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Two cross-sectional studies in south India assessing the effect of an HIV prevention programme for female sex workers on reducing syphilis among their clients

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ABSTRACT

Objective To assess the impact of the *Avahan* HIV prevention programme for female sex workers (FSWs) in south India on reducing syphilis prevalence among their clients, by comparing rates of syphilis over time as reported in two large-scale surveys of FSWs' clients.

Methods A random-effect multilevel logistic regression analysis was performed using syphilis as the dependent variable, with individual independent variables (from the two survey rounds) at level 1 and the district-level programme (from the *Avahan* computerised monitoring and information system) and contextual variables (from Indian government datasets) at level 2. Programme variables included their 2006 value and their difference in value between 2008 and 2006, as well as the interaction between the latter and the study round. The analysis also controlled for baseline syphilis prevalence and its interaction with the study round.

Results Syphilis decreased significantly among FSWs' clients, from 4.8% (round 1) to 2.6% (round 2), p<0.001. The OR of the interaction term between the difference in programme coverage of FSWs and the round was 0.98 (p=0.023), suggesting that increased coverage was associated with a reduced incidence of syphilis.

Conclusions This study suggests that the *Avahan* intervention programme among FSWs reduced syphilis rates among their clients.

INTRODUCTION

In India, preventing the transmission of HIV and other sexually transmitted infections (STIs) is an important public health priority.[1] The primary drivers of the HIV epidemic in India are unprotected sex in the context of the sex trade, unprotected anal sex between men and injection drug use.[2] Female sex workers' (FSWs') clients constitute an important bridging population for transmitting HIV/STI to the general population.[3–5] As syphilis is a curable STI responding more quickly to preventive interventions than HIV infection, and given the association between syphilis and HIV,[6–8] studying the impact of HIV/STI prevention programmes on syphilis prevalence is of particular interest. Despite decades of efforts, there are problems in effective implementation of STI control programmes, because STIs are not simply medical problems but also have complex behavioural, social, political and economic aspects.[9] Changing STI epidemiology worldwide might prove challenging for control efforts owing to such factors as the failure to avoid unsafe sex, people with infection not accessing health services, the failure to identify and treat patients with symptoms and the failure of health services' to provide adequate treatment.[9]

Avahan, the India AIDS Initiative of the Bill & Melinda Gates Foundation, a comprehensive HIV prevention programme, has been operational in the six most affected Indian states since 2004.[10] Although the *Avahan* programme was implemented in six Indian states, this analysis uses data from four southern states, where heterosexual HIV transmission is predominant. Details of the programme are presented in the online supplementary material. The programme is essentially aimed at high-risk groups, especially FSWs, and only covers their clients indirectly by targeting truck drivers (who are known to be frequent users of sexual services) and men in hot spots with a high concentration of FSWs. The programme effect was expected through a combination of strategies focusing on a 'core' group. This included communication aimed at behavioural change to reduce the number of sexual partners, condom distribution and promotion, and STI treatment. Since 2008, the programme has been progressively transferred to the management of community-based organisations and government agencies.

Since a randomised design was not feasible, the *Avahan* evaluation plan adopted sophisticated mathematical models to estimate the programme's impact on high-risk populations and the general population, based on serial cross-sectional integrated behavioural and biological assessment surveys (IBBAs) among high-risk groups, as well as general population surveys.[11–14] In addition, numerous studies based on statistical models using HIV surveillance data on pregnant women have been carried out to understand the impact of *Avahan*.[15–17]

Previous analyses using IBBA data on FSWs' clients did not consider all 17 districts; they

examined HIV/STI risk factors in districts of selected states based on the first round of the survey.[18 19] The effect of the programme on the prevalence of HIV/STI among FSWs' clients has not been examined using both rounds of IBBA data. In this paper, we attempted to understand the effect of *Avahan* on syphilis prevalence among FSWs' clients using statistical techniques.

METHODS

Data sources

This study is based on data from two rounds of IBBA among FSWs' clients in 17 target districts of four southern Indian states (Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra). The study design, including all the procedures followed for the IBBA surveys, has been described elsewhere[18 20] and is summarised in the online supplementary material methods section.

