

Adult female syphilis prevalence, congenital syphilis case incidence and adverse birth outcomes, Mongolia 2000–2016: Estimates using the Spectrum STI tool

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ARTICLE INFO

Article history:

Received 15 December 2017

Received in revised form 26 February 2018

Accepted 8 March 2018

Available online 9 March 2018

Handling Editor: Jianhong Wu

Keywords:

Syphilis

Congenital syphilis

Surveillance

Screening

Antenatal care

Epidemiological modelling

ABSTRACT

Introduction: Mongolia's health ministry prioritizes control of Sexually Transmitted Infections, including syphilis screening and treatment in antenatal care (ANC).

Methods: Adult syphilis prevalence trends were fitted using the Spectrum-STI estimation tool, using data from ANC surveys and routine screening over 1997–2016. Estimates were combined with programmatic data to estimate numbers of treated and untreated pregnant women with syphilis and associated incidence congenital syphilis (CS) and CS-attributable adverse birth outcomes (ABO), which we compared with CS case reports.

Results: Syphilis prevalence in pregnant women was estimated at 1.7% in 2000 and 3.0% in 2016. We estimated 652 CS cases, of which 410 ABO, in 2016. Far larger, annually increasing numbers of CS cases and ABO were estimated to have been prevented: 1654 cases, of which 789 ABO in 2016 – thanks to increasing coverages of ANC (99% in 2016), ANC-based screening (97% in 2016) and treatment of women diagnosed (81% in 2016). The 42 CS cases

Abbreviations: ABO, Adverse Birth Outcome; ANC, antenatal care; ANC-1, attendance of antenatal care at least once during a pregnancy; CI, confidence interval; CS, Congenital Syphilis; F, women; N, sample size tested; NCCD, Mongolia National Center for Communicable Diseases; RPR, Rapid Plasma Reagin test; STI, sexually transmitted infection; TP, *Treponema pallidum*; WHO, World Health Organization.

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Peer review under responsibility of KeAi Communications Co., Ltd.

<https://doi.org/10.1016/j.idm.2018.03.003>

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reported nationally over 2016 (liveborn infants only) represented 27% of liveborn infants with clinical CS, but only 7% of estimated CS cases among women found syphilis-infected in ANC, and 6% of all estimated CS cases including those born to women with undiagnosed syphilis.

Discussion/Conclusion: Mongolia's ANC-based syphilis screening program is reducing CS, but maternal prevalence remains high. To eliminate CS (target: <50 cases per 100,000 live births), Mongolia should strengthen ANC services, limiting losses during referral for treatment, and under-diagnosis of CS including still-births and neonatal deaths, and expand syphilis screening and prevention programs.

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1. Introduction

Mother to child transmission (MTCT) of syphilis during pregnancy, commonly referred to as congenital syphilis (CS) can result in stillbirth, neonatal death and congenital abnormalities including low birth weight and prematurity (Gomez et al., 2013). Diagnosis and treatment of infected pregnant women with a single dose of benzathine penicillin can prevent MTCT and the adverse birth outcomes (ABO) of CS (Darville, 1999; World Health Organization, 2016a). Despite the fact that eliminating MTCT of syphilis through expanded screening and treatment in antenatal care (ANC) is highly cost-effective in a range of settings (Kahn et al., 2014; Owusu-Edusei et al., 2014) the World Health Organization (WHO) estimated that in 2012 nearly one million pregnant women globally had probable active syphilis, which caused around 350,000 ABO (Wijesooriya et al., 2016).

