Implementation of the Right to Healthy Environment:
Regulations for running air conditioners in public buildings and recognition of biological pollutants.

Authors:
1. Raja Singh, Research Scholar and Visiting Faculty, School of Planning and Architecture, New Delhi

2. Anil Dewan, Professor and Head, Department of Architecture, School of Planning and Architecture, New Delhi.

Please address correspondence to the authors c/o: Raja Singh, Department of Architecture, School of Planning and Architecture, 4 Block B, IP Estate, New Delhi 110002. Mobile: +91 9888312502 email: rajaphd@spa.ac.in

Abstract:

The Indian Supreme Court has declared the right to healthy environment a fundamental right available to citizens of India. This in contrast to Indian executive's abstention from voting on the resolution for the right to healthy environment at United Nations Human Rights Council. Indian citizens may now be forced move courts for basic rights like clean and healthy air instead of a stronger executive action. This study uses an example of nine public buildings in New Delhi to show that air conditioners have an impact on the indoor air quality of congregational. This impact is all the more severe as it has a relation to the spread of airborne infections like COVID-19. The study highlights the paradox of fresh air intake for infection control and how it brings in polluted air due to ill equipped air conditioning systems. It also highlights biological contaminants' non recognition as pollutants. The data was gathered by the use of the Right to Information Act, 2005 and was studied to reinforce the evidence-based lack of regulations and implementation in New Delhi. The focus today must be on making regulations so that people in India realise their right to breathable air and a healthy environment. (199 words)

Keywords: Right to Healthy Environment, Human Rights, Clean Air, Air Conditioners, Pollutants.

The United Nations Human Rights Council has recently resolved 'that right to a clean, healthy and sustainable environment' is a human right[i]. India, currently a member in the Human Rights council, abstained from voting along with China, Japan and Russia. This is despite the fact that in India, the Supreme Court of India has taken a view in 1991 that 'right to life also relates to quality of life and article 21 entitles every person to live in a pollution-free environment.'[ii] This is also in line with Article 48-A of the Indian Constitution that provides that 'The State shall endeavour to protect and improve the environment....' This is also despite the fact that the Indian Parliament has already passed The Air (Prevention and Control of Pollution) Act in 1981[iii] and has also recently created a central body to manage air quality in its capital. This method, with Supreme Court taking lead, means the law having taken constitutional dimension, immunes it from the 'infirmities of the ordinary law remedy' where 'the legislation could legalise the illegality.[iv]' This means that any person walking on the street can move the highest court and demand their fundamental right to a healthy environment and no legislation can come their way. It is worthy to note that, the Stockholm conference in 1972 and the Rio Declaration of 1992 are the two international events that have impacted the Indian Supreme Court jurisprudence in this area[v]. But there is still a concern regarding why there was an abstention from voting in the Human Rights Council on this matter by the Indian government, despite the fact that the judiciary has time and over recognised the fundamental right to a healthy environment. The current pandemic situation is a time to rethink the priorities with respect to public health and its legislative responsibility.

But regardless of the lackadaisical legislative approach at an international forum, the Article 142 of the Indian Constitution, giving omnibus powers to the Apex Court in India, the right to a healthy environment remains. The COVID-19 pandemic and its aftermath has opened up two unique situations in this implementation of right to healthy environment. One is the use of air conditioners in public buildings and another is the recognition of biological contaminants as pollutants.

