Studying the Double Paradox in Air Conditioning at Indian Airports for Airborne Infection Prevention and $PM_{2.5}$ filtration.

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Abstract:

Airports are hubs of diverse human interaction. In case of pandemics, they may serve as primary centres for spread of diseases, especially airborne transmitted. Appropriate methods for prevention of spread of airborne infections must be integrated with the Air conditioning systems of airports. Along with UVGI and other sanitisation methods, dilution ventilation can be the easiest and most available method for prevention of airborne infection. This means intake of outside air into the indoor which flushes out the aerosolised droplets containing pathogens. Though, this process is adopted, it may present the challenge of high concentration particulate matter, an air pollutant in major developing countries, which may enter through the air conditioner. Appropriate filtration is necessary so that along with airborne disease prevention, the risk of PM 2.5 induced lung issues is also reduced. A series of Right to Information applications were filed to get information on the Air conditioners of 61 Indian airports. Out of these 27 fell in 'non-attainment' of Air Quality list. On appraisal of filter systems it was found that 23 had intake of fresh air, but only 5 had filters of rating MERV 10 and above in their Air Conditioning systems. It can be concluded that the mostly the airports did not have the appropriate filter required for filtering PM 2.5, which is a major pollutant in Indian cities. In light of COVID-19, where Dilution was suggested, it may lead to entry of polluted air in the indoors.

Keywords:

Air Conditioning Systems, Filtration, Airborne Infection Control, Dilution Ventilation, Particulate Matter.

1. Introduction:

Airports are hubs of human interaction at a large scale. They are of all the more consequence during pandemics when human movement across continents becomes the carrier of diseases[1]. Airports are good examples for public spaces where most people are unique visitors. This makes keeping a track on their previous activities very difficult. In the case of airborne diseases, where the risk of disease spread is of great potential and is unseen, this fact of novel interactions of people is of great concern. In large congregations that happen in these high volume enclosed spaces, having airborne infection control measures is of utmost importance. At the same time, the air intake should be free from PM 2.5 which is a key cause of lung diseases[2].

This study aims to look at the measures in place in the Air Conditioning systems of the Airports with respect to Airborne Infection Spread. This is for two reasons, Firstly, whether there is dilution ventilation and other measures for airborne infection control[3,4] and secondly, whether the air conditioning system has filtration capacity to filter out PM 2.5. This is particularly important for airports that are located in cities with chances of high PM 2.5 concentration. A list airports which are located in the 'Non-Attainment list of cities' was made and the airports under study were checked. 'Non-Attainment list of is a list of cities where the Ambient Air Quality Standards prescribed by the Central Pollution Control board are not met[5]. In Indian cities, the major polluter is Suspended Particulate matter, PM 2.5 [6] which has an aerodynamic diameter of 2.5 microns. Our study looks at whether the filters present in the Air conditioning systems of the airports have the appropriate MERV capacity, with MERV and above being ideal[7] to filter out PM 2.5. This is important to understand because airport managers are allowing in fresh air into the airport from the outside for dilution ventilation[8]. This dilution ventilation plays a key role in flushing out the aerosolised pathogens[9], but in this process also brings in pollutants which the filtration system of the air conditioner must be capable of filtering. Otherwise, the action of dilution ventilation, may lead to lung issues caused due to inhaled particulate matter.

The airports authority of India is the statutory body in India created by an act of the Parliament of India[10]. This body is responsible for creating, upgrading, maintaining and managing civil aviation infrastructure in India. It also directly manages 125 airports in India. Being a government run organisation, it was under the purview of the Right to Information Act, 2005[11]. This Act, aimed at bringing transparency to government functions is also a boon for the researchers who can access information from government bodies and other public authorities. The advantage of this approach is a time bound and approved source of information right from the source.

2. Aims and Objectives

The aim of this study is:

2.1.1. To perform an appraisal of the air conditioning systems present in Indian Airports with respect to the types of AC's and presence of Airborne Infection Control measures.

2.1.2. To study the filtration capacity of airports in cities with high urban pollution, with respect to suspended particulate matter PM 2.5.

3. Methodology

3.1.1. Creating a set of questions or parameters for which the information from the airport is required to be received. Creating a list of airports from which the information needs to be obtained.

