Risk factors for *Chlamydia trachomatis* infection in adolescents: results from a representative population-based survey in Germany, 2003–2006

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Infections with *Chlamydia trachomatis* (CT) can lead to severe sequelae; however, they are not notifiable in Germany. We tested urine samples from participants of KiGGS (German Health Interview and Examination Survey for Children and Adolescents) for CT infections and linked the results to demographic and behavioural data from 1,925 participants (girls aged 15–17 years and boys aged 16–17 years) to determine a representative prevalence of CT infection in adolescents in Germany and to assess associated risk factors. Prevalence of CT infection was 2.2% (95% CI: 1.4–3.5) in girls and 0.2% (95% CI: 0.1–0.7) in boys. CT infection in girls was associated with higher use of alcohol, marijuana and cigarettes, lower social status, oral contraceptive use, pregnancy, repeated lower abdominal pain and higher rates of doctors' consultations within the preceding three months and consultation of gynaecologists within the last 12 months. In multiple logistic regression, we identified two predictors for CT infection: marijuana consumption often or several times within the last 12 months ($F(1,164)=7.56$; $p<0.05$) and general health status less than 'very good' ($F(1,164)=3.83$; $p=0.052$). Given our findings, we recommend enhancing sex education before sexual debut and promoting safe sex practices regardless of the contraceptive method used. Well-informed consumption of alcohol should be promoted, the risky behaviour of people intoxicated through consumption of marijuana highlighted and doctors' awareness of CT screening enhanced.

Introduction

Infections with *Chlamydia trachomatis* (CT) are the most frequently reported urogenital, bacterial sexually transmitted infections (STIs) worldwide. Latest figures (2005) from the World Health Organization (WHO) show that there were an estimated 101.5 million new cases per year of CT infection among adults aged 15 to 49 years [1].

In Europe, prevalence of CT infection among unscreened asymptomatic women ranges between 1.7% and 17% [2], with sexually active women and men under the age of 20 years and 25 years respectively being most affected. CT infections are asymptomatic in up to 90% of women and more than 50% of men [3]. Chlamydial infections can cause infertility in men and women and according to WHO, 10–15% of women with untreated infections develop symptomatic pelvic inflammatory disease or other severe sequelae such as infertility or extrauterine pregnancies [4]. However, the effect of screening programmes and intensified testing, CT persistence and natural history of CT infections are still under debate [5-10].

In Germany, infections with CT are not mandatorily reportable and no prevalence data exist at the national level. A laboratory reporting system exists only in one federal state, Saxony, where an increase in the number of reported infections has been observed, from 26.3 per 100,000 inhabitants in 2003 to 100.8 per 100,000 in 2009 [11].

Population-based studies have been performed in the United Kingdom (UK) (National Survey of Sexual Attitudes and Lifestyles, Natsal) [12], France (NatChla study) [13] and the United States (National Health and Nutrition Examination Survey, NHANES) [14] and prevalence of CT infection estimated. In the French study, which was performed among 18–29 year-olds, the prevalence in men was 2.5% (95% CI: 1.2–5.0) and 3.2% (95% CI: 2.0–5.3) in women. Infections were associated with last sex with a casual partner in both men and women, last sex with a new partner and living in Paris in men, and multiple partners in the last year, same-sex partners and low educational level in women [13]. In the UK study, sexual behaviour was assessed in 16–44 year-olds, such as age at first sex, contraception used at first intercourse, condom usage, pregnancy

and history of STIs. The highest prevalence of CT infection (3.0%; 95% CI: 1.7–5.0) was found in women aged 18–24 years. Factors associated with higher prevalence in both sexes were occurrence of first intercourse before the age of 16 years, main source of information about sexual matters being friends and not being sexually competent at first intercourse [12,15]. In the United States study, CT prevalence of 3.9% (95% CI: 2.2–6.9) was found in 14–19 year-old females and was – together with gonorrhoea, *Trichomonas* or herpes simplex virus 2 infection – associated with more lifetime sexual partners. The risk of infection was higher soon after sexual initiation [14].

