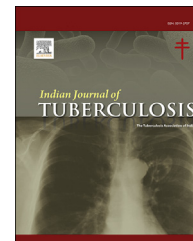


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Review article

Addressing the challenges in implementing airborne infection control guidelines and embracing the policies

Bella Devaleenal Daniel ¹, Abinaya Baskaran ¹, Baskaran D, Hephzibah Mercy, Padmapriyadarsini C*

Department of Clinical Research, ICMR-National Institute for Research in Tuberculosis, 1, Mayor Satyamoorthy Road, Chetpet, Chennai, 600031, Tamil Nadu, India

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ABSTRACT

Airborne pathogens not only lead to epidemics and pandemics, but are associated with morbidity and mortality. Administrative or managerial control, environmental control and use of personal protective equipments are the three components in airborne infection control.

National and international guidelines for ideal airborne infection control (AIC) practices are available for more than a decade; however the implementation of these need to be looked into, challenges identified and addressed for effective prevention of airborne disease transmission. Commitment of multiple stakeholders from policy makers to patients, budget allocation and adequate fund flow, functioning AIC committees at multiple levels with an inbuilt reporting and monitoring mechanism, adaptation of the AIC practices at various health care levels, supportive supervision, training and ongoing education for health care providers, behaviour change communication to patients to adapt the practices at health care facility level, by health care personnel and patients will facilitate health system preparedness for handling any emergencies, but will also help in reducing the burden of persisting airborne diseases such as tuberculosis. Operational research in this least focused area will also help to identify and address the challenges.

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1. Introduction

Globally, there has been a steady rise in transmission of diseases which spread by airborne route. Some of these spread in a rapid manner for varied reasons, affecting masses of people

across various geographical locations and impacting their lives in many different ways. Airborne transmission of disease causing pathogens could occur direct route or indirectly through droplets of various sizes and fomites.¹ Examples of airborne viral illnesses include but not limited to Severe Acute

* Corresponding author.

E-mail address: padmapriyadarsi.nic@icmr.gov.in (P. C).

¹ Both authors contributed equally.

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Respiratory Syndrome (SARS) infections, Middle East Respiratory Syndrome viruses (MERS), mumps, measles, varicella, Respiratory Syncytial Virus (RSVs) etc.² Similarly bacterial illnesses such as tuberculosis (TB), diphtheria, etc. also spread by droplet transmission. Factors influencing the air borne transmission of disease causing pathogens include seasonal patterns,³ weather,⁴ environmental pollution, socio-economic,⁵ poor living conditions, literacy level etc. However, during pandemics, factors such as malnutrition, poor living conditions and comorbidities contribute to serious debilitations and mortality⁶ in both the developing and developed nations equally. Pandemics due to airborne pathogens such as Spanish flu in 1918, Asian flu (H2N2) in 1957 and Hong Kong flu (H3N2) in 1968, pandemic influenza (pH1N1) in 2009, MERS between 2012 and 2019, not only affected millions of people but were associated with mortality as well.^{7–11} The 21st Century COVID 19 pandemic is a reminder that airborne pathogens could impact not only the health status, but also other vital factors such as economy, citizens livelihood, international travel etc.¹²

The health care providers' (HCP) not only play a major role in providing routine health care but also are the frontline warriors in any public health emergencies including epidemics/pandemics. They are at increased risk of exposure to infectious pathogens, thereby getting infected and transmitting it to other HCPs and patients. The risk of annual latent tuberculosis infection ranged from 0.5% to 14.3% and annual incidence of TB disease was between 69 and 5780 per 100,000 population among HCPs.¹³ The associated risk factors included but not limited to the place of work (inpatient TB ward, emergency care, laboratories, internal medicine units etc.) and occupational categories such as doctors, radiology technicians, nurses, paramedics and ward attendants.¹³

