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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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REFERENCES

1 National AIDS Control Organization. *HIV Sentinel Surveillance and HIV estimation in India, 2007: a technical brief*. Ministry of Health and Family Welfare, 2007.
2 National Institute of Medical Statistics and National AIDS Control Organization. *Technical report India HIV estimates*. Ministry of Health and Family Welfare, 2010.
3 Over M, Piot P. HIV infection and sexually transmitted diseases. In: Jamison DT, Mosley WH, Measham AR, *et al*., eds. *Disease control priorities in developing countries*. New York: Oxford University Press, 1993:455–528.
4 Semple SJ, Strathdee SA, Gallardo CM, *et al*. Psychosexual and social-cognitive correlates of sexual risk behavior among male clients of female sex workers in Tijuana, Mexico. *AIDS Care* 2010;22:1473–80.
5 Lowndes CM, Alary M, Meda H, *et al*. Role of core and bridging groups in the transmission dynamics of HIV and sexually transmitted infections in Cotonou, Benin, West Africa. *Sex Transm Infect* 2002;78(Suppl 1):i69–77.
6 Arora PN, Sastry CV. HIV infection and genital ulcer disease. *Indian J Sex Transm Dis* 1992;13:71–3.
7 Lynn WA, Lightman S. Syphilis and HIV: a dangerous combination. *Lancet Infect Dis* 2004;4:456–66.
8 Buchacz K, Patel P, Taylor M, *et al*. Syphilis increases HIV viral load and decreases CD4 cell counts in HIV-infected patients with new syphilis infections. *AIDS* 2004;18:2075–9.
9 Mayaud P, McCormick D. Interventions against sexually transmitted infections (STI) to prevent HIV infection. *Br Med Bull* 2001;58:129–53.
10 Bill & Melinda Gates Foundation. *Avahan—The India AIDS Initiative: the business of HIV prevention at scale*. New Delhi, India: Bill & Melinda Gates Foundation, 2008.
11 Chandrasekaran P, Dallabetta G, Loo V, *et al*. Evaluation design for large-scale HIV prevention programmes: the case of Avahan, the India AIDS initiative. *AIDS* 2008;22(Suppl 5):S1–15.
12 Boily MC, Lowndes CM, Vickerman P, *et al*. Evaluating large-scale HIV prevention interventions: study design for an integrated mathematical modelling approach. *Sex Transm Infect* 2007;83:582–9.
13 Boily MC, Pickles M, Lowndes CM, *et al*. Positive impact of a large-scale HIV prevention programme among female sex workers and clients in South India. *AIDS* 2013;27:1449–60.
14 Pickles M, Boily MC, Vickerman P, *et al*. Assessment of the population-level effectiveness of the Avahan HIV-prevention programme in South India: a preplanned, causal-pathway-based modelling analysis. *Lancet GH* 2013;1:e289–99.
15 Ng M, Gakidou E, Levin-Rector A, *et al*. Assessment of population-level effect of Avahan, an HIV-prevention initiative in India. *Lancet* 2011;378:1643–52.
16 Banandur P, Mahajan U, Rajaram S, *et al*. Population-level impact of Avahan in Karnataka state, South India using multilevel statistical modelling techniques. *J Acquir Immune Defic Syndr* 2013;62:239–45.
17 Moses S, Ramesh BM, Nagelkerke NJD, *et al*. Impact of an intensive HIV prevention programme for female sex workers on HIV prevalence among antenatal clinic attenders in Karnataka state, south India: an ecological analysis. *AIDS* 2008;22 (Suppl 5):S101–8.