A standard set of core programme indicators was available for all districts covered by *Avahan* as part of a management information system and the details of these indicators are discussed elsewhere.[21] We estimated (1) programme coverage (the proportion of FSWs ever contacted by the programme in a given year); (2) the proportion of FSWs contacted monthly and (3) the proportion of condom requirements met in a given year. Details of the estimation of these three indicators are provided in the online supplementary material methods section. These three indicators were computed for the years 2006–2008 as the information was only complete for all districts for this time period. (The programme's transfer to the government only began in 2008.) We used the value of the indicators in 2006 and the difference in the value between 2008 and 2006 in the statistical analysis.

We also employed several contextual variables at the district level collected from multiple sources for all 17 districts. The complete list of variables used in our analyses is provided in online supplementary appendix table 1. The contextual variables reflect the districts' sociodemographic and economic development and these influence the sex work environment.

The ethics committees of all institutions involved in the data collection approved the study and its consent procedures. (Details of ethical considerations are given in the online supplementary material methods section.)

Statistical analyses

We examined the prevalence of syphilis, HIV, *Chlamydia trachomatis* (CT) and *Neisseria gonorrhoeae* (NG) among FSWs' clients in both study rounds for all 17 IBBA districts. Demographic and behavioural differences in FSWs' clients between study rounds were studied. We also examined the differences in syphilis prevalence between study rounds according to individual characteristics. Variables were selected based on the existing literature and earlier research using IBBA client data.[18 19] Subsequently, we constructed multilevel logistic regression models, with syphilis as the dependent variable. Since our main interest was the difference in syphilis prevalence between the rounds, the study round was the main independent variable in the analysis. First, we considered the individual variables in the multilevel logistic regression model, with a random intercept for the districts and a random coefficient for the round, as the difference in HIV prevalence varied widely amongst districts. We retained all individual variables with p values ≤ 0.05 in the model.

Second, to select the contextual variables, we applied a univariate linear regression model with the aggregate syphilis prevalence rate in each district as the dependent variable and contextual variables as independent variables. Contextual variables with p values <0.10 in the univariate linear regression model were added to the previous multilevel logistic regression model. We also included the aggregate baseline of each district's syphilis rate as an additional district-specific variable. After removing the contextual variables with $p>0.05$, we obtained another model with individual and contextual variables. The aggregate baseline of syphilis prevalence was the only district-level variable found to be significantly associated with the dependent variable.

To the last model described above, we added the three pairs of district-level programme variables (2006 value and difference between 2008 and 2006), along with interaction terms between rounds and the difference in programme indicators between 2008 and 2006. The programme indicators reflecting a significant interaction ($p<0.05$) with the round were retained, as they show the correlation between the change in programme indicators and that of syphilis prevalence. Finally, as we were interested in factors affecting the different outcomes between the IBBA rounds, we examined the interaction of rounds with each of the other individual and district-level contextual factors included in the last multilevel model described above. We included all the interactions with a p value <0.05 in this final model. All these analyses used Stata/IC release 12.1 for Windows (StataCorp LP, College Station, Texas, USA).

RESULTS

The proportion of men approached who provided a blood sample was relatively low, but increased from round 1 (46.2%) to round 2 (57.5%). The response rate was higher in Karnataka state in both rounds (80.5% in round 1 and 91.5% in round 2). District-specific response rates for both rounds are provided in online supplementary appendix table 2.

Overall, 7071 and 6859 clients provided serum samples in round 1 and round 2, respectively. Syphilis prevalence declined from 4.8% (95% CI 4.3% to 5.3%) in round 1 to 2.6% (95% CI 2.3% to 3.0%) in round 2. In Andhra Pradesh and Karnatka, we observed a considerable decline between the two rounds (table 1). The decline in syphilis prevalence was significant in nine of 17 districts between the two rounds, but a large increase was seen in one district (Chennai). High-titre syphilis (rapid plasma reagin titre ≥ 8) declined ($p=0.017$) from 1.6% (95% CI 1.3% to 1.9%) in round 1 to 1.2% (95% CI 0.9% to 1.4%) (data not shown).

