %, chlamydia** | **Specificity %, gonorrhea** | **Specificity %, chlamydia** |
| --- | --- | --- | --- | --- | --- | --- |
| Genital fluid | F | PCR or LCR | 93.3 [[1-3](#_ENREF_1)] | 88.6 [[1-3](#_ENREF_1)] | 99.7 [[1-3](#_ENREF_1)]\* | 99.7 [[1-3](#_ENREF_1)] |
| Genital fluid | F | Culture | 75.7 [[2](#_ENREF_2), [3](#_ENREF_3)] | 74 [[4](#_ENREF_4)] | 100 [[1-3](#_ENREF_1)] | 100 [[4](#_ENREF_4)] |
| Urine | F | PCR or LCR | 91.6 [[1-3](#_ENREF_1)] | 87 [[1-3](#_ENREF_1)] | 99.7 [[1-3](#_ENREF_1)]\* | 99.8 [[1-3](#_ENREF_1)] |
| Urine | F | SDA | 91.6 [[1-3](#_ENREF_1)] | NA | 99.7 [[1-3](#_ENREF_1)]\* | NA |
| Genital fluid | F | Gram stain, or culture/gram stain | 75.7 [[2-4](#_ENREF_2)] | NA | 98.8 [[4](#_ENREF_4)] | NA |
| Genital fluid / serum | F | EIA / antibody test / Indirect haem-agglutination | 75.7 [[2-4](#_ENREF_2)] | 71.0 [[4](#_ENREF_4)] | 99.0 [[2-4](#_ENREF_2)] | 99.0 [[4](#_ENREF_4)] |
| Genital fluid / urine / serum | F | DFA | NA | 82.5 [[5](#_ENREF_5)] | NA | 99.8 [[5](#_ENREF_5)] |
| Urine | M | PCR or LCR | 80.9 [[2](#_ENREF_2), [3](#_ENREF_3)] | 87.8 [[2](#_ENREF_2), [3](#_ENREF_3)] | 99.9 [[2](#_ENREF_2), [3](#_ENREF_3)] | 99.3 [[2](#_ENREF_2), [3](#_ENREF_3)] |
| Urine | M | EIA / antibody test / Indirect haem-agglutination | 80.9 [[2](#_ENREF_2), [3](#_ENREF_3)] | NA | 99.9 [[2](#_ENREF_2), [3](#_ENREF_3)] | NA |

Abbreviations: EIA = Enzyme Immuno-Assay; DFA = Direct Fluorescent Antibody test; LCR = Ligase Chain Reaction (a type of nucleic amplification assay); NA = Not Applicable, not used in studies included in the current estimation; PCR: Polymerase Chain Reaction (a type of nucleic amplification assay; SDA = Strand Displacement Assay.

\* For gonorrhea, specificities of PCR/LCR/SDA in genital/cervical fluid were pooled with those of urine, as these were not statistically different.

**SDC 2. Chlamydia and gonorrhea prevalence data that met inclusion criteria, before and after adjustments for diagnostic test performance, missing high-risk populations and urban-to-rural prevalence ratio, for the Spectrum-STI prevalence trend estimation for 15-49 year-old adults, Morocco.**