18 Subramanian T, Gupte MD, Paranjape RS, *et al*. HIV, sexually transmitted infections and sexual behaviour of male clients of female sex workers in Andhra Pradesh, Tamil Nadu and Maharasthra, India: results of a cross-sectional survey. *AIDS* 2008;22(Suppl 5):S69–79.
19 Shaw YS, Deering KN, Reza-Paul S, *et al*. Prevalence of HIV and sexually transmitted infections among clients of female sex workers in Karnataka, India: a cross-sectional study. *BMC Public Health* 2011;11(Suppl 6):S4.
20 Saidel T, Adhikary R, Mainkar M, *et al*. Baseline integrated behavioural and biological assessment among most at-risk populations in six high-prevalence states of India: design and implementation challenges. *AIDS* 2008;22(Suppl 5):S17–34.
21 Verma R, Shekhar A, Khobragade S, *et al*. Scale-up and coverage of Avahan: a large-scale HIV-prevention programme among female sex workers and men who have sex with men in four Indian states. *Sex Transm Infect* 2010;86(Suppl 1): i76–82.
22 Alary M, Jayachandran AA, Lowndes CM, *et al*. Ecological analysis of the association between high-risk population parameters and HIV prevalence among pregnant women enrolled in sentinel surveillance in four southern India states. *Sex Transm Infect* 2010;86:i10–16.
23 Steen R, Vuylsteke B, DeCoito T, *et al*. Evidence of declining STD prevalence in a South African mining community following a core-group intervention. *Sex Transm Dis* 2000;27:1–8.
24 Wi T, Ramos ER, Steen R, *et al*. STI declines among sex workers and clients following outreach, one time presumptive treatment and regular screening of sex workers in the Philippines. *Sex Transm Infect* 2006;82:386–91.
25 Lowndes CM, Alary M, Labbé A-C, *et al*. Interventions among male clients of female sex workers in Benin, West Africa: an essential component of targeted HIV preventive interventions. *Sex Transm Infect* 2007;83:577–81.
26 Deering KN, Boily MC, Lowndes CM, *et al*. A dose-response relationship between exposure to a large-scale core group HIV prevention intervention and consistent condom use with different sexual partners of female sex workers in south India. *BMC Public Health* 2011;11(Suppl 6):S8.
27 Rojanapithayakorn W. The 100% condom use programme in Asia. *Reprod Health Matters* 2006;14:41–52.
28 Eloundou-Enyegue PM, Meekers D, Calves AV. From awareness to adoption: the effect of AIDS education and condom social marketing on condom use in Tanzania (1993–96). *J Biosoc Science* 2005;37:257–68.
29 Steen R, Wi TE, Kamali A, *et al*. Control of sexually transmitted infections and prevention of HIV transmission: mending a fractured paradigm. *Bull World Health Organ* 2009;87:858–65.
30 Alary M, Banandur P, Rajaram SP, *et al*. Increased HIV prevention program coverage and decline in HIV prevalence among female sex workers in south India. *Sex Transm Infect* 2013;89(Suppl 1):A58–9.
31 Ramesh BM, Moses S, Washington R, *et al*. Determinants of HIV prevalence among female sex workers in four south Indian states: analysis of cross-sectional surveys in twenty-three districts. *AIDS* 2008;22(Suppl 5):S35–44.