The guidelines for environmental infection control in health-care facilities were released by Centre for Disease Control and Prevention (CDC) in 2003. This was later updated over a period of time addressing specific diseases.¹⁴ World Health Organization (WHO) released the "Hospital Infection Control Guidance for Severe Acute Respiratory Syndrome (SARS)" on 24 April 2003, interim guidelines promoting non-pharmacological practices and principles for infection prevention and control for epidemic and pandemic acute respiratory diseases in healthcare in 2007, and later updated it in 2014 following H1N1 influenza pandemic (2009). The Government of India released National airborne infection control (AIC) guidelines in 2010 aimed at improving the health system preparedness to curb the spread of airborne infections as well as provide insights about household precautions. In addition to the universally recommended standard precautions, the guidelines project the hierarchy of AIC namely administrative control, environmental control and personal protective equipments. The guidelines were developed with the consideration of TB as the prototypic disease transmitted via airborne route, but also apply to other airborne infectious diseases as well.¹⁵ The National Guidelines for Infection Prevention and Control in Healthcare Facilities was released in India in January 2020. Though various national and international AIC guidelines are available, awareness and extent of implementation of these guidelines still remain poorly understood. P.T. James et al assessed the awareness of AIC practices among HCPs in a

tertiary care centre in Kerala, South India.¹⁶ Despite reasonable awareness among HCPs, there were lacunae in the practices. A panel of multidisciplinary experts conducted site visits to document the AIC practices and review the resource capacity across varied health settings in selected states in India. Based on their observations, they provided facility specific recommendations to improve the awareness and practice of the National AIC guidelines and showed them to be effective.¹⁷ Several obstacles and limitations for implementation of adequate infection control practices include but not limited to managerial support, poor funding, shortage of manpower, limited awareness and lack of institutional commitment.¹⁸ Here we reviewed the key pillars of AIC (administrative control, environmental control and personal protective equipments) as per WHO and National guidelines with an objective to understand the challenges in implementation and propose possible solutions for addressing these challenges.

1.1. Administrative control key features

The National AIC guidelines 2010, recommends considering the following key elements in administrative control.

- Availability of infection control committee, infection control plan and training documents in every healthcare setting.
- Screening of respiratory symptomatics immediately upon arrival.
- Segregation and fast-tracking the respiratory symptomatics.
- Provision of masks, patient education on cough etiquette and safe disposal of sputum for symptomatic patients.
- To have designated personnel to implement and monitor the practices.

1.1.1. Challenges in administrative control

The administrative control has the largest impact in AIC prevention control strategies and acts as the first line of defence against transmission of airborne pathogens. The protocol calls for prompt triage of persons with presumed TB based on respiratory symptoms. Screening of these patients requires an understanding by the HCP about identification of a potentially infectious person. Segregation of the respiratory symptomatics need availability of separate space in health care facilities designated for the purpose. In case, such space is not available, respiratory symptomatics could be segregated in an open well ventilated place. Fast-tracking of patient services for respiratory symptomatics decreases the exposure time of others. Expediting respiratory symptomatic services at the expense of others could be difficult. Also, attention should be paid to the type of health care facility that could benefit from fast-tracking of respiratory symptomatics. For instance, this feature might not be effective in a health care centre meant for respiratory diseases, rather this could be useful in general hospitals and OPDs. Implementation of administrative control measures doesn't require huge materialistic investments or resources. Successful implementation of administrative measures is achieved by prioritizing training and education of human resources (Table 1).

1.2. Environmental control key features

The key component of environmental control is dilution of infectious agents in the air and achieving maximum air exchange. This is achieved by

- Attaining the minimal (about 6–12) air changes per hour (ACH) to eliminate or decrease the infectivity in the air.
- Ensuring effective unrestricted ventilation by following proper operations in facilities which are dependent on natural ventilation.
- Verifying the design, operation and maintenance of the system, where mechanical ventilation is utilized.
- Adapting the most favourable seating arrangements between the staff and patient to reduce the risk of disease transmission.

- Opting for special devices like high efficiency particulate air (HEPA) filters and ultraviolet germicidal irradiation (UVGI) filters in high risk settings where adequate air exchange by natural ventilation is not feasible, and if the funds permit.
- Assigning staff for monitoring environmental control activities.

