

# A survey of syphilis knowledge among medical providers and students in Rhode Island

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## Abstract

**Background:** In the United States, syphilis cases have increased dramatically over the last decade. Recognition and timely diagnosis by medical providers are essential to treating syphilis and preventing further transmission.

**Methods:** From 2016 to 2017, a cross-sectional survey was performed among medical students, residents, fellows, and attending physicians in Rhode Island. Topics included demographics, level of medical training, experience diagnosing and treating syphilis, and familiarity with the reverse testing algorithm. Participants were asked 25 true/false questions to assess basic knowledge of syphilis, which covered five domains: epidemiology, transmission, clinical signs and symptoms, diagnosis, and treatment. Univariate and bivariate analyses were performed to determine knowledge levels across provider characteristics. Significance was defined as  $p < 0.05$ .

**Results:** Of the 231 participants, 45% were medical students, 34% were residents or fellows, 11% were medicine attendings (non-infectious diseases), and 10% were infectious diseases attendings. The overall mean score was 9.79 (out of 25; range = 0–23,  $p \leq 0.001$ ). Mean scores differed significantly ( $p < 0.001$ ) across groups, including 7.68 for students (range = 0–16), 10.61 for residents/fellows (range = 3–17), 10.41 for non-infectious diseases attendings (range = 4–18), and 16.38 for infectious diseases attendings (range = 6–23). Familiarity with the reverse sequence algorithm was low with only 22% having heard of it. Infectious diseases attendings were significantly more knowledgeable compared to other groups. Overall and across domains, infectious diseases attendings had significantly higher scores except when compared to non-infectious diseases attendings in the epidemiology domain and residents/fellows in the transmission domain.

**Conclusion:** Overall syphilis knowledge among non-infectious diseases medical providers was low. Improved education and clinical training are needed to promote early diagnosis, treatment, and prevention efforts.

## Keywords

Syphilis, medical students, healthcare providers, diagnosis, prevention

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## Introduction

In 2017, a total of 30,644 cases of primary and secondary syphilis infection, caused by *Treponema pallidum*, were reported in the United States.<sup>1</sup> The incidence (9.5 cases per 100,000 population) again rose markedly after nearly two decades of an uptrend, marking a 10% increase from the preceding year and a 450% relative increase since syphilis incidence reached its historic nadir around the year 2000. The resurgence in incident syphilis infection has been concentrated among certain subpopulations, the most notable of whom are gay, bisexual, and other men who have sex with men (MSM). MSM accounted for approximately 68% of

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cases in 2017.<sup>2</sup> Populations of color also experience disproportionately high rates, with a rate of 24.2 cases per 100,000 population among Black/African American individuals compared to 5.4 among White individuals.<sup>1</sup> By age group, individuals 20–29 years of age experience the highest annual rates of syphilis diagnoses. Increasing rates of congenital and ocular syphilis cases have also been reported.<sup>3,4</sup> In response to the increasing number of syphilis cases, the Centers for Disease Control and Prevention (CDC) has issued a call to action to better engage medical providers and the public.<sup>5</sup>

In addition to epidemiologic changes, the methods for syphilis screening and diagnosis are also evolving. Traditional syphilis testing involves a two-stage algorithm with an initial non-treponemal test (i.e. rapid plasma reagin (RPR) or venereal disease research laboratory (VDRL)) which, if positive, is followed by a confirmatory treponemal test (i.e. fluorescent treponemal antibody absorption (FTA-ABS) or *Treponema pallidum* particle agglutination (TP-PA)).<sup>6</sup> However, the CDC has recently indicated support of a “reverse algorithm” for syphilis testing, which involves initial testing with a treponemal-specific antibody test in the form of cheaper and higher-throughput enzyme or chemiluminescence immunoassays (EIA/CIA), followed by confirmatory testing with a non-treponemal test.<sup>7</sup> A recent survey of laboratories in the United States found that 28% of pathology laboratories reported having revised their syphilis screening algorithm within the past 2 years, and 16% reported currently using the reverse sequence approach.<sup>8</sup> Awareness of high-risk populations and appropriate diagnostic approaches among medical providers is critical to accurately diagnose and treat syphilis. In order to assess knowledge and awareness of syphilis, we conducted a cross-sectional survey to assess general and reverse sequence-related knowledge among medical providers in Rhode Island (RI).