Mongolia has experienced a gradual rise in STIs including syphilis since the Soviet Union collapsed in the 1990s (Ebright, Altantsetseg, & Oyungerel, 2003; Garland, Tabrizi, Chen, Byambaa, & Davaajav, 2001; Purevdawa et al., 1997; Schwebke, Aira, Jordan, Jolly, & Vermund, 1998) and STIs account for over one-third of all reportable diseases (Baigalmaa et al., 2012). Reported adult syphilis and congenital syphilis cases rose over 2004–2015 (Azyei et al., 2014; Baigalmaa et al., 2012; Erdenetungalag et al., 2017), and an outbreak was reported in 2012 (Munkhzul, Batdorj, & Baigalmaa, 2012). STI control is a health sector priority in Mongolia, but the STI program lacks human and financial resources, and coverage of ANC, syphilis screening and treatment in ANC are incomplete. Pregnant women are screened at no cost, with a treponemal test confirmed with an RPR test. Women identified as positive are referred to an STI clinic for confirmatory testing and treatment with benzathine penicillin. In 2007–2008 a study in Ulaanbaatar piloted point-of-care screening and treatment within ANC sites, which improved treatment coverage considerably and reduced ABO cases; however this one-stop service was not rolled out (Gantsetseg, Delgersuren, Oyungerel, & Tuul, 2013; Munkhuu, Liabsuetrakul, Chongsuvivatwong, McNeil, & Janchiv, 2009). Assessment and monitoring of syphilis in pregnant women and CS are needed for program improvement.

In 2016, the WHO launched the sexually transmitted infections (STI) Strategy (2016–2021), which has as a global target the reduction of CS incidence to below 50 cases per 100,000 live births by 2030 (World Health Organization, 2016b). WHO criteria for country-level validation of elimination of mother-to-child transmission (EMTCT) of syphilis incorporate three process targets – coverage of ANC (at least 1 visit, abbreviated ANC-1) $\geq 95\%$, syphilis testing in ANC $\geq 95\%$, and $\geq 95\%$ of women found infected receiving treatment (World Health Organization, 2014). In 2016, Avenir Health, in collaboration with WHO, developed the Spectrum-STI model, to allow countries to estimate historic and expected trends of adult syphilis, gonorrhoea and chlamydia (Korenromp et al., 2017). In 2017, this model was used in Mongolia (Badrakh et al., 2017), with an extension to estimate the incidence of CS cases and CS-attributable ABOs, and evaluate the reporting completeness of CS cases and progress toward the WHO elimination criteria.

2. Methods

2.1. Spectrum STI model

Spectrum-STI (Korenromp et al., 2017) was developed as part of the Spectrum suite of demographic and health burden and program impact modelling tools (Avenir Health, 2017). For implementation in Mongolia, data and assumptions used were reviewed, discussed and agreed during a technical workshop in February 2017. Participants included representatives of Mongolia's Ministry of Health, Mongolia National Center for Communicable Diseases (NCCD), local STI clinic providers, and technical and donor partners supporting or implementing the national STI response including the WHO country office.

2.2. Prevalence of active syphilis in pregnant women

Spectrum-STI fits data from periodic sentinel sero-surveys and routine programmatic screening in pregnant women attending ANC using logistic regression, assuming no systematic prevalence differences between these data types. 95% confidence intervals (CI) were generated by bootstrapping (Korenromp et al., 2017).

Data were standardized before analysis to ensure that they reflected active syphilis (defined as concurrent positivity on both Rapid Plasma Reagin (RPR) and *Treponema pallidum* (TP) tests, as in previous estimates of adult syphilis by the WHO (Newman et al., 2015)). Each data point was assigned a weight according to its national coverage and representativeness. In Mongolia this was operationalized as the number of sites sampled, out of a maximum of 22 sites sampled in ANC surveys in 2009 and 2014 (i.e., capital Ulaanbaatar and one site in each of 21 provinces).

2.3. Extension of Spectrum STI to estimate congenital syphilis

CS numbers were estimated using Spectrum estimates of syphilis prevalence in women, proportions of women screened and treated, and annual numbers of pregnancies. The number of syphilis-exposed pregnancies is calculated by multiplying the Spectrum-estimated syphilis prevalence with the annual number of pregnancies. Service coverage data (proportions of pregnant women who attended ANC at least once; women attending ANC screened for syphilis; and women screened, identified as positive and treated appropriately) were then used to estimate the fraction and number of pregnant women whose syphilis remained untreated. Coverage of ANC-1 and of syphilis screening were assumed equal in women with and without active syphilis. We defined adequate maternal treatment according to WHO definitions, as at least once dose of 2.4 million units of benzathine penicillin (World Health Organization, 2016a).

For Mongolia, ANC-1 coverage was based on data from national reproductive and health surveys. Any missing values were interpolated from values at years with data before and after. Numbers and proportions of pregnant women in ANC screened for syphilis were available from routine records (Cardoso et al., 2016; Munkhuu et al., 2009; Winscott, Taylor, & Kenney, 2010). We estimated annual numbers of pregnancies as numbers of women newly registered into ANC divided by ANC-1 coverage.