1.2.1. Challenges in environmental control

Environmental control forms the second line defence factor in stopping the spread of TB in health care settings, after administrative control. The methods to achieve environmental control include ventilation (natural and mechanical), UVGIs, filtration and other methods of air purification.

Table 1 – Addressing challenges in implementation of administrative control.

Commonly faced administrative control challenges	Possible ways of tackling the administrative obstacles
Non-availability/non-functioning of facility infection control committees ^{17,18}	Constitution of facility infection control committee with the staff which oversee/implement AIC practices at primary level centres. Constitution of a committee including the staff and experts for secondary as well as tertiary level centres.
Non-availability of facility AIC plan ^{17–20}	Development of e-platform for submission of risk assessment report, minutes of the meeting etc. and monitoring by the higher level committees. Standardized AIC plan for each level of health care facilities drafted by experts/programme managers in district/state Infection control committees for adaptation and customization by individual facilities. Inclusion of budget in the programme implementation plan and allocation of adequate annual funds for implementation.
Screening, ²¹ identification, segregation ¹⁹ and fast-tracking of services for respiratory symptomatic patients not widely done ¹⁷	Appropriate training of concerned HCPs and supervision of implementation by the allotted HCP/facility-in-charge. (or) Self-identification ²² by the patients with proper signage placed at the entrance, in the event of staff shortage. Fast-tracking of services by having special stamps that could serve as an indicator for the staff.
Inadequate AIC practices followed by the patients visiting the health facility ²³	An onerous task, which solely can be achieved by repeated patient education and sustainable demonstration by the staff in adhering to the practices.
Lack of patient education ^{20,23} and display of Information Education and Communication materials ¹⁷	Rigorous motivation and encouragement of the staff to educate the patients. Preparation of patient educational materials such as posters for display in health care facilities and pamphlets for distribution to patients by the Programme managers.
Lack of designated staff to overlook the AIC practices	Designation of all the staff on rotational basis to ensure the implementation of practices, promoting a sense of responsibility among all the staff equally.
Lack of adequate awareness of the guidelines ²⁰ and Institutional Commitment	Providing repeated education to the staff by a member of the infection control committee/facility in charge, insisting on the benefits of AIC practices.
Lack of adequate staff training in infection control policies.	Incorporation of AIC training programme in the Programme implementation plan and regular annual training of HCPs.
Lack of motivation among the staff for implementation of AIC practices.	Awards to the staff who are actively involved in AIC implementation at the facility/district level. ²⁴ Motivation by the facility-in-charges/programme managers by provision of appropriate support in the form of weekly briefings, incentives etc. for implementation.
Frequent turnover of HCPs which affects the knowledge and routine practices to be followed.	Sensitisation of newly recruited HCPs along with proper orientation, delegation of their responsibilities by the senior staff or the facility-in-charge.
Inappropriate infrastructure resulting in lack of space for segregation, ventilation etc. ²⁵	To involve AIC experts/engineers from planning to completion so that infrastructure can be in accordance with the guidelines ex. place for segregation, appropriate cross ventilation etc.

Some forms of environmental control measures are simple and economical while some others might be complex and costly. Ex. UVGI and HEPA filter, air-conditioners, air-purifiers etc. Parmar et al showed that minor renovations in existing natural ventilation helped to achieve the minimal required ACH.¹⁷ Researchers from Peru estimated the effectiveness of natural ventilation by assessing different hospital room types constructed in the old fashioned way before 1950s and in the modern era between 1970 and 1990 using the Wells-Riley equation. They found that higher rates of air exchange, absolute ventilation (which is the amount of air inflow per unit time (m^3/h)) was achieved by opening the windows and doors, especially in old buildings. They noticed that the calculated risk of respiratory infection contagion was slightly higher in mechanically ventilated rooms (39%), even with the recommended air changes, compared to the rooms with natural ventilation (11%) when exposed to a source of infection. Factors such as heat loss, culture, tradition or security pose as barriers in practicing natural ventilation. Given that isolation of an infected person is often difficult, it is safer to keep the windows and doors open to reduce the risk of transmission. The protective effects of ventilation could be achieved with half open windows as well.²⁶ Installation of negative pressure rooms are costly with operational challenges and require maintenance. However, mechanical ventilation will be

