HHS Public Access

Author manuscript

Indian J Tuberc. Author manuscript; available in PMC 2016 March 30.

Published in final edited form as:

Indian J Tuberc. 2015 October ; 62(4): 211–217. doi:10.1016/j.ijtb.2015.11.006.

Airborne infection control in India: Baseline assessment of health facilities

Malik M. Parmar[a,*], **K.S. Sachdeva**[c], **Kiran Rade**[b], **Mayank Ghedia**[b], **Avi Bansal**[d], **Sharath Burugina Nagaraja**[e], **Matthew D. Willis**[f], **Dyson P. Misquitta**[g], **Sreenivas A. Nair**[b], **Patrick K. Moonan**[f], and **Puneet K. Dewan**[h]

[a]National Professional Officer – Drug Resistant TB, World Health Organization – Country Office for India, New Delhi, India

[b]World Health Organization – Country Office for India, New Delhi, India

[c]Central TB Division, Ministry of Health and Family Welfare, New Delhi, India

[d]National JALMA Institute for Leprosy & Other Mycobacterial Diseases, Agra, India

[e]Department of Community Medicine, ESIC Medical College & PGIMSR, Bangalore, India

[f]U.S Centers for Disease Control, Atlanta, USA

[g]Doctoral Scholar, Tata Institute of Social Sciences, Mumbai, India

[h]Bill & Milanda Gates Foundation, India Country Office, India

Abstract

Background—Tuberculosis transmission in health care settings represents a major public health problem. In 2010, national airborne infection control (AIC) guidelines were adopted in India. These guidelines included specific policies for TB prevention and control in health care settings. However, the feasibility and effectiveness of these guidelines have not been assessed in routine practice. This study aimed to conduct baseline assessments of AIC policies and practices within a convenience sample of 35 health care settings across 3 states in India and to assess the level of implementation at each facility after one year.

Method—A multi-agency, multidisciplinary panel of experts performed site visits using a standardized risk assessment tool to document current practices and review resource capacity. At the conclusion of each assessment, facility-specific recommendations were provided to improve AIC performance to align with national guidelines.

Result—Upon initial assessment, AIC systems were found to be poorly developed and implemented. Administrative controls were not commonly practiced and many departments needed renovation to achieve minimum environmental standards. One year after the baseline assessments, there were substantial improvements in both policy and practice.

[*]Corresponding author at: World Health Organization – Country Office for India, RK Khanna Stadium, 1st floor, Africa Avenue Road, Safdarjung Enclave, New Delhi 110029, India. Tel.: +91 96547 27772. parmarm@who.int (M.M. Parmar).

Conflicts of interest

The authors have none to declare.

Conclusion—A package of capacity building and systems development that followed national guidelines substantially improved implementation of AIC policies and practice.

Keywords

Airborne Infection Control (AIC); Tuberculosis (TB); Health Care Facilities (HCF); Revised National Tuberculosis; Control Program (RNTCP); India

1. Background

The risk of nosocomial transmission of airborne infections like *Mycobacterium tuberculosis* from individuals with disease to health care workers (HCWs) and other patients has been recognized for many years.[1–13] A systematic review of 51 studies conducted in low- to middle-income countries found that TB incidence among HCWs was high, ranging from 69 to 5780 per 100,000.[1] Evidence shows that TB is a significant occupational problem among HCWs,[1–13] especially in hospitals with no TB control measures in place.[2] Nosocomial outbreaks of airborne infections like influenza H1N1, H5N1, drug-susceptible, multidrug-resistant TB (MDR TB), and extensively drug-resistant TB (XDR TB), especially among HCWs with HIV infection, and reported high rates of morbidity and mortality have been linked to the absence or limited application of airborne infection-control strategies.[6,7,14] Since then, there has been renewed interest in understanding the impact of infection control measures in medical facilities.