Proportions of ANC women screened for syphilis, and found syphilis-positive and treated for syphilis with benzathine penicillin are not routinely recorded. We estimated treatment coverage considering data from a study of one-stop syphilis screening and treatment piloted in Ulaanbaatar in 2007–8 (Gantsetseg et al., 2013; Munkhuu et al., 2009) as an upper limit to nation-wide treatment coverage (see Results).

The CS estimation used the WHO's case definition of CS, recommended for surveillance purposes (World Health Organization, 2014):

- a stillbirth, live birth, or fetal loss at >20 weeks of gestation or >500 g birthweight born to a syphilis seropositive mother without adequate syphilis treatment; OR
- a stillbirth, live birth, or child aged <2 years with microbiological evidence of syphilis infection.

According to this definition, the estimation included all infants (with or without clinical findings at birth) born to women with untreated syphilis, as well as liveborn infants with clinical findings of CS born to women with treated infections. Syphilis-exposed infants without clinical signs born to untreated mothers were termed “non-clinical CS”. Infants born with clinical findings of CS, from both treated and untreated women were termed Adverse Birth Outcome (ABO), which includes stillbirths, neonatal deaths and premature or LBW infant.

In Mongolia, due to ANC-1 and syphilis screening coverages below 100%, some pregnant women with untreated syphilis had not been diagnosed, and these women would not count among nationally reported CS cases, although they fall under WHO's CS surveillance case definition. To provide both total CS case burden, and CS case numbers expected to be reported if surveillance were 100% complete, we estimated CS cases in turn, as total for all mothers including those screened and not screened in ANC, and for the subset of women with syphilis infection status known through ANC-based screening.

2.4. Estimation of adverse birth outcomes

ABOs were estimated using Spectrum estimates of syphilis prevalence in women, proportions of women screened and treated, annual numbers of pregnancies, and a tool developed by WHO to estimate CS-attributable ABO at country and global levels (Wijesooriya et al., 2016; World Health Organization, 2017). The WHO tool calculates ABO by applying fixed global estimated risk probabilities, from a meta-analysis of various types of (normal and adverse) birth outcomes of women with untreated maternal syphilis. For pregnant women with untreated syphilis risk probabilities were: stillbirth 21%, neonatal death 9%, prematurity/low birth weight 6% and clinical CS 16%, giving a total of 52% with any ABO (Gomez et al., 2013). Thus, the remaining 48% (=100% minus 52%) of births to untreated mothers constitute non-clinical CS. For women whose syphilis was treated during pregnancy, the risks of ABO were reduced by the estimated effectiveness of treatment: 82% reduction for stillbirth, 80% reduction for neonatal death, 64% reduction for prematurity/low birth weight, and 97% reduction for clinical CS, leaving a total risk of 8% of any CS-attributable ABO among treated mothers (Blencowe, Cousens, Kamb, Berman, & Lawn, 2011).

2.5. Congenital syphilis case reporting completeness

CS case reporting is mandatory in Mongolia. In 2016 the national CS case definition covered liveborn infants born to pregnant women with treated or untreated diagnosed syphilis, that exhibited clinical signs or symptoms of congenital syphilis, as well as stillbirths to mothers diagnosed with syphilis but untreated or incompletely treated. Completeness of CS case reporting was evaluated by comparing CS case numbers reported by the NCCD to the Spectrum CS case estimates based on the WHO's surveillance case definition of CS.

3. Results

3.1. Prevalence of active syphilis in pregnant women

Two data sources were identified: national ANC syphilis prevalence data from routine programmatic screening reported annually from 1997 to 7 ANC sentinel surveys conducted between 2002 and 2014 (Supplemental File 1). No adjustments were made for diagnostic tests, as the routine screening and the surveys both used treponemal testing confirmed with RPR, the gold standard for identifying probable active syphilis. Syphilis prevalence was estimated to have risen from 1.7% at 2000 to 3.0% at 2016 (Fig. 1).