Talking about the first, the use of air conditioners in enclosed public environment has been a concern and has been attributed to the spread of diseases that spread through the airborne route[vi]. The most common causality in India of this is the spread of Tuberculosis which is a leading killer in India[vii][viii]. But it is only COVID-19 that has brought this issue back to scientific discourses[ix]. The concern is that air conditioners may aid in spread of airborne infection, if proper measures to do otherwise are not in place. By increasing the number of people in an enclosed, the risk of airborne spread of disease increases. Because of this logic, there needs to be special focus on public buildings[x] which are congregational in nature. The types of such buildings may include, but is not limited to the following, stadiums, cinema halls, theatres, convention halls, auditoriums, community halls, banquet halls, public canteens, restaurants, museums, bus terminals, airport terminals, train terminals, hospital waiting halls, and all other assembly spaces are having a Heating, Ventilation and Air Conditioning system. Otherwise, these may be naturally ventilated using windows, ceiling fans, wall fans, exhaust fans and even evaporative coolers, especially in the areas under the composite climate in North India. The disadvantage of having natural ventilation is that the fresh air amount may not be calculated in these spaces, and more often than not though this amount may be more than the require amount, but the reverse is also possible. In cold climates, for example, where there an absence of quantified inlet of fresh air through an HVAC system, the doors and windows are simply shut and there is an installed heating system. Due to thermal comfort considerations, even though the building is naturally ventilated by typology, the fresh air supply in these buildings may be minimal. In such cases, the Heating, Ventilation and Air Conditioning system will ensure the supply of fresh air through the air handling units. Talking again about composite climates, which are predominantly hot, the windows may be closed in extreme heat or extreme cold periods, which is common in this type of climate. This will again lead to a loss of fresh air supply into these buildings. The fate of many of the naturally ventilated buildings, in such climates is met with the use of multiple split air conditioner systems[xi]. This arrangement is done with sealing of windows in order to reduce the energy load on the air conditioner and retaining the cooled air, so to say, inside for a longer period of time. The fundamental problem with such a system is that it keeps recirculating the same air within as the split air conditioner has no means of fresh air supply. This system may work well in residential buildings where the user may open the building as per his choice, but more often than not, does not work in assembly buildings. The visitor to these buildings depends upon the air coming through the duct to fulfil the fresh air and filtration requirements and assumes a supply of a good quality, healthy air. It is therefore important that fresh air supply and filtration of the air along with any other treatment must be appropriately integrated within the HVAC system. This not only ensures justice to the assuming visitor, but should also be a legal requirement.

The regulation in India regarding air conditioning is in the form of guidelines or is partially part of the non-mandatory National Building Code, 2016[xii]. Only as a result of the COVID-19 pandemic did we see a flood of guidelines issued by various agencies including CPWD[xiii], ISHRAE[xiv] and other agencies. Even the internationally recognised ASHRAE released the position paper during the pandemic in 2020[xv]. Prior to this, their widely followed ASHRAE 62.1, standard for ventilation, did not pay much attention to spread of biological contaminants and its prevention, especially with regards to ventilation through mechanical systems. The major concerns with the above mentioned documents are their suggestive nature. They are not judiciable when violated. They may also be called best practices. The only method of enforcing these best practices is through municipal byelaws, as Article 243W of the Indian constitution vests 'construction of buildings' and 'public health' to be run as self-government by municipalities in urban areas. The byelaws recognise the need for ventilation, but may be missing of directly linking it to spread of airborne diseases through air conditioning systems. They may also lack teeth, as far as enforcement of mechanical ventilation specifications may be concerned as these are not mandated and are left to the wisdom of the constructing body. These constructing bodies or individuals may base their air conditioning decision on cost, energy efficiency or thermal comfort, all very appropriate parameters. But the cost may be prevention of spread of airborne infection, which is not mentioned explicitly in the bye laws of Delhi, for example[xvi].

The second matter of concern is the definition of pollution and what includes in the list of pollutants. The Air (Prevention and Control of Pollution) Act, 1981 defines air pollutant as any solid, liquid or gaseous substance 2[(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment;[xvii]' It further defines air pollution as 'the presence in the atmosphere of any air pollutant' This play of words has enabled the Delhi Pollution Control Committee to assume that 'the issue of indoor air is not covered under the purview of the Air Act.[xviii]' At the Central government in India level though, a committee for Indoor Air Quality has been formed by the Ministry of Environment, Forest and Climate Change. This committee may look at pollutants from the lens of combustion fumes as they have a focus on use of cleaner fuels for indoor cooking in the rural areas.[xix] [xx] This brings to light the issue of non-recognition of biological contaminants that may be suspended in the air like the suspended chemical and dust particles. These may include aerosolised virus, bacteria, spores etc. The Indian Standard Code IS 9679 titled as 'Code of Practice for Work Environment Monitoring (Airborne Contaminants)'[xxi] excludes these contaminants of biological nature.[xxii] The scientific research on the other hand considers biological contaminants as a potentially infectious pollutant source[xxiii] which should be removed by ventilation to prevent further infection and spread to susceptible individuals. This process may be called dilution ventilation and has been recognised as a potent way of airborne infection control.[xxiv] If the government accepts these aerosolised biological pathogens as pollutants, it comes under the purview of the Air pollution legislation[xxv] and will be given the required impetus to deal with it as a public health issue. It will then cease to be simply an issue deal by the air conditioning consultant and become a matter that is judiciable under law. It will further strengthen the movement of right to Healthy Environment.