3.1.2. Formulate the list of methods that are possible to obtain information from the airports. Choose the suitable method for obtaining information- using the Right to Information Act. 2005 for sending applications for technical information from the airports.

3.1.3. Follow up with airports for the information. Collect and collate the information.

3.1.4. Compile and analyse the information against the parameters or the objectives of this research. Report the results and suggest recommendations.

3.1.5. To get the information about the present Air Conditioning Systems, the Airborne Infection control measures and the ventilation situations of the airports many methods could be adopted. These methods are listed in Table 1.

Table 1: The reason of choosing the methodology.

S.No.	Method	Advantages and Opportunities	Disadvantages and Threats
	Seek for secondary data from the airport as they have Engineers on board responsible for the air conditioning systems. This will be through correspondence which may be a physical letter or an email.	Getting information directly from the source.	1. Possible reluctance as data sharing may put the airport in bad light. 2. Lack of accountability in providing a reply. Depends upon the interest of the airport.
	Visit the airport and seek information by meeting the persons in charge and	1. This will enable	1. Visiting the airport is seen with a lot of reluctance,

	get relevant documents.	information direct from the source. 2. Will provide an opportunity to explain the bonafides of the work and its need in research.	especially the services area due to security prohibition, especially when the security is managed by another paramilitary agency, with set standards of operations. 2. Visiting airports during the pandemic was especially discouraged due to a higher chance of getting infected in a public space.
	Visit the airport and perform investigations with respect to the parameters of ventilation and Airborne Infection Control	1. Most accurate data would be possible to achieve	1. The process may be bureaucratically daunting and being high security area, permission may not be granted. 2. Risk of spread of disease, any non-required people will be prohibited during the pandemic.
	File an application under the Right to Information Act, 2005 to the airport seeking for the information and get a reply within the time period stipulated by law.	1. Information right from the source, free from bureaucratic delays as reply has to be provided	1. There may be a bias, but unlikely as this document has legal implications for the information provider. [12]

		within 30 days by law.	

90 applications under the Right to Information Act, 2005 were sent to the airports managed by Airports Authority of India. Out of these 61 gave the reply to the information as per the law. The remaining 29 either refused information based on some minor technical discretion, or simply did not respond in violation of the law. This research takes into consideration the replies received from 58 airports in India across the 5 sub regions of airports in India namely: Northern, Eastern, Western, Southern and North-Eastern.

The applications consisted of 10 questions that were framed in order to procure the information from the airports they were addressed to. The Questions were as follows:

1. Please provide the type of ventilation-HVAC[i] System that has been provided in the Terminal

2. Please provide the steps/precautions taken to prevent the transmission/spread of airborne diseases like COVID-19, Tuberculosis, Measles, etc.?

3. Please inform whether there is an integration of UV light disinfection technologies/UVGI/ UAGI technology in the HVAC System/Ventilation system in the interior of the Terminal.

4. Please inform whether there are filters used in the HVAC System in the interior of the Terminal.

5. Please provide the specifications/details of the filters that are being used in the Terminal. Please provide the size of the minimum size of particles that can be filtered with the filters used (least count of the filter in microns)

6. Is there a provision of incorporating the outside fresh air into the interior of the Terminal via the HVAC System/Ventilation System or by any other mechanism?

7. Please provide the detail of the Fresh Air intake capacity of the HVAC/Ventilation system used for dilution ventilation which flushes the inside air and brings in fresh air from the outside.

8. What are the Air Changes per hour of fresh air into the Terminal?

9. Are there rooms/spaces in Terminal where Split Air Conditioner/Room Air Conditioners have been used and the inside air is constantly recirculated?

10: Please provide the peak occupancy capacity of the terminal.

In case the building is constructed/in use, please provide the requested information. In case the Building is under construction, please provide the information in light of the proposed plan and design. Kindly Note: Information is sought for the Civil Enclave only.

These questions were designed to get a complete picture of the Air Conditioning systems present in the airport and to get the ventilation measures and the airborne infection control measures in these airports. They were specifically aimed at the following information:

1. Whether the airport air conditioning has provisions for the intake of fresh air inside the volume of the enclosed space and provides dilution ventilation for flushing of aerosolised droplets containing pathogens?