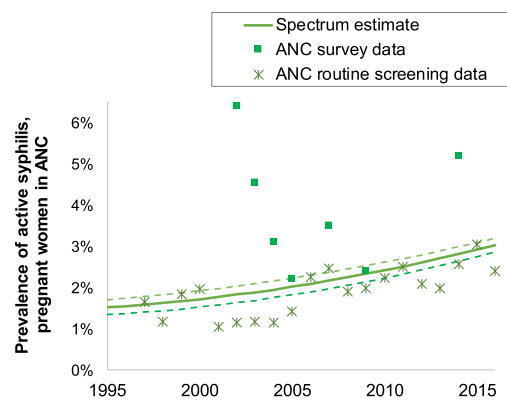
3.2. Process indicators of CS prevention

Between 2000 and 2016, national ANC-1 coverage improved from 97% to 99% and coverage of ANC-based syphilis screening (among pregnant women attending ANC) improved from 40% to 97%, according to country reports (Supplemental file 2).

There are no routine data on the coverage of syphilis treatment among women diagnosed during ANC. The only data available to inform this estimate was a pilot of a one-stop ANC-based screening and treatment service in 2007–08, where in the control (state-of-the-art) group, 89.6% of pregnant women diagnosed with syphilis in ANC were adequately treated (Gantsetseg et al., 2013; Munkhuu et al., 2009). This study was conducted in the capital Ulaanbaatar, with relatively good services and service access. We further considered that treatment coverages above 80% would result in an implausibly high share of clinical congenital syphilis cases among treated mothers, much higher than in clinic registry reviews (see Discussion). Given this limited data, we capped treatment coverage at 81% at 2016, and assumed a gradual linear increase from 65% in the year 2000.

3.3. Adverse birth outcomes

The Spectrum-estimated annual number of ABOs was 461 in 2000, and 410 in 2016 (Fig. 2). The fluctuation in annual numbers reflects the combined effects of changes in maternal syphilis prevalence (Fig. 1), coverages of ANC-based syphilis screening and treatment (Supplemental file 2) and annual births. In 2016, of 410 estimated CS-related ABO, 174 (42%) were



Notes : The Antenatal Care (ANC) clinic-based sentinel survey in 2004, for which a 3.1% prevalence was reported, is shown in this Figure (as in Supplemental file 1, for context) but it was not included in the statistical trend fitting, since the absolute numbers underlying the reported prevalence were not retrievable.

Fig. 1. Syphilis prevalence in pregnant women in Mongolia: Spectrum estimation, and underlying ANC data. Notes to Fig. 1: The Antenatal Care (ANC) clinic-based sentinel survey in 2004, for which a 3.1% prevalence was reported, is shown in this Figure (as in Supplemental file 1, for context) but it was not included in the statistical trend fitting, since the absolute numbers underlying the reported prevalence were not retrievable.

stillbirths, 78 (19%) neonatal deaths, 69 (17%) premature birth and/or low birth weight, and 89 (22%) clinical symptoms in a liveborn infant.

ABOs in women who did not attend ANC (Fig. 3a, red bars) were estimated to have fallen to near-0 by 2016, whilst numbers fell in women who attended ANC but were not screened (orange bars), rose in women who were screened but not treated (yellow bars), and rose in women screened and treated (blue bars). In 2016, of the 410 estimated ABOs 2% were among mothers not in ANC, 9% in mothers attending ANC but not screened, 54% in mothers screened but not treated, and 36% in mothers treated.

Increased access to ANC-1, syphilis screening and treatment were estimated to have averted increasing numbers of ABOs (from 125 in 2000 to 789 in 2016), despite increasing maternal prevalence and increasing annual pregnancies (Fig. 3a, green bars).

3.4. CS case incidence, including non-clinical CS

In 2016, on top of the 410 ABOs, Spectrum estimated 242 non-clinical CS cases occurring in infected mothers not adequately treated, of which 203 in mothers tested but not treated (Fig. 3b). Total CS cases were estimated to have fallen over 2000–2016 (as ABO). However, (potential) CS cases averted (Fig. 3b, green bars) had increased by more than 6-fold from 2000 (261 cases prevented) to 2016 (1654 cases prevented).