Apart from the two important issues discussed above, namely the spread of airborne disease through building ventilation systems and secondly the inclusion of biological contaminants as pollutants, there is a third very important yet unnoticed issue. It is the intake of polluted outdoor air by the air conditioning system of the building, done in order to provide for dilution ventilation for airborne infection control. To put it simply, the outside air is pumped into the interior for dilution ventilation. This dilution ventilation aids in airborne infection control as it helps in decreasing the concentration of aerosolised pathogens in the interior air. This outside air must also be of appropriate quality, with respect to the non-biological contaminants. In case this air contains other pollutants like suspended particulate matter PM 2.5, then it will cause other lung issues[xxvi]. This is all the more true in the case of Indian cities like New Delhi which has been under an air quality crisis[xxvii]

In this paper, a study appraising 9 public buildings in New Delhi is performed. This is shown in Table 1. This is done to further strengthen the evidence based statements made in the paper till now. Public Buildings in Delhi are defined by the Delhi Development authority which also defines assembly buildings[xxviii]. This study used a unique approach to get the information directly from the source itself. First a list of government owned buildings having a character of a public assembly space was considered. This was followed by framing applications for information under the Right to Information Act, 2005[xxix]. This method ensures information within 30 days of application and the information is signed by an officer from the public authority. This is a reliable and a partially unexplored way of information procurement for researchers using this government transparency act[xxx].

The questions asked in the Right to Information application are as follows:

1. Please provide the provisions that have been integrated in the architectural/services design of the [building space in question] for preventing the spread of COVID through the airborne route.

2. Provide the details of the Air Changes per Hour inside the various spaces within [building space in question]. Air Changes per hour is a unit to measure the amount of Fresh Air that will be supplied to the hall for dilution ventilation inside the [building space in question]

3. Provide the details of the HVAC system that has been put in the [building space in question] along with its ventilation details, i.e. the technical specifications for the provision of fresh air and the exhaust of the interior air into and from the inside spaces.

4. Is there any provision of UVGI treatment of the air which is to be supplied to the inside of the [building space in question]

5. Please specify the details of the filters (HEPA or others) that will be provided in the HVAC system of the [building space in question]. Also mention the least count of the filters which will tell us the minimum size of particles it can measure.

6. What additional measures have been integrated in the design of the [building space in question] to prevent the spread of airborne diseases like COVID-19, Tuberculosis, Measles and SARS etc.

7. Is there any integration of the real time monitoring with meters/sensors of the levels of Carbon Dioxide in the Ventilation/HVAC system of [building space in question]

From the airborne infection control point of view, none of the 9 buildings under study had the provision for UVGI[xxxi] One building did not have fresh air supply and two did not provide the details. The Community hall at Begumpur, the building is question used multiple split air conditioners. This ensured recirculation of the inside air[xxxii]. This method increases airborne risk spread in the indoors[xxxiii]. All the 8 of the 9 buildings had some kind of filtration for the air supplied into the indoors. None of these had filters that may efficiently filter the PM 2.5[xxxiv] before it is taken inside of the space. This means this is a double paradox where the fresh air is supplied for airborne infection spread prevention, but in a city like Delhi, with higher ambient pollution, this means intake of PM 2.5. This situation can be curbed by having appropriate filtration for PM 2.5 before its intake into the interior space. The study also points out to the fact that 8 out of 9 buildings had no monitoring (or detail skipped) of the CO2 in the inside. CO2 or carbon dioxide monitoring is the surrogate or a biomarker for the ventilation inside the space.[xxxv]As the number of people increase in the room, the concentration of carbon dioxide will increase. This is because humans release carbon dioxide as a by-product of respiration. This high carbon dioxide can be lowered by an intake of fresh air into the space. This intake of fresh air through the air conditioners will lower the carbon dioxide concentration. In this way carbon dioxide becomes an indicator of fresh air ventilation in the space. This mere carbon dioxide concentration has also been directly used as proxy to the spread of airborne diseases like TB through the Rudnick Milton equation[xxxvi] which has been used in experiments around the world[xxxvii]. The basis of all this is the work done in the creation of the Wells Riley equation[xxxviii]

It is suggested that the main problem in this scenario is lack of enthusiasm in creation and implementations of regulations for air conditioning systems in public buildings. The buildings byelaws, having judiciable effect, must be integrated as air conditioners in public spaces are a public health issue. It is not in the best interest of the society if this area is regulated only by self-regulation by the industry as is the case currently. The regulations in this area must be developed by a multidisciplinary collaboration between HVAC engineers, architects, doctors, disease researchers, air quality researchers and practitioners. Only when this happens will we see regulations which are not quick fix solutions, but are valid for the worst situation, even in times of normalcies. This will also enable the recognition of biological contaminants as pollutants, and thus become a matter of public discourse and an integral part of law. The COVID-19 pandemic is our wakeup call to recognise the fundamental right to a healthy environment and take actions in this regard.

