Epidemiology of *Chlamydia trachomatis* in the Middle East and North Africa: Updated systematic review, meta-analyses, and meta-regressions

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BACKGROUND

- Chlamydia trachomatis* (CT) epidemiology in the Middle East and North Africa (MENA), the region with the highest rates of primary infertility, is poorly understood.
- The World Health Organization (WHO) recently formulated the ‘Global Health Sector Strategy on STIs, 2016-2021’ with the aim of ending STI epidemics as a public health concern by 2030.

OBJECTIVE

- To inform efforts attending to the Global Health Sector Strategy on STIs 2016-2012 through a comprehensive epidemiological assessment of CT infection in MENA.

METHODOLOGY

- Systematic review of all epidemiological evidence for CT infection in MENA up to November 2017, and reporting findings following the PRISMA guidelines (Fig. 1).
- Data synthesized by at-risk population and type of assay used for CT infection ascertainment.
- Pooled mean CT prevalence in at-risk populations and by type of assay used for CT infection ascertainment estimated using random-effects meta-analyses with inverse variance weighting (Table 1).
- Sources of between-study heterogeneity and their independent contribution to CT prevalence assessed using meta-regression analyses (Table 2).

RESULTS

- 519 CT prevalence measures identified in MENA, of which 496 were eligible for analysis (Fig. 1).
- Estimates for the pooled mean CT prevalence (and 95% confidence intervals) are found in Table 1.
- At-risk population, assay type, sample size, country and sex were identified as predictors of between-study heterogeneity in CT prevalence in Table 2.

Figure 1. Study selection process for CT epidemiology studies in MENA.

Table 1. Findings of the meta-analyses of CT prevalence studies in MENA by at-risk population and CT ascertainment.