## Materials and methods

From 2016 to 2017, a one-time, cross-sectional survey (see Supplemental Digital Content 1, with questions and answers provided) was administered to medical students, residents, fellows, and attending physicians at the largest tertiary care system in RI. Surveys were distributed in person in paper format by the first and second authors to colleagues and attending physicians within the institution via convenience sampling at several departmental and student gatherings, including Internal Medicine and Infectious Diseases Grand Rounds events. Participants were asked to fill out a self-administered questionnaire with no limitation on time. In the setting in which these surveys were administered, there was a reasonable expectation that no participants would consult technical materials to assist in answering questions. Rationale for the survey was withheld prior to administration to avoid biasing results. The presiding institutional review board (IRB) approved the use of a standardized informed consent script in lieu of a signed form; signatures were not collected

given that they would be the only source of identifying information in the study. The large group nature of most recruitment settings precluded tracking the numbers of individuals invited to participate; as a result, the number of participants who declined to participate was not available.

The survey included a short series of initial demographic questions to assess level of medical training, prior education related to syphilis, and clinical experience with syphilis diagnosis and management. Survey participants were then asked 25 true/false questions to assess knowledge about syphilis. As is consistent with validated knowledge measures for other sexually transmitted infections (STIs), each of the 25 questions also included a “Don’t know” response option to discourage guessing.<sup>9,10</sup> The assessment was divided into five distinct domains, each consisting of five questions: epidemiology, transmission, clinical features, diagnosis, and treatment. A sixth domain included the reverse testing algorithm, with two questions assessing familiarity with and prior use of the algorithm and three questions testing knowledge of the algorithm itself. The survey assessment was developed by three content experts, including two infectious diseases (ID) specialists and one non-ID physician with expertise in STIs. Items were reviewed and edited for content and clarity. If any of the content experts felt an item did not adequately represent the domain or was not written clearly, it was discarded or re-written until a consensus was reached on the content and wording of the specific item. The survey was piloted with colleagues within the field for content and clarity, and those involved in this process were excluded from the formal study. Study data were managed using the Research Electronic Data Capture (REDCap) system.<sup>11</sup>

## Statistical analysis

Analyses were conducted using IBM SPSS Statistics for Windows, Release 20.0.0 (IBM Corp., Armonk, NY). Participants were classified into four groups for analysis: medical students, residents or fellows, non-ID internal medicine attendings (including subspecialists within internal medicine), and ID attendings. Initial analyses included a descriptive summary of participant demographics and clinical experience. Analyses of the 25-item syphilis knowledge scale included an examination of the full instrument for skew and kurtosis, an overall measure of normality using the Shapiro–Wilk test, and a test of the reliability of the instrument using the coefficient alpha statistic—a measure of internal consistency.<sup>12</sup> We also examined the relationships of the five knowledge domain subscales to each other, to the overall 25-item knowledge scale, and to the reverse sequence scale score using Pearson  $r$  correlations. Analysis of variance (ANOVA) was used to examine for any group differences on the five knowledge domain subscales, the overall 25-item knowledge scale, and the reverse sequence scale score. If the ANOVA was statistically significant ( $p < 0.05$ ), post hoc

least significant difference tests were conducted to identify any group differences between ID attendings and each of the other three participant groups.

## Results

### Demographics

A total of 231 participants completed the survey; 45% were medical students, 34% were residents or fellows, 11% were non-ID medicine attendings, and 10% were ID attendings (Table 1). Of the total sample, 51% identified as female and 42% identified as male (7% did not respond); this varied by training level, with 59% of medical students identifying as female, compared to 48% of non-ID attendings and 33% of ID attendings. In total, 80% of participants were 34 years of age or younger, with 60% between 25 and 34 years of age. This also varied by training level, with all but four medical students and residents/fellows reporting their age below 34 years, and non-ID and ID attendings reporting a wide range, with the majority over 35 years of age (88%;  $p < 0.05$ ). Regarding race, 62% identified as White, 23% Asian/Pacific Islander, 8% Black/African American, and 7% multiracial or another race. In total, 10% identified their ethnicity as Hispanic/Latino and 65% as non-Hispanic/Latino, and 25% gave no response.