Overall, HIV prevalence declined from 5.4% (95% CI 4.8% to 5.9%) in round 1 to 4.9% (95% CI 4.4% to 5.4%) in round 2. Surprisingly, HIV prevalence in Chennai district increased between the study rounds. Though HIV prevalence declined in 12 districts, the decline was significant in only two districts. When we excluded the data from Chennai, we noticed a statistically significant decline in HIV prevalence between study rounds, from 5.5% (95% CI 5.0% to 6.1%) to 4.5% (95% CI 4.0% to 5.0%). Overall, in the non-Karnataka districts, CT prevalence declined from 1.7% in round 1 to 0.7% in round 2. However, NG prevalence was lower at 0.4% in round 1 and 0.2% in round 2.

Differences in FSWs' clients' demographic and behavioural characteristics between study rounds were examined (see online supplementary appendix table 3). Consistent condom use with FSWs increased noticeably from round 1 (37%) to round 2 (61%), and other significant differences in demographic and behavioural characteristics were seen between rounds.

Syphilis prevalence increased with client age (table 2). Similarly, syphilis rates were higher among illiterate clients,

Table 1 Comparison of the prevalence of syphilis*, HIV, CT and NG between round 1 and round 2 IBBAs among clients of FSWs by district and state

	Syphilis prevalence			HIV prevalence			CT prevalence			NG prevalence		
State/district	Round 1 % (95% CI)	Round 2 % (95% CI)	p Value	Round 1 % (95% CI)	Round 2 % (95% CI)	p Value	Round 1 % (95% CI)	Round 2 % (95% CI)	p Value	Round 1 % (95% CI)	Round 2 % (95% CI)	p Value
Andhra Pradesh	6.1 (5.1 to 7.1)	1.3 (0.8 to 1.8)	<0.001	6.5 (5.5 to 7.6)	5.2 (4.2 to 6.2)	0.074	1.2 (0.6 to 1.8)	0.6 (0.3 to 0.9)	0.062	0.4 (0.1 to 0.8)	0.0 (NE)	NE
East Godavari	7.1 (4.6 to 9.6)	2.2 (0.8 to 3.7)	0.001	9.1 (6.3 to 11.8)	7.2 (4.7 to 9.8)	0.345	1.2 (0.0 to 2.3)	1.0 (0.0 to 2.0)	0.817	0.0 (0.0 to 0.0)	0.0 (NE)	NE
Guntur	11.2 (8.1 to 14.3)	1.0 (0.0 to 2.0)	<0.001	7.5 (4.9 to 10.1)	5.9 (3.6 to 8.2)	0.372	0.9 (0.0 to 2.1)	0.3 (0.0 to 0.7)	0.278	0.0 (0.0 to 0.0)	0.0 (NE)	NE
Hyderabad	5.4 (3.2 to 7.6)	2.3 (0.8 to 3.7)	0.019	3.7 (1.9 to 5.5)	5.3 (3.1 to 7.4)	0.285	2.0 (0.4 to 3.5)	1.5 (0.3 to 2.7)	0.647	0.0 (0.0 to 0.0)	0.0 (NE)	NE
Vishakhapatnam	3.2 (1.5 to 5.0)	1.0 (0.0 to 2.0)	0.026	8.0 (5.3 to 10.6)	3.5 (1.7 to 5.2)	0.006	0.5 (0.0 to 1.3)	0.3 (0.0 to 0.7)	0.666	1.8 (0.1 to 3.6)	0.0 (NE)	NE
Warangal	3.5 (1.7 to 5.3)	0.3 (0.0 to 0.7)	0.001	4.5 (2.5 to 6.5)	4.2 (2.3 to 6.2)	0.857	1.2 (0.0 to 2.4)	0.0 (NE)	NE	0.6 (0.0 to 1.4)	0.0 (NE)	NE