required wherever there are implementation inadequacies in natural ventilation due to local conditions.²⁷ Improving the ventilation was found to be the most effective and efficient solitary initiative by a modelling study conducted in South Africa. It modelled improved natural ventilation, use of mechanical ventilation systems such as fans, and the impact of HEPA and UVGI filters for prevention of XDR TB transmission. Improvement in natural ventilation alone and mechanical ventilation prevented 33% and 12% of XDR TB transmission respectively. Addition of HEPA filters to mechanical ventilation reduced the infectivity by further 10%, while there was a 32% decline in transmission rates with the combined use of UVGI and mechanical ventilation.²⁸ Installing split air conditioners and keeping doors and windows closed indicates a complete lack of air-exchange (see Fig. 1). Therefore particular attention must be given to ensure adequate ventilation when installing measures for climate control¹⁵ (Table 2).

1.3. Challenges in PPE

PPE is the third important defence mechanism in improving AIC. It should be used together with proper hygienic practices. PPE includes gloves, gowns, masks, goggles, N95 particulate respirators etc. HCPs are required to take adequate precautions such as hand hygiene before and after providing care

Table 2 – Addressing challenges in implementation of environmental control.

Commonly faced environmental control challenges	Possible ways of tackling the difficulties in implementing environmental control
Lack of awareness about the right environmental practices among the staff in the facility	Providing ongoing education to the staff by a member of the infection control committee/facility in charge, insisting on the benefits and vital role of environmental control in achieving AIC. Incorporation of AIC training programme in the Programme implementation plan and regular annual training of HCPs.
Closed doors and windows restricting the air-exchange Improper seating arrangement between the HCP and staff	Opening of the windows and doors ²⁶ to its maximum capacity. Assigning a staff to take charge of the same. Minor modifications in the seating arrangements as per NAIC guidelines (Fig. 2) to ensure direction of airflow between the patient and the staff and not from patient to staff (see Fig. 1). Picture (A) shows potential air transmission between the health care worker and patient. Picture (B) depicts ideal seating arrangement between the health care worker and patient. Staff seating to be placed near a clean air source and patient seating to be placed near an exhaust. ¹⁵
Imprecise handling of the additionally installed ventilator systems	Proper training and education of the staff about the right methods of operating the mechanical ventilator systems during installation and also to have a manual for reference in future.
Closing doors and windows in a room with split air conditioners, which doesn't allow air-exchange	Following proper instructions in installation of air-conditioners as per the National Guidelines. Ensure location of air conditioners near the door, away from the exhaust fan. Exhaust fan to be installed on the opposite end allowing adequate air-exchange. Provision of space under the door for easy air-entry. ¹⁵
Poor hygiene and pest infestations around the facility surroundings as the reason for keeping the openings closed.	Maintenance of good hygiene and sanitation with adequate help from the local government and multi sectoral/inter departmental coordination.
High cost of mechanical ventilation systems, costs involved in their installation and maintenance, need for prior planning and designing of the infrastructure for their placements.	Appropriate budgeting and allocation of funds by the program managers to allow proper maintenance and functioning of appliances appropriately. ²⁹

Table 3 – Addressing challenges in the implementation of PPE.

Commonly faced challenges in PPE usage	Possible ways of managing the issues surrounding PPE
Non-availability/Limited availability ³³ of the required PPE materials	Allocating adequate funds and ensuring supply based on the needs by the facility in charge/programme managers. Routine budgeting for funds in programme implementation plan. Educating and encouraging the staff for the rational use of PPE. ³⁴ (appropriate method of using the PPE, scenarios where PPE is a mandate, optimal usage and re-use of appropriate PPE etc.)
Lack of knowledge and usage of incorrect PPE (over protecting/under protecting) ³⁰	Proper educational sessions on correct PPE selection. Overseeing the appropriate use of PPE and reducing its wastage and prevention of cross contamination by a monitoring/infection control committee. ³⁴
Lack of compliance among healthcare workers handling patients with presumed/diagnosed airborne infections ^{30,35}	Repeated education to the healthcare workers, reinforcing the importance of using the PPEs in appropriate situations. Monitoring the staff on proper use of PPE, by the infection control committee/governing body/officer-in-charge
Improper donning/doffing techniques leading to impaired protection ³⁶	A short educational session (using videos etc.) about the proper techniques of wearing and removal can be conducted/circulated at a regular frequency.
Perceived difficulties in usage of PPEs such as face-mask or N95 ^{33,35}	These are perceptions and not facts, therefore can be removed by constant re-assurance.