### Experience with syphilis

Participants were asked six questions regarding their clinical experience, as well as about familiarity and use of the reverse sequence testing algorithm (Table 1). In total, 88% of the total group reported having no experience or feeling very or somewhat inexperienced with diagnosing and treating syphilis; this increased to 96% after excluding ID attendings. In contrast, 86% of ID attendings felt somewhat or very experienced with diagnosing and treating syphilis. Overall 61% felt training related to syphilis was somewhat or very inadequate, including 73% of students and 67% of residents/fellows. Conversely, 67% of non-ID attendings and 86% of ID attendings stated their training was somewhat or very adequate.

In the past 12 months, 71.9% of participants reported testing fewer than 10 patients for syphilis, and 70.6% had not treated (or referred for treatment) any patients with syphilis. Most of the residents/fellows and non-ID attending groups reported testing 1–20 patients (78.5% and 66.6%, respectively), and few from the residents/fellows and ID attending groups reported testing no patients (8.9% and 9.5%, respectively). While 42.8% of ID attendings reported treating more than three patients in the last 12 months, only 1.3% of the entire remaining group reported the same. The table illustrates other differences in the subgroups.

The study sample demonstrated limited familiarity with the reverse sequence algorithm, as 78% of participants

reported having never heard of it; this ranged from 10% among ID physicians to 93% and 92% among non-ID physicians and medical students, respectively. While 27% of residents/fellows felt at least somewhat familiar with the algorithm, 62% of ID attendings felt familiar or very familiar with the algorithm. Only 12% of the sample reported ever using the algorithm, including 1% of medical students, 4% of non-ID attendings, 15% of residents/fellows, and 67% of ID attendings.

### Reliability of the knowledge scale

The characteristics of the 25-item knowledge scale were examined and found to not violate an assumption of normality using the Shapiro–Wilk test ( $p = 0.136$ ). The scale was also found to have non-significant skew and kurtosis values. The total knowledge scale had good internal consistency ( $\alpha = 0.74$ ). Correlations between each of the five subscales (all sections excluding the reverse sequence algorithm section) were all positive ( $p$  values  $< 0.01$ ;  $r = 0.20$ – $0.52$ ) and supported summing them to form a total 25-item knowledge score. The reverse sequence scale score was also positively correlated with each of the five knowledge subscales (all  $p$  values  $< 0.01$ ;  $r = 0.24$ – $0.57$ ) and was positively correlated ( $p < 0.01$ ;  $r = 0.54$ ) with the total 25-item knowledge score.

### Knowledge scores by group

The total 25-item knowledge score and the score of each of the six survey domains (each with five questions, except for the reverse algorithm domain, which contains three knowledge questions) were analyzed for all participants together and by level of training (Table 2). The mean 25-item score was 7.68 for medical students (range = 0–16), 10.61 for residents/fellows (range = 3–17), 10.41 for non-ID attendings (range = 4–18), and 16.38 for ID attendings (range = 6–23); the entire sample mean was 9.79 (range = 0–23,  $p \leq 0.001$ ).

In the *epidemiology* domain, questions were asked regarding the trend in cases nationally and about key demographic groups, including males, African Americans, and MSM, and their respective contributions to the case trends. The overall group answered a mean of 2.16 questions correctly (43%). Compared with other domains, while there was a statistical difference between groups (ANOVA  $p = 0.016$ ), the scores were closer between groups than in the other domains: students answered 1.94 correctly (39%), residents/fellows 2.16 (43%), non-ID attendings 2.19 (44%), and ID attendings 2.86 (57%). In total, 75% of the participants answered a question regarding the trend in new cases correctly, while a decreasing percentage answered questions about the significant contribution of males (56% correct), African Americans (39%), and MSM (18%) to the number of new cases correctly (Table 3).