India is the highest TB burden country accounting for one-fourth of the global incidence with 2.2 million incident TB cases emerging annually.[15] In 2012, India's Revised National TB Control Program (RNTCP) managed 1.46 million TB cases,[16] and unknown thousands more were managed in the private sector.[17–20] Prevailing infection control practices in India revolve around biomedical waste management and disposal of sharps; while airborne infection control (AIC) measures are largely absent from the health care facilities' policies and practices.[21] Nosocomial TB has in large part not been addressed by researchers in India, but those few studies that have been published have uniformly reported much higher TB disease rates among HCW than estimated to occur in the general population.[9,12,13]

To address the need for a simple, effective, and affordable AIC program in health care facilities in India, National Guidelines on Airborne Infection Control in Health Care and other settings in India – 2010 (NAIC) were published as the first, formal national guidelines on reducing the risk of airborne infections in health care facilities and special high-risk settings in India (e.g. respiratory disease wards, MDR-TB wards, Antiretroviral treatment centers, and TB culture and drug susceptibility testing laboratories).[21]

Till date, there has not been any large-scale, representative assessment of AIC practices over a broad spectrum and at multiple levels of health care in India. Therefore, as part of the national effort to assess the baseline implementation of the NAIC guidelines, we conducted systematic facility assessments to assess the risk of airborne transmission in 35 selected health care facilities, ranging from tertiary level medical colleges to primary health centers from the 3 states of West Bengal, Gujarat, and Andhra Pradesh. Each site received a tailored

set of recommendations of administrative, environmental, and personal protective measures, in line with national guidelines.

We also sought to reassess the implementation of NAIC recommended administrative and managerial control measures by the administrators at state, district, and health care facilities, one year after baseline recommendations.

2. Objectives

- To conduct systematic baseline assessments of AIC administrative, environmental, and personal protective policies and practices within HCF in India and
- To assess the level of NAIC guidelines implementation after one year.

3. Methods

During October 2009–September 2011, 35 HCFs across 13 districts in 3 states of India – West Bengal, Gujarat, and Andhra Pradesh – were selected for facility-based assessments for the risk of airborne disease transmission. The states, districts, and facilities were a nonrepresentative convenience sample, but were purposefully selected to provide experiences with AIC practices at all levels of the health system. Of the 35 facilities, 11 were from West Bengal (across 3 districts), 11 were from Gujarat (across 7 districts), and 13 were from Andhra Pradesh (across 3 districts). At the conclusion of each assessment, a series of written recommendations were provided to HCF administrators to improve policies and practice, based on the NAIC guidelines. After one year, each facility was reassessed to compare NAIC implementation as compared to baseline assessment results.

A multi-agency, multidisciplinary panel of experts conducted standardized risk assessments, including field-based observational visits to document infection control practices, human resource capacity, and administrative and environmental controls. The expert panel included members from the respective state AIC committees with support from the Central TB Division – India (CTD), World Health Organization (WHO), and the Program for Appropriate Technology in Health (PATH). The principal investigator and most of the coauthors were members of these baseline assessments. A standardized risk assessment methodology utilized a structured reporting format covering a range of AIC interventions [i.e., equipment/material to conduct baseline assessment like incense sticks to assess direction of air flow, measuring tape to measure volume of rooms, Vaneometer™ (i.e., swing-vane aneometer) (Dwyer Instruments, Michigan City, IN, USA) and DCFM700 Digital Anemometer (General Tools, New York, NY USA) to measure air velocity from openings, AirMeter 460 (Dwyer Instruments, Michigan City, IN, USA) to measure air velocity from ducts, and digital and mobile phone cameras to take pictures for documentation]; quarterly reports on AIC to monitor implementation of AIC guidelines; structured checklist to monitor coordination mechanisms for tracking administrative activities of the state and district level coordination mechanism; and a predetermined set of monitoring indicators covering administrative and managerial control measures at state, district, and facility levels for data compilation and analysis.

4. Variables and data collection

A predetermined set of indicators of AIC policies and practices were used for describing key administrative, environmental, and personal protective measures (Table 1).

Data were extracted from the detailed reports of the baseline facility risk assessment of all the 35 HCFs. We used a structured checklist to monitor coordination mechanisms and the quarterly AIC reports from the state, district, and facility level submitted to CTD.

5. Data entry, quality assurance, and analysis

All data were entered twice by independent data entry operators in Epi-Info (Centers for Disease Control and Prevention, Atlanta, GA, USA) and checked for internal validation for quality and consistency. The two databases were then compared for discrepancies and a final database was created after correcting discrepancies by referring to the original records and consulting with the concerned HCF administrators. We compared baseline AIC practices and policies, and assessed any change one year later.

6. Ethical approval

As this study represents evaluation of programmatic implementation of national guidelines for AIC in health care facilities, there were no patient-based data and hence no human subjects involved as study population. No formal ethical review was required; however,approval for theactivitywas sought from the Central TB Division, Ministry of Health and Welfare, Government of India (MoHFW, GoI), as per the recommendation of the National Airborne Infection Control Committee.