Maharashtra	5.0 (3.9 to 6.1)	3.9 (2.9 to 4.8)	0.126	7.6 (6.3 to 8.9)	6.1 (4.9 to 7.2)	0.078	2.7 (1.9 to 3.5)	1.1 (0.6 to 1.6)	0.001	0.7 (0.3 to 1.1)	0.6 (0.2 to 1.0)	0.682
Mumbai	3.3 (1.5 to 5.1)	4.9 (2.7 to 7.0)	0.277	8.6 (5.9 to 11.4)	5.7 (3.3 to 8.0)	0.112	4.3 (2.3 to 6.3)	2.4 (0.9 to 4.0)	0.150	1.0 (0.0 to 2.0)	1.6 (0.3 to 2.9)	0.466
Parbhani	3.2 (1.5 to 4.9)	3.0 (1.4 to 4.7)	0.884	5.0 (2.8 to 7.1)	3.3 (1.5 to 5.1)	0.239	2.7 (1.1 to 4.3)	0.0 (NE)	NE	0.5 (0.0 to 1.2)	0.0 (NE)	NE
Pune	6.0 (3.7 to 8.3)	3.2 (1.5 to 4.9)	0.061	6.5 (4.1 to 8.9)	6.9 (4.5 to 9.4)	0.800	2.5 (1.0 to 4.0)	1.0 (0.0 to 2.0)	0.103	0.3 (0.0 to 0.7)	0.5 (0.0 to 1.2)	0.567
Yevatmal	7.5 (4.9 to 10.1)	4.5 (2.5 to 6.5)	0.073	10.5 (7.5 to 13.5)	8.3 (5.6 to 11.0)	0.270	1.3 (0.2 to 2.3)	1.0 (0.0 to 2.0)	0.735	1.0 (0.0 to 2.0)	0.3 (0.0 to 0.7)	0.177
Tamil Nadu	3.8 (2.7 to 4.9)	4.6 (3.4 to 5.8)	0.341	2.7 (1.8 to 3.6)	5.9 (4.6 to 7.2)	<0.001	0.8 (0.3 to 1.3)	0.4 (0.1 to 0.8)	0.188	0.0 (NE)	0.0 (NE)	NE
Chennai	4.4 (2.4 to 6.4)	11.8 (8.6 to 14.9)	<0.001	2.2 (0.8 to 3.7)	12.0 (8.9 to 15.2)	<0.001	1.5 (0.3 to 2.7)	0.0 (NE)	NE	0.0 (NE)	0.0 (NE)	NE
Madurai	3.0 (1.3 to 4.7)	1.0 (0.0 to 2.0)	0.043	2.2 (0.8 to 3.7)	3.7 (1.9 to 5.6)	0.216	0.0 (NE)	0.8 (0.0 to 1.6)	NE	0.0 (NE)	0.0 (NE)	NE
Salem	4.0 (2.1 to 6.0)	1.0 (0.0 to 1.9)	0.005	3.5 (1.7 to 5.4)	2.0 (0.6 to 3.3)	0.173	1.0 (0.0 to 2.0)	0.5 (0.0 to 1.2)	0.393	0.0 (NE)	0.0 (NE)	NE
Karnataka	3.9 (3.1 to 4.7)	1.8 (1.2 to 2.3)	<0.001	4.2 (3.4 to 5.0)	3.3 (2.6 to 4.1)	0.124	2.3 (1.7 to 2.8)	NA	NA	0.6 (0.3 to 0.9)	NA	NA
Bangalore Urban	4.5 (2.8 to 6.1)	0.8 (0.1 to 1.6)	<0.001	2.4 (1.2 to 3.5)	1.9 (0.9 to 3.0)	0.587	3.1 (1.8 to 4.4)	NA	NA	0.6 (0.0 to 1.2)	NA	NA
Belgaum	3.9 (2.0 to 5.8)	2.0 (0.5 to 3.4)	0.122	6.6 (4.2 to 9.0)	3.0 (1.3 to 4.6)	0.014	1.2 (0.2 to 2.3)	NA	NA	0.0 (0.0 to 0.0)	NA	NA
Bellary	6.0 (3.7 to 8.3)	2.7 (1.0 to 4.4)	0.030	5.4 (3.3 to 7.6)	6.8 (4.3 to 9.3)	0.415	1.7 (0.4 to 2.9)	NA	NA	0.5 (0.0 to 1.1)	NA	NA
Shimoga	2.1 (0.8 to 3.5)	1.5 (0.2 to 2.8)	0.527	2.4 (0.9 to 3.8)	1.9 (0.5 to 3.2)	0.630	0.7 (0.0 to 1.5)	NA	NA	0.5 (0.0 to 1.1)	NA	NA
Mysore	2.9 (1.3 to 4.6)	2.4 (0.9 to 3.8)	0.609	5.4 (3.3 to 7.6)	4.0 (2.1 to 5.9)	0.331	4.0 (2.1 to 5.9)	NA	NA	1.4 (0.3 to 2.5)	NA	NA
Total	*4.8 (4.3 to 5.3)*	*2.6 (2.3 to 3.0)*	*<0.001*	*5.4 (4.8 to 5.9)*	*4.9 (4.4 to 5.4)*	*0.227*	*1.9 (1.5 to 2.2)*	*0.7 (0.5 to 1.0)*	*<0.001*†	*0.5 (0.3 to 0.6)*	*0.2 (0.1 to 0.3)*	*0.058*†

