ASHRAE Research Project Report CO-RP3

Academic Research to Support Facility Guidelines Institute & ANSI/ASHRAE/ASHE Standard 170

Contractor: Facilities Guidelines Institute American Society for Healthcare Engineering (ASHE)

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Shaping Tomorrow's Built Environment Today

Academic Research to Support Facility Guidelines Institute & ANSI/ASHRAE/ASHE Standard 170

ASHRAE CO-RP-03

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Finally, we are grateful for the broader, interested engineering and scientific community members who contributed by identifying articles for review. This research project has been of keen interest to many parties and we hope that the broader healthcare community finds it valuable.

Executive Summary

The purpose of this study was to conduct a review of **ANSI/ASHE/ASHRAE Standard 170-2013 – Ventilation of Healthcare Facilities** to determine whether the 886 requirements defined in the Standard (Part 4 of the FGI Guidelines) are supported by engineering and (or) scientific evidence. This process began by assembling each of the requirements into a comprehensive spreadsheet (Appendix A). From this, the authors and the Project Monitoring Subcommittee (PMS) assigned these requirements into one of three (3) categories: **Rational inclusion** defines requirements that fall under practical engineering or life-safety requirements; **Clinical inclusion** defines requirements that support clinical practices; **Evidence-based inclusion** defines those remaining requirements that are supported by published scientific literature.

Next, those categorized for evidence-based inclusion were aligned with found citations that related to the requirement. Finally, the authors provided opinions on whether the evidence suggested the requirement was a **basic necessity**, an **enhanced requirement**, requires a **change to the standard**, is **procedural**, or **requires further investigation.**

Approximately 162 (18%) of the Standard 170-2013 requirements were categorized under the definition of rational inclusion. Another 5 requirements (<1%) were categorized under the definition of clinical inclusion. The remaining 719 requirements (81%) were further categorized into eight (8) topical subcategories and subjected to an extensive literature review to determine the strength of evidence supporting these standards.

These topical subcategories included:

1. Ventilation rate
2. Supply and exhaust air distribution

3. Pressure relationships
4. Anterooms
5. Temperature
6. Relative humidity
7. Recirculation
8. Filtration

Keywords and medical subject headings (MeSH) related to these topical areas were systematically searched using available databases (e.g. *PubMed*, *Science Direct*, *Scopus*, etc.). A total of 2,542 publications were initially found. A cursory review of each publication reduced the number of relevant articles to 831 related to ventilation of healthcare facilities (Appendix B) of which 304 (cited by this document) provided original measurements through numerical, experimental, or hybrid methodologies.

Next, the conclusiveness of findings (e.g. *conclusive*, *partially conclusive*, *and non-conclusive*) for each publication was assessed relative to the quality of the study (e.g. *good*, *average*, *and poor*). Qualitative values were numerically weighted from 1 (e.g. randomized, clinical trial) to 6 (recommendations without supporting evidence) and tabulated. In addition, the type of study (e.g. experimental, numerical, case study, literature review, etc.) and study environment (hospital, lab-scale, simulation, etc.) was recorded for each article.

Overall, there are 209 requirements (23.6%) that were determined to be a Basic Necessity as supported by rational inclusion, clinical requirements or evidence and 6 requirements (0.7%) were considered to be Enhanced practices. Twelve requirements (1.4%) were determined to be procedural and not subject to evidence. Evidence was found to support a change to the standard for 8 requirements (0.9%). The remaining 651 requirements (73.5%) did not have evidence or conclusive evidence and are recommended for further study.

Contents

Introduction

The Facilities Guidelines Institute (FGI), the American Society for Healthcare Engineering (ASHE), and ASHRAE SSPC 170 committee with ASHRAE TC 9.6 have contracted Clemson University, The University of Nebraska – Lincoln, and Affiliated Engineers, Inc. to conduct a line-by-line review of ASHRAE standard 170-2013 Ventilation of Health Care Facilities. The goal of the review was to determine whether or not the 886 requirements defined in standard 170 are supported by engineering and/or scientific evidence. ASHRAE standard 170 is adopted by numerous jurisdictions as the ventilation code for health care facilities. It is also referenced in part 4 of the FGI Guidelines, which is adopted by numerous jurisdictions as code for the design of health care facilities.

The project started in October of 2016 with a process of categorizing requirements into rational inclusion, clinical inclusion, and evidence-based requirements. Rational inclusion is defined as requirements that fall under practical engineering, reliability and/or life safety requirements. Clinical inclusion is applied to requirements that are mandated by clinical practices. Any remaining requirement was then included in the literature review to determine if any evidence was available to support the requirement.

The research team frequently met with the Project Monitoring Subcommittee (PMS) team consisting of members of the FGI, ASHE, and ASHRAE (see Acknowledgements), to review the team's progress and provide guidance at each major milestone: categorization, review of rational inclusion, and review of evidence. Meetings took place on the phone as well as in person at the January 2017 ASHRAE Winter meeting (Las Vegas, NV), the April 2017 FGI meeting (St. Louis, MO), and the June 2017 ASHRAE Summer meeting (Long Beach, CA). The final presentation for this research project was presented at the 2018 ASHRAE Summer meeting (Houston, TX). The research team has issued: this report, a spreadsheet that aligns the ASHRAE 170 requirements with the categories and supporting evidence placed in Appendix A,

and an online bibliography of all the referenced evidence to facilitate future cross references placed in Appendix B.

Rational Inclusion

Rational inclusion is defined as the ASHRAE 170 requirements that are supported by engineering practices, reliability, and/or life safety requirements. Approximately 18% (162 of the 886) requirements fall into the rational inclusion category. Examples of these requirements include:

> 6.1.2.1.i: Provide heat sources and essential accessories in number and arrangement sufficient to accommodate the facility need (reserve capacity), even when any one of the heat sources or essential accessories is not operating due to a breakdown or routine maintenance.