Within KiGGS (German Health Interview and Examination Survey for Children and Adolescents), the general health of children and adolescents aged 0–17 years was mapped nationwide between May 2003 and May 2006. It was a population-based survey that collected health status data from 17,641 participants in 167 representative sites. The participation rate was 66.6% overall. Through a brief non-responder questionnaire, it was shown that the data collected were representative for the health status of adolescents in Germany [16]. Detailed sampling methods have been described previously by Kamtsiuris et al. [17].

In our study presented here, we retrospectively tested urine samples from 1,925 KiGGS participants (girls aged 15–17 years and boys aged 16–17 years) for CT infection and linked the results to the participants' demographic and behavioural data to determine a representative prevalence of CT infection in adolescents in Germany and to assess associated risk factors. To our knowledge, this is the first time that representative population-based CT-data have been linked to demographic and behavioural data in Germany. We have previously reported the results of a random sample of 12–17 year-old KiGGS participants that was tested for CT in pools of four [18]. However, no representativeness was assured due to this subsampling and we re-tested all urine specimens in pools of four as well as in single testing [19].

In our study, we estimated the prevalence of CT infection stratified by age and sex in Germany and identified risk factors (demographic, behavioural and health-related) associated with CT infection, representative for German adolescents. In addition, we assessed the usage of healthcare structures associated with CT infection.

Methods

Data collection in KiGGS included questionnaires filled in by parents and adolescents in parallel, an interview and a physical examination performed by a medical doctor. Biological specimens were taken and results could be linked to survey data. Urine samples were stored at –50°C and retrospectively tested for CT. To reduce costs and given our experience with the results from the previous random sample [18], we limited the age groups to be tested to 16–17 year-old boys and 15–17 year-old girls.

We used BD ProbeTec ET System (strand displacement amplification (SDA) system), a nucleic acid amplification test (NAAT), for pooled and single-specimen testing [19]. Testing was performed between January 2009 and February 2010. For the analyses shown here, we only used results from single-specimen testing.

We divided Germany into two geographical regions by federal state: 'East' (Brandenburg, Mecklenburg-Vorpommern, Saxony, Saxony-Anhalt, Thuringia and Berlin) and 'West' (Schleswig-Holstein, Hamburg, Bremen, Lower Saxony, North Rhine-Westphalia, Hesse, Bavaria, Rhineland-Palatinate, Saarland and Baden-Württemberg).

The size of a residential municipality was defined as 'rural' if it had fewer than 5,000 inhabitants, 'provincial' if between 5,000 and <20,000, 'urban' if between 20,000 and <100,000 and 'metropolitan' if 100,000 or more.

For comparison of behavioural factors, self-reported variables covering the last 12 months were grouped, such as the consumption of alcohol (beer, wine and hard liquor (schnapps)) into 'two glasses per week or more' and 'one glass per week or less'. Marijuana consumption was grouped as 'often or several times' (defined as 'frequent') and 'once or never'. Tobacco smokers were defined as currently being smokers; non-smokers were defined as participants who did not report smoking at the time of the survey. Frequent smokers were defined as participants who reported smoking daily, several times or at least once a week. Being frequently in smoky rooms was defined as being in the room daily, several times a week or at least once a week (the duration of stay in the room was not defined); the analysis was stratified by smoker status (smoker and non-smoker).

Variables such as socio-economic and migrant status were defined according to standardised procedures within KiGGS. A value for social status was calculated according to Winkler [20,21] using data on the education, occupation and net household income of parents. The social status index could vary between 3 and 21: values of 3–8 were defined as low social status, 9–14 as medium and 15–21 as high. As the methods used to calculate this index were based on data from the national adult health survey from 1998, they were adjusted for inflation and changes in educational systems using data from a telephone survey performed in 2003–04 [20].