p Value based on Pearson χ^2 test.
*A subject was considered as having active syphilis when both the rapid plasma reagin and *Treponema pallidum* haemaglutination assay tests were positive.
†These p values are given for the comparisons between non-Karnataka districts, as NG and CT were not available in Karnataka in round 2. CT prevalence in non-Karnataka districts was 1.7% in round 1 (0.4% for NG).
CT, *Chlamydia trachomatis*; FSW, female sex worker; IBBA, integrated behavioural and biological assessment survey; NA, not available; NE, not estimated; NG, *Neisseria gonorrhoeae*.

Table 2 Syphilis prevalence among clients of FSWs, from IBBA round 1 and round 2 data, by individual characteristics

Characteristics	Round 1 % (95% CI)	Round 2 % (95% CI)	Total % (95% CI)
Age of respondent			
<25	2.6 (1.9 to 3.3)	1.4 (0.9 to 1.9)	2.1 (1.6 to 2.5)
25–34	4.6 (3.8 to 5.4)	2.4 (1.9 to 3.0)	3.5 (3.0 to 3.9)
≥35	7.3 (6.2 to 8.4)	4.1 (3.2 to 4.9)	5.7 (5.0 to 6.4)
Can read and write			
No	7.3 (6.1 to 8.5)	3.2 (2.3 to 4.0)	5.3 (4.6 to 6.1)
Yes	3.9 (3.4 to 4.4)	2.5 (2.0 to 2.9)	3.2 (2.8 to 3.5)
Marital status			
Currently married	5.9 (5.2 to 6.6)	2.9 (2.4 to 3.4)	4.4 (3.9 to 4.8)
Separated/ divorced/ widowed	8.8 (4.8 to 12.8)	4.7 (2.0 to 7.5)	6.6 (4.2 to 9.0)
Never married	2.7 (2.1 to 3.3)	2.0 (1.4 to 2.6)	2.4 (2.0 to 2.8)
Age at first sex			
<20	4.8 (4.1 to 5.5)	2.7 (2.2 to 3.2)	3.8 (3.4 to 4.2)
20–24	4.7 (3.9 to 5.5)	2.3 (1.8 to 2.9)	3.5 (3.0 to 4.0)
≥25	5.0 (3.2 to 6.7)	3.7 (2.0 to 5.3)	4.4 (3.1 to 5.6)
Age at first paid sex			
<20	4.5 (3.7 to 5.3)	2.5 (1.9 to 3.2)	3.6 (3.1 to 4.1)
20–24	5.0 (4.3 to 5.7)	2.6 (2.0 to 3.1)	3.8 (3.4 to 4.3)
≥25	4.9 (3.6 to 6.2)	2.9 (2.1 to 3.7)	3.7 (3.0 to 4.4)
Typology of FSWs			
Public place	4.2 (3.5 to 5.0)	2.9 (2.3 to 3.5)	3.6 (3.1 to 4.0)
Brothel	5.4 (4.6 to 6.3)	3.6 (2.8 to 4.4)	4.6 (4.0 to 5.2)
Home	4.5 (3.3 to 5.7)	0.8 (0.2 to 1.4)	2.9 (2.2 to 3.7)
Other	4.9 (2.5 to 7.4)	1.3 (0.5 to 2.1)	2.3 (1.4 to 3.1)
Consistent condom use with FSW			
No	5.4 (4.7 to 6.1)	3.9 (3.2 to 4.7)	4.8 (4.3 to 5.3)
Yes	3.6 (2.9 to 4.4)	1.8 (1.4 to 2.2)	2.5 (2.1 to 2.9)
Anal sex with a man/transgender in past 6 months			
No	4.7 (4.2 to 5.2)	2.4 (2.0 to 2.8)	3.6 (3.3 to 3.9)
Yes	6.3 (4.1 to 8.5)	4.1 (2.8 to 5.4)	4.9 (3.7 to 6.0)
Circumcised			
No	4.8 (4.3 to 5.4)	2.7 (2.3 to 3.1)	3.8 (3.5 to 4.1)
Yes	4.5 (3.2 to 5.7)	2.1 (1.3 to 3.0)	3.3 (2.6 to 4.1)
HIV infection status			
Negative	4.1 (3.6 to 4.5)	1.6 (1.3 to 1.9)	2.8 (2.6 to 3.1)
Positive	17.1 (13.4 to 20.9)	22.2 (17.8 to 26.6)	19.5 (16.7 to 22.4)