That supports reliability of a healthcare facility ensure that the building has a backup heating source.

> 6.5.2: If radiant cooling panels are utilized, the chilled-water temperature shall always remain above the dew-point temperature of the space.

That supports the prevention of condensation forming, which can lead to wet spots on the floor that can cause falls or water damage to parts of the facility.

The research team reviewed and received signoff from the PMS on the rational inclusion items in November 2016, which then allowed the team to move forward with the clinical inclusion and evidence-based phases of the project.

It is important to mention that 28 (2% of the 886) requirements were found in the standard where the statement itself is rational; however, the quantity must be scientifically supported by evidence. An example of this is:

6.3.1.1.i: Outdoor air intakes for air-handling units shall be located a minimum of 25 ft (8 m) from cooling towers and all exhaust and vent discharges.

This requirement is rational in that it is known cooling towers are potential sources of airborne bacteria such as legionella; however, the distance of 25 ft (8m) requires evidence to justify this value. No evidence was found that directly addresses this requirement; yet, some of them appeared in other ASHRAE standards or guidelines or in requirements by other agencies[1]. For example, Table 5.2 of ASHRAE Standard 62 tabulates minimum separation distances between air intake and discharged air depending on the type of exhaust air [2].

Clinical Inclusion

At the completion of the rational inclusion phase of the project the research team had approximately 80% of the requirements remaining to review. Many of these requirements required further research to either contain them within clinical or evidence-based requirements categories. To support this effort the research team met with facilities staff and clinicians from Greenville Health System in Greenville, SC. The focus of the meeting was to determine if there are any clinical procedures mandating the requirements found within standard 170.

Some key findings of the meeting are:

- Proving a scientific basis for many requirements may be impossible as the experiments needed to support a statistically significant result would likely not be approved.
- Spaces are often operated at conditions outside those defined by standard 170 in order to improve clinical outcomes:
    - ER Trauma rooms are often operated at 90F to prevent heat loss from trauma victims.

    - NICUs require precise temperature regulation that is a function of a babies' weight as premature babies have little to no body fat.
    - Operating room temperatures are becoming colder over time to enhance the surgeon's comfort. However, the comfort may not improve with colder temperatures as the clothing worn by surgeons is often impermeable and inhibits evaporation of moisture from the surgeon's skin, which is a primary mechanism for the body to regulate its temperature.
- Operating rooms may have significant traffic into and out of the operating room during the procedure (per the Greenville Health internal count, one door opening per two minutes on average), which can impact the HVAC controller's ability to maintain pressurization in the operating room.
- Orthopedic operating rooms have odor issues due to the adhesives used during a surgical procedure. Air changes are often increased to dilute the odors.
- Staff working in decontamination areas are frequently too warm due to the clothing they are required to wear.

Clinical Sources and Circular References

A number of clinical publications such as AORN, American Society of Gastro Neurology, American Lung Association, etc. were reviewed to determine if clinical guidance was published that could support the requirements of standard 170. The overarching conclusion is that the standard 170 or FGI is routinely referenced as the source, rather than a separate clinical source, for requirements regarding temperature, humidity, pressure relationships or air changes.

Clinical Conclusions

Based on the research and investigations completed as part of the clinical research phase there are two major conclusions:

First, there is limited understanding of clothing value (clo) and metabolism rate (met) for healthcare workers required to fully understand the healthcare worker's thermal comfort. ASHRAE Standard 55 Thermal Environmental Conditions for Occupancy does not cover many healthcare facility occupants including patients (met is too low) and staff (clo and/or met values too high). This conclusion does not support or refute the temperature and humidity values currently included in ASHRAE standard 170 either. Further research is warranted not only because of the goal of achieving better thermal comfort for healthcare workers, but also the potential to improve patient outcomes by reducing caregiver's discomfort and distractions.

Second, the bulk of the items that were potentially considered under clinical inclusion moved to the evidence-based category due to the frequency of circular references. It is important to find the original source of the referenced literature to accurately weigh the value of the requirement.

Literature Review

The ASHRAE 170 requirements that did not fit into the Rational or Clinical Inclusion categories were reviewed and further categorized. A total of eight mutually exclusive and collectively exhaustive research questions were identified. Each ASHRAE 170 requirement that requires scientific evidence is mapped to one of the research questions. The research questions are identified and described below.

- **Question 1:**

  What is the minimum ventilation rate in Health Care Facilities (HCF) that provides control for comfort, asepsis and odor?

This is, perhaps, the key question with a need for research support. Ventilation rate differs with respect to space function in hospitals, yet how it is regulated is ambiguous. There are other issues worthy to explore under this question such as: (1) Is air change per hour (ACH) an effective metric to measure ventilation rate? (2) What weight should energy consumption have in determining ventilation rates, that is, is it worth it to consume extra energy and provide higher ventilation rates?

Table 7.1 in the Standard reserved two columns to recommend minimum outdoor and total ACH for various space functions. In addition, four requirements directly address this issue.

- **Question 2:**

  What Supply-Exhaust location and boundary condition can result in the best control for comfort, asepsis and odor?

  Location and Boundary conditions (BCs) of the inlets and outlets of a patient care space have proven to play an important role in environmental asepsis. Boundary conditions include the location and placement of air entering and leaving a space as well as entering and leaving temperature, humidity, flow rate, and composition of air. There are a total of 27 requirements in ASHRAE 170 pertaining to this issue and they seem to need evidence. Specifically, air distribution with respect to space function has been a debatable topic in the literature.

- **Question 3:**

  What is the desirable pressurization strategy and minimum pressure differential in HCFs that provides control for comfort, asepsis and odor?

  In this question, two major issues need evidence. First, the desirable pressure relationship with adjacent spaces given the space function. In ASHRAE 170, two pressurization strategies (positive and negative) are recognized while pressurization is not required (NR) for many of spaces, such as patient corridors. Second, the pressure differential shown in the literature to best serve the

purpose behind the adopted pressurization strategy. ASHRAE recommends 2.5 Pa as adequate pressure differential. A total of 88 requirements (almost 10%) address this issue.