Supplementary Online Material

The *Avahan* programme has mainly targeted FSWs, high-risk men who have sex with men and transgenders (MSM-T), other high-risk men, such as clients of FSWs and truck drivers, and IDUs. Peer-based outreach education, clinical services for managing STIs, promotion and distribution of condoms, community mobilization and building an enabling environment are the key elements of the programme. The programme was implemented in 83 districts, with some districts where *Avahan* was the first or only such programme, and others where it added to already existing programmes.

Methods

Study population

We used two rounds of IBBA survey data collected from the clients of FSWs in 17 target districts of four southern Indian states: Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra. Both survey rounds followed the same study design and sampling procedures. The study design as well as the procedure followed for round-1 survey has been described elsewhere.[1,2] Briefly, random samples of clients of FSWs were selected using cluster or time-location cluster sampling, depending upon the local sex work typology. The target sample size for each district in each round was 400, except for Bangalore (Karnataka state), where it was 700. In the districts of Andhra Pradesh, Tamil Nadu and Maharashtra, the data collection was carried out during the years 2006-07 and 2009-10. However, in the districts of Karnataka, the IBBAs among clients of FSWs were carried out during the years 2007-08 and 2011-12.

Clients of FSWs who provided consent were interviewed using a structured questionnaire by trained field interviewers and information was collected on socio-demographic

characteristics, sexual behaviours, and condom use. Blood and urine samples were collected from all consenting men for HIV and STI testing. Blood was tested for HIV using standard serological tests and urine was tested using nucleic acid amplification methods for *Neisseria gonorrhoeae* (NG) and *Chlamydia trachomatis* (CT). However, in the districts of Karnataka, CT and NG was not tested for in the round-2 IBBA survey. Serum samples were tested for syphilis antibodies using a Rapid Plasma Reagin (RPR) test (Span Diagnostics, Surat, India). All samples positive by RPR were then tested with a Treponema Pallidum Haemagglutination Assay (TPHA) test (Glaxo-Omega, Alloa, Scotland, United Kingdom). A subject was considered as having active syphilis when both the RPR and TPHA tests were positive.

District level programme and contextual variables

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.[3] We used three programme variables for this study: 1) the number of FSWs ever contacted by the programme in a given year; 2) the number of FSWs contacted monthly by the programme; and 3) the number of condoms distributed to FSWs by the NGOs in a given year. These numbers were converted into percentages using the estimated number of FSWs in the district as the denominator for indicators 1 and 2; for indicator 3, we used as the denominator the expected number of condoms needed by FSWs in the district, based on the estimated number of FSWs and the mean number of client-contacts estimated from the IBBA data. These indicators were computed for years 2006 to 2008 as the information was complete for all districts only for this time period (the program started being handed over to the government 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 used several contextual variables at the district level collected from multiple sources for all 17 districts, and the complete list of the variables used in the multilevel model are provided in the appendix table. The contextual variables considered are thought to reflect the socio-demographic and economic development of the district and also influence the sex work environment.

Ethical considerations

No names or other contact information were recorded either on the questionnaire or on the biological samples collected. A detailed and standardized consent process was implemented for each respondent, and consent was obtained separately for the interview and for collecting biological samples. The study was approved by the ethics committees of all institutes that were involved in the data collection for this study: the National AIDS Research Institute, Pune (Maharashtra), the National Institute of Epidemiology, Chennai (Tamil Nadu), the National Institute of Nutrition, Hyderabad (Andhra Pradesh), and St. John's Medical College, Bangalore (Karnataka), India, as well as Family Health International, Arlington, VA, USA, and the University of Manitoba, Winnipeg, Canada. Finally, statutory approval for the IBBA and its protocols was obtained from the Health Ministry Screening Committee (HMSC) of the Indian Council of Medical Research, Government of India.

[1]Saidel T, Adhikary R, Mainkar M *et al.* Baseline integrated behavioural and biological assessment among most at-risk populations in six high-prevalence states of India: design and implementation challenges. *AIDS* 2008; **22 (Suppl 5)**:S17-34.

[2]Subramanian T, Gupte MD, Paranjape RS et al. HIV, sexually transmitted infections and sexual behaviour of male clients of female sex workers in Andhra Pradesh, Tamil Nadu and Maharasthra, India: results of a cross-sectional survey. *AIDS* 2008; **22 (Suppl 5)**:S69-79.

[3]Verma R, Shekhar A, Khobragade S *et al.* Scale-up and coverage of Avahan: a large-scale HIV-prevention programme among female sex workers and men who have sex with men in four Indian states. *Sex Transm Infect* 2010; **86 (Suppl 1)**:i76-82.

Supplementary Online Material Tables

Appendix Table 1: List of individual, programmatic and contextual variables included in the multilevel modelling analysis