The KiGGS participants were selected in a complex two-step sampling technique, based on a systematic sample of 167 study locations and local population registries. For all statistical analysis, we used sampling weights to adjust for sampling and study design-driven

Table 1

Urine specimens positive for *Chlamydia trachomatis* and weighted age- and sex-specific prevalence[a] of *C. trachomatis* infection, KiGGS participants[b], Germany, 2003–2006 (n=1,925)

Age in years	Female		Male	
	Number positive/ total number tested	Prevalence of CT infection (95% CI)	Number positive/ total number tested	Prevalence of CT infection (95% CI)
15	6/381	1.4 (0.6–3.3)	NA	NA
16	6/378	1.8 (0.6–4.9)	1/408	0.2 (0.0–1.3)
17	12/377	3.3 (1.8–6.1)	2/381	0.2 (0.1–1.0)
Total	**24/1,136**	**2.2 (1.4–3.5)**	**3/789**	**0.2 (0.1–0.7)**

CI: confidence interval; CT: *Chlamydia trachomatis*; KiGGS (German Health Interview and Examination Survey for Children and Adolescents); NA: not applicable.

[a] Weighted prevalence, as a percentage. As selected persons were representative for the general population, weighted proportions are reported. In addition, actual numbers are shown here to allow assessment of the size of the study and number of participants included in each subgroup.

[b] Samples tested were from 16–17 year-old boys and 15–17 year-old girls.

unequal probabilities of the participants being selected for the study [16]. As the selected persons were representative for the general population, apart from Table 1, we report (weighted) proportions, not actual numbers. .

Statistical analysis was performed using the Complex Samples Module in SPSS Statistics Version 17.0.3 and 18.0.0 (IBM SPSS, Chicago, IL, United States). For descriptive analyses of categorical data, frequencies and proportions were calculated. For measures of association chi-square and Fisher´s exact test were applied and odds ratios (ORs) with 95% confidence intervals (CIs) calculated. For continuous data, means were computed using the Complex Samples General Linear Model for linear regression analysis and Student's two-sample t-test. Statistical significance for all tests was set at the ‹0.05 level.

We performed multiple logistic regressions to assess risk factors for positive CT test results in girls aged 15–17 years. The criterion for inclusion in the multiple logistic regression model was having been statistically significant in a preliminary simple logistic regression, and as a result of this, boys were not included. Regression coefficients, Wald statistics and ORs with 95% CIs were assessed in two different models assessing behavioural risk factors and health(care)-related factors for the CT test results.

Data protection was assured, as no patient-identifying data were made available to us. Approval was granted by the Ethics Committee from University Hospital Charité in Berlin.

Results

Study population

We tested urine samples of 1,925 KiGGS participants: 789 boys aged 16–17 years and 1,136 girls aged 15–17 years. These numbers represent all study participants for whom urine samples were available. Overall, urine samples were collected for 92% of boys and 83% of girls in the respective age groups. We did not see a systematic bias in those who provided a urine sample, as there was no difference in their socio-demographic variables compared with those who did not provide a sample. The 1,925 participants included could be regarded as representative of the German population based on the geographical area of residence, the size of the residential municipality and social status (data not shown).

Prevalence of *C. trachomatis* infection

Overall, the weighted prevalence of CT infection was 2.2% among the girls tested and 0.2% among the boys (Table 1). The prevalence increased by age in the girls, being highest (3.3%; 95% CI: 1.8–6.1) in those aged 17 years.

Behavioural risk factors/indicators

No difference in geographical region of residence, size of residential municipality, migrant status or educational level could be found between CT-positive and CT-negative participants. Girls from low or medium social status were five times more likely to be CT-positive than girls from high social status (2.8% of girls from low or medium social status were CT-positive compared with 0.5% of girls from high social status (OR: 5.4; 95% CI: 0.9–31.4).