CT infection ascertainment	Studies		Sample		CT prevalence		Heterogeneity measures			
	N	Tested	CT +ve	Range (%)	Pooled mean (%)	95% CI	I ² * (%; 95% CI)	Prediction interval† (95%)		
General populations										
Current genital infection										
PCR (current infection)	38	24 299	671	0-12-8	3-0	2-0-4-1	93-8 (92-4-95-0)	0-11-6		
Culture (current infection)	6	5 020	55	0-15-0	1-5	0-1-4-2	86-1 (71-8-93-1)	0-13-6		
DFA (current infection)	13	2 052	66	0-12-5	2-7	1-4-4-2	64-0 (34-8-80-1)	0-8-7		
Overall (current infection)	57	31 371	792	0-15-0	2-8	2-0-3-7	92-3 (90-7-93-5)	0-10-5		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	28	5 158	353	0-22-2	6-0	4-1-8-1	83-5 (77-2-88-1)	0-04-18-3		
IgM (recent infection)	12	2 718	72	0-14-0	1-8	0-3-4-2	85-8 (77-0-91-3)	0-13-5		
IgA (recent infection)	3	317	8	0-40-4	6-5	0-29-5	93-5 (84-5-97-3)	0-100		
Not specified	11	3 300	187	0-19-9	6-6	4-1-9-6	87-2 (79-1-92-2)	0-2-19-7		
Unclear	2	1 698	11	0-2-3-2	1-2	0-5-9	93-7 (79-6-98-0)	-		
Populations at intermediate risk										
Current genital infection										
PCR (current infection)	12	2 836	66	0-26-1	2-3	0-8-4-6	88-7 (82-1-92-8)	0-13-7		
Overall (current infection)	12	2 836	66	0-26-1	2-3	0-8-4-6	88-7 (82-1-92-8)	0-13-7		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	2	1 133	31	1-4-17-4	7-1	0-30-0	97-0 (92-1-98-8)	-		
Not specified	1	308	15	-	4-9	2-8-7-9	-	-		
Populations at high risk										
Current genital infection										
PCR (current infection)	29	5 701	455	0-72-9	5-3	2-0-10-0	97-6 (97-1-98-1)	0-38-3		
Culture (current infection)	1	116	8	-	6-9	3-0-13-1	-	-		
DFA (current infection)	1	30	9	-	30-0	14-7-49-4	-	-		
Current rectal infection										
PCR (current infection)	7	1 506	129	3-6-18-3	7-7	4-2-12-0	85-2 (71-5-92-3)	0-24-9		
Overall (current infection)	31	7 353	601	0-72-9	6-3	3-4-10-0	96-8 (96-2-97-4)	0-35-3		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	4	472	364	19-8-100	80-9	43-8-100	98-6 (97-7-99-1)	0-100		
IgM (recent infection)	1	154	45	-	29-2	22-2-37-1	-	-		
Not specified	1	30	11	-	36-7	19-9-56-1	-	-		
Infertility clinic attendees										
Current genital infection										
PCR (current infection)	26	4 073	468	0-39-4	10-8	7-7-14-3	90-5 (87-3-92-9)	0-2-32-5		
Culture (current infection)	8	1 445	188	1-1-65-3	12-7	4-8-23-6	95-9 (93-7-97-3)	0-59-4		
DFA (current infection)	13	932	131	4-3-33-0	15-0	10-5-20-2	74-0 (55-0-85-0)	2-1-35-5		
Overall (current infection)	47	6 450	787	0-65-3	12-2	10-0-15-1	90-5 (88-3-92-4)	0-3-35-2		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	32	3 774	752	0-53-3	21-9	16-9-27-4	92-9 (91-0-94-4)	1-3-55-9		
IgM (recent infection)	14	3 045	326	0-86-7	11-5	5-5-19-3	97-0 (96-0-97-7)	0-51-1		
IgA (recent infection)	7	2 394	90	0-8-7	2-4	0-5-5-5	90-1 (82-1-94-5)	0-16-4		
Not specified	5	847	178	5-5-32-3	18-0	8-1-30-8	94-4 (89-8-97-0)	0-72-2		
Unclear	6	486	77	3-3-33-0	14-7	6-8-24-6	85-2 (69-8-92-8)	0-53-7		
Women with miscarriage or ectopic pregnancy										
Current genital infection										
PCR (current infection)	3	256	36	1-4-22-9	10-8	1-4-26-9	90-9 (76-4-96-5)	0-100		
Culture (current infection)	2	112	7	5-0-16-7	7-1	0-21-8	52-1 (0-88-0)	-		
DFA (current infection)	3	434	76	7-2-25-5	14-4	4-9-27-6	90-8 (76-1-96-5)	0-100		
Overall (current infection)	8	802	119	1-4-25-5	11-5	5-6-19-2	87-5 (77-6-93-0)	0-42-5		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	7	512	83	6-4-45-0	19-8	10-4-31-1	85-8 (72-7-92-6)	0-61-0		
IgM (recent infection)	6	376	83	0-38-3	18-0	9-3-28-6	77-4 (49-9-89-8)	0-56-0		
Not specified	2	149	13	0-14-6	4-7	0-27-9	93-8 (80-0-98-1)	-		
Unclear	1	84	2	-	2-3	0-3-8-3	-	-		
Symptomatic women										
Current genital infection										
PCR (current infection)	48	14 360	1 116	0-68-0	8-7	6-1-11-6	96-9 (96-4-97-3)	0-35-1		
Culture (current infection)	13	3 085	831	0-7-89-3	25-7	9-4-46-6	99-3 (99-1-99-4)	0-98-7		
DFA (current infection)	18	2 046	346	0-60-0	16-6	10-5-23-7	93-1 (90-5-95-0)	0-52-6		
Overall (current infection)	79	19 491	2 293	0-89-3	12-7	9-4-16-5	98-1 (97-9-98-3)	0-54-6		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	25	2 607	657	0-86-0	21-5	14-6-29-2	95-1 (93-8-96-2)	0-65-9		
IgM (recent infection)	9	1 042	160	0-86-0	13-9	1-9-33-6	98-2 (97-6-98-7)	0-91-3		
IgA (recent infection)	5	365	93	3-7-59-6	24-9	6-6-49-6	96-0 (93-0-97-7)	0-100		
Not specified	14	4 672	1 017	2-6-46-6	17-9	9-8-27-9	98-4 (98-0-98-7)	0-65-6		
Unclear	8	1 423	136	1-7-30-0	8-7	5-2-12-8	81-9 (65-5-90-5)	0-3-24-9		
Symptomatic men										
Current genital infection										
PCR (current infection)	14	7 160	726	4-2-33-3	13-9	8-3-20-6	97-3 (96-5-98-0)	0-46-4		
Culture (current infection)	5	4 744	75	0-4-19-6	8-7	1-1-21-7	97-3 (95-6-98-3)	0-72-7		
DFA (current infection)	13	2 288	335	4-7-52-0	29-4	16-1-44-6	97-0 (95-9-97-7)	0-88-4		
Overall (current infection)	32	14 192	1 136	0-4-52-0	18-4	13-3-24-0	98-1 (97-8-98-4)	0-55-5		
Anti-CT immunoglobulins										
IgG (lifetime exposure)	8	831	164	5-1-46-0	16-9	9-4-25-8	89-9 (82-6-94-2)	0-52-8		
IgM (recent infection)	3	330	24	2-8-12-2	6-0	1-4-13-0	78-5 (31-0-93-3)	0-100		
Not specified	7	1 952	719	5-7-49-1	21-5	8-6-38-0	97-9 (96-9-98-5)	0-83-0		
Unclear	6	4 731	224	1-6-76-9	31-3	11-2-55-9	99-0 (98-6-99-3)	0-100		