- **Question 4:**

  Is the presence of an anteroom necessary in Protective Environments (PEs) and Airborne Infection Isolation Rooms (AIIRs)? If so, what requirements should be contemplated?

  Anterooms are recognized within ASHRAE Standard 170, however, there are no explicit recommendations that necessitate the use of an anteroom. Furthermore, pressurization strategies for anterooms is of interest and corresponding recommendations should be examined against the existing literature.

- **Questions 5 and 6:**

  What are the desirable temperature and relative humidity (RH) ranges in HCFs that provide control for comfort, asepsis and odor?

  Responses to these two queries are, purportedly, out of the scope of this standard. ASHRAE Standard 55, 2013 "Thermal Environmental Conditions for Human Occupancy" regulates the temperature and RH range. Also, considerable discussions can be found in Chapter 9 of the ASHRAE Handbook of Fundamentals. Nevertheless, one can argue that thermal comfort in hospitals follow different human thermoregulation principles. Table 7.1 and three requirements within the text of Standard 170 address this issue.

- **Question 7:**

  How is recirculation viewed in HCFs in accordance with the control for comfort, asepsis and odor?

  Table 7.1 specifies, with respect to space function, whether the exhaust air shall be directly discharged to outdoors or air recirculation by means of room units are allowed. Many of the recommendations here may fall into the rational inclusion category. For example, exhaust air

from the AIIR shall be discharged outside without being returned into the Air Handling Unit (AHU). However, further corroboration might be needed via research.

- **Question 8:**

  What is the minimum filtration required in HCFs that provides control for comfort, asepsis and odor?

  Minimum filter efficiencies are regulated in Table 6.4 with respect to space designation. No explanations were offered within the text as to the evidentiary basis of those recommendations. A systematic literature review can endorse/impugn minimum requirements. Moreover, ASHRAE Standard 52.2, Methods of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size has propounded this topic in detail. Therefore, these recommendations do not originate in Standard 170 and borrow their validity from other ASHRAE publications.

Literature Search Method

To identify relevant articles, several combinations and permutations of the following keywords or medical subject headings (MeSH) were systematically searched using the following databases: PubMed, Engineering Village, Science Direct, and Scopus: ventilation, mechanical ventilation, hospitals, healthcare facilities, ventilation rate, airflow, supply diffuser, exhaust air, air exchange, pressure, temperature, relative humidity, filtration, recirculation, and air change per hour (ACH). Only articles in English were considered and no exclusion criteria were adopted with respect to publication date. A total of 2,542 articles were initially found. In the first round, the review was performed by solely focusing on the title to exclude irrelevant articles. For example, articles that studied ‘mechanical ventilators’ or ‘supply chain management in hospitals’ were likely to be included in the search results. The list of references of relevant articles were also searched to identify publications that otherwise could have been forsaken. In

addition, authors with similar research interests and extensive work in the field were targeted to ensure that their work was included in the database. Lastly, an online spreadsheet was created and shared with a panel of experts in ASHRAE T.C.9.6 Healthcare Facilities to review the database and add relevant articles. Having completed all of these steps, the number of relevant articles was reduced to 831 articles (see Appendix B).

Next, user-defined variables were set to account for strength of evidence factors such as the conclusiveness of findings (e.g. conclusive, partially conclusive, non-conclusive, etc.) relative to the comprehensiveness and quality of the study (e.g. good, average, poor, etc.). These qualitative values are tabulated and numerically weighted according to Table 1. Moreover, method type (i.e. experimental, numerical, review) and study environment (i.e. real condition, controlled lab, computer simulation) was recorded for each article.

Table 1 Quality Assessment Matrix

	Quality Level of Literature Review	**Quality Level Corroborated with Medical and Engineering Literature**
Level 1	Systematic reviews of multiple randomized controlled trials (RCTs) or nonrandomized studies; meta-analysis of multiple experimental or quasi-experimental studies; meta-synthesis of multiple-qualitative studies leading to an integrative interpretation.	1.1 clinical trial randomized with direct evidence

Level 2	Well-designed experimental (randomized) and quasi-experimental (nonrandomized) studies with consistent results compared to other, similar studies.	2.1 clinical trial randomized 2.2 clinical trial non-randomized 2.3 physical or biological CFU experiment in OR repeated with computational fluid dynamics (CFD) 2.4 physical or biological experiment not repeated
Level 3	Observational studies, well-designed qualitative studies, integrative or systematic reviews of observational or qualitative studies, or RCT or quasi-experimental studies with inconsistent results compared to other, similar studies.	3.1 scale model experiment with CFD 3.2 scale model experiment no CFD
Level 4	Professional standards or guidelines with studies to support recommendations.	4.1. CFD and other simulation modeling 4.2 Case study
Level 5	Opinions of recognized experts, case studies.	5.1. Literature review on standards
Level 6	Recommendations from manufacturers or consultants who may have a financial interest or bias.	6.1. Guidelines without supporting evidence

Literature Review Results

1. Ventilation rate and boundary conditions

Introduction

Ventilation rates are specified for most spaces governed by ASHRAE standard 170. A number of spaces are of particular interest due to their high quantity or stringent requirements. Patient rooms and exam rooms are some of the most common space types found in health care facilities (HCF's), and consequently their impact on the facility design, construction, and operation is magnified. Operating rooms, procedure rooms, waiting rooms, protective environment rooms, and airborne infectious isolation rooms all have stringent requirements that can be burdensome to implement.