A large majority of participants reported that they consumed alcohol, there was no difference between CT-positive and CT-negative participants (100% compared with 92.5%). However, in 15 and 16 year-old girls, elevated consumption of alcohol (defined as two or more glasses per week), and frequent marijuana consumption (defined as often or several times) within the last 12 months was associated with CT infection, as shown in Table 2. Consumption of wine and hard

Table 2

Risk factors for *Chlamydia trachomatis* infection by *C. trachomatis* positivity and sex, KiGGS participants[a], Germany, 2003–2006 (n=1,925)

Risk factor	Age in years[c]	Female			Male[b]	
		Percentage CT positive[d]	Percentage CT negative[d]	Unadjusted OR (95% CI)[d]	Percentage CT positive[d]	Percentage CT negative[d]
Alcohol consumption (≥2 glasses/week)[e]	15	22.0	9.9	2.6 (0.3–24.2)	NA	NA
	16	73.3	16.9	13.5 (2.7–66.7)	100	48.4
	17	9.4	21.6	0.4 (0.0–3.0)	0	57.9
Marijuana consumption (often/several times)[f]	15	20.6	1.9	13.1 (1.3–133.2)	NA	NA
	16	43.0	5.3	13.4 (1.2–149.0)	0	9.3
	17	16.0	7.4	2.4 (0.5–12.6)	0	12.1
Tobacco smoking						
Smokers	NA	68.5	35.0	4.0 (1.6–10.0)	43.1	43.0
Mean number of cigarettes smoked daily	NA	13.3	7.8	p<0.02	22.0	9.6
Mean age when started smoking	NA	13.6 years	13.9 years	p=0.53	11.0 years	14.2 years
Being frequently in smoky rooms[g]						
All participants	NA	91.6	66.2	5.6 (1.6–19.4)	65.0	73.4
Smokers only	NA	90.0	81.0	2.1 (0.4–10.2)	100	84.1
Non-smokers only	NA	94.2	58.4	11.7 (1.4–97.9)	38.6	64.8

CI: confidence interval; CT: Chlamydia trachomatis; KiGGS (German Health Interview and Examination Survey for Children and Adolescents); NA: not applicable; OR: odds ratio.

[a] Sample comprised 16–17 year-old boys and 15–17 year-old girls.

[b] Due to small numbers and lack of statistical significance, no OR is shown for boys.

[c] Applicable for consumption of alcohol and marijuana only. For tobacco smoking, the participants were analysed by the respective age group (see footnote a).

[d] Weighted percentage, unless otherwise specified (as in Mean number of cigarettes smoked daily and Mean age when started smoking, where significance was calculated using Complex Samples General Linear Model for linear regression analysis). As selected persons were representative for the general population, (weighted) proportions, not actual numbers, are reported.

[e] Consumption of two or more glasses per week in comparison with one glass per week or less.

[f] 'Often/several times' in comparison with 'once/never'.

[g] Defined as being in the room daily, several times a week or at least once a week (the duration of stay in the room was not defined).

liquor was particularly associated with CT infection in the 15–16 year-old girls (data not shown).

Of all the participants tested, 66.6% of those who were CT-positive and 38.5% of those who were CT-negative smoked tobacco (OR: 3.2; 95% CI: 1.4–7.3). The mean number of cigarettes smoked daily was 13.9 in those who were CT-positive and 8.7 in those who were CT-negative (p=0.02). A total of 89.7% of CT-positive and 69.3% of CT-negative participants reported being in a smoky room at least once a week (OR: 3.9; 95% CI: 1.3–11.3).

Oral contraceptive use was associated with CT infection. Girls taking them were three times more likely to be CT-positive than those who did not (4.1% vs 1.3%; OR: 3.2; 95%CI: 1.1–8.7). In 15 year-old girls, CT-positivity was 5.3% in those who took oral contraceptives and 0.8% in those who did not (OR: 7.3; 95% CI: 1.3–42.1). In 16 year-old girls, it was 4.6% in those using oral contraceptives and 0.5% in those who did not (OR: 9.4; 95% CI: 0.9–96.7).