FSW, female sex worker; IBBA, integrated behavioural and biological assessment survey.

those who had sex with brothel-based FSWs, those reporting anal sex with a man or male transgender in the past 6 months and those with HIV. As expected, syphilis prevalence was lower among clients who reported consistently using condoms with FSWs.

Table 3 shows the results of the multilevel logistic regression models. The left columns provide results from the multilevel model, including only the significant individual characteristics and baseline syphilis prevalence without interaction and programme indicators. The model shows that syphilis prevalence among FSWs' clients declined between the two survey rounds (adjusted OR=0.49, 95% CI 0.38 to 0.62). Syphilis prevalence increased with age and was lower among literate clients. Clients who had sex with brothel-based FSWs had higher syphilis prevalence than those who had sex with home-based FSWs. Clients who had sex with a man or male transgender in the past 6 months had higher syphilis prevalence. Consistent condom use with FSWs was associated with lower syphilis prevalence. Similarly, HIV infection increased the likelihood of syphilis. Furthermore, baseline syphilis prevalence was largely associated with overall syphilis prevalence.

We introduced the interaction between rounds and individual variables, as well as programme indicators, into the model to examine their influence on the decline in syphilis prevalence between the study rounds (see the right-hand columns of table 3). We observed a negative interaction between the rounds and a difference in programme coverage of FSWs between 2008 and 2006. Other significant interactions between the rounds were seen for baseline syphilis prevalence, HIV infection status and typology of the FSWs. The variance of the random intercept was reduced from 0.17 in the null model to 0.07 in the model, with individual variables with random slope. The random intercept from the final multilevel model indicates that after the introduction of significant individual characteristics and programme indicators, the unexplained variation at district level was drastically reduced (0.17 to insignificant). The random coefficient for the round indicates significant heterogeneity in the changes in syphilis prevalence across districts, but its variance was reduced after introducing the programme variables and interaction terms. We found a significant interaction between rounds and HIV infection, with a significant decline in syphilis prevalence between the two survey rounds among FSWs' clients without HIV (OR=0.35, p<0.001) (table 4), whereas there was a non-significant increase in syphilis among clients with HIV infection (OR=1.24, p=0.322). The decline in syphilis among clients was significant across all categories of FSW typologies, but was greater among home-based FSWs' clients. The decline in syphilis prevalence was small and not significant when the coverage of FSWs by the programme was higher in 2006 than in 2008. However, it became greater as the coverage of FSWs by the programme between 2006 and 2008 increased and statistically significant starting from the first quartile.

DISCUSSION

We assessed the effect over time of changes in FSW programme coverage on the lower syphilis rate among FSWs' clients in the second IBBA round. The programme indicators among FSWs were used to assess the impact on clients, since a direct and strong correlation between HIV prevalence among FSWs and their clients was identified in another Indian study.[22] In addition, studies elsewhere have shown declines in client STI prevalence as a result of interventions with FSWs.[23 24] The *Avahan* programme is only directly involved with FSWs' clients in condom social marketing and franchised STI clinics. Thus, we were interested in assessing the indirect effect of programme indicators that were very specific to FSWs on syphilis prevalence among their clients.

We used multilevel analysis controlling for potential individual and contextual confounding factors, as well as for baseline syphilis prevalence at the district level and its interaction with the survey round, which explains why a decrease in prevalence is more likely in districts with higher baseline values. Syphilis prevalence declined significantly among FSWs' clients (about 90%) in correlation with increases in *Avahan* programme coverage among FSWs. Greater increases in district-level programme coverage among FSWs led to larger decreases in syphilis prevalence, with no significant decrease in districts without improvement in coverage. Perhaps integrated HIV preventive interventions aimed at reaching both FSWs and their clients can significantly affect sexual behaviour and reduce STI prevalence.[25] Evidence suggests that consistent condom use during commercial sex has increased as a result of