The main purposes of heating, ventilation, and air-conditioning (HVAC) systems are to (1) generate and maintain comfort for occupants (2) provide oxygen, and (3) dilute and remove contaminants from the space [3–6]. Extra attention must be paid to achieve these goals in HCFs [7]. A vast variety of occupants ranging from patients dealing with hypothermia to surgeons undergoing a challenging operation makes it extremely difficult to assure everyone's comfort. Airborne contamination in hospitals may include exposure to aerosolized pharmaceuticals, strong chemicals and airborne pathogens [8]. Thus, a well-designed HVAC system in a healthcare setting is meant to exceed the premise of 'comfortable environment' and offer a 'healing environment'. This is not a trivial task and should not be viewed as a simple 'tweak' to a typical commercial ventilation system. Concepts such as space pressurization and special filtration are commonly employed in healthcare ventilation design. Increased cooling loads from intense lighting and medical equipment, as well as special considerations for microbial transmission have increased the energy consumption of hospitals up to 5 times of a comparable office buildings [9].

ASHRAE standard 170-2013 states its purpose to 'define ventilation system design requirements that provide environmental control for comfort, asepsis, and odor in healthcare facilities' [10]. Among other

factors, ventilation rate and boundary conditions are deemed to contribute to the above-mentioned environmental control measures. Through setting a minimum ventilation rate, or the amount of conditioned air brought into the space, one can control the indoor temperature and relative humidity [11,12]. Ventilation rate, paired with filtration and other removal processes, can dilute the contaminants in the space [13–15].

Many studies state that the ventilation rate is not the only parameter affecting thermal comfort and contaminant control [16–20]. Ventilation boundary conditions (BC), or the configuration of air inlets/outlets, has been shown to be an influential variable [21,22]. Various ventilation types (e.g. mixing, displacement, underfloor, etc.) have emerged because of different flow patterns created by each type. Boundary conditions can alter both temperature and contaminant distributions within the space.

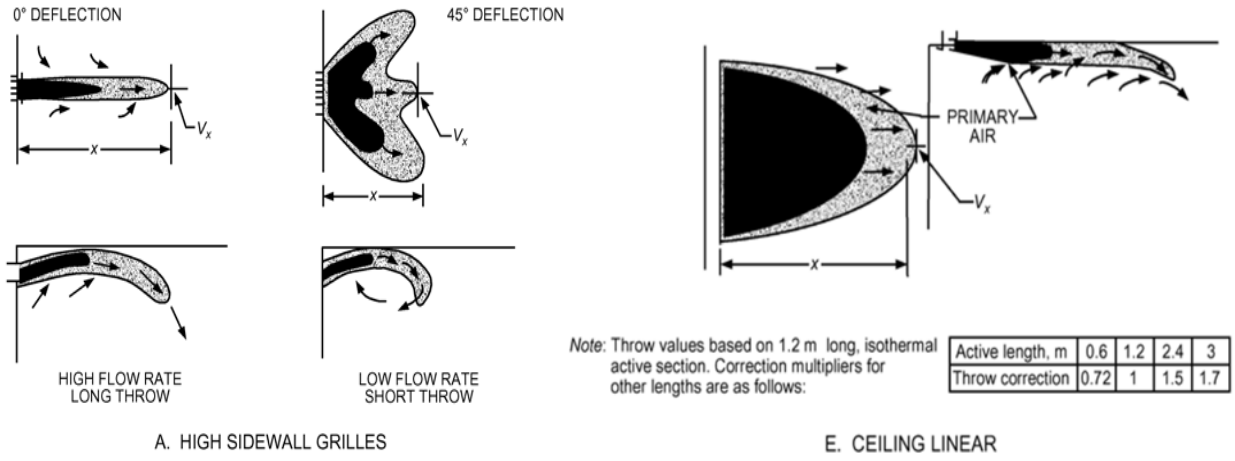

Figure 1: Group A and Group E Diffusers- Courtesy of ASHRAE Handbook of Fundamentals (2013) [305]

ASHRAE Standard 170 aims to regulate the boundary conditions through a series of regulations. For instance, Group A and E supply air outlets are required for Airborne Infection Isolation Rooms (AIIRs). Referring to Chapter 20 of the ASHRAE Handbook of Fundamentals, these groups are defined as 'high sidewall grilles' and 'ceiling linear diffusers' (*Figure 1*). Furthermore, exhaust grilles or registers shall be located directly above the patient head on the ceiling or on the wall near the head of the bed. The

Standard recommends placing the exhaust grilles as close to the pathogen generation source (patient's head) as possible while a mixing ventilation type dilutes pathogen concentrations throughout the room. As asserted by the purpose of the standard, ASHRAE 170 offers a set of like recommendations to improve thermal comfort and cleanliness of healthcare environments.

Thus, this study aims to evaluate all the requirements pertaining to ventilation rate and boundary conditions in healthcare facilities against scientific evidence. Results of this review are presented for space functions in the order of availability of evidence. Articles were reviewed with original measurements as well as those without measurements (e.g. review papers, professional standards or guidelines, and opinion papers).

Descriptive Statistics

Of the 719 Standard 170-2013 requirements subject to evidence-based inclusion and subsequent literature review, 161 requirements pertain to ventilation rates in health care facilities (HCF). A total of 110 articles provided evidence on ventilation rates. Of those, the articles were only associated with 45 (28%) of the 161 requirements, suggesting the scarcity of direct evidence in the literature. Those related to spaces consist mainly of patient rooms (35%), operating theaters (26%) and isolation rooms (15%). Those articles related to spaces consist mainly of patient rooms (35%), operating theaters (26%) and isolation rooms (15%). Most other space types listed in ASHRAE 170-2013 do not have published evidence of any kind that was found by the research team.

Studies with direct measurements of ventilation rates and physical/biological outcomes were scarce as shown in **Figure *2***. Descriptive statistics of evidence quality shows a mean/median/mode of 3.7/4/3 indicating that identified papers congregated around experimental/CFD methods in controlled environments (Levels 3 and 4). None of the retrieved evidence proposed a methodology to investigate

the effect of outside air rate. No evidence was found for 61% of the requirements pertaining to minimum ventilation rate.