Items in the transmission domain tested knowledge of the different routes, timing, and potential for transmissibility of

**Table 1.** Demographics and clinical experience of survey participants.

	Total (%) (n=231)	Medical students (%) (n=104)	Residents/ fellows (%) (n=79)	Non-ID attending (%) (n=27)	ID attendings (%) (n=21)
<b>Sex</b>					
Male	41.5	31.7	45.6	51.8	61.9
Female	51.0	58.7	49.4	48.2	33.3
No response	6.5	9.6	5.1	0.0	4.7
<b>Age</b>					
<25 years	20.3	45.2	0.0	0.0	0.0
25–34 years	59.7	53.9	96.2	11.1	14.3
35–44 years	6.1	1.0	3.8	25.9	14.3
45–54 years	6.5	0.0	0.0	29.6	33.3
55–64 years	6.1	0.0	0.0	29.6	28.6
65+ years	1.3	0.0	0.0	3.7	9.5
<b>Race</b>					
American Indian/Native American	0.0	0.0	0.0	0.0	0.0
Asian/Pacific Islander	22.9	30.8	20.3	14.8	4.8
Black/African American	7.8	10.6	8.9	0.0	0.0
White	61.9	49.0	64.6	81.5	90.5
Multiracial/other/unknown	7.4	9.6	6.3	3.7	4.8
<b>Ethnicity</b>					
Non-Hispanic/Latino	65.4	65.4	63.3	70.4	52.4
Hispanic/Latino	9.5	14.4	6.3	3.7	4.8
No response	25.1	20.2	26.6	25.9	42.9
<b>Number of patients screened for syphilis (last 12 months)</b>					
None	40.3	73.1	8.9	29.6	9.5
1–10	31.6	16.4	48.1	40.7	33.3
10–20	17.8	7.7	30.4	25.9	9.5
30–50	5.2	2.9	7.6	0.0	14.3
50–100	3.5	0.0	5.6	0.4	14.3
>100	1.7	0.0	0.0	0.0	19.5
<b>Number of patients treated or referred for treatment for syphilis (last 12 months)</b>					
None	70.6	85.6	67.1	59.2	23.9
1	16.0	11.5	20.3	25.9	9.5
2–3	8.2	2.9	10.1	11.1	23.8
4–5	4.3	0.0	2.5	0.0	38.1
6–10	0.4	0.0	0.0	3.7	0.0
>10	0.4	0.0	0.0	0.0	4.7
<b>Amount of clinical experience diagnosing/treating syphilis</b>					
None	34.2	64.4	11.4	7.7	4.8
Very inexperienced	42.0	27.9	70.9	44.4	0.0
Somewhat inexperienced	12.1	5.8	11.4	40.7	9.5
Somewhat experienced	10.0	1.0	6.3	7.4	71.4
Very experienced	1.7	1.0	0.0	0.0	14.3
<b>Adequacy of syphilis training</b>					
Very inadequate	22.9	38.5	13.9	7.4	0.0
Somewhat inadequate	38.1	34.6	53.2	25.9	14.3
Somewhat adequate	34.2	26.0	30.4	66.7	47.6
Very adequate	4.8	1.0	2.5	0.0	38.1
<b>Familiarity with reverse sequence algorithm</b>					
Never heard of it	78.4	92.3	73.4	92.3	9.5
Somewhat familiar	13.9	6.7	22.8	3.7	28.6
Familiar	6.1	1.0	3.8	3.7	42.9
Very familiar	1.7	0.0	0.0	0.0	19.1
<b>Prior use of reverse sequence algorithm</b>					
Yes	12.1	1.0	15.2	3.7	66.7
No	80.5	91.4	77.2	88.9	28.6
Unsure	7.4	7.7	7.6	7.4	4.8

ID: infectious diseases.