The activities undertaken by the state, district, and HCF administrators and AIC committees for this evaluation were within normal scope of their work and there were no additional duties associated with this study. Additional review by CDC institutional review board was not required because CDC investigators were determined not to be engaged in human subjects research as defined by relevant US government regulations (i.e., CDC investigators did not interact with study subjects or have access to identifiable data for study subjects).

7. Results

The characteristics of the 35 HCFs assessed in the study are described in Table 2. Amongst the 35 HCFs, 21 had specific high-risk departments of interest: 10 (29%) had antiretroviral treatment (ART) centers, 7 (20%) had a bronchoscopy suite, and 4 (11%) had departments specializing in MDR-TB treatment. While of the highest proportion of HCFs were secondary-level institutes (46%), 8 (23%) were primary health centers, 7 (20%) were tertiary-level medical colleges, 2 (6%) were for profit, private multi-specialty hospitals, and 2 (6%) TB laboratories.

7.1. HCF administrative IC systems

Few facilities had infection control committees (31%), infection control plans (14%), or infection control related activities (e.g., annual IC training) in place at baseline, and among

those infection control systems in place, 'airborne' related activities were not included (Table 3).

7.2. Administrative AIC practices

Administrative measures specific to AIC were negligible. None of the facilities offered masks to patients with respiratory symptoms, applied fast-track screening algorithms, or isolated potentially infectious patients in separate waiting areas. Six (18%) facilities informed patients on cough hygiene, including 2 (6%) where patients were observed practicing proper cough hygiene/etiquette. TB surveillance among HCW (passive or active) was practiced only in 1 facility.

7.3. Environmental AIC measures

In total, 187 various departments across the 35 HCFs, ranging from registration and outpatient departments to high-risk settings, were assessed for minimum recommended (Table 6) air changes per hour (ACH). Almost half of the departments assessed ($n = 103$) did not have the minimum recommended ACH at the time of testing. Notably, minimum ACH was determined to be achievable in 73% of the departments with natural ventilation alone (i.e., by virtue of the design of the health care facility structures), or through minor renovation. However, 51 (27%) of the departments tested required major renovations, decompression, or relocation of waiting areas to achieve the minimum ACH and prevent airborne transmission from infectious patients.

7.4. Personal protective AIC measures

Among the high-risk departments where infectious TB was most likely to be encountered (e.g. TB culture and drug susceptibility testing laboratories, MDR-TB treatment wards, and ART Centers), routine N95 respirators use was observed in only 2 of the 21 facilities with specific high-risk departments listed in Table 2. Unfortunately, in both departments, proper technique for use and fit needed improvement; there was no record of proper fit testing or training for the respirators issued.

7.5. Reported improvements in AIC activities one year after baseline assessments

The implementation of administrative and managerial control measures reported by the administrators at state, district, and health care facilities, one year after issuance of baseline recommendations, are described in Table 4. It was encouraging to observe that the efforts of advocacy, capacity building, coordination mechanisms, baseline assessments, and follow-up with state and districts officials and HCF administrators lead to substantial improvement in AIC policy and practice. Moreover, the lessons learnt to mitigate the challenges faced after the baseline assessment and recommendations are summarized in Table 5. As a health system strengthening activity, this experience has developed into a broader initiative to ensure greater accountability, systematic scale-up, and sustainability of AIC systems in the country.

8. Limitations

Our assessment and intervention involved purposively selected states and a limited number of purposively selected health care facilities. These may not be representative or applicable across all settings in India. The effect of the intervention on infection control policies and practices was assessed from regular reports provided by the facilities, and those results were not independently validated. Follow-up assessment on adherence to environmental recommendations has not yet been conducted at the time of preparation of this paper. A sequel to this study is planned in which all the 35 health care facilities will be subjected to post-assessments using the same methodology as the baseline. This will give a comparison with greater validity and also open the opportunity to assess the effectiveness of environmental and personal protective measures recommended in the baseline risk assessments in line with the national guidelines. Although, air velocity was measured in various settings to assess ACH, measurement of ventilation, e.g., using tracer gas (e.g., CO_2) dilution methods, could not be undertaken as the objectives focused around assessing feasibility of implementation of AIC measures in health care settings in India. The study also does not assess the impact of these interventions on reduction of nosocomial transmission, neither by surveillance among HCWs nor use of tuberculin skin tests at entry level and annually, as there were no human subjects involved and this is beyond the scope of the study objectives.