1. **chlamydia**

| **Country$** | **Years** | **Location** | **Population** | **N** | **Specimen** | **Diagnostic test** | **Observed Preva-lence** | **Test-adjusted** | **Urban-rural ad-justed\*\*** | **High-risk-adjusted** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Morocco | 1999 | Rabat and Sale [[6](#_ENREF_6)] | ANC clinic attendees | 323 | Urine | NAAT | 2.7% | 2.9% | 2.7% | **2.9%** |
| Morocco | June to July 1999 | Rabat and Sale [[6](#_ENREF_6)] | Family planning clinic attendees | 518 | Urine | NAAT | 4.8% | 5.3% | 5.0% | **5.5%** |
| Morocco | 2011 | Rabat, Salé, Agadir and Fes [[7](#_ENREF_7)] | Family planning clinic attendees | 537 | GE | NAAT | 3.0% | 3.0% | 2.8% | **3.1%** |
| Morocco | 2012 | Rabat, Salé, Agadir and Fes [[7](#_ENREF_7)] | ANC clinic attendees (1st/2nd trimester) | 252 | GE | NAAT | 3.6% | 3.7% | 3.4% | **3.8%** |
| Morocco | 1994-1996 | Casablanca [[8](#_ENREF_8)] | Pregnant women, hospital | 81 | Serum | DFA | 8.6% | 10.3% | 9.5% | **10.5%** |
| Morocco | 1994-1996 | Casablanca [[8](#_ENREF_8)] | Male blood donors, hospital | 200 | Serum | DFA | 2.0% | 2.2% | 2.0% | **2.2%** |
| Egypt | 1985-1987 | Alexandria [[9](#_ENREF_9)] | ANC clinic attendees | 100 | GE | Culture | 3.0% | 4.1% | 3.8% | **4.1%** |
| Egypt | 1986-1988 | Cairo [[10](#_ENREF_10)] | Gynecology clinic, check-up | 50 | Serum | DFA | 2.0% | 2.2% | 2.0% | **2.2%** |
| Egypt | 1989-1991 | Cairo [[11](#_ENREF_11)] | ANC clinic attendees | 30 | Serum | DFA | 0.0% | 0.03% | 0.0% | **0.0%** |
| Egypt | 1991-1993 | Cairo [[12](#_ENREF_12)] | Male hospital, controls in STI study | 20 | GE | DFA | 5.0% | 5.8% | 5.4% | **6.0%** |
| Egypt | 1992-1994 | Cairo [[13](#_ENREF_13)] | ANC clinic attendees | 32 | GE | DFA | 12.5% | 14.9% | 13.9% | **15.3%** |
| Egypt | 1991-1993 | Cairo [[14](#_ENREF_14)] | Family planning clinic attendees | 30 | Serum | EIA | 3.3% | 3.3% | 3.1% | **3.4%** |
| Egypt | 1999-2000 | Greater Cairo [[15](#_ENREF_15)] | Family planning clinic attendees | 108 | Urine | NAAT | 2.8% | 3.0% | 2.8% | **3.1%** |
| Egypt | 1999-2000 | Greater Cairo [[15](#_ENREF_15)] | ANC clinic attendees | 604 | Urine | NAAT | 1.3% | 1.4% | 1.3% | **1.5%** |
| Egypt | 2001-2003 | Cairo [[16](#_ENREF_16)] | ANC clinic attendees | 20 | GE | Culture | 15% | 20.3% | 18.9% | **20.7%** |
| Region\* | 2012 | North Africa and Middle East [[3](#_ENREF_3)] | Women | 438\* | NA | NA |  |  |  | **4.95% (3.3-7.4)** |

1. gonorrhea

| **Country$** | **Years** | **Location** | **Population** | **N** | **Specimen** | **Diagnostic test** | **Observed preva-lence** | **Test-adjusted** | **Urban-rural adjusted\*\*** | **High-risk adjusted** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Morocco | 1999 | Rabat and Sale [[6](#_ENREF_6)] | ANC | 323 | Urine | PCR | 0.62% | 0.35% | 0.33% | **0.36%** |
| Morocco | 1999 | Rabat and Sale [[6](#_ENREF_6)] | Family Planning clinic attendees | 518 | Urine | PCR | 0.97% | 0.73% | 0.69% | **0.76%** |
| Morocco | 2011 | Rabat/ Salé/ Agadir /Fes [[7](#_ENREF_7)] | ANC | 252 | Genital | PCR | 0.79% | 0.53 | 0.50% | **0.55%** |
| Morocco | 2011 | Rabat/ Salé/ Agadir /Fes [[7](#_ENREF_7)] | Family planning clinic attendees | 537 | Genital | PCR | 0.37% | 0.08 | 0.07% | **0.08%** |
| Egypt | 1999-2000 | Greater Cairo [[15](#_ENREF_15)] | Family Planning clinic attendees | 108 | Urine | PCR | 2.8% | 2.7% | 2.6% | **2.8%** |
| Egypt | 1999-2000 | Greater Cairo [[15](#_ENREF_15)] | ANC | 604 | Urine | PCR | 2.0% | 1.8% | 1.7% | **1.9%** |
| Region\* | 2012 | North Africa and Middle East [[3](#_ENREF_3)] | Women | 5,444\* | NA | NA |  |  |  | **0.62%  (0.41-0.83)** |