**Table 2.** Survey scores by group (ANOVA).

	Sample size (n = 231)	Mean ( $\sigma$ )	<i>p</i> value
<b>Epidemiology: five items</b>			
Student	104	1.94 (1.18)	0.016
Resident or fellow	79	2.16 (1.20)	
Attending (other)	27	2.19 (1.27)	
Attending (infectious disease)	21	2.86 (1.06)	
Total	231	2.13 (1.21)	
<b>Transmission: five items</b>			
Student	104	1.96 (1.13)	0.006
Resident or fellow	79	2.41 (1.30)	
Attending (other)	27	2.11 (1.16)	
Attending (infectious disease)	21	2.86 (1.20)	
Total	231	2.21 (1.22)	
<b>Clinical features: five items</b>			
Student	104	1.53 (1.08)	<0.001
Resident or fellow	79	2.25 (0.88)	
Attending (other)	27	2.07 (1.33)	
Attending (infectious disease)	21	3.43 (0.87)	
Total	231	2.01 (1.17)	
<b>Diagnosis: five items</b>			
Student	104	1.56 (1.28)	<0.001
Resident or fellow	79	2.23 (1.17)	
Attending (other)	27	2.44 (1.12)	
Attending (infectious disease)	21	3.52 (1.08)	
Total	231	2.07 (1.33)	
<b>Treatment: five items</b>			
Student	104	0.69 (0.86)	<0.001
Resident or fellow	79	1.56 (0.97)	
Attending (other)	27	1.59 (1.50)	
Attending (infectious disease)	21	3.71 (1.38)	
Total	231	1.37 (1.34)	
<b>Reverse sequence algorithm: three items</b>			
Student	104	0.07 (0.25)	<0.001
Resident or fellow	79	0.37 (0.54)	
Attending (other)	27	0.04 (0.19)	
Attending (infectious disease)	21	1.81 (1.08)	
Total	231	0.32 (0.69)	
<b>Knowledge: 25 items</b>			
Student	104	7.68 (3.81)	<0.001
Resident or fellow	79	10.61 (2.69)	
Attending (other)	27	10.41 (3.72)	
Attending (infectious disease)	21	16.38 (3.60)	
Total	231	9.79 (4.23)	

ANOVA: analysis of variance;  $\sigma$ : standard deviation.

syphilis. The participants as a whole answered a mean of 2.21 (44%) questions correctly. Knowledge of transmission

by the oral route, transplacentally in pregnancy, and the intravenous route was centered around 50%, with a range of 40%–76% by group except for only a third of non-ID attendings answering correctly for the congenital question. Each of the groups performed poorly on questions regarding time to onset of symptoms after transmission (35%) and the contagiousness of late latent syphilis (19%). ID attendings outperformed medical students and non-ID attendings, but not residents/fellows (score differential of  $-0.45$  for residents/fellows,  $p=0.13$ ; see Supplemental Digital Content 2 for the table with comparison of each group to ID attendings).

Questions regarding clinical features and the domains thereafter showed an increasing separation between groups in knowledge as noted in the table, with the exception of residents/fellows and non-ID attendings, who generally scored similarly across the domains. The overall mean for clinical features was 2.01 (40%). Non-student providers did well on a question about the classic painless chancre (73%–81% correct), and two-thirds of the participants recognized rash as the most common symptom of secondary syphilis. The group performed less well on questions regarding tertiary syphilis, overestimating disease progression without treatment and the frequency of tabes dorsalis as a manifestation (quite rare). One question regarding the commonality of central nervous system (CNS) involvement in early disease was answered correctly by few—11% of the total answered correctly, including only 19% of ID providers.

In the diagnosis domain, the participants answered an average of 2.07 (41%) of the questions correctly. Of the providers, scores were only 2.23 (44%) for residents/fellows and 2.44 (49%) for non-ID attendings, compared with 3.52 (70%) for ID providers. Around 40% of residents, fellows, and non-ID attendings missed a question about the classic first test for diagnosis, though 20% of ID providers did as well. In total, 33% of non-ID providers/students (with similar scores between these three groups) and only 42% of ID providers answered a question correctly regarding sensitivity of screening, favoring an overestimate of its sensitivity. In addition, 75% of the non-ID specialist providers and students and nearly half of ID attendings failed to recognize the propensity of non-treponemal titers to wane in time without treatment.