Notes:

The authors declare no conflict of interest.

Table 1: Appraisal of the Heating Ventilation and Air Conditioner systems of 9 public buildings in New Delhi

S. No.	Public Building Description	Type of Air Conditioner	Fresh Air Provisions	Filter provision with details	UVGI details	Co2 monitoring details
1	Convention Hall, Integrated Exhibition Convention Centre, New Delhi. Future venue for government events, private events and public gatherings of up to 7720 people.	Central HVAC with AHUs	5 CFM/person + 0.6 CFM/sqft. Heat Recovery wheel present.	Pre Filters only. (10 microns/90% efficiency)	No UVGI present	CO2 monitoring present.
2	Indira Gandhi Indoor Stadium. Apart from sports facility, venue for mass gathering events.	Central HVAC with multiple AHUs and additional openings with exhaust fans.	155452 CMH Fresh air. Total AHU capacity 2025242 CMH. Therefore 7.67 & Fresh Air.	MERV 6 Filter (90% arrestance/35-40% efficiency)	No UVGI	No CO2 monitoring.
3	Inter State Bus Terminal, Kashmere gate, New Delhi. One of Delhi's busiest bus terminals retrofitted into an air conditioned space.	Central HVAC with AHUs. Split Air Conditioner in some areas.	Fresh Air provided. Details not provided.	Pre Filter only. EU 4 (MERV 7-8)	No UVGI	Detail not provided.
4	National Museum	HVAC with AHUs. VRV also present.	8 to 10% Fresh Air provided.	Pre Filters only. (10 Microns)	No UVGI	No CO2 monitoring
5	Air Conditioned Community Hall, managed by South Delhi Municipal Corporation at Begumpur, a representative of marriage banquet halls in Delhi	Multiple Split Air Conditioners, with no precautions possible for airborne disease prevention	No fresh air supply. Internal air in recirculated	No filters present.	No UVGI	Detail not provided

6	Siri Fort Auditorium, a major government owned events auditorium	HVAC with AHUs	Details not provided	Pre filters (5 microns)	No UVGI	No CO2 monitoring
7	Abhimanch Hall, an auditorium for plays in Delhi's theatre district. Also a practice stage for National School of Drama.	HVAC with AHU	Details not provided (as the air conditioner is very old, according to managers)	Details not available	No UVGI	No CO2 monitoring
8	New Maharashtra Sadan Canteen, representative of a government owned public restaurant	HVAC with AHUs	Fresh air supplied. Details not provided.	Pre Filters present (5 microns/98%efficiency)	No UVGI	Detail not provided.

Legend:
HVAC: Heating Ventilation and Air Conditioning System
AHU: Air Handling Unit
UVGI: Ultra Violet Germicidal Irradiation
CO2: Carbon Dioxide gas
CFM: Cubic Feet per minute
CMH: Cubic metre per hour

References:

[i] The Human Rights Council, "The right to a clean, healthy and sustainable environment," (General Assembly, United Nations: Human Rights Council, United Nations General Assembly, 2021).

[ii] "Sub hash Kumar v. State of Bihar," (1991). B.N. Kirpal et al. (Eds.), Harish Salve, *Justice between Generations: Environmental and Social Justice, Supreme But Not Infallible*, (New Delhi: Oxford University Press, 2004).

[iii] Republic of India, "The Air (Prevention and Control of Pollution) Act, 1981," (1981).

[iv] Udit Raj Rai, *Fundamental Rights and their Enforcement*, Eastern Economy Edition (New Delhi, n.d.).

[v] [CSL STYLE ERROR: reference with no printed form.]

[vi] R. A. Hobday, and S. J. Dancer, "Roles of sunlight and natural ventilation for controlling infection: Historical and current perspectives," *Journal of Hospital Infection* 84/4 (2013), pp. 271–282.

[vii] M. Pai, S. Kalantri, A. N. Aggarwal, D. Menzies, and H. M. Blumberg, "Nosocomial India," 12/9 (2006), pp. 1311–1318.