A total of 5% of all CT-positive girls were pregnant, compared with 0.1% of all who were CT-negative (OR: 91.1; 95% CI: 5.3–1,560.7). Vice versa, of all pregnant girls, 65.8% were CT-positive compared with a prevalence of 2.1% in non-pregnant girls.

A multiple logistic regression analysis was performed using CT-positive status as outcome, three health behaviour predictors (frequent marijuana consumption within the last 12 months, being frequently in smoky rooms and use of oral contraceptives), as well as one social class predictor. As shown in Table 3, according to the Wald criterion, only frequent marijuana consumption reliably predicted CT-positivity (Wald-F(1,164)=7.56; p<0.05). The OR indicates that girls frequently smoking marijuana are six times more likely to be CT-positive than those who do not frequently

Table 3

Multivariate logistic regression models of *Chlamydia trachomatis* prevalence in 15–17 year-old girls as function of behavioural risk factors and health(care)-related factors, KiGGS participants, Germany, 2003–2006 (model 1, n=1,041; model 2, n= 945)[a]

Factor	B	Wald-F	OR (95% CI)
Model 1: Behavioural risk factors			
Social class	−1.63	2.88	0.20 (0.03–1.31)
Frequent marijuana consumption	1.88	7.56	6.54 (1.70–25.18)
Frequent exposure to smoky rooms	1.47	3.53	4.36 (0.93–20.53)
Oral contraceptive use	0.71	1.30	2.03 (0.59–6.94)
(Constant)	−5.18	64.93	NA
Model 2: Health(care) factors			
General health status 'very good'	−2.07	3.83	0.13 (0.02–1.02)
Repeated episodes of lower abdominal pain within last 3 months	0.78	1.92	2.2 (0.72–6.70)
Gynaecologist visit within last 12 months	1.56	3.40	4.77 (0.90–25.46)
(Constant)	−5.23	77.82	NA

B: regression weight; CI: confidence interval; KiGGS (German Health Interview and Examination Survey for Children and Adolescents); NA: not applicable; OR: odds ratio.

[a] The fewer numbers are due to missing data.

smoke marijuana. Although being frequently in smoky rooms was not significantly identified as a predictor of CT-positivity (F(1,164)=3.53; p=0.06), its effects need to be assessed through larger studies.

Health(care)-related factors

All CT-positive participants were less likely to rate their general health status as 'very good', compared with those who were CT-negative, 2.5% vs 21.0% (OR: 10.5; 95% CI: 2.3–47.6). CT-positive girls additionally reported more frequently repeated episodes of lower abdominal pain within the last three months than CT-negative girls did, 45.5% vs 23.5% (OR: 2.7; 95% CI: 1.0–7.3).

Participants with CT more often consulted a doctor within the last three months, (82.2% vs 63.2%; OR: 2.7; 95% CI: 1.1–6.8). In girls, this difference was also seen in those visiting a gynaecologist within the last 12 months, 81.1% in those who were CT-positive compared with 46.0% in those who were CT-negative (OR: 5.0; 95% CI: 1.4–17.9).

The multiple logistic regression analysis to predict CT-positive status in girls showed that only general health status 'very good' significantly improved the model (F(1,164)=3.83, p=0.052). The OR and regression weight indicated that having a general health status that was not considered 'very good' increased the chance of being CT-positive. The other two predictors of the logistic regression model were repeated episodes of lower abdominal pain within the last three months and a gynaecologist visit within the last 12 months. According to the Wald criterion, the ladder variable did not significantly predict a positive CT status. (F(1,164)=3.40, p=0.07). However, the OR indicates an almost five times higher chance of being CT-positive if the girl had been to a gynaecologist within the last 12 months. Another possible predictor of the model that was not significant (F(1,164)=1.92; p=0.17) was repeated episodes of lower abdominal pain, but the OR showed a more than double increased chance of CT infection.

Healthcare structures

Overall, adolescents visited the following medical specialists at their last consultation: general practitioner 42.4%, paediatrician 12.6%, dermatovenerologist 6.6% or gynaecologist 8.5%. The medical specialty at the last visit by CT-positivity and sex is shown in Table 4.