The treatment domain demonstrated limited knowledge of management outside ID providers. While the entire participant group answered an average of 1.37 (27%) of these questions correctly, ID providers answered far more correctly than others at an average of 3.71 (74%)—3.0 more on average than students and 2.1 more than both resident/fellow and non-ID attending groups ( $p < 0.001$  for both). Excluding students, who only answered an average of 13% correctly and generally performed poorly for each question, there were a couple of treatment questions largely answered incorrectly by non-ID providers as well. A total of 87% of the resident/fellow and non-ID groups answered a question about treatment of secondary syphilis incorrectly, as did

**Table 3.** 25-item survey performance (percent correct by question).

	Correct response (T/F)	Medical students (%)	Residents/fellows (%)	Non-ID attendings (%)	ID attendings (%)	Total (%)
<b>Epidemiology</b>						
The number of annual cases of primary and secondary syphilis in the United States has remained stable from 2005 to 2015.	F	75	73	67	95	75
Of all primary/secondary cases in the United States, males and females account for approximately the same number per year.	F	53	47	70	90	56
African American/Blacks have the highest rates of syphilis in the United States compared to other racial or ethnic populations.	T	33	42	44	52	39
Gay, bisexual, and other men who have sex with men account for approximately half of all new primary and secondary syphilis cases in the United States each year.	F	15	25	19	10	19
Over half of all new primary and secondary syphilis cases occur among HIV-positive individuals.	F	18	29	19	38	24
<b>Transmission</b>						
Syphilis is rarely transmitted by oral sex.	F	40	61	52	76	52
Syphilis is not transmissible via intravenous drug use or contaminated blood.	F	63	61	56	57	61
A developing fetus can be infected transplacentally at any stage of syphilis.	T	51	61	33	76	55
The median time from transmission to onset of symptoms of primary syphilis is 1 week.	F	33	37	37	38	35
A patient with late latent syphilis is not considered to be contagious.	T	10	22	33	38	19
<b>Clinical features</b>						
Primary syphilis classically involves a painful ulcer.	F	53	73	74	81	65
A rash is the most common symptom of secondary syphilis.	T	56	77	67	86	67
Syphilis commonly involves the central nervous system during primary and secondary stages of the disease.	T	16	3	11	19	11
Without treatment, half of people infected will develop tertiary disease.	F	16	32	30	81	29
Tabes dorsalis, or posterior column and posterior root spinal cord disease, is the most common manifestation of neurosyphilis.	F	12	41	26	76	29
<b>Diagnosis</b>						
Treponemal-specific antibody testing (e.g. FTA, TP-PA) is the classic initial test to diagnose syphilis.	F	20	58	63	81	44
Almost all patients with primary syphilis will have a positive syphilis screening test.	F	32	35	33	43	34
Non-treponemal tests remain elevated through all stages of syphilis (e.g. RPR, VDRL).	F	27	23	26	52	28
Pregnancy can cause a false-positive non-treponemal test (e.g. RPR, VDRL).	T	30	53	63	76	46
The initial screening test for syphilis can involve either a treponemal or non-treponemal test.	T	47	53	59	100	55
<b>Treatment</b>						
Secondary syphilis is treated with intramuscular benzathine penicillin G for three doses at weekly intervals.	F	7	14	11	38	13
Late latent syphilis is treated with intravenous penicillin G for 10–14 days.	F	6	27	19	71	20
Ciprofloxacin is a second-line agent for the treatment of syphilis.	F	19	35	22	81	31
Successful treatment of syphilis is measured by a decline in non-treponemal antibody titers.	T	20	25	52	86	32
The Jarisch–Herxheimer reaction following treatment of syphilis is a severe, life-threatening anaphylactic reaction to penicillin.	F	17	54	56	95	42

ID: infectious diseases; FTA: fluorescent treponemal antibody; TP-PA: *Treponema pallidum* particle agglutination; RPR: rapid plasma regain; VDRL: venereal disease research laboratory.

75% regarding treatment of late latent syphilis. More non-ID attendings were familiar with following non-treponemal titers (52% answered correctly), but only 25% of residents/fellows knew the same (compared with 86% of ID attendings).

Finally, specific knowledge of the reverse sequence algorithm was assessed via questions on steps in the testing pathway. The performance on the three questions was very poor among non-ID providers and students. Less than 3% of both student and non-ID attending groups answered any of the questions correctly. Residents/fellows, who had reported more but still limited familiarity, did score better with a mean score of 0.37 of 3 (12%). ID attendings did much better with an average score of 1.81 (60%).