Results for pressure relationships, air distribution, anterooms, temperature and RH, recirculation and filtration were similar with less than 30% of requirements supported by conclusive or partially conclusive evidence in the published literature. Of these, roughly half support current Standard requirements. The vast majority of evidence-based literature is based on experiments or numerical studies under conditions that may or may not be representative of actual acute care environments.

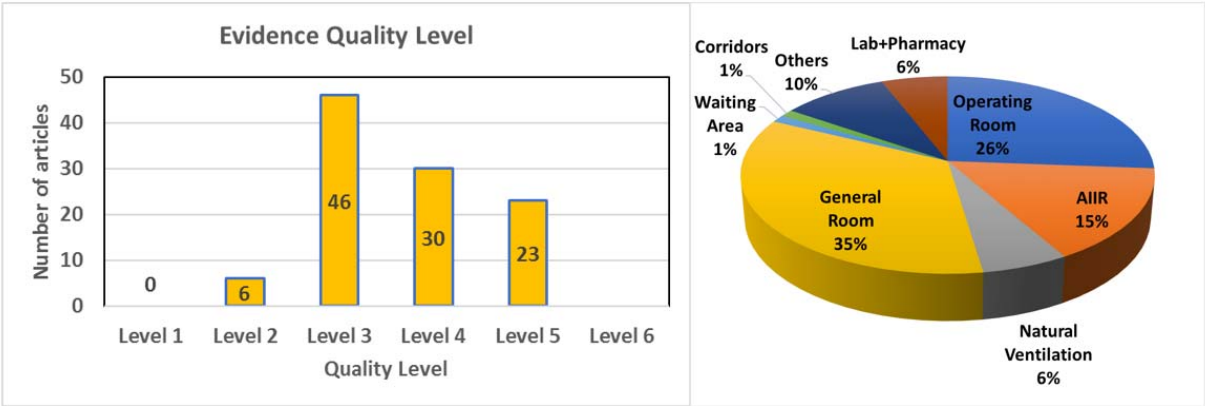

Figure 2 Evidence Quality Level (left) and Distribution of Evidence (right) for Ventilation Rate Articles

Similar analysis showed that little conclusive data is available on air distribution systems based on the 79 articles found and reviewed [23,24]. The quality of the evidence is similar to the ventilation rate with mean/median/mode of 3.5/3/3. Boundary condition requirements are not specified for every space and there are a limited number of articles addressing the space functions (**Figure *3***). Further, the majority of experimental studies were conducted in test chambers, general rooms in a controlled environment, and may not entirely embody a real scenario. No evidence was found for four (14%) of the BC requirements.

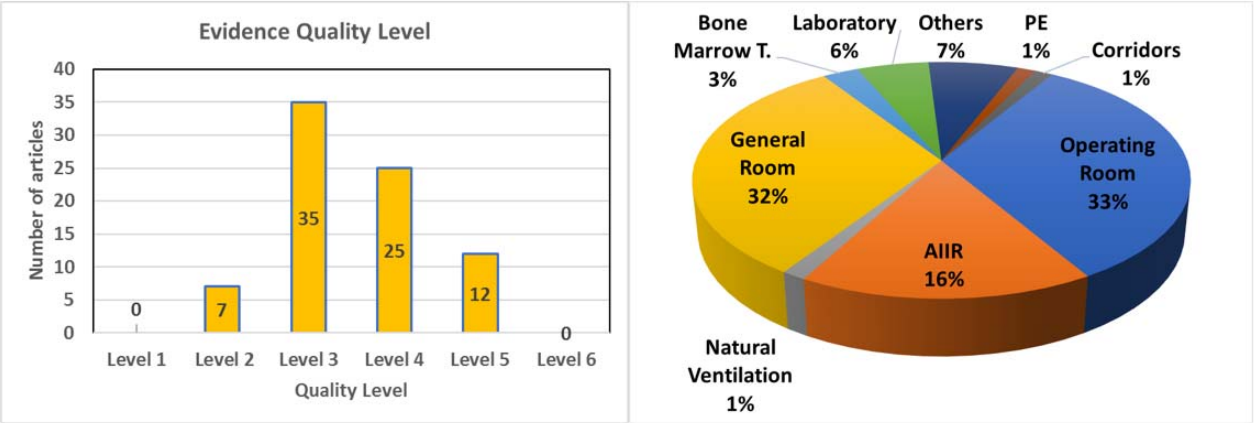

Figure 3 Evidence Quality Level (left) and Distribution of Evidence (right) for Boundary Condition Articles

Summary of Evidence

1. General Room

The performance of different ventilation systems in typical commercial buildings has been reviewed by Cao and colleagues [25]. Healthcare facilities however, must be studied separately as contamination and comfort conditions are different. Studies have been developed aiming to find the optimum placement of inlets/outlets in a general hospital room and the results are inconsistent. For example, the displacement ventilation (DV) and mixing ventilation (MV) systems were extensively evaluated and compared. Many papers suggested that MV better controls the average particle concentrations through effective dilution of contaminants and thus is a better system in HCFs [23,26–31]. Kang et al. showed that lower supply air temperature (hence, lower airflow speed) increased particle counts in the breathing zone [32]. However, a collaborative research project conducted in 2008 showed that DV can produce equivalent or better results when the exhaust outlets are located at ceiling level [33–35]. All of these studies were conducted either numerically, or in an empty room; however, movement of occupants can significantly change the air motion [11,36]. Different assumptions about the source and location of contaminants, as well as the experimental procedure, were the main reason for the conflicting results. Size of the surrogate particles used in the experiments resulted in varying conclusions [26].