Abbreviations: ANC = antenatal clinic attendants; DFA = Direct Fluorescent Antibody test; EIA = Enzyme Immuno-Assay; FP = family planning clinic (female) clients; N = sample size tested; LCR = Ligase Chain Reaction (a type of nucleic amplification assay); PCR: Polymerase Chain Reaction (a type of nucleic amplification assay); PHC = Primary Health Care; High-risk adjusted = prevalence after (+10%) adjustment for missing high-risk populations; SDA = Strand Displacement Assay Test-adjusted = prevalence after adjusting for diagnostic test sensitivity & specificity; Weight = statistical weight used in the Spectrum trend estimation.

\* The WHO’s estimate for the North Africa and Eastern Mediterranean region [[3](#_ENREF_3)]was included as a data point, with a notional sample size (for use in the trend fitting) inferred from the reported 95% confidence interval, as , where p is the estimated prevalence, and U and L are the upper and lower bounds of the reported 95% confidence interval [[17](#_ENREF_17)].

\*\* All studies were urban; hence the urban/rural adjustment was in all cases downward, applying a 0.90 ratio urban-to-rural, and a year-specific proportion of the national population that was urban, increasing from 52% at 1995 to 60% at 2016 [[18](#_ENREF_18)].

$ As described in Methods, all data points from Morocco were weighted 100%, data points from Egypt weighted 10%, and the WHO’s latest regional estimate for the Eastern Mediterranean region [[3](#_ENREF_3)] weighted 1%.