2. To know the size of the filters used in the HVAC systems of the airport in order to filter the various contaminants like pathogens, dust and other pollutants like particulate matter.
3. Whether Ultra Violet Germicidal Irradiation[13] has been integrated into the air conditioning system of the airport?
4. Whether there are types of air conditioning systems which do not have or have a reduced capacity to bring in fresh air- like split air conditioning systems.

4. Results

There were a total 61 airports that were studied. Out of these 6 did not have flight operations, but has an operation building. The type of air conditioner system in the air ports varied from being a full-fledged central Heating Ventilation and Air Conditioning System to ones with split Acs in a room. The total diversity in Air Conditioning systems is given in Table 2. The filtration has been listed in Table 3. Out of 61 airports, 43 had filtration of some kind, majority being pre filters of MERV values in the range of 5 to 8. Only 5 had filters of MERV value equal to or above 10. It was also found that out of the 61 airports, 27 came under the Non-Attainment category. Out of these, 23 had intake of fresh air through the HVAC system, but only 5 had filters of rating MERV 10 and above in their Air Conditioning systems. The consequences of these values have been discussed in the discussion.

Table 2: List of the type of Air Conditioning Systems along with the numbers of airports having these.

S. No.	Type of Air Conditioning System	No. of Airports with system

1.	Central HVAC System	18
2.	VRV/VRF/Package/Cassette type.	8
3.	Split/ Room Air Conditioner/ Tower Type standalone	12
4.	HVAC + Split	8
5.	HVAC + VRV	1
6.	Heat Generator System	1
7.	Details not provided	3
8.	HVAC + HVLS Fan	1
9.	No HVAC	4
10.	VRF + Split Combination	2

6 out of 61 have installed UVGI system, while 19 had the work of installation in the pipeline. 43 out of the 61 had provision for a filter within the HVAC system. The filter type details are as listed in Table 3.

Table 3: List of the type of filter integrated into the Air Conditioning systems of all the airports studied.

S. No.	Type of Filter integrated in the HVAC System	No. of Airports with filter

1	MERV <5-6	5
2	MERV 5-6	2
3	MERV <7-8	8
4	MERV 7-8	6
5	MERV 10	1
6	MERV 8	2
7	MERV 13	1
8	MERV 8 + MERV 14	1
9	MERV 8 + MERV 11	1
10	HEPA	2

Table 4: The appraisal of the Air Conditioning system and Filtration of airports in cities in Non-Attainment list[5].

S. No.	List of Cities which fall under Non-Attainment list and which have the airport.	Type of Air Conditioning System	Whether Fresh air through HVAC supplied	Rating of Filter integrated into the HVAC (in MERV)
1	Udaipur, Rajasthan	H	1	8
2	Gwalior, Madhya Pradesh	V	1	5-6
3	Kanpur. Uttar Pradesh	V+S	0	n.p
4	Ludhiana, Punjab	S	0(n.p)	5-6
5	Srinagar, J&K UT	H+S	1	6-8
6	Agra, Uttar Pradesh	H+S	1	8
7	Allahabad (Prayagraj), U.P	H	1	8+11
8	Dehradun, Uttarakhand	H	1	<7-8
9	Ghaziabad, Uttar Pradesh	V	1	8
10	Jammu, J&K UT	n.p	1	n.p
11	Amritsar, Punjab	H	1	>14
12	Mohali/Chandigarh,	H	1	13

	Punjab/UT			
13	Patna, Bihar	H+V	1	13
14	Raipur, Chattisgarh	H	1	10
15	Bhubaneshwar, Odisha	H+S	1	<7-8
16	Gaya, Bihar	H+S	1	<5-6
17	Silchar, Assam	S	0	OEM(HEPA)
18	Dimapur, Nagaland	V	1	n.p
19	Pune, Maharashtra	H	1	5-6
20	Vadodara, Gujarat	H	1	<7-8
21	Akola, Maharasthtra	S	0	n.p
22	Aurangabad, Maharasthra	H	1	<7-8
23	Indore, Madhya Pradesh	H+S	1	<7-8
24	Jalgaon, Maharashtra	S	0	n.p
25	Visakhapatnam, A.P.	H	1	<5-6
26	Pathankot, Punjab	H	1	<7-8
27	Kolkatta, West Bengal	H	1	8