Others compared MV, with the downward ventilation system (DW). Qian and colleagues (2006) studied the effect of ventilation strategies on the removal of gaseous contaminants in hospitals. The results suggest that at low ACH (e.g. 4) the DW and the MV perform similarly and behave the same way [29]. The supply flowrate must be strong to create enough momentum for the downward system to perform well [37]. Olmedo et al. showed the downward flow is difficult to achieve in the presence of a heat plume as it is unable to penetrate the micro-environment of a heat source [38]. When there is ample momentum, particles disperse primarily along the ceiling and later fill the lower space due to the downward nature of the flow [39]. Chao and Wan (2006) showed that the DW ventilation could efficiently remove and contain particles compared to MV when sufficient flowrate is provided [40]. Placing the outlet at a higher location is more efficient in removing the fine particles and placing it at lower levels helps in curbing the transmission of large particles [37]. Further, escaping through the exhaust grilles was the major removal mechanism for small size particles. Hence, the location of exhaust significantly affects the dispersion of particles indoors [41].

A ceiling-mounted supply diffuser generates vertical airflow when it is used together with a high location of distributed return openings. This type of flow can produce lower personal exposures especially when the supply temperature is less than the room air temperature (i.e. summer) [42]. Chung and Hsu tested the ventilation efficiency in an experimental chamber by measuring CO_2 levels at the boundaries, and six points inside the room and concluded that placing the inlets/outlets at opposite walls created a straight flow direction that could efficiently remove the contaminants [43]. As suggest by many studies, the path between the source and the exhaust vents is a key contributing factor to an effective air distribution system and must not be interrupted by other objects [25,44,45].

Minimum ventilation rates are required to create a pleasant thermal environment, as well as clean air. The majority of evidence is focused on the latter. However, Memarzadeh and Manning have developed extensive CFD models and showed that to provide thermal comfort, a minimum of 4 air changes per

hour (ACH) is necessary while 6 ACH is optimum for a medical/surgical patient room [46]. Cheng and Lin (2015) focused on the upper bound of this problem and suggested increasing air exchange rate beyond 10 ACH leads to less control over the thermal conditions due to higher turbulence, draft [47,48]. Using a well-mixed condition theory, one can show that the contaminant level decreases asymptotically with an increase in the ventilation rate [49,50]. This means that increasing the ventilation rate beyond a certain limit has less marginal return [51]. The recommended '*optimum*' ventilation rate greatly varied depending on source location, type of room, and boundary conditions ranging from 3 ACH [42], 4 ACH [33–35,52,53], 6 ACH [54–57], 9 ACH [58], to even 12 ACH [31]. It was also mentioned that high air exchange rates can result in the resuspension of larger particle sizes that might have been otherwise settled [54,55]. Fresh air was also found to affect contamination via fomite and direct contact [59]. However, 4 ACH seemed sufficient when compared to higher rates [60]. Studies have shown that increasing ventilation rate in a poor air distribution design has no effect [44], while reduced ventilation rate can achieve the same results by placing the contaminant removal vents near the source [16,17].

2. Operating Rooms:

There are two major air distribution systems commonly used in operating rooms (ORs) : conventional system and non-aspirating air flow system [61]. The former is somewhat equivalent to MV and is based on contaminant dilution. The non-aspirating sometimes referred to as a laminar air flow (LAF) is a specialized system through which supply air is directly blown to the surgical table and is removed by the outlets mainly on the surrounding walls [62]. Lewis (1993) presented a description of different LAF systems used in ORs [63]. However, many recent papers point to a study done by Charnley when advocating LAF where he reported great reduction in infection rate by adopting the new ventilation system [64]. Ever since, two systems of laminar air flow have been considered; these being horizontal [12] and vertical [7,65]. Many articles have been published in favor of LAF by showing improvements in indirect [66–70] (i.e. reducing bacterial load) or even direct patient outcome[71–75] (i.e. surgical site infection (SSI) decrease).

Horizontal laminar air flow (HLAF), or a system by which clean air is horizontally entrained into the sterile zone, has been shown effective [7,76]. However, it was shown to be more sensitive to obstacles and chances are higher that occupants block the streamline of a HLAF [77]. A very recent study shows that LAF is not disturbed by patient's convective heat plume and effectively washes out the surgical table with clean air [78]. The effectiveness of LAF has been critically questioned by different groups of researchers [79,80]. Some studies reported no significant improvements upon using LAF [81,82] studies have shown that the use of LAF had drastically increased the SSI [83,84]. Others reported insignificant difference of LAF on indirect measures such as particle counts and bacterial load [85–87]. One study demonstrated that the use of recirculation and split unit systems in an operating room produced unfavorable results and is not recommended [88]. Lily and colleagues found that use of non-aspirating units in a burn operating theatre did not result in any significant improvement [89].

Similar to the previous section, increasing ventilation rate causes an asymptotic trend. Intag (1975) collected data on post-operative infection and air change rates and showed that a higher rate could result in lower infection [90]. Russenberger and Wanner (1996) conducted experiments in an OR with different air change rates and showed that 20 ACH is appropriate [91]. Bacterial load in an OR with and without surgical activities showed that 15 ACH produces the lowest contamination [92]. A study considered room geometry and ventilation rate and recommended airflow rates between 20 and 25 ACH [93]. Another work studied a wider range of 18.75 to 150 ACH and showed that 20 ACH results in lower deposition of particle on targeted areas [94]. Some studies considered higher ventilation rates (~40 ACH) and reported effective performance with potential energy savings of up to 15% [95–97]. It was shown that adding a 0.5m skirt around the laminar supply diffuser helps direct clean air to the patient bed [95,98,99]. Sadrizadeh et al. stated that a flowrate above 40 ACH will contribute to more turbulence and increase the chances of infection [77,100].

Further studies suggested that inlet air velocity shall be used as an indicator of ventilation instead of air change rate and good results were found at 0.25 m/s [101,102]. Chow and Yang (2005) reported that decreasing inlet air velocity from 0.38 to 0.25 m/s had little impact on particle concentrations [19]. Increasing the air velocity shifts the high velocity profile from the core to the edge of the supply jet [95,103].