Discussion

In this first, representative, population-based study of adolescents in Germany, we found an increase in the prevalence of CT infection with age in girls. As participants were unaware of their test results when filling out the questionnaire, we consider that their responses were unbiased. The estimated prevalence was particularly high in those who reported oral contraceptive use or who were pregnant. Independent predictors of CT infection were found to be frequently smoking marijuana and a general health status less than 'very good'. Social status, consumption of alcohol or marijuana and smoking were associated with CT- infection rates. Repeated lower abdominal pain was associated

Table 4

Medical specialty visited at last consultation by *Chlamydia trachomatis*-positivity and sex, KiGGS participants[a], Germany, 2003–2006 (n=1,925)

Medical specialty visited at last consultation	Female			Male[b]	
	Percentage CT positive[c]	Percentage CT negative[c]	Unadjusted OR (95% CI)	Percentage CT positive[c]	Percentage CT negative[c]
General practitioner	44.3	40.7	1.2 (0.5–2.8)	22.0	49.1
Gynaecologist	24.3	15.0	1.8 (0.7–4.6)	0.0	0.0
Ophthalmologist	15.7	4.5	4.0 (0.8–19.8)	0.0	3.7
Paediatrician	9.9	12.4	0.8 (0.2–2.9)	35.0	12.8
Dermatovenerologist	0.0	6.3	NA	43.1	7.1
Other[d]	5.8	21.1	0.2 (0.1–1.0)	0.0	27.2

CI: confidence interval; CT: *Chlamydia trachomatis*; KiGGS (German Health Interview and Examination Survey for Children and Adolescents); NA: not applicable; OR: odds ratio.

[a] Sample comprised 16–17 year-old boys and 15–17 year-old girls.

[b] Due to small numbers and lack of statistical significance, no OR is shown for boys.

[c] Weighted percentage. As selected persons were representative for the general population, (weighted) proportions, not actual numbers, are reported.

[d] Comprised internist, orthopaedist, otorhinolaryngologist (ear, nose and throat doctor), neurologist/psychiatrist, psychologist, surgeon, radiologist, urologist, school physician, other doctor.

with CT infection in girls and infected girls consulted a gynaecologist more often than CT-negative girls did.

An estimation of sexual experience in German youth has been reported through another representative national study, a telephone survey performed by the Federal Centre for Health Education (BzgA) during the same time period [22]. In this study, 2,500 randomly chosen adolescents aged 14–17 years were asked about their attitudes and behaviour concerning sexuality and contraception. Some 23% of the 15 year-old girls were sexually experienced, reaching 73% in 17 year-old girls. A total of 35% and 66% of 16 and 17 year-old boys respectively were sexually experienced. Taking these results into account, our findings showed the highest prevalence of CT infection (6.8%) in 15 year-old girls who were presumably sexually experienced. Overall, the prevalence in girls aged 15–17 years was 4.4% and 0.8% in 16–17 year-old boys. However, participants in both surveys were probably not identical, limiting further analysis.

A 2.2% prevalence of CT infection in all girls aged 15–17 years in our study in Germany was lower than the 3.9% found by Forhan et al. in females aged 14–19 years in the United States [14]. The highest prevalence we found, in 15 year-old girls presumed to be sexually experienced (6.8%), was comparable to the 7.1% found in sexually experienced female NHANES participants in the United States [14]. Most other population-based studies were performed in sexually experienced participants aged 18–24 years, showing among women a prevalence of 3.6% (95% CI: 1.9-6.8) in France, 4.7% (95% CI: 2.5–8.5) in Slovenia and 3.0% (95% CI: 1.7–5.0) in the UK [12,13,23]. In an observational study performed in 2004 among sexually experienced females aged 14–20 years in Berlin, Germany, CT-positivity of 6.5% (95% CI: 4.7–9.0) was found [24]. In a study performed in 2008–09 in a mid-sized town in Germany, a prevalence of 4.2% was found in 14–19 year-old females and was associated with an early age of first sexual contact and increasing number of lifetime sexual partners [25]. The prevalence in our study might have been underestimated due to the long storage time between taking of specimens being taken and testing. In addition, if the collected urine was not first-void, there could be a reduction in sensitivity [3,26,27].