9. Discussion

Across a broad range of health facilities in 3 states, AIC practices were poorly implemented prior to the adoption of the NAIC guidelines. Specifically, AIC systems in India were underdeveloped, the airborne component was generally not included in existing infection control systems, and administrative controls were not commonly practiced. There were IC systems in place in many settings, and those could be leveraged for AIC through training and education of key staff members. About half of the departments surveyed within the participating facilities needed minor renovation to achieve minimum environmental standards. Most environments could be effectively ventilated with natural ventilation, but nonusage of available ventilation (i.e., shut windows) or layered modifications, such as deliberate blocking of windows, had reduced the potential ventilation. This is substantiated by the study on natural ventilation by Escombe et al.,[22] which concluded that opening windows and doors maximizes natural ventilation so that the risk of airborne contagion is much lower than with costly, maintenance-requiring mechanical ventilation systems. Natural ventilation is particularly suited to limited-resource settings and tropical climates, where the burden of TB and institutional TB transmission is highest. The tendency toward better climate control with air-conditioners created AIC risk and engineers will need to be sensitized on optimizing the balance of cooling expense and risk and comfort.

Use of personal protective measures by HCWs was found to be negligible even in high-risk settings. This challenge might be overcome through proper training, education, and monitoring mechanisms. It was observed that HCWs were well trained and demonstrated competency with other infection control practice, such as biomedical waste management.

Integrating AIC principles into existing general infection control training and education modules was recommended.

Despite poor implementation of AIC practices at baseline, we found substantially improved AIC practices after raising awareness of the NAIC guidelines and offering facility-specific recommendations to enhance policy and improve practice. This suggests that concerted effort to implement NAIC guidelines can effectively improve facility infection control standards and limit the risk of nosocomial airborne infection transmission, even in settings where AIC measures were lacking.

Our experience demonstrates that AIC implementation is fundamentally feasible, even in low-resource settings. India needs to move toward scale-up of the intervention package, with emphasis on integration of AIC into existing health system IC activities that include development and implementation of an integrated comprehensive infection control training material for frontline HCWs. The systematic scale-up across all health care facilities in the country can serve as preparedness plan for airborne pathogens of pandemic potentials. This can also help curb transmission of endemic diseases like TB and M/XDR TB, as a primary prevention intervention to complement the larger TB control efforts in India.

Acknowledgments

We are thankful to the State Program Managers of Andhra Pradesh, Gujarat, and West Bengal, and their staff, for providing the necessary support for the study. This research was supported through an operational research course, which was jointly developed and run by the Center for Operational Research, International Union against Tuberculosis and Lung Disease – South East Asia Regional Office in India, Central TB Division, World Health Organization, and the National Tuberculosis Institute, Bangalore. We also acknowledge the Chairperson and members of the National Airborne Infection Control Committee for necessary guidance to conduct the pilot implementation and this study. We are grateful to all senior officials of Central TB Division, WHO India and the RNTCP Medical Consultants who have contributed to this effort. We thank CDC, Atlanta for supporting in building capacity of the National and State AIC Committee members through their experts and USAID for funding the technical assistance through WHO and PATH India for supporting this activity. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the CDC or WHO.

References

1. Joshi R, Reingold AL, Menzies D, Pai M. Tuberculosis among health-care workers in low- and middle-income countries: a systematic review. PLoS Med. 2006; 3(12):e494. [PubMed: 17194191]
2. Roth VR, Garrett DO, Laserson KF, et al. A multicenter evaluation of tuberculin skin test positivity and conversion among health care workers in Brazilian hospitals. Int J Tuberc Lung Dis. 2005; 9(12):1335–1342. [PubMed: 16466055]
3. Chen G, Fa'asino A, Fujita Y, et al. Risk assessment on TB transmission in health center settings of Marikina and Paranaque cities, Philippines. J Natl Inst Public Health. 2009; 58(1)
4. Fennelly KP, Iseman MD. Health care workers and tuberculosis: the battle of a century. Int J Tuberc Lung Dis. 1999; 3(5):363–364. [PubMed: 10331721]
5. Sepkowitz KA. Tuberculin skin testing and the health care worker: lessons of the Prophit Survey. Int J Tuberc Lung Dis. 1996; 77(1):81–85.
6. Menzies D, Fanning A, Yuan L, Fitzgerald M. Tuberculosis among health care workers. N Engl J Med. 1995; 332(2):92–98. [PubMed: 7990907]
7. Pearson ML, Jereb JA, Frieden TR, et al. Nosocomial transmission of multidrug-resistant *Mycobacterium tuberculosis*. A risk to patients and health care workers. Ann Intern Med. 1992; 117(3):191–196. [PubMed: 1352093]