Sl. No	Variables	Source
	Individual variables:	
1	Age in completed years (15-24 years =1, 25-34 years=2 & 35+ years=3)	IBBA data from two rounds
2	Literacy (Illiterate = 0, Literate=1)	IBBA data from two rounds
3	Marital status (Currently married=1, Marriage dissolved=2, Never Married=3)	IBBA data from two rounds
4	Age at first sex (<19 years =1, 20-24 years=2, 25+ years=3)	IBBA data from two rounds
5	Age at first paid sex ((<19 years =1, 20-24 years=2, 25+ years=3)	IBBA data from two rounds
6	Typology of FSWs (Public place=1, Lodge/Dhaba/Brothel=2, Home =3, Others=4)	IBBA data from two rounds
7	Number of FSWs in past 1 month (<2=1, 2=2,3=3, 4=4, 5+=5)	IBBA data from two rounds
8	Number of FSWs in past 6 months (<2=1, 2=2,3=3, 4=4, 5+=5)	IBBA data from two rounds
9	Round of IBBA survey (Round 1=0 & Round 2 =1)	IBBA data from two rounds
10	Ever had anal sex with FSW (No=0, Yes=1)	IBBA data from two rounds
11	Had anal sex with a man/hijra in the past 6 months (No=0, Yes=1)	IBBA data from two rounds
12	Had circumcision (No=0, Yes=1)	IBBA data from two rounds
13	Bought sex from FSW at places travelled in the past one year (No=0, Yes=1)	IBBA data from two rounds
14	Consistently used Condoms with FSWs (No=0, Yes=1)	IBBA data from two rounds
15	Condom use last time with Occasional FSWs (No=0, Yes=1, No occasional clients=2)	IBBA data from two rounds
16	Condom use last time with regular FSWs (No=0, Yes=1, No regular clients=2)	IBBA data from two rounds
17	Have a main/steady female partner (No=0, Yes=1, No main non-paying partner=2)	IBBA data from two rounds
18	HIV infection status (Negative=0, Positive=1)	IBBA data from two rounds
19	Experiences any STI symptoms in the last 1 month (No=0, Yes=1)	IBBA data from two rounds
20	Syphilis status (Negative=0, Positive=1)	IBBA data from two rounds
21	Heard/ seen/ read any advertisements/ messages on STI in past 6 months (No=0, Yes=1)	IBBA data from two rounds

	Program variables:	
1	Mean Percentage of Female sex workers covered by the programme (2006 and the difference between 2008 and 2006)	Avahan CMIS data
2	Mean Percentage of female sex workers contacted regularly (2006 and the difference between 2008 and 2006)	Avahan CMIS data
3	Mean Percentage of condom requirement met under the programme (2006 and the difference between 2008 and 2006)	Avahan CMIS data
	Distal variables:	
1	Total literacy rate in the population	Census of India 2001
2	Total female literacy rate	Census of India 2001
3	Percentage of Muslim population	Census of India 2001
4	Total fertility rate	http://www.jstor.org/stable/4411750
5	Total number of tourist spots in the district	http://districts.nic.in, www.karnatakastat.com, www.tamilnadustat.com, www.andhrapradeshstat.com, www.maharashtra.com,http://www.aptourismdirectory.com/APD/Prakasam.htm, http://districts.nic.in/
6	Mean age at marriage for boys	District Level Household Survey-3, 2007-2008
7	Mean age at marriage for girls	District Level Household Survey-3, 2007-2008
8	Percentage of married couples using condoms	District Level Household Survey-3, 2007-2008
9	Infant mortality rate	Census of India 2001
10	Total migration outside of district among men	Census of India 2001
11	Total migration outside of district among women	Census of India 2001
12	Total urban migration outside the district	Census of India 2001
13	Proportion of urban migration among men outside the district	Census of India 2001
14	Number of urban migrants among women outside the district	Census of India 2001
15	Total migration of men from other states	Census of India 2001
16	Proportion of total male migration of men from other states	Census of India 2001
17	Proportion of total male migration of women from other states	Census of India 2001
18	Percentage urban migration from other states	Census of India 2001
19	Percentage urban female migration from other states	Census of India 2001