In our study, prevalence of CT infection was higher in girls than in boys. Men in general are reported to have CT infections at an older age than women [28, 29]. The reason could be that (younger) females tend to have sex with older males, as shown in previous studies [30, 31]. Bridging by age (defined as having sexual partners in more than one age group) was a predictor for reduced condom use, probably due to differences in power to make decisions on contraceptive use with older partners [30,32]. Furthermore, 'age-bridgers' engaged in more risky sexual behaviour in a cohort of CT-positive heterosexual young men aged 14–24 years [33]. Other reasons for higher prevalence in young girls could be cervical ectopy [34], earlier sexual debut or more partners during this earlier period of sexual experience [23,25].

Poor healthcare-seeking behaviour associated with higher infection rates, lower partner referral or inadequate care have been reported for people with lower socio-economic status in many countries [35-37]: our findings of a higher prevalence in girls with low or medium social status are therefore not surprising. In Germany, a quarterly fee has to be paid by persons insured by one of the general health insurances in order to access healthcare, posing a possible barrier for people with a small income. Therefore the higher prevalence in groups with low or medium social status could be due to a lower healthcare use and subsequently a lower chance to be tested for CT [38-40].

Although the number of participants in our study was small, we found an association between alcohol consumption and infection, particularly in younger girls. Excessive consumption of alcohol has been reported in association with an increase in sexual encounters and multiple (new) sexual partners and engagement in (unprotected) casual sex [41, 42]. In a study performed among female Irish students, consumption of alcohol by the person themselves or by their partners was the most frequent cause of unprotected sex [43]. Alcohol consumption can lead to failure in condom usage, such as breakage or falling off, and was positively associated with infection if male partners had drunk alcohol [44,45].

We found that tobacco smoking was associated with CT infection, similar to the findings of a study among women aged 18–25 years in Costa Rica [46]. The immunosuppressive effect of cigarette smoking on the cervical epithelium – due to a decrease in the concentration of Langerhans' cells and hence reduced ability to present viral antigens to T lymphocytes and subsequent persistence of local viral infection and the increased likelihood of the development of a virally induced neoplastic transformation – has been shown for human papillomavirus previously [47]. Smoke-induced persistent *C. pneumoniae* infections have been observed in endothelial cells [48]. Whether there is a biological effect of smoking on CT infection is, however, unknown and warrants further investigation. In our studied population, it is also possible that smoking was associated with an active nightlife, resulting in smoking and drinking with peers and more frequently engaging in casual sex; unfortunately, however, there was no systematic gathering of this information in the survey. Adolescents who reported being frequently in smoky rooms might also be from families with lower social status and hence smoking might be a confounder. Nevertheless, a dose–response relationship in the number of cigarettes smoked per day supports some effect of smoking in our study.

An association between the consumption of marijuana and CT infection was found in African-American adolescents [49]. In a representative survey performed by BzgA in 2011, no association between taking illegal drugs – dominated by marijuana in Germany – and social or educational status was found [50]; hence, social class might have little influence on marijuana consumption in Germany.

Oral contraceptive use and pregnancy was positively associated with CT infection in our study, as previously reported [34,45,51]. One explanation could be that young girls who take the pill no longer use condoms [24], as pregnancy prevention has been frequently reported as a major reason for condom use in young females. In the United States, an increase in oral contraceptive intake from 8% in 9th-grade females to 30% in 12th-grade females was found as was a concomitant decrease in condom use from 56% to 49% in those sexually active females [52]. We do not know if the pregnancies in our study were unwanted; however, in the UK, which has the highest teenage-pregnancy rates in Western Europe [53], CT infection rates are very high in young girls too, with 3,027 reported infections per 100,000 population in females aged 15–19 years in 2011 in England [54]. In our study, the number of pregnant girls was very low, and hence the confidence intervals were very wide.