8. Joshi, R.; Patil, S.; Kalantri, S.; Schwartzman, K.; Menzies, D.; Pai, M. Prevalence of abnormal radiological findings in health care workers with latent tuberculosis infection and correlations with T cell immune response; PLoS Med. 2007. p. e805www.plosmedicine.org

9. Pai M, Gokhale K, Joshi R, et al. *Mycobacterium tuberculosis* infection in health care workers in rural India: comparison of a whole-blood interferon gamma assay with tuberculin skin testing. J Am Med Assoc. 2005; 293:2746–2755.

10. Pai M, Joshi R, Dogra S, et al. Serial testing of health care workers for tuberculosis using interferon gamma assay. Am J Respir Crit Care Med. 2006; 174:349–355. [PubMed: 16690977]

11. Rao KG, Aggarwal AN, Behera D. Tuberculosis among physicians in training. Int J Tuberc Lung Dis. 2004; 8:1392–1394. [PubMed: 15581213]

12. Gopinath KG, Siddique S, Kirubakaran H, Shanmugam A, Mathai E, Chandy GM. Tuberculosis among healthcare workers in a tertiary care hospital in South India. J Hosp Infect. 2004; 57:339–342. [PubMed: 15262396]

13. Mathew, A.; David, T.; Kuruvilla, PJ.; Jesudasan, M.; Thomas, K. Risk factors for tuberculosis among health care workers in southern India; San Francisco. Presented at the 43rd Annual Meeting of the Infectious Diseases Society of America (IDSA); 2005.

14. Shenoi SV, Escombe AR, Friedland G. Transmission of drug-susceptible and drug-resistant tuberculosis and the critical importance of airborne infection control in the era of HIV infection and highly active antiretroviral therapy rollouts. Airborne Infect Control TB HIV Infect Clin Infect Dis. 2010; 50(S3):S231–S237. [PubMed: 20397953]

15. WHO Global Tuberculosis Report. 2012. WHO/HTM/TB/2012.6www.who.int

16. TB India – 2013: RNTCP Status Report. New Delhi: Central TB Division, Directorate General of Health Services, Ministry of Health and Family Welfare; 2012. www.tbcindia.nic.in

17. Bhanu NV, Banavalikar JN, Kapoor SK, Seth P. Suspected small scale interpersonal transmission of *Mycobacterium tuberculosis* in wards of an urban hospital in Delhi, India. Am J Trop Med Hyg. 2004; 70:527–531. [PubMed: 15155985]

18. Dewan PK, Lal SS, Lonnroth K, et al. Improving tuberculosis control through public-private collaboration in India: literature review. Br Med J. 2006; 332:574–578. [PubMed: 16467347]

19. Rangan S. The public-private mix in India's Revised National Tuberculosis Control Programme – an update. J Indian Med Assoc. 2003; 101:161–163. [PubMed: 14603964]

20. Uplekar MW, Rangan S. Private doctors and tuberculosis control in India. Int J Tuberc Lung Dis. 1993; 74:332–337.

21. New Delhi: Directorate General of Health Services – Ministry of Health & Family Welfare, Nirman Bhawan; 2010. Guidelines on Airborne Infection Control in Healthcare and Other Settings – In the context of tuberculosis and other airborne infections – April 2010 [Provisional]. www.tbcindia.nic.in

22. Escombe, AR.; Oeser, CC.; Gilman, RH., et al. Natural ventilation for the prevention of airborne contagion. PLOS Med. 2007. http://dx.doi.org/10.1371/journal.pmed.0040068

Table 1

Component-wise themes to assess administrative, environmental, and personal protective AIC measures.

Component	Themes	
1. Administrative AIC measures	**i.**	HCF administrative IC systems with AIC components (e.g., established IC Committees, IC Focal points, written AIC plan)
	ii.	Administrative AIC practices (e.g., screening, fast-tracking, segregation of infectious cases, TB surveillance in health care workers.)
2. Environmental AIC measures	**i.**	Environmental IC aspects of various general health departments like Registration, outpatient and inpatient areas, Radiology, Pharmacy.
	ii.	Environmental IC aspects of special high-risk settings like ART Centers, Integrated HIV Counseling and Testing Centers, Microscopy Centers, MDR TB Wards, MTB Culture-DST laboratories, and Bronchoscopy Centers (e.g., minimum air change per hour, building designs facilitating minimum air change per hour)
3. Personal protective AIC measures	**i.**	Availability and use of N95 particulate respirators in high-risk settings (e.g., ART Centers, MDR TB wards, Bronchoscopy suits.)