3.5. CS case reporting completeness

Mongolia reported fluctuating annual CS case numbers over 1998–2016 (Supplemental file 3); all were liveborn infants with clinical symptoms. The 42 cases reported in 2016 represent 27% of the Spectrum-estimated 158 liveborn infants with clinical CS (of whom 69 premature/LBW + 89 with clinical symptoms), but only 7% of the 613 Spectrum-estimated CS cases (410 ABOs + 203 non-clinical) among women with diagnosed syphilis (that is, those women who should get counted for surveillance if diagnosis and reporting were 100%), and only 6% of the 652 Spectrum-estimated CS cases (410 ABOs + 242 non-clinical) using the WHO case definition.

3.6. Future CS burden with improved ANC and STI program impact

We next explored the impact on CS and ABO burden in 2017, of increasing treatment coverage of women found syphilis-infected during ANC to 95% (the WHO target proposed for global syphilis elimination (World Health Organization, 2014)) – while keeping ANC-1 coverage and screening coverage at 2016 levels (99% for ANC-1 and 97% from screening). The WHO CS tool estimated 366 CS cases of which 274 ABO (Table 1) if the syphilis prevalence in ANC women stayed at 3.0%, and 121 CS cases, of which 91 ABO if the maternal prevalence was lowered to 1%; the latter corresponds to 170 CS cases per 100,000 live births.

Even if all syphilis-infected pregnant women were treated (i.e. increasing coverage for ANC-1, ANC-based syphilis screening, and ANC-based syphilis treatment all to 100% in 2017), with an unchanged 3.0% prevalence of syphilis there would still be 190 cases in 2017, corresponding to 267/100,000 live births (Table 1), so the 50/100,000 elimination threshold could not be reached, due to remaining risks of CS and ABO despite treatment. Achieving the WHO elimination threshold of 50 CS cases per 100,000 live births therefore requires not only further program coverage improvements but also lowered adult syphilis prevalence, for example, 99% ANC-1 coverage, 97% coverage of both ANC-based syphilis screening and ANC-based syphilis treatment, and maternal prevalence lowered to 0.60%.

3.7. Sensitivity analysis

Sensitivity of 2016 model projections to maternal syphilis prevalence in 2016, CS case incidence, CS-attributable adverse birth outcomes, and CS reporting completeness, are recorded in Table 2.

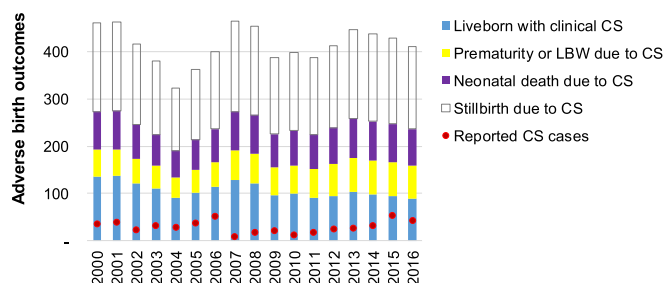


Fig. 2. Adverse birth outcomes due to Congenital Syphilis, Mongolia: Spectrum estimation, by type of birth outcome.