Legend:

H: Central HVAC System

V: VRF/VRV/Cassette/Package type AC system

S: Split/Tower type standalone AC

n.p: not provided

OEM: Original Equipment Manufacturer

HEPA: High Efficiency Particulate Filter

MERV: Minimum Efficiency Reporting Value

HVAC: Heating, Ventilation and Air Conditioning

VRV/VRF: Variable Refrigerant Volume/Variable Refrigerant Flow

5. Discussion:

The study brought to light the state of the Air Conditioning systems at airports in India. Airports being a primary source of diverse human interaction, pose a key threat to the spread of airborne infections. Appropriate methods for airborne infection control are recommended to reduce the infection spread. The study first and foremost found out that out of the 61 airports in question, only 18 had a full-fledged Heating Ventilation and Air Conditioning system with appropriate Air Handling units for any fresh air or UVGI intervention[8,13] to take place. Out of the remaining, 12 were depending on split air conditioning systems[14] which have no provisions for fresh air intake and constantly recirculate the air inside the space. These spaces cannot provide a quantified amount of fresh air into the space and have to depend upon measures like opening the windows and gates in some cases[15]. There were others which used a package type air conditioner system using variable refrigeration flow. This technology is used as it achieves energy savings due to lower usage when the demand is lower. The downside to this technology is the absence of a full-fledged air handling unit. In some cases, treated air units were installed, but it lacked quantification like the one present in Air Handling Units. Talking about the presence of integration of Ultraviolet Germicidal

Irradiation in the air conditioning system, out of the 61 airports, 6 had installed the UVGI system at an earlier stage of the pandemic while 19 others were in the process of installation.

Talking about filtration of fresh air intake, out of 61, 43 had filtration of some kind, majority being pre filters of MERV values in the range of 5 to 8. Only 5 had filters of MERV value equal to or above 10[7]. This means their general capability to filter of PM 2.5; the major pollutant in most cities of the developing world is very low. It is very important that the fresh air intake in the cities that fall in the 'Non-Attainment' list of Ambient air quality in India, be filtered and made free from PM 2.5, which is the major pollutant, caused due to burning of fossil fuel like coal and farm waste. A separate list was made of airports which fall in cities that come under the Non-Attainment list of ambient air quality by the Central Pollution Control Board of India[5]. Table 4 contains the list of the airports that fall in the cities with non-attainment. It was found that out of the 61, 27 came under the Non-Attainment category. Out of these, 23 had intake of fresh air through the HVAC system, but only 5 had filters of rating MERV 10 and above in their Air Conditioning systems. This shows a clear lack of preparedness for the Particulate matter pollution that is a leading cause of lung issues in India[2].

This is all the more critical when Right to Health environment has time and again being declared as a human right[16]. Efforts need to be put in place to have appropriate measures for indoor air quality in large public spaces. There should be monitoring the the levels of the indoor air displayed to the occupants[17] of the space so that awareness about this issue can be created. Ventilation of buildings needs more focus[18] and this is not more a engineering problem, but is a public health issue.[19]

6. Conclusion and Recommendation:

As stated in the discussion section, the airports studied in this list have an appropriate amount of work to be done in improving their Air Conditioning systems. This is to not only deal with spread of airborne infection spread, but also to filter out the PM 2.5 that may enter through the inlet of the HVAC systems in these airports. The situation of this double paradox was exists for 27 airports which have to increase fresh air intake for dilution ventilation but out of of these only 5 had filters which could efficiently filter most part of the PM 2.5. This means that large public buildings in India, especially airports, which are places of large public exposure need appropriate indoor air quality. This can be achieved by having laws governing the indoor air quality and the allied equipment. The enforcement of Indoor Air Quality standards must be strictly performed and must be under legal obligation. This is all the more relevant when we face the threat of airborne pandemics and a perpetual problem of particulate matter pollution in cities of the developing world.

7. Note

No funding was taken for this study. There are no conflicts of interest/competing interests to be declared by the authors.

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely ob-served by the authors.

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