Table 2. Meta-regression findings for the sources of between-study heterogeneity in CT prevalence in MENA

Predictors		Studies	Univariable analyses		Multivariable analysis	
		Total N	OR (95% CI)	p-value*	AOR (95% CI)	p-value**
At-risk population	General populations	113	1-00		1-00	
	Populations at intermediate risk	15	0-76 (0-35-1-66)	0-488	2-13 (1-01-4-48)	0-047
	Populations at high risk	37	2-50 (1-46-4-29)	0-001	8-08 (4-55-14-34)	<0-0001
	Infertility clinic attendees	111	3-84 (2-62-5-61)	<0-0001	3-76 (2-64-5-35)	<0-0001
	Women with miscarriage or ectopic pregnancy	24	4-01 (2-11-7-61)	<0-0001	2-76 (1-53-4-98)	0-001
	Symptomatic women	140	3-71 (2-59-5-32)	<0-0001	3-51 (2-51-4-90)	<0-0001
	Symptomatic men	56	5-64 (3-54-8-99)	<0-0001	9-65 (5-61-16-61)	<0-0001
	Assay type					
	PCR (current infection)	170	1-00		1-00	
	Culture (current infection)	35	1-94 (1-12-3-36)	0-018	1-29 (0-77-2-16)	0-333
Sample size	DFA (current infection)	61	2-69 (1-73-4-17)	<0-0001	1-97 (1-28-3-04)	0-002
	Anti-CT immunoglobulins					
	IgG (lifetime exposure)	106	3-36 (2-33-4-85)	<0-0001	2-28 (1-60-3-25)	<0-0001
	IgM (recent infection)	45	1-27 (0-77-2-08)	0-343	0-94 (0-60-1-48)	0-795
	IgA (recent infection)	15	1-02 (0-46-2-25)	0-966	0-82 (0-41-1-66)	0-584
	Not specified (IgG, IgM, or IgA)	41	2-55 (1-52-4-26)	<0-0001	2-05 (1-28-3-28)	0-003
	Unclear	23	2-10 (1-09-4-04)	0-027	1-44 (0-79-2-62)	0-231
	Year of publication†					
	≥200	152	0-37 (0-28-0-50)	<0-0001	0-59 (0-44-0-77)	<0-0001
	Year of data collection (median)	496	0-97 (0-95-0-98)	<0-0001	-	-
Country	Other MENA countries	226	1-00		1-00	
	Egypt	83	1-61 (1-10-2-36)	0-015	0-92 (0-65-1-32)	0-660
	Iran	145	0-83 (0-60-1-14)	0-243	0-85 (0-64-1-12)	0-243
	Pakistan	42	0-28 (0-17-0-47)	<0-0001	0-29 (0-17-0-49)	<0-0001
Sex	Men	126	1-00		1-00	
	Women	370	1-37 (1-00-1-89)	0-052	2-13 (1-43-3-16)	<0-0001

*Predictors with p-value ≤0.1 were eligible for inclusion in the multivariable analysis.
**Predictors with p-value <0.05 were retained in the final multivariable model.
†Only year of publication was considered for the multivariable meta-regression analysis due to collinearity with year of data collection.
Adjusted R² in the final multivariable model=32-0%
AOR=Adjusted odds ratio. CI=Confidence interval. OR=Odds ratio.

CONCLUSIONS

- CT prevalence in MENA’s general populations is comparable to global levels.
- The high CT prevalence in infertility clinic attendees and in women with miscarriage or ectopic pregnancy may suggest considerable CT disease burden with important socio-cultural implications.
- CT transmission appears to be driven by pockets of high sexual risk behavior.
- Targeted and culturally-sensitive sexual health programs including screening services for at-risk populations are warranted.

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