Table 2

Characteristics of the Health Care Facilities assessed ($N = 35$).

Characteristic	*n* (%)
State	
Andhra Pradesh	13 (37%)
Gujarat	11 (31%)
West Bengal	11 (31%)
Type of facility	
Medical college	7 (20%)
Private tertiary	2 (6%)
District or subdistrict hospital	11 (32%)
Primary health care center	8 (23%)
TB hospital or clinic	4 (12%)
TB laboratories	2 (6%)
ART only	1 (3%)
Facilities with specific high-risk departments	
ART Centers	10 (29%)
Bronchoscopy suites	7 (20%)
MDR TB Wards	4 (11%)

Table 3

Results of baseline HCF AIC risk assessment: Administrative IC systems and practices; environmental and personal protective AIC measures (*N* = 35).

Indicator	*N* = 35 (%)
HCF administrative IC systems with AIC components	
IC Committee in place	11 (31%)
IC Committee met regularly (>2 times per year)	8/11 (73%)
Written IC plan available	5 (14%)
Written plan includes AIC	0/5 (0%)
IC focal point in place	7 (20%)
Funds routinely available for IC	7 (20%)
IC training for health care workers conducted annually	5 (14%)
IC training includes AIC	1/5 (20%)
Administrative AIC practices	
Cough hygiene information in registration/waiting areas	6/33 (18%)[a]
Patients observed to practice cough hygiene	9/33
Chest symptomatics given masks/tissues/counseling	0/33 (0%)
Dustbins for disposal of any masks/tissues	9 (26%)
Screening and fast-tracking of chest symptomatics	0/33 (0%)
Separation of chest symptomatics in waiting areas	0/33 (0%)
Inpatient segregation practiced by nursing staff	3/23 (13%)
Designated staff responsible for opening windows/vents	0
TB surveillance among HCW (passive or active)	1 (3%)
Environmental AIC measures	
Number of departments assessed	187 (100%)
Minimum ACH possible with natural ventilation alone (including those where minor renovation required)	137 (73%)
Waiting areas that need decompression or relocation	85/165 (52%)
Requiring renovation to achieve minimum ACH, decompression, or segregation	86 (46%)
Personal protective AIC measures	
HCFs where N95 respirators were observed to be used by HCWs in high-risk settings	2/21 (10%)

[a]Labs excluded.

Table 4

Uptake of the administrative and managerial control measures: one-year follow-up results from AIC reporting system.

Indicator of administrative AIC measures	Baseline (*n*/*N*)	One year (*n*/*N*[a])	Percent change
HCF with IC Committee in place	11/35	27/34	48%
IC committee meeting regularly	8/11	21/27	5%
Written IC plan available	5/35	19/34	42%
Written IC plan includes AIC	0/5	19/19	100%
IC focal point in place	7/35	30/34	68%
Health care worker surveillance (passive/active)	1/35	17/34	47%
Cough hygiene information	6/33	21/34	44%
Screening and fast-tracking[b]	0/33	20/32	63%
Separation of suspects[b]	0/33	18/32	56%

[a] 1/35 HCF did not report.

[b] 2 labs excluded.

Table 5

Lessons learnt: one-year follow-up of pilot implementation of national AIC guidelines.

Challenges	Mitigation measures
Gap in engineering capacity to implement environmental recommendations	4 architects from India trained in AIC at Boston (PIH-CDC) followed by in-country training of architects/engineers of 6 states with support of PATH in 2010–11
Routine quarterly AIC reporting	Intensive efforts to generate reasonable levels of reporting
Slow actions by HCF on recommendations from baseline assessments	Periodic reviews of progress made by HCF on recommendations from baseline assessments and site visits if required
Frequent change IC focal point in many facilities of Andhra Pradesh state	Resensitization of new IC focal points in the state

Table 6

Minimum air-changes per hour (ACH) required for various health care settings.[21]

Type of health care setting	Minimum ACH	Minimum ventilation rate (l/s/patient)
Registration/Waiting	>6	>40
Outpatient departments	>6	>40
Inpatient departments	>6	>40
High-risk settings	>12	80–160
ART Centers		
TB/Chest departments		
Bronchoscopy procedure rooms		
MDR-TB wards and clinics		
Airborne isolation rooms		