[viii] K. S. Sachdeva, R. D. Deshmukh, N. S. Seguy, S. A. Nair, B. B. Rewari, R. Ramchandran, M. Parmar, V. Vohra, S. Singh, M. Ghedia, R. Agarwal, A. N. Shah, D. Balasubramanian, M. Bamrotiya, R. Sikhamani, R. S. Gupta, and S. D. Khaparde, "Tuberculosis infection control measures at health care facilities offering HIV and tuberculosis services in India: A baseline assessment," *Indian Journal of Tuberculosis* 65/4 (2018), pp. 280–284.

[ix] C. Xu, W. Liu, X. Luo, X. Huang, and P. V. Nielsen, "Prediction and control of aerosol transmission of SARS-CoV-2 in ventilated context: from source to receptor," *Sustainable Cities and Society* 76 (2022), p. 103416.

[x] Delhi Development Authority, "Unified Building Bye Laws for Delhi," (2016),.

[xi] R. Singh, and A. Dewan, "Rethinking Use of Individual Room Air-conditioners in View of COVID 19," *Creative Space* 8/1 (2020), pp. 15–20.

[xii] Bureau of Indian Standards, *National Building Code 2016*, (2016).

[xiii] Central Public Works Department, "Guidelines for Running of Air Circulation, Air Cooling and Air Conditioning Equipments during COVID-19," (New Delhi: Central Public Works Department, Government of India, 2020).

[xiv] Indian Society of Heating, refrigeration and Air Conditioning Engineers, "ISHRAE COVID-19 Guidance Document for Air Conditioning and Ventilation," (New Delhi: Indian Society of Heating, refrigeration and Air Conditioning Engineers, 2020).

[xv] P. W. Francisco, S. J. Emmerich, L. J. Schoen, M. J. Hodgson, W. F. Mccoy, S. L. Miller, Y. Li, H. Kong, R. N. Olmsted, C. Sekhar, S. A. Parsons, and P. Wargocki, "ASHRAE Position Document on Airborne Infectious Diseases by ASHRAE Board of Directors," *Ashrae Standard* (2020), p. 26 pp.-26 pp.

[xvi] Delhi Development Authority, "Unified Building Bye Laws for Delhi," (2016),.

[xvii] Republic of India, "The Air (Prevention and Control of Pollution) Act, 1981," (1981).

[xviii] Dr. M.P. George, Scientist, Delhi Pollution Control Committee, "Subject: Writ Petition (C) 7810/2021 titled as 'Raja Singh v. Union of India & Ors.,'" 2021.

[xix] T. Ganguly, K. L. Selvaraj, and S. K. Guttikunda, "National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans," *Atmospheric Environment: X* 8 (2020), p. 100096.

[xx] Ministry of Health and Family Welfare, "Report of the Steering Committee on Air Pollution and Health Related Issues," (2015).,Planning Commission, Government of India, "Report of the Working Group on Environment and Environmental Regulatory Mechanisms In Environment & Forest for the Eleventh Five Year Plan (2007-2012)," (2007).

[xxi] Bureau of Indian Standards, *Code of Practice for Work Environment Monitoring (Airborne Contaminants*, (1980).

[xxii] Raja Singh; Anil Dewan, "Using global research on Ventilation and Airborne Infection Control for impacting Public Policy through Indian Judiciary," *Indoor and Built Environment* Accepted for Publication (n.d.),.

[xxiii] C. Xu, W. Liu, X. Luo, X. Huang, and P. V. Nielsen, "Prediction and control of aerosol transmission of SARS-CoV-2 in ventilated context: from source to receptor," *Sustainable Cities and Society* 76 (2022), p. 103416.

[xxiv] A. R. Escombe, C. C. Oeser, R. H. Gilman, M. Navincopa, E. Ticona, W. Pan, C. Martínez, J. Chacaltana, R. Rodríguez, D. A. J. Moore, J. S. Friedland, and C. A. Evans, "Natural ventilation for the prevention of airborne contagion," *PLoS Medicine* 4/2 (2007), pp. 0309–0317.,H. Cox, R. Escombe, C. McDermid, Y. Mtshemla, T. Spelman, V. Azevedo, and L. London, "Wind-driven roof turbines: A novel way to improve ventilation for TB infection control in health facilities," *PLoS ONE* 7/1 (2012), pp. 1–6.,J. Atkinson, Y. Chartier, C. Lúcia Pessoa-

Silva, P. Jensen, Y. Li, and W.-H. Seto, "Natural Ventilation for Infection Control in Health-Care Settings WHO Library Cataloguing-in-Publication Data: Natural ventilation for infection control in health-care settings," 1 (2009),.,Indian Society of Heating, refrigeration and Air Conditioning Engineers, "ISHRAE COVID-19 Guidance Document for Air Conditioning and Ventilation," (New Delhi: Indian Society of Heating, refrigeration and Air Conditioning Engineers, 2020).,Y. Li, G. M. Leung, J. W. Tang, X. Yang, C. Y. H. Chao, J. Z. Lin, J. W. Lu, P. V. Nielsen, J. Niu, H. Qian, A. C. Sleigh, H. J. J. Su, J. Sundell, T. W. Wong, and P. L. Yuen, "Role of ventilation in airborne transmission of infectious agents in the built environment - A multidisciplinary systematic review," *Indoor Air* 17/1 (2007), pp. 2–18.