to patients. Full PPEs are required to be worn in situations such as nebulization, endotracheal intubation, manual ventilation, oral/air-way suctioning, cardiopulmonary resuscitation, bronchoscopy etc. Aerosol generating procedures strictly recommends the usage of N95 particulate respirator.¹⁵ Knowledge and practice of appropriate donning and doffing off the PPE are vital in prevention of cross contamination.²⁵

Inconsistent/inappropriate use of PPE increases the risk of self/environmental contamination. Another factor that is responsible for cross contamination while using PPE is improper donning and doffing methods.³⁰ Also inappropriate use of PPE leads to wastage and shortage thereby exposing the needy to the risk of infection³¹ (Table 3).

Sterilizing PPE similar to other medical devices for recycling/reuse is questionable as there is limited knowledge on

its efficacy post sterilization. Also using radiation to sterilize them could reduce the functionality as it might affect the material. Damage to the material and reduced performance is expected in gas sterilization using hydrogen peroxide.³²

2. Discussion

Airborne transmission of respiratory infectious agents could be controlled by prevention of pathogen release from the source, its transport through air or touching the contaminated surfaces and protection of the susceptible contacts.¹ There are global and national guidelines for improving the AIC practices since more than a decade, however the awareness and practice of these guidelines is still limited.

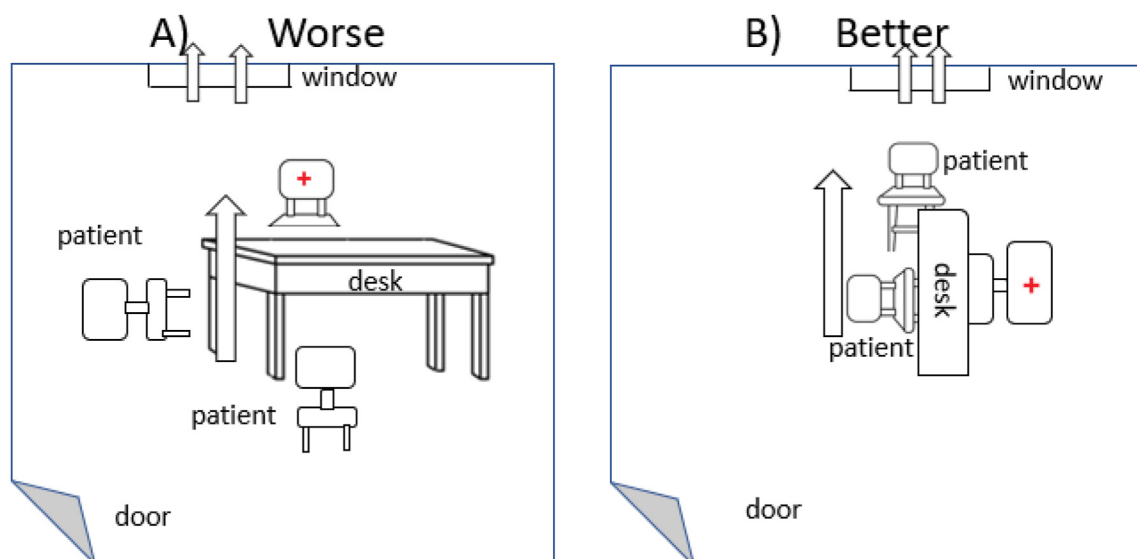


Fig. 1 – Roles and responsibilities for implementation of AIC practices in a health care facility.