Effective ventilation to remove medical gas waste in OR's have also been investigated and the best results were obtained at 20 ACH [104,105]. Turning off the ventilation system during non-occupancy periods does not produce negative outcomes contingent on the ventilation system restarting at least 30 minutes prior to use [106,107]. Some researchers have found that the role of ventilation rate and air pathways from supply to exhaust openings and reducing the surgical site infection is insignificant [19,95,98,108,109].

3. Surgical Lamp/Surgical equipment/Surgical Table Placement

The surgical light is deemed to bring about complications in the laminar air flow due to heat dissipation and stagnation of air [95,97]. McNeill and colleagues tested the effect of the supply air jet acceleration when reaching to the surgical light, which resulted in an increase in turbulence intensity [21]. Studies show that the effect of smaller surgical lights on the flow is negligible [7,95]. Surgical lights with different projected areas were tested in an OR with a ventilation rate of 162 ACH and it was concluded that lights with less than 15% of the supply diffuser area do not introduce any further infection risk as they do not contribute much to the airflow within the ultra-clean area [110]. A recent study, however, found that the disturbance created by surgical light heat plume on the airflow was minimal as it is close to the air inlet and the forced-air velocity dominates the convective flow due to surgical light heat flux [78]. One study found that the LAF size significantly impacted the number of colony forming units on the surgical table. A proper size for LAF was not reported [111].

4. Airborne Infection Isolation Rooms (AIIRs):

A retrospective study of a major nosocomial outbreak revealed the role of air distribution in a Hong Kong patient ward. Further simulations exhibit improvements in ventilation design by increasing the number of diffusers [112]. Eleven numerical and experimental studies have been conducted to identify the best location of exhaust grilles and supply diffusers in the AIIR. Eight of these studies show that the best results are obtained when the exhaust grille is placed near the patient's head either on the ceiling [22,113–115] or on the headwall [116–118] such that it is not blocked by the patient's bed [98]. Two investigations cited that the exhaust outlet shall not be placed close to the entrance door [117,119]. While others indicated that the lower exhaust grilles outperform other options [120–123]. One study simulated seven ventilation arrangements and showed that for a particular source (a patient cough), the effect of ventilation arrangement is negligible [124]. The optimum location of the supply diffuser in the AIIR is within the range between the center of the room [118,120] and the foot-end of the patient bed [117], or on the wall opposite to the headwall [116].

Many studies have shown that little benefit is achieved by increasing the air change rate beyond 6 ACH in AIIRs [113,115,117]. However, one indicated that 9 ACH is more prudent due to the sensitivity of the space [125]. One study observed that tracer gas concentration inside the isolation room increased for higher ventilation rates (e.g. 20 ACH) [126]. Memarzadeh and colleagues obtained better results with 12 ACH when compared to 16 ACH using computer simulations [127]. On the contrary, a study on several ventilation rates in AIIR reported lower concentrations when the flow rate increased from 12 to 24 ACH [128]. Particles, when generated continuously, accumulated inside the AIIR for 6 ACH showing lack of effective removal [9]. Changing the flow rate from 0 to 48 ACH, better containment was achieved for higher rates [129].

Ventilation rate in AIIR can also affect the effectiveness of ultra-violet germicidal irradiation (UVGI) lights [130–132]. Studies showed that the best combinatory results are also obtained for 6 ACH [113,133,134].

5. Other space functions

Evidence on other space functions in the hospital is sporadic. Only seven papers were found on protective environment and patient corridors. A one-half scale model of a Bone Marrow Transplant (BMT) room was constructed to evaluate ventilation efficiency at the University of Minnesota. A ceiling level supply diffuser was located at the room door and the exhaust was in the toilet room. Local age of air at the bed was less than half of that near the window, indicating effective air distribution [135]. Fungal contamination was never detected in BMT rooms with LAF plus high efficiency particulate arresting (HEPA) filters [136]. Virtually no particles were identified at the patient's breathing zone in the protective environment (PE) room equipped with the downward ventilation system [137]. It was also found that the HEPA filters without LAF were less effective [136,138].

Mousavi (2015) performed experimental and numerical studies in an actual hospital corridor and found that placing an exhaust outlet between each two supply diffusers in the corridor could significantly reduce particle concentrations in the corridor [139,140]. Mousavi also developed CFD models and showed that 4 ACH provides ample air quality in patient corridors [140]. However, it can be reduced to 2 ACH upon modifications in the inlet/outlet arrangement [139].

A Proper ventilation system for a pharmacy was described by Rousseau and colleagues (2007); however, no scientific measurements of system performance and ventilation rate were reported [141].

Some studies address the effectiveness of the ventilation system in laboratories. The defining factor was a need for intensive cooling loads as a result of equipment load [142,143]. Memarzadeh and colleagues developed numerical models to investigate the performance of bench exhaust system and ceiling mounted radiant cooling panels in laboratories [144]. Comparing a traditional system with 13 ACH with a series of new scenarios showed that a combination of bench exhausts and radiant cooling systems could

provide better thermal conditions using only 6 ACH. Concentrations of chemical spills in laboratories should be sufficiently low at 6 ACH with no tangible health concerns [145].

Beggs and colleagues utilized Monte Carlo models to assess the infection risk in hospital waiting areas. Under the well-mixed assumption and providing 3 air change rates, it was concluded that the ventilation rate was adequate to pose minimal risk of acquiring infection during a visit [146].

2. Pressurization and anterooms: Tools for Containment

Introduction

Pressurization is applied to operating rooms, procedure rooms, airborne infectious isolation rooms, protective environment rooms, ante rooms and others as listed in Standard 170. According to the Greenville Health staff, maintaining a specific pressure differential creates air flow control challenges and can be a burden on maintenance staff. Enhanced certainty about the impact of air flow paths and desired pressure differentials is critical to justify these regulations.