Table 3 Multilevel logistic regression model of determinants of syphilis prevalence among clients of FSWs, IBBA round 1 and round 2

Characteristics	Without programme variable and interaction terms			With programme variable and interaction terms		
Fixed part of the model	**AOR**	**p Value**	**95% CI**	**AOR**	**p Value**	**95% CI**
Constant	0.01	<0.001	0.01 to 0.02	0.01	0.030	0.01 to 0.03
IBBA round						
Round 1						
Round 2	0.49	<0.001	0.38 to 0.62	0.33	0.066	0.10 to 1.08
Age of respondent (years)						
<25						
25–34	1.43	0.009	1.09 to 1.88	1.47	0.006	1.12 to 1.92
≥35	2.32	<0.001	1.76 to 3.04	2.31	<0.001	1.76 to 3.03
Can read and write						
No						
Yes	0.66	<0.001	0.54 to 0.81	0.65	<0.001	0.53 to 0.80
Typology of FSWs						
Public place-based	1.14	0.436	0.83 to 1.56	0.94	0.734	0.67 to 1.33
Brothel-based	1.34	0.092	0.95 to 1.88	1.11	0.575	0.78 to 1.58
Home-based						
Other	1.09	0.733	0.67 to 1.77	1.27	0.449	0.69 to 2.33
Anal sex with a man/transgender in past 6 months						
No						
Yes	1.58	0.002	1.18 to 2.11	1.53	0.005	1.14 to 2.06
Consistent condom use with FSWs						
No						
Yes	0.80	0.034	0.64 to 0.98	0.85	0.141	0.69 to 1.05
HIV infection status						
Negative						
Positive	6.88	<0.001	5.51 to 8.59	4.14	<0.001	3.04 to 5.64
Baseline syphilis prevalence	1.19	<0.001	1.10 to 1.30	1.18	<0.001	1.10 to 1.26
Programme indicators						
FSW programme coverage at baseline				1.00	0.685	0.99 to 1.01
Difference in coverage between the two rounds				1.00	0.327	1.00 to 1.01
Interaction between round and						
Difference in coverage between the two rounds				0.98	0.023	0.97 to 0.99
Baseline HIV prevalence				0.85	0.003	0.76 to 0.94
Status of HIV				3.57	<0.001	2.26 to 5.64
Typology of FSWs						
Public place-based				4.61	0.003	1.67 to 12.72
Brothel-based				4.04	0.006	1.48 to 11.04
Other				2.33	0.186	0.67 to 8.12

Random part of the model				
Estimated district-level variance of	**Estimated variance**	**95% CI of variance**	**Estimated variance**	**95% CI of variance**
Round	0.07	0.03 to 0.17	0.04	0.01 to 0.10
Intercept	0.00	Not significantly different from 0	0.00	Not significantly different from 0

AOR, adjusted OR; FSW, female sex worker; IBBA, integrated behavioural and biological assessment survey.

the *Avahan* programme and this has contributed to reduced HIV/STI transmission between FSWs and clients in Karnataka.[13 14] A mathematical modelling study indicated that during the first 4 years of *Avahan*, most of the HIV infections averted owing to the programme were among FSWs' clients, followed by the general population, men who have sex with men and FSWs.[14] Importantly, analysis of data from Karnataka found a dose–response relationship between intervention exposure and self-reported condom use in commercial partnerships.[26] Much of the increase in consistent condom use can be attributed to *Avahan*, especially in districts where it has remained the only prevention programme in place for high-risk groups.[13] In Thailand, explicit messages to men about the risks of STIs from unprotected commercial sex resulted in higher reported condom use, lower reported numbers of sex worker visits and lower infection rates.[27] Social marketing of condoms has effectively increased supply and demand.[28] The success of the intervention efforts depends not on reaching all people but on reaching the right people (those most at risk) with effective interventions. Prevention efforts that effectively reduce transmission in the high partner 'core' population are necessary and often sufficient, to reduce transmission in the population at large.[29]

A study using data from the two IBBA rounds among FSWs in 24 *Avahan* programme districts showed HIV prevalence declining from 2006 to 2007 (17.0%) to 2010 (14.2%).[30] Furthermore, the syphilis prevalence among FSWs declined