Frequent staff turnover, training needs for the newly hired staff, heavy patient load, staff and patient perceptions of using appropriate PPE are some of the barriers for infection control in a health care setting where as ample infection control supplies, adequate funds, integration of infection control team with the clinical team, adequate cleaning team, staff knowledge etc. act as facilitators.³⁵ A study in a large medical centre in United States of America during the COVID 19 pandemic showed that rigorous implementation of comprehensive AIC plan covering various aspects could prevent the nosocomial transmission of COVID 19 which is known to be highly transmissible. One COVID 19 transmission was attributed to be hospital acquired among 8370 patients who were hospitalized for non COVID reasons.³⁷ Multipronged interventions including proactive screening, isolation, masking of patients and HCPs, monitoring PPE usage and HCP education were shown to be effective in

prevention of COVID 19 transmission among HCPs in Hong Kong.³⁸

Key stake holders including policy makers, programme managers and HCPs need to be sensitized regarding the necessity for successful implementation of AIC guidelines in disease prevention and transmission by multiple advocacy meetings. Advocacy for financial plan and budget allocation not only for implementation of infection control practices but also for sustaining these activities at national, state and district level by the programme managers is vital.³⁹ Building a system for monitoring mechanisms at multiple levels, creation of reporting mechanisms with specific timelines through electronic applications could facilitate review of the implementation. National and international level conferences, seminars, expert meetings and webinars with a focus on AIC could play a role in sensitizing the scientific committee in AIC implementation and its role in prevention of disease