[xxv] Republic of India, "The Air (Prevention and Control of Pollution) Act, 1981," (1981).

[xxvi] S. Rizwan, B. Nongkynrih, and S. K. Gupta, "'Air pollution in Delhi: Its Magnitude and Effects on Health,'" *Indian Journal of Community Medicine : Official Publication of Indian Association of Preventive & Social Medicine* 38/1 (2013), pp. 4–8.

[xxvii] "National Clean Air Programme," (Ministry of Climate, Forest and Climate Change, Government of India, 2019).

[xxviii] Delhi Development Authority, "Unified Building Bye Laws for Delhi," (2016),.

[xxix] Republic of India, "The Right to Information Act, 2005," (2005).

[xxx] Raja Singh, *RTI for Research: Using the Right to Information Act, 2005 for Research in India*, (New Delhi: BooksBonanza, n.d.).

[xxxi] A. R. Escombe, D. A. J. Moore, R. H. Gilman, M. Navincopa, E. Ticona, B. Mitchell, C. Noakes, C. Martinez, P. Sheen, R. Ramirez, W. Quino, A. Gonzalez, J. S. Friedland, and C. A. Evans, "Upper-room ultraviolet light and negative air ionization to prevent tuberculosis transmission," *PLoS Medicine* 6/3 (2009), pp. 0312–0323.

[xxxii] C. Xu, W. Liu, X. Luo, X. Huang, and P. V. Nielsen, "Prediction and control of aerosol transmission of SARS-CoV-2 in ventilated context: from source to receptor," *Sustainable Cities and Society* 76 (2022), p. 103416.,R. Singh, and A. Dewan, "Rethinking Use of Individual Room Air-conditioners in View of COVID 19," *Creative Space* 8/1 (2020), pp. 15–20.

[xxxiii] Y. Li, G. M. Leung, J. W. Tang, X. Yang, C. Y. H. Chao, J. Z. Lin, J. W. Lu, P. V. Nielsen, J. Niu, H. Qian, A. C. Sleigh, H. J. J. Su, J. Sundell, T. W. Wong, and P. L. Yuen, "Role of ventilation in airborne transmission of infectious agents in the built environment - A multidisciplinary systematic review," *Indoor Air* 17/1 (2007), pp. 2–18.,A. R. Escombe, D. A. J. Moore, R. H. Gilman, M. Navincopa, E. Ticona, B. Mitchell, C. Noakes, C. Martinez, P. Sheen, R. Ramirez, W. Quino, A. Gonzalez, J. S. Friedland, and C. A. Evans, "Upper-room ultraviolet light and negative air ionization to prevent tuberculosis transmission," *PLoS Medicine* 6/3 (2009), pp. 0312–0323.

[xxxiv] "Comparative Guide to Norms for the Classification of Air Filters | Venfilter Air filters and industrial ventilation," (n.d.), Available at https://www.venfilter.com/normativa/comparative-guide-norms-classification-air-filters.

[xxxv] Bureau of Indian Standards, *National Building Code 2016*, (2016).,C. M. Issarow, N. Mulder, and R. Wood, "Modelling the risk of airborne infectious disease using exhaled air," *Journal of Theoretical Biology* 372 (2015), pp. 100–106.

[xxxvi] S. N. Rudnick, and D. K. Milton, "Risk of indoor airborne infection transmission estimated from carbon dioxide concentration," *Indoor Air* 13/3 (2003), pp. 237–245.

[xxxvii] E. T. Richardson, C. D. Morrow, D. B. Kalil, L. G. Bekker, and R. Wood, "Shared air: A renewed focus on ventilation for the prevention of tuberculosis transmission," *PLoS ONE* 9/5 (2014), pp. 1–7.

[xxxviii] R. L. RILEY, "Aerial dissemination of pulmonary tuberculosis.," *American Review of Tuberculosis* 76/6 (1957), pp. 931–941.