Table 4 Changes in syphilis prevalence among clients of FSWs between the study rounds at different levels of the independent variables having a significant statistical interaction with the study round

Factors having a significant interaction with the round	AOR	95% CI	p Value	p Value of the interaction term
Baseline syphilis prevalence				0.003
Minimum value (2.13%)	0.78	0.53 to 1.16	0.220	
25th Centile (3.23%)	0.65	0.48 to 0.89	0.007	
50th Centile (4.04%)	0.57	0.44 to 0.75	<0.001	
75th Centile (5.97%)	0.42	0.32 to 0.55	<0.001	
Maximum (11.22%)	0.18	0.09 to 0.37	<0.001	
Difference in covered value				0.023
Minimum (−5.9%)	0.92	0.59 to 1.43	0.711	
25th Centile (17.9%)	0.61	0.47 to 0.80	<0.001	
50th Centile (26.4%)	0.53	0.41 to 0.67	<0.001	
75th Centile (42.6%)	0.40	0.30 to 0.53	<0.001	
Maximum* (106.3%)	0.13	0.06 to 0.31	<0.001	
HIV infection status				<0.001
Negative	0.35	0.27 to 0.47	<0.001	
Positive	1.24	0.81 to 1.89	0.322	
Typology of FSWs				
Public place-based	0.54	0.38 to 0.76	<0.001	0.003
Brothel-based	0.65	0.45 to 0.93	0.018	0.006
Home-based	0.12	0.05 to 0.30	<0.001	
Other	0.27	0.12 to 0.62	0.002	0.186

*Coverage can be>100% because the denominator of this indicator is based on the estimate of the size of the FSW population at any moment in the district, whereas the number of women actually covered in the district might be higher than the denominator in places with high turnover of FSWs (mean duration of FSWs in the district of <1 year).
AOR, adjusted OR; FSW, female sex worker.

significantly from 11.7% to 7.1%. Similarly, the CT/NG prevalence among FSWs showed a significant decline (7.2% to 5.9%). These results suggest that *Avahan* intervention contributed to the lower rate of STI/HIV among FSWs and their clients.

Though, overall, syphilis prevalence among FSWs' clients decreased between the study rounds, surprisingly there was an increase in syphilis prevalence among FSWs' clients in Chennai district. This probably underestimated the reduction in syphilis prevalence found among FSWs' clients between the study rounds. Data indicate that in Chennai the percentage of clients who had anal sex with a man or male transgender increased from round 1 (3.2%) to round 2 (30.0%). Similarly, in Chennai, the clients reporting condom use consistently with FSWs declined from 24.0% in round 1 to 12.0% in round 2. These differences in FSWs' clients' characteristics might have led to an increase in syphilis prevalence in Chennai.

Along with programme coverage, baseline syphilis prevalence also influenced the decline in syphilis prevalence, with no significant decline in districts with low baseline prevalence. The greatest decline was in districts with the highest baseline syphilis prevalence (about 80%). Similarly, FSWs' clients without HIV experienced a significant decline in syphilis prevalence of 65% between the two survey rounds. In addition, the decline in syphilis prevalence among FSWs' clients between the two rounds was found to be highest among clients of home-based FSWs (a decrease of about 90%). HIV prevalence among home-based FSWs was lower than among FSWs of other typologies.[31] Similarly, the decline in syphilis prevalence among clients of brothel-based FSWs was slightly lower.

This study has some limitations. It is based on client samples from FSW solicitation sites, such as public places, brothels, homes and other venues. Thus, all possible clients might not have been included in the sampling frame. Similarly, the sample consisted of clients who had paid for sex in the past month, which might have oversampled clients with frequent FSW contact, thus possibly over-representing higher-risk clients. In addition, since all behavioural responses were self-reported, the possibility of social desirability bias cannot be ruled out. Another limitation is that the response rate was generally low and increased greatly between rounds, with the potential of inducing biases in the trend analysis. Though we noticed significant changes in the characteristics of clients between study rounds, the absolute differences and their significance were mostly small, partly owing to large sample sizes.

In conclusion, in four south Indian states we observed a strong and favourable impact of the *Avahan* HIV prevention programme for FSWs in reducing their clients' rate of syphilis. This study also highlights the importance of scaling-up intervention programmes targeting FSWs, to reduce their rates of HIV/STI infection and also those of their clients.

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