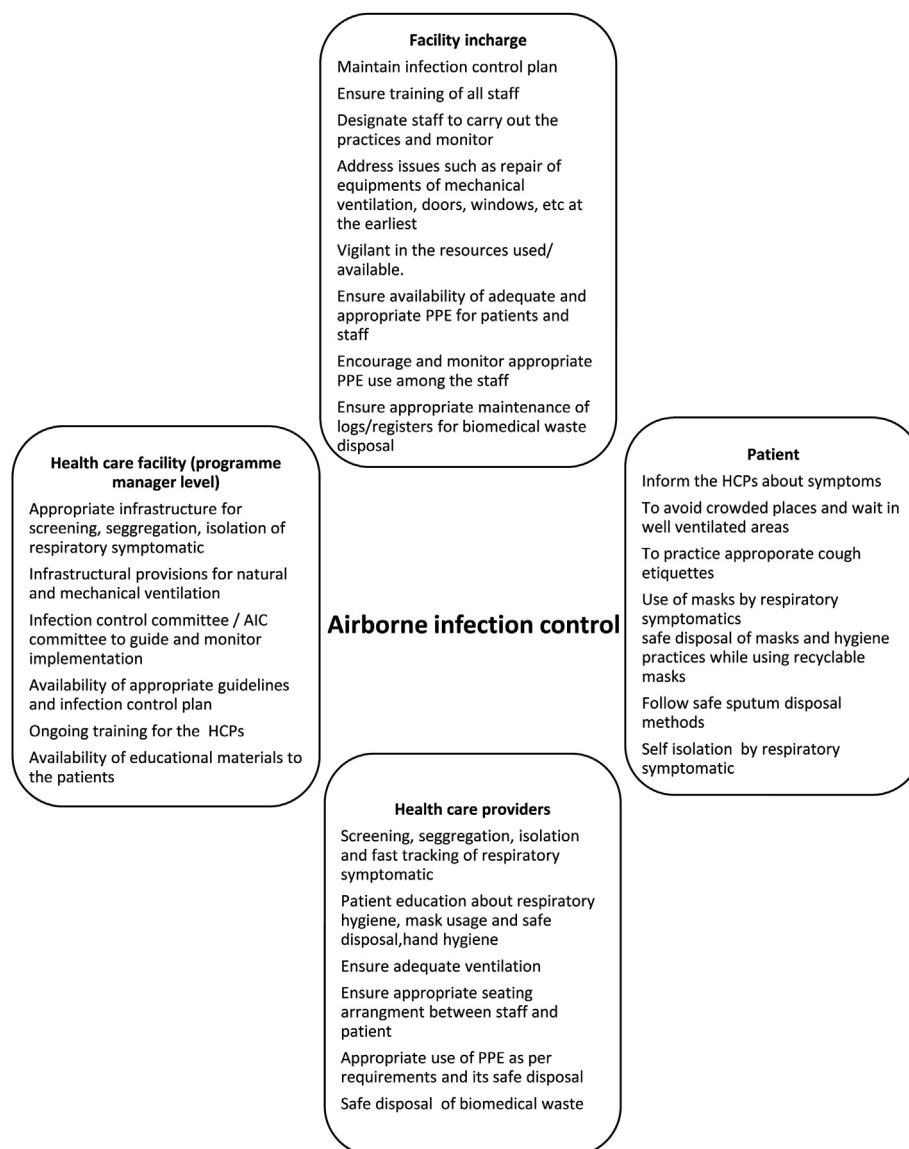


Fig. 2 – Ideal seating arrangement between health care provider and patient for appropriate airflow as per Indian National AIC guidelines.

transmission. Operational research to understand the strengths and gaps and identify solutions is the need of the hour to strengthen the implementation.

At the field level, multi-pronged approach is essential for the successful implementation of AIC practices (Fig. 2). Routine and continuing education of HCPs in AIC practices as per the guidelines need to be included in the programme implementation plan, implemented and monitored as well. Role of functional AIC committees including experts, clinicians, public health personnel, community representatives, engineers at multiple level (national, state, district, tertiary, secondary and primary health facility level etc.) to update the guidelines, train the HCPs and community and monitor the implementation of these guidelines is vital. Multisectorial coordination including AIC experts from the planning stage till completion would help to address the infrastructural issues. Adequate stock of PPEs and its appropriate use is essential for protection of HCPs as well as prevention of spread of nosocomial infections. Community preparation including behaviour change communication regarding cough etiquette, isolation of respiratory symptomatic, seeking early care and treatment in case of sickness, safe disposal of sputum, appropriate hand hygiene practices, ensuring adequate ventilation in the residence to the level feasible while suffering from respiratory illness should be continuously given even in times without epidemics or pandemics. Children should be educated in schools regarding respiratory and hand hygiene practice. Development and use of patient friendly educational materials including videos, skits, catchy slogans, identifying a celebrity ambassador for campaign etc. will help to raise awareness and encourage the practice. Improvement of awareness among the community might lead to self-discipline, eliminate stigma associated with some of the respiratory diseases ensuring appropriate AIC behaviour by the patients.

3. Conclusion

Effective implementation of the AIC practices is of utmost importance in this era of pandemics and epidemics due to transmission of pathogens which spread by airborne or droplet route. The guidelines and policies are in place; however its practice is very limited especially due to poor awareness. It is the need of the hour to focus on the implementation of these guidelines and policies at every level to ensure adequate health care system preparedness to tackle any health system emergency. The challenges in implementation of these guidelines and its appropriate solutions need to be looked into at the each level of health care system. Commitment at the Programme/managerial level, every level of HCP cadre and community is essential for the effective implementation of AIC practices which will pave way for prevention and control of airborne diseases.

Authors contribution

Bella Devaleenal Daniel, (a) conception, design and/or analysis and interpretation of data and to (b) drafting the article or

revising it critically for important intellectual content and on (c) final approval of the version to be published.

Abinaya Baskaran, (a) Design, analysis and interpretation of data and to (b) drafting the article, revising it critically for important intellectual content (c) final approval of the version to be published.

D. Baskaran, (a) Design (b) revising it critically for important intellectual content and on (c) final approval of the version to be published.

Hephzibah Mercy, (a) analysis and interpretation of data and to (b) drafting the article (c) final approval of the version to be published.

C. Padmapriyadarsini, (a) Design (b) revising it critically for important intellectual content and (c) final approval of the version to be published.

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Declaration of competing interest

The authors have none to declare.

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