**SDC 3. Assumptions informing the estimations of prevalence, incidence, and UD reporting completeness and etiology in Morocco**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Gonorrhea** | | **Chlamydia** | | **Comments** |
|  | **1995** | **2015** | **1995** | **2015** |  |
| M/F ratio in prevalence | 0.86 [[3](#_ENREF_3)] | | 0.80 [[3](#_ENREF_3)] | | Assumption of WHO 2012 regional and global estimates [[3](#_ENREF_3)] |
| Duration of infection, if untreated, men | 0.4 years [[3](#_ENREF_3)] | | 0.9 years | | Male chlamydia duration fitted to the WHO’s stated average 0.8 year duration [[3](#_ENREF_3)], weighted between the fractions treated and untreated |
| Duration of infection, if treated, men | 0.04 years [[3](#_ENREF_3)] | | 0.08 years [[3](#_ENREF_3)] | | Assumption of WHO 2012 regional and global estimates [[3](#_ENREF_3)] |
| **Weighted duration of infection, men** | **0.32 years** | **0.25 years [**[**3**](#_ENREF_3)**]** | **0.87 years** | **0.84 years [**[**3**](#_ENREF_3)**]** | Assumption of WHO 2012 regional and global estimates [[3](#_ENREF_3)] |
| Duration of infection, if untreated, women | 0.50 years [[3](#_ENREF_3)] | | 1.25 years [[3](#_ENREF_3)] | | Assumption of WHO 2012 regional and global estimates [[3](#_ENREF_3)] |
| Duration of infection, if treated, women | 0.08 years [[3](#_ENREF_3)] | | 0.15 years [[3](#_ENREF_3)] | | Assumption of WHO 2012 regional and global estimates [[3](#_ENREF_3)] |
| **Weighted duration of infection, women** | **0.46 years** | **0.43 years** | **1.22 years** | **1.19 years** | Calculated from the above |
| % of incident male cases developing UD | 64% [[3](#_ENREF_3)] | | 11% [[19](#_ENREF_19)] | | For chlamydia WHO globally assumed 54% symptomatic worldwide [[3](#_ENREF_3)]; STDSIM modeling for Uganda and other sub-Sahara African countries assumed 11% [[19](#_ENREF_19)]. For Morocco, we chose 11% because that results in a UD reporting completeness estimate more consistent with the UD reporting completeness estimated in parallel based on the gonorrhea incidence estimate. Even with only 11% of chlamydia symptomatic, estimated UD reporting completeness is still slightly higher relative to gonorrhea cases than relative to chlamydia cases (e.g. at 2015, 77% and 69%, relative to estimated treated UD cases) |
| % of UD cases seeking treatment & treated | 32% | 65% [[3](#_ENREF_3)] | 32% | 65% [[3](#_ENREF_3)] | 2015 value is WHO’s assumption used in 2012 global and regional estimates, for middle-income countries with intermediately high treatment access and coverage including Morocco [[3](#_ENREF_3)]. This is in line with 51% found in Morocco’s 2009 UD etiology study [[20](#_ENREF_20)] and 46% in Morocco’s 2013 youth KAP study [[21](#_ENREF_21)]. We assumed coverage at 1995 to have been half that of 2015, based on lower coverages (of any treatment) found in Morocco’s 2007 youth KAP study [[22](#_ENREF_22)] and (of public-clinic-based treatment) in Morocco’s 2001 UD etiology study [[23](#_ENREF_23)]. |
| % of all UD cases treated | 21%  (= 64%\* 32%) | 42%  (= 64%\* 65%) | 3%  (= 11%\* 32%) | 7.2%  (= 11%\* 65%) | We chose 21% to produce plausible patterns over time in prevalence (declining), incidence (declining but less steeply), treatment coverage (improving) and reporting completeness (improving) |

# **SDC4. Derivation of the incidence hazard and rate, from prevalence**

It is possible to derive the incidence hazard and rate from prevalence [[24](#_ENREF_24)]. Let us assume a Susceptible-Infected-Susceptible model [[25](#_ENREF_25)] for a curable infection, e.g. syphilis. Let S represent the susceptible population and I the infected one. Let us denote the incidence hazard rate and the recovery rate by and, respectively, where, and D being the duration of infection. The infection dynamics can then be described by the system:

where is the (background, non-STI-related) mortality rate [[25](#_ENREF_25)].

Since prevalence is given by, one can use Eq.S1 to show that the prevalence satisfies the equation . Solving the latter ordinary differential equation gives the Equation in the main text Methods, which describes the relation between the incidence hazard rate, the prevalence and the recovery rate:

, for all. When the prevalence (at times and), and the recovery rate are known, solving Eq1 for gives the incidence hazard rate in the interval (). That equation is non-linear but can be solved numerically, using a Newton type algorithm. If is not very large, a good starting point is, where and.

The assumed durations of STI episodes (from the WHO 2012 regional and global estimation [[3](#_ENREF_3)], as averages between treated and untreated episodes, in years) are given in SDC3.

**SDC 5. Reported Urethral Discharge cases in Morocco**

The table below shows urethral discharge (UD) case notifications, nationally aggregated, reported by Morocco’s Ministry of Health in September 2016.

Morocco has had two phases in UD case reporting within the 1993-2016 period: Before the year 2000, cases were notified as either gonococcal urethritis or non-gonococcal urethritis, with the differentiation based purely on clinical grounds. From the year 2000 onwards, as the syndromic case management approach was implemented nation-wide, cases were instead notified as urethral discharge cases, defined as any new UD case in a male patient consulting for a new disease episode, independent of the cause. This includes reinfections, whereas treatment failures are not notified as new cases.