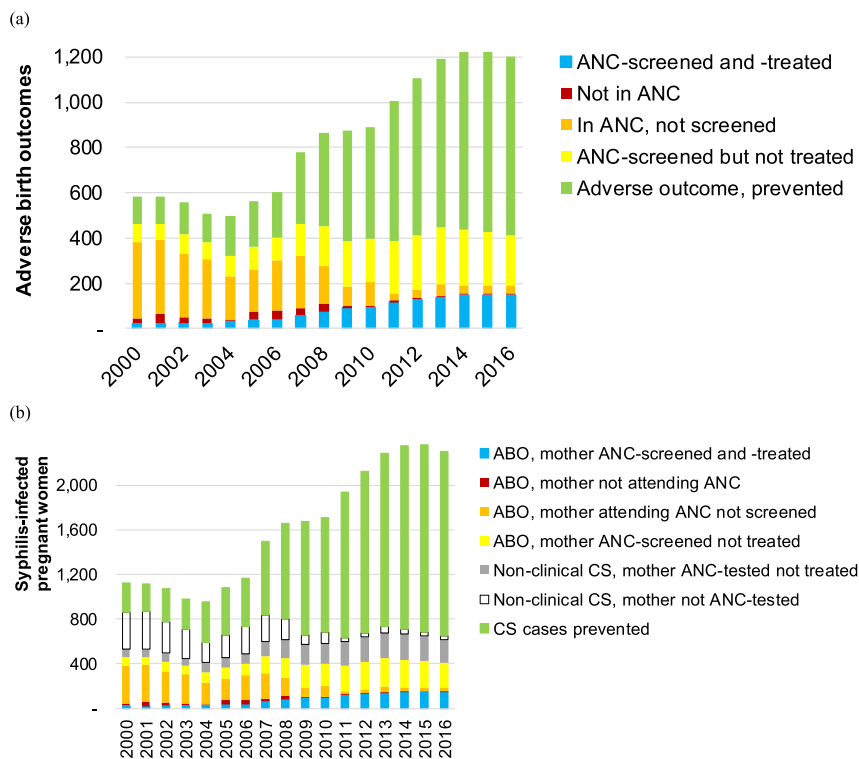


Fig. 3. Spectrum estimates for Mongolia: (a) Adverse birth outcomes due to Congenital Syphilis, and (b) Congenital syphilis cases, prevented and not prevented by ANC-based screening and treatment.

Spectrum's ANC syphilis prevalence in 2016 of 3.0% may be an over-estimate, as the latest screening, in 2016, reported 2.38% prevalence (Fig. 1, Supplemental file 1). If maternal syphilis prevalence in 2016 had been 2.4% then CS cases would fall from our best estimate of 652 to 513 and ABOs from 410 to 323. However, if prevalence in women not attending ANC is higher than in women who attend, Spectrum may under-estimate maternal syphilis. If prevalence in 2016 had been 3.4% then estimated CS cases would have totalled 740, and ABOs 466.

When varying assumptions on the three ANC service determinants, estimates of CS and ABO are especially sensitive to coverage of syphilis treatment, for which there are no routine data and which of the three ANC service coverage indicators, is probable farthest below the 95%–100% target.

Risks and rates of ABO for syphilis-infected mothers who received treatment may have been higher in Mongolia than the value used in the WHO tool (2.6% clinical CS risk for liveborn births to treated mothers). The only local study, conducted in Ulaanbaatar in 2003, found 5.6% of infants born to mothers with syphilis and who were treated during the pregnancy had

Table 1
Future scenarios of reduction and elimination of CS and ABOs, Mongolia.

	Syphilis prevalence, pregnant women	CS cases (ABO + non-clinical)	ABO cases	CS case rate per 100,000 live births
2016 actual (99.4% ANC, 97% ANC-based screening, 81% ANC-based treatment)	3.0%	652	410	834/100,000
99.4% ANC, 97% ANC-based screening, 95% ANC-based treatment	3.0%	366	274	515/100,000
100% ANC, 100% ANC-based screening, 100% ANC-based treatment – but no decrease in maternal prevalence	3.0%	121	91	170/100,000
Elimination of CS i.e. 50 CS cases per 100,000 live births: 99.4% ANC-1, 97% screening, 97% treatment & maternal ANC syphilis prevalence lowered to 0.60%	0.60%	41	30	50/100,000

ABO = Adverse Birth Outcome due to CS; ANC = antenatal care; LBW = Low Birth Weight; CS = Congenital Syphilis. The bold denotes the actual best estimate for Mongolia as of 2016.

Table 2

Sensitivity analysis: determinants of estimated maternal syphilis prevalence, CS case incidence, CS-attributable adverse birth outcomes, and CS reporting completeness, Mongolia at 2016.