## Discussion

With the reemergence of syphilis in the past decade, medical providers should be well informed and proactive about recognizing risk, testing at-risk populations, and providing treatment. However, the results of this study demonstrate low syphilis knowledge and clinical experience across non-ID medical provider groups. In contrast with ID specialists, who felt confident in their experience with syphilis (e.g. 86% feeling somewhat or very experienced), other medical providers were much less confident (e.g. only 8 of the remaining 210 participants expressed feeling somewhat or very experienced). Even among ID specialists, only one provider reported that they had treated more than five patients for syphilis in the past year. Furthermore, nearly half (43%) had tested 10 or fewer patients in the last year. Few non-ID physicians reported treating more than one syphilis case per year, with 87% of residents/fellows and 85% of non-ID attendings having reported treating one patient or no patients for syphilis in the past year.

While the acceptable score on this set of knowledge questions is undefined, the average score on the 25-item knowledge scale among ID attendings was 66%, which may be used as a benchmark for comparing provider groups. Knowledge scores were low across all non-ID medical providers. Average scores among the other groups included 31% for medical students, 44% for residents/fellows, and 42% for non-ID attendings. Consistent with these findings, individuals in the study reported inadequate syphilis-related training. Only 27% of medical students, 33% of residents/fellows, and 67% of non-ID attendings reported somewhat or very adequate training compared with 86% of ID attendings.

The results by domain and by question indicate certain areas where gaps in knowledge among providers and students are most prominent, even when accounting for limitations related to their level of training. While there appeared to be a recognition of change in the trend of cases for syphilis, all groups performed poorly on questions that assessed knowledge of key demographics in which the trend is most prominent—men, MSM, and African Americans. Student

knowledge dropped as questions moved toward more practical knowledge, such as diagnosis and treatment, which would be expected with more theoretical than practical training at that stage; however, non-ID provider knowledge was only marginally better. For example, where medical students were able to answer about a third of questions correctly regarding diagnosis, non-ID attendings and residents/fellows were answering correctly on average only in the mid-40% range. In particular, practical aspects of testing and treatment were frequently missed—including knowledge of the temporal decline of non-treponemal titers (22% correct for residents/fellows, 25% for non-ID attendings) and the limitations in screening test sensitivity (35% correct for residents/fellows, 33% for non-ID attendings). Recognition of classic signs of syphilis, such as the painless chancre of primary syphilis and rash of secondary, was reasonably high, but an important missed clinical feature component was that of CNS involvement in early disease (11% correct across all groups, including 19% of ID providers). While this may be reflective of the item quality, it is our suspicion that the early CNS spread of the spirochete is underrecognized. While often being asymptomatic, early CNS involvement contributes to not only headache in secondary syphilis but also, for example, the uptrend in ocular syphilis cases, with 38% of the ocular cases in North Carolina from 2014 to 2015 being reported in the primary or secondary stage of infection.<sup>4</sup> Finally, treatment knowledge was quite limited, but part of this may be explained by the need for providers to consult a decision tool (e.g. using a treatment chart by stage) when addressing each case when outside of high-volume settings such as STI clinics.

We have observed in practice that generalists and trainees in our hospital system are seeing greater numbers of inpatients with syphilis, including more advanced stages of disease, which has led to more frequent contact with ID specialists for referrals or questions regarding treatment. Based on our survey, there are training level-appropriate means by which to address these gaps in knowledge, though it is important to note that institution-dependent gaps may exist. Based on our results, there are opportunities to strengthen epidemiological knowledge (e.g. populations at risk) for the current syphilis resurgence across all groups. Students and providers both would benefit from improved knowledge of key clinical features and transmission patterns for the disease. Providers, particularly non-ID trained attendings and trainees, would benefit from improved training on key components of diagnosis and testing. While teaching specifics of treatment may not be high-yield in the age of UpToDate, it is nonetheless warranted to teach the general principles of management and ensure access to the appropriate tools for decision-making.

Our study also explored provider knowledge regarding the reverse sequence testing algorithm. Paralleling increasing syphilis incidence in the United States, there has been a shift toward treponemal-specific tests as the first-line screening

modality for suspected syphilis cases due to reduced cost.<sup>8</sup> Our hospital system recently implemented the reverse algorithm to diagnose syphilis. However, as evidenced by this study, medical providers may possess limited awareness about this algorithm and interpretation of results. Improved efforts are needed to educate medical providers on the reverse sequence algorithm, particularly before an institution makes a major shift in its testing approach.