CT-positive girls more frequently reported lower abdominal pain than CT-negative girls. These symptoms may be related to CT infection as lower abdominal pain has been described in acute CT infection and also in patients with pelvic inflammatory disease [55]. In our study however, we do not know whether participants were aware of a possible previous untreated CT infection or the detailed time frame of pain. Also, lower abdominal pain can have many causes and it is therefore difficult to establish a causal link between lower abdominal pain and CT infection. Even if the pain was linked to CT infection, physicians might not have considered CT infection and might not have taken their sexual history. Our study was performed in 2003–2006 and CT screening for young sexually active women was only introduced in 2008 in Germany. Therefore, physicians were unable to test asymptomatic persons free of charge at that time and consequently might have missed some CT infections.

Currently, annual CT screening for sexually active women under the age of 25 years can be performed using urine samples [56] and it is common practice for this to be done at gynaecologists' practices; however, the extent of screening uptake is currently unknown in Germany. From our study, we recommend extending the screening guidelines to other specialties in Germany, such as GPs, paediatricians and dermatovenerologists, as in our study, the majority of adolescents attended these doctors and as urine can easily be collected in these practices.

There are several limitations of our study. First, no data on sexual activity were collected; estimation of sexual activity had to be derived from another national representative study, thus posing a risk of uncertainty. However, as both surveys were representative,

behavioural data from the other representative survey were applied to our participants. Second, lower abdominal pain was reported by participants and not verified by clinical examination during the study visit. Similarly, information on most other risk factors analysed were self-reported and recall-bias or social expectancy is possible. However, as participants were unaware of their CT-infection status, this bias is likely to be equally distributed. Third, as the number of urine samples positive for CT was low, this led to wide confidence intervals in the univariate and multivariable analysis. Therefore, it is possible that more risk factors would have been identified if there had been a larger sample size or higher prevalence. Nevertheless, we believe that the results presented in this paper are valuable, as it is very difficult to obtain such a large, representative sample size.

Recommendations

To reduce CT prevalence, particularly in young girls, a number of interventions need to take place in Germany.

- Sex education needs to be enhanced before sexual debut and safe sex practices promoted with all new partners, regardless of the contraceptive method used.
- All sexually active girls and boys should be offered a CT test when attending a medical doctor. Those tested positive should be treated adequately, regardless of whether or not they have symptoms, to reduce the prevalence in the community. Asymptomatic men represent a reservoir for CT, potentially leading to females becoming infected. In a study of asymptomatic couples in Germany in 1996 using ligase chain reaction, more infections were detected in urine specimens from males than from females [57]: this supports the inclusion of men in CT screening. It has been shown that screening coverage needs to increase up to 26–43% to bring about substantial reductions of CT prevalence [58].
- Social discrimination needs to be reduced by ensuring uniform access to the healthcare system.
- Well-informed consumption of alcohol should be promoted and the risky behaviour of people intoxicated through consumption of marijuana highlighted through targeted adolescent health campaigns.
- Doctors should be made more aware of the need to test for CT and continuing sexual health education for doctors adopted. Screening should be extended to other specialties , so that urine samples for testing are taken at all consultations, not just those of gynaecologists. A GP's surgery can be an ideal place for CT screening, as adolescents perceive it as a normal place to discuss health issues [59] and hence can particularly be used to increase testing in boys.
- Appropriate models should be created for payment of counselling, particularly regarding contraception and sexual behaviour.

For the next round of this population-based survey starting at the end of 2013, it is encouraged to test specimens for CT shortly after sampling to reduce possible loss in sensitivity due to long storage. In addition, basic questions regarding sexual behaviour should be included. Finally, repeated cross-sectional surveys on a representative sample of German youth will provide information on possible changes in prevalence and risk behaviour and hence allow revaluation of recommendations.

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Conflict of interest

None declared.

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