	Best/default assumption	Alternative assumption	Syphilis prevalence, pregnant women	CS cases (ABO + asymptomatic)	ABO cases	Reporting completeness, as reported CS cases relative to estimated:		
						... live births with ABO	... CS cases, incl. ABO and non-clinical live births	CS cases (incl. ABO and non-clinical) among mothers whose syphilis was diagnosed during ANC
Best estimate			3.0%	652	410	27%	6.4%	6.8%
Syphilis prevalence, pregnant women, 2016	3.0%	2.4%, as measured in routine ANC screening at 2016		513	323	34%	8.2%	8.7%
		3.4%, assuming a 5-fold higher rate in pregnant women not screened in ANC (3.4% of the pregnant population)		740	466	23%	5.7%	6.0%
Coverage of antenatal care (one or more visits)	99.4%	98-100%	3.0%	642–675	405–421	26-27%	6.2–6.5%	6.8–6.9%
Coverage of syphilis screening, among ANC women	97%	94-100%	3.0%	602–704	386–435	25-28%	6.0–7.0%	6.6–7.1%
Coverage of syphilis treatment, among ANC women found syphilis-infected at screening	81%	62-100%	3.0%	264–1040	225–595	17-55%	4.0–16%	4.2–19%
Risk of liveborn with clinical CS (premature, LBW or other clinical symptoms) in syphilis-infected mother treated	2.6%	5.6% (Erdenetungalag et al., 2017)	3.0%	705	463	20%	6.3%	6.0%

ABO = Adverse Birth Outcome due to CS; ANC = antenatal care; LBW = Low Birth Weight; CS = Congenital Syphilis.

clinical CS (Munkhuu, Liabsuetrakul, Chongsuvivatwong, Geater, & Janchiv, 2006). If we use this higher risk rate for treated mothers, numbers of CS cases and ABO cases in 2016 increase to 705 and 463, respectively.

4. Discussion

Based on surveillance surveys and routine programmatic screening data available from 1997 to 2016, the Spectrum-STI estimation and the WHO CS tool highlight the persistently high burden of maternal and congenital syphilis in Mongolia. The estimations suggest that there has been a steady ongoing reduction in CS cases and a corresponding increase in ABOs averted by ANC-based screening and treatment. However, due to increasing maternal prevalence and rising numbers of births the numbers of CS cases and ABO not prevented are still very high and well above the WHO elimination target. Much of this burden is not captured in Mongolia's national reporting system. As in other countries (Cardoso et al., 2016; Winscott et al., 2010) under-reporting of CS and ABO reflects both women not seen, screened and/or treated in ANC, and under-diagnosis among mothers and infants followed through ANC services. These challenges with health care access and quality of ANC services were compounded by Mongolia's case definition, which (up to mid-2017) included only liveborn infants with clinical symptoms born to women diagnosed with syphilis. This meant that many stillbirths and neonatal deaths attributable to CS were not identified, and nor were infants born to untreated infected mothers without clinically diagnosed symptoms, in whom the CS may have contributed to prematurity, low birth weight (Gomez et al., 2013), and/or compromised growth and development later in infancy and childhood (Gupta & Kumar, 2012).

Adjusting the reportable case definition of CS in Mongolia to align with the WHO case definition, to include all births (live, and dead) to mothers with untreated syphilis or not screened for syphilis (World Health Organization, 2014) would improve the completeness of CS case reporting and allow Mongolia to monitor progress toward the global CS elimination threshold of 50/100,000 live births, which is based on the WHO case definition. Along with changing its CS case definition, Mongolia will need to put in place a better system for tracking women through pregnancy and birth. This should include testing for syphilis of all women who have a stillbirth. In the short term, Mongolia could undertake a retrospective evaluation cross-linking maternal syphilis laboratory records with registries of live births and foetal deaths, or disease registries to assess the contribution of CS to national stillbirth reports, and identifying missed cases of CS (Cardoso et al., 2016; Winscott et al., 2010).

Over 2000–2016, annual CS case reports fluctuated in Mongolia; the year-on-year fluctuations, however, did not parallel the year-on-year variation in annual CS cases estimated using Spectrum-STI (Fig. 2). National CS case reports reflect not only population-level epidemiological trends, but also changes in access to ANC care and STI treatment, reporting practices by physicians and medical institutions and reporting guidelines. Changes in these other factors limit the use of case reporting for monitoring and evaluating STI control and highlight the value of the Spectrum STI model to estimate trends over time.

Observational studies in Mongolia have associated lack of syphilis screening in pregnant women with late ANC attendance, history of prior STI, and living far away from screening services (Munkhuu et al., 2006). The Spectrum methodology estimated that 33–37% of live births with clinical CS between 2012 and 2016 were in mothers screened in ANC. This appears in line with Mongolia's CS case registry; over the same 4 year period 53% of liveborn clinical CS cases were infants born to women screened at least once during pregnancy, and 24% to women screened two or more times (Erdenetungalag et al., 2017).