STI notifications are channeled from the health center, to the province, to the region, and finally to the national Department of Epidemiology at the Ministry of Health.

There have been no formal evaluations of STI notification completeness. However, in 2006 a system was launched to remind provinces that signaled late or missing notifications, and notifications are considered to be (more) complete since 2006.

| **Year** | **UD cases** |
| --- | --- |
| 1993 | 19,948 |
| 1994 | 27,012 |
| 1995 | 28,260 |
| 1996 | 32,397 |
| 1997 | 35,603 |
| 1998 | 37,865 |
| 1999 | 52,698 |
| 2000\* | 61,474 |
| 2001 | 70,083 |
| 2002 | 62,763 |
| 2003 | 67,273 |
| 2004 | 60,051 |
| 2005 | 56,181 |
| 2006 | 58,910 |
| 2007 | 59,121 |
| 2008 | 64,915 |
| 2009 | 64,416 |
| 2010 | 60,026 |
| 2011 | 62,054 |
| 2012 | 69,730 |
| 2013 | 71,129 |
| 2014 | 70,154 |
| 2015 | 71,999 |

**\*** Introduction of the syndromic case management approach, nation-wide

**SDC 6. UD etiology, measured in studies among male UD patients in clinics in Morocco**

Table S6 and Figure S6 (left) show the three studies of UD etiology done in Morocco since 1995. Over 1995-2009, the proportion of UD due to gonorrhea increased (p=0.004 in linear-by-linear trend test), the proportion due to chlamydia fluctuated non-significantly (p=0.94) while the proportion with no germ identified decreased non-significantly (p=0.21). An increasing proportion due to gonorrhea is consistent with a larger increase in the proportion of gonorrhea episodes treated for gonorrhea than for chlamydia (see Figure 3), due to a higher proportion of episodes that is symptomatic for gonorrhea than for chlamydia.

This time trend in the etiological distribution ignores that some of the difference may reflect the different sites of the 1995-1996 study (Agadir) compared to the 2001 and 2009 studies (Rabat/Salé). However, lacking a UD etiology time series from within one site or a comparable set of sites, for the Spectrum estimation we took the etiological distributions as observed at these 3 time points as if they indicated the etiological distribution nation-wide. Figure S6 (right) shows the corresponding etiology distribution assumed in the Spectrum estimations of gonorrhea and chlamydia reporting completeness, imputing the etiological proportions observed at 1995-96, 2001 and 2009 linearly to intermediate years, and applying the 2009 UD etiological distribution also for the years 2010-2015.

**Table S6. UD etiology, measured in studies among male UD patients in clinics in Morocco**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Time** | **N tested** | **Population** |  | **NG alone** | **CT alone** | **NG+CT** | **NG total** | **CT total** | **No germ** |
| 1995-1996 | 79 | UD clinic patients | Agadir [[26](#_ENREF_26)] | 35.4% | 10.1% | 8.9% | 44.3% | 19.0% | 45.6% |
| 2001 | 399 | UD clinic patients | Rabat/Salé [[23](#_ENREF_23)] | 41.6% | 5.3% | 10.8% | 52.4% | 16.1% | 42.3% (reported) or 41.4% (re-calculated) |
| 2009 | 171 | UD patients, basic health services | Rabat/Salé [[20](#_ENREF_20), [27](#_ENREF_27)] | 55.5% | 3.0% | 7.3% | 62.8% | 10.3% | 34.1% |

Abbreviations: CT = Chlamydia trachomatis; NG = Neisseria gonorrhea; UD = Urethral Discharge.

**Figure S6. Urethral Discharge case reports and etiological distribution, adult men in Morocco:   
(left) data; (right) Spectrum model fit.**



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