20	Average per capita income	http://des.kar.nic.in/indexie.html, http://www.tn.gov.in/dear/tab/7.pdf, AP directly from the Central statistical office upon request , http://maharashtrastat.com
21	Percentage of persons aged 15 to 49 years	Census of India 2001
22	Percentage of females aged 15 to 49 years	Census of India 2001
23	Total population aged 15 to 49 years	Census of India 2001
24	Total population of females aged 15 to 49 years	Census of India 2001
25	Percentage of widowed/divorced/separated adult female population of age 15-49 years	Census of India 2001
26	Percentage of urban population between 15 to 49 years	Census of India 2001
27	Percentage of urban females between 15-49 years	Census of India 2001
28	Total urban population between 15-49 years	Census of India 2001
29	Total urban female population aged between 15-49 years	Census of India 2001
30	Percentage of widowed/divorced/separated adult urban female population of age 15-49 years	Census of India 2001
31	Total scheduled caste and scheduled tribe population	Census of India 2001
32	Total scheduled caste and scheduled tribe male population	Census of India 2001
33	Total scheduled caste and scheduled tribe female population	Census of India 2001
34	Percentage of SC & ST population	Census of India 2001
35	Percentage of SC & ST female population	Census of India 2001
36	Scheduled caste and scheduled tribe population in urban areas	Census of India 2001
37	Scheduled caste and scheduled tribe male population in urban areas	Census of India 2001
38	Scheduled caste and scheduled tribe female population in urban areas	Census of India 2001
39	Percentage of SC & ST urban population	Census of India 2001
40	Percentage of SC & ST urban female population	Census of India 2001
41	Percentage of female population in urban areas	Census of India 2001
42	Literacy rate in urban areas	Census of India 2001
43	Proportion of urban female migration both within and outside the district	Census of India 2001
44	Sex ratio (15-49 years)	Census of India 2001
45	Total urban female migration both within and outside the district	Census of India 2001
46	Percentage of boys married under 21 years of age	Census of India 2001
47	Percentage of girls married under 18 years of age	Census of India 2001

Appendix Table 2: Response rate, programme coverage value among FSWs in 2006 and in 2008 and the difference in coverage value among FSWS between 2006 and 2008 according to districts

District name	Response rate		Coverage value in 2006	Coverage value in 2008	Difference in coverage value between 2006 & 2008
	Round-1	Round-2			
East Godavari	28.4	43.9	21.5	52.1	30.6
Guntur	41.6	63.4	31.9	67.5	35.7
Hyderabad	38.3	39.2	26.2	90.9	64.7
Vishakhapatnam	34.5	45.6	26.4	91.0	64.6
Warangal	30.1	45.3	20.2	114.1	93.9
Mumbai	48.6	54.0	92.9	87.0	-5.9
Parbhani	51.3	61.5	63.2	84.8	21.6
Pune	43.7	64.6	5.2	22.3	17.1
Yevatmal	43.5	46.2	26.8	53.2	26.4
Chennai	42.0	58.0	86.5	106.3	19.8
Madurai	35.0	31.7	72.4	88.1	15.7
Salem	36.0	59.0	61.7	79.6	17.9
Bangalore Urban	68.6	89.1	19.4	125.7	106.3
Belgaum	76.1	93.3	17.5	57.5	40.0
Bellary	84.6	89.6	94.2	111.4	17.3
Shimoga	88.6	87.3	77.5	120.1	42.6

Mysore	100.0	100.0	64.8	97.4	32.7

Appendix Table 3: Percent distribution of clients of FSWs according to demographic and behaviour characteristcis between round-1 and round-2 IBBA survey

Characteristics	Round-1	Round-2	p- value
Age of respondent			< 0.001
<25	31.6	27.0	
25-34	38.8	43.2	
35+	29.6	29.8	
Can read and write			0.121
No	25.7	24.6	
Yes	74.3	75.4	
Marital status			<0.001
Currently married	59.9	62.4	
Separated/Divorced/Widowed	2.7	3.4	
Never married	37.4	34.2	
Age at first sex			0.013
<20	55.9	54.5	
20-24	36.1	38.3	
25+	8.0	7.2	
Age at first paid sex			<0.001
<20	37.8	31.2	
20-24	47.2	46.1	
25+	15.0	22.7	
Typology of FSWs			<0.001
Public place	41.5	45.4	
Brothel	37.1	29.4	
Home	17.0	13.0	
Other	4.3	12.2	
Consistent condom use with FSW			<0.001
No	63.4	39.4	
Yes	36.6	60.6	
Anal sex with a man/transgender in last six months			<0.001
No	93.5	87.2	
Yes	6.5	12.8	
Had circumcision			0.603
No	85.1	84.8	
Yes	14.9	15.2	