Over 2012–2016 Spectrum estimated that 26–30% of liveborn ABO cases were among mothers diagnosed and treated for syphilis. In comparison, NCCD's registry recorded 4% (2/52) in 2015 and 0% (0/42) in 2016 liveborn ABO cases among mothers treated. The higher percentage estimated by Spectrum probably reflects that the subset of ABO actually diagnosed were only the most symptomatic infants, while less severe cases of clinical CS, as are more likely to occur to women treated (but, for example, treated too late to prevent the CS entirely) may more often be under-diagnosed. A quarter of ABO among treated mothers is high but in line with the Ulaanbaatar study (Munkhuu et al., 2009), where several syphilis-infected mothers received treatment late. Also some treated women may have been re-infected during the pregnancy, a risk given incomplete coverage of partner notification and treatment (Munkhuu et al., 2009).

Improving timely treatment coverage of pregnant women who test positive for syphilis, through point-of-care testing paired with same-visit treatment for infected women, is critical for CS prevention, especially in a country with a high maternal prevalence of syphilis. Currently, pregnant women are screened for syphilis in ANC using point-of-care tests, but then blood samples of women screening positive are sent to an STI clinic for confirmatory testing, and confirmed-infected women have to attend the STI clinic to get treated – despite the Ulaanbaatar trial having demonstrated how syphilis treatment coverage of pregnant women can improve and CS deliveries be reduced if ANC clinics offer immediate on-site treatment for women diagnosed (Munkhuu et al., 2009). Mongolia's Ministry of Health is exploring ways to introduce the 'one-stop service' nation-wide, building on the success of the Ulaanbaatar trial (Munkhuu et al., 2009).

The rise in syphilis prevalence in ANC women in Mongolia is in line with increasing case reports of adult syphilis between 2000 and 2016 (Baigalmaa et al., 2012; Munkhzul et al., 2012). It is also in keeping with rises in syphilis test positivity rates from laboratories nation-wide. Trends in test positivity rates, however, are not a good measure of population changes, as they may also reflect changes in the profile of people tested (e.g. targeting higher-risk individuals through contact tracing and partner notification), and patterns of re-testing following diagnosis and treatment. To reduce syphilis prevalence in the overall population, notification and treatment of partners of pregnant women, and systematic tracing of partners of all syphilis patients is essential and needs to be systematically pursued (Munkhuu et al., 2009).

After earlier Spectrum-based estimations of adult STI rates in Zimbabwe and Morocco, the extension to estimate CS expands the utility of this tool to inform STI (and HIV) surveillance and program evaluation and planning, and monitor

countries' progress towards CS elimination. General limitations of the Spectrum estimation approach have been described elsewhere (Korenromp et al., 2017), and any modelling assumptions and data inputs described can be scrutinized. Sensitivity analysis showed that estimated CS and ABO incidence and CS reporting completeness were especially sensitive to uncertainties in maternal syphilis prevalence, and maternal treatment coverage.

In conclusion, Mongolia suffers a persistently high syphilis prevalence in pregnant women resulting in a very high rate of CS. CS rates have been reduced by increasing coverage of syphilis screening in ANC, but the impact of ANC-based screening is being limited by much lower levels of treatment coverage, as women are referred for treatment and not treated immediately on-site. Under-diagnosis of CS also hampers monitoring progress toward CS elimination. Mongolia is now using Spectrum-STI syphilis estimates in its target setting, planning and performance monitoring for HIV/AIDS grants through the Global Fund to fight AIDS, Tuberculosis and Malaria (Country Coordinating Mechanism Mongolia, 2017).

Competing interests and source of funding

The project was funded by the World Health Organization, Department of Reproductive Health and Research. The views expressed in this paper are those of the authors and do not necessarily represent the position of Avenir Health, the World Health Organization, the U.S. Centers for Disease Control and Prevention, Mongolia's Ministry of Health, or other affiliated organization. The authors declare no conflicts of interest.

Acknowledgements

We thank Dr. Jane Rowley and Dr. N. Saman Wijesooriya for comments on drafts of this paper, and are grateful to Kendall Hecht (Avenir Health) for having programmed the user interface of the online Spectrum-STI tool.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.idm.2018.03.003>.

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