To the best of our knowledge, this study was one of the first to develop a survey to assess syphilis knowledge among medical providers across multiple subject domains. Similar surveys have previously been developed for other infectious diseases, particularly for HIV.<sup>13–15</sup> While a small number of syphilis knowledge surveys have previously been developed, many have been limited in scope, as either secondary to HIV knowledge questionnaires or part of a broader STI survey, or otherwise focused on at-risk individuals rather than providers.<sup>16–21</sup> Work that more closely mirrors our own has been performed in Brazil with respect to maternal and congenital syphilis by Dos Santos et al.<sup>22,23</sup> The two 2015 studies targeted obstetricians/nurses and pediatricians, respectively, in municipal maternity hospitals in Brazil in an area with a high incidence of congenital syphilis. The studies used guidance from the Brazilian Ministry of Health to develop a survey assessing knowledge of testing and compliance with management guidelines, though it is notable that some of the items were specific to practice guidelines such as recording of data or providing post-test counseling. In both studies, Dos Santos et al. identified gaps in particular areas of knowledge and guideline compliance that may contribute to the persistently high incidence of congenital syphilis in the Northeast of Brazil. A similar study regarding congenital syphilis and health provider knowledge was carried out in Colombia in 2015, also detecting knowledge deficits and reporting limitations in training on syphilis.<sup>24</sup> In contrast, our study is unique in its broader scope in assessing provider knowledge beyond maternal and congenital cases, and the instrument is the first developed to assess provider knowledge since the recurrent rise in cases in the United States. It is also the first to assess institutional awareness of the reverse sequence algorithm. However, the South American studies may inform a means by which our tool could be adapted in the future to more specifically identify guideline compliance by providers, particularly for providers who would be expected to evaluate and manage a larger number of patients with syphilis.

We acknowledge several limitations of this study. Although we evaluated the reliability and validity of the syphilis knowledge measure in this sample, future studies should continue to test and refine this measure in other settings and populations. In addition, given that students and medical providers are historically difficult to engage in research, we used a convenience sampling approach in large group settings to obtain the greatest number of participants possible. In doing so, there is a significant risk of sampling bias, and our approach also limited our ability to track the

number who were approached and who declined to participate. Our sample included a limited number of attending physicians and the study was conducted in an urban academic healthcare center, which also limits its generalizability. It is notable regarding setting, however, that we suspect that knowledge is likely to be even lower in institutions without teaching programs. Finally, due to the nature of the study setting and the desire to maximize participation, the survey could not assess all important areas of syphilis knowledge, such as management of congenital syphilis. The instrument can be adapted to better suit provider populations and settings where needed.

## Conclusion

Overall syphilis knowledge among medical providers was low. Lack of familiarity with and education on the reverse sequence algorithm was prominent, even within an institution that utilizes this testing modality. Concerted efforts to improve provider education and clinical training around syphilis, including addressing epidemiology, practical clinical considerations, and reverse testing algorithm are necessary to address rising syphilis incidence in the United States.

## Author contributions

J.B., M.C., and P.A.C. conceived of the study design. J.B. and P.A.C. designed the survey with assistance from M.C.M. and J.L.F. J.B. (MD, medical resident, male) and S.M. (BA, medical student, female) administered the survey. A.A. oversaw data collection and management. J.L.F. conducted the statistical analysis. J.B. wrote the first draft of the manuscript and subsequent drafts. M.C.M., J.L.F., M.C., and P.A.C. contributed to subsequent writing and editing. All authors have reviewed and approved the final manuscript for submission.

## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Ethical approval

Ethical approval for this study was obtained from Lifespan—Rhode Island Hospital IRB, The Miriam Hospital IRB (RIH IRB 1 - 00000396, RIH IRB 2 - 00004624, TMH IRB - 00000482).

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## Informed consent

Verbal informed consent was obtained from all subjects before the study. The presiding institutional review board (IRB) approved the use of a standardized informed consent script in lieu of a signed form; signatures were not collected given that they would be the only source of identifying information in the study.



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Supplemental material for this article is available online.

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