Indoor air quality takes a different meaning in healthcare facilities due to the nature and virulence of contaminants and physical conditions of occupants. From the engineering perspective, this change translates to a series of well-designed policies and practices to dilute, remove, contain, and disinfect micro-organisms. This, in part or in whole, can be achieved by the ventilation system. Pathogens are diluted by the ventilation system; they are removed by filters and through direct exhaust, and can be contained near the generation source via pressurization strategies and the use of ancillary spaces (e.g. anterooms) [68]. In general, it is desired to create a clean-to-dirty airflow path in the space such that the 'clean air' is less affected by contaminants carried by the 'dirty-air' [147]. Utilization of anterooms can also help achieve isolation conditions and maintain room pressure stability [148] such that the pressure differentials due to opening of door and the air exchanged with corridors are minimized [149]. It also provides a suitable location for hand washing, donning and doffing PPE, and storage of respirators [134].

While ASHRAE Standard 170 does not require anterooms, the effectiveness of this ancillary space has been studied. In addition, two major questions are raised and explored about pressurization:

1. Is pressurization an effective strategy to contain contaminants through creating the clean-to-dirty path?
2. How much pressure difference with adjacent spaces is sufficient to bring about containment?

Descriptive Statistics

ASHRAE Standard 170 contains 88 requirements pertaining to pressurization, and 25 requirements pertaining anterooms in HCFs. A pressure relationship is not required for 24 spaces (27%) and the collected articles provide evidence (partially or conclusively) for 26 of the 88 requirements. Evidence quality for pressurization is moderate with a mean/median/mode of 3.5/3/3 (Figure 4). Similarly, quality evaluation for anteroom papers shows a mean/median/mode of 3.2/3/3.

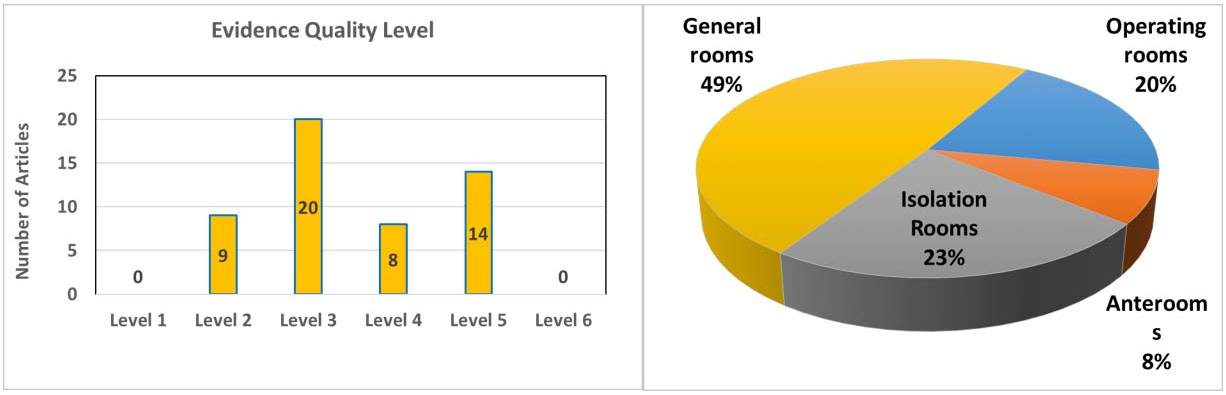

Figure 4 Evidence Quality Level (left) and Distribution of Evidence (right) for Pressurization Articles

Summary of Evidence

1. Pressurization

Many observational and retrospective studies have demonstrated a conclusive association between the lack of pressurization or the physical proximity to disease outbreaks [150–153]. For example, Edlin and colleagues (1992) conducted a smoke test in a hospital with 16 isolation rooms hosting

immunosuppressed patients with tuberculosis (TB), where in fact only one had negative pressure. A cluster sample of 346 patients found that 21 nosocomial TB infections occurred in the rooms that were located two rooms or less from the index patient [154]. Related, there are numerous case studies, reports, and evidence of the like exhibiting a lack of proper pressurization [155–158] or a calibration error of the continuous pressure monitoring device [159]. On the other hand, a longitudinal study revealed that the degree of fungal contamination was lower in a bone-marrow-transplant (BMT) room with positive pressure as it limits the contamination from adjacent spaces [136].

More recently, evidence has shown that airborne transmission of severe acute respiratory syndrome (SARS) is possible, especially for the epidemics that occurred in Hong Kong and Toronto [112,160]. In both events, there was a clear association between the temporal-spatial infection pattern between the index case and secondary cases that could not be explained by the known limitations of either contact or droplet transmission. A retrospective airflow analyses found the supply air rate (20.2 m^3/min) (713.4 ft^3/min) to be nearly 4 times the exhaust rate (5.2m^3/min) (183.6 ft^3/min) in the index patient room, resulting in a strong outflow of contaminated air to the corridor and adjacent rooms. Another retrospective study of nosocomial transmission of VZV to three (3) health care workers found tracer gas (NO2) concentrations in a nursing station equal to (or greater) than concentrations of NO2 released through an open door from a nearby isolation room under 0.7m^3/min (24.7 ft^3/min) negative air pressure [161].

In general, pressurization is deemed to be an effective containment strategy when the door is closed [53,148,162–168]. However, pressure relationship is lost, or reversed, when the door opens [164–166,169–171]. Studies showed that in a practical range of pressure difference, door opening terminated the pressure differential regardless of the amount [172]. Cases with -3.0 Pa [171,173,174], -7.0 Pa [164], -15 to -30 Pa [126] have been reported. Therefore, pressurization must be assessed with the effects of door opening and traffic flow [175]. For example, a combined effect of door opening and low ventilation rate in the absence of

negative pressure difference could result in high probabilities of infection in bronchoscopy suites [176]. Lastly, leakage of the room can greatly affect the pressure difference [177,178].

Experiments in an AIIR with 2.5 to 20 Pa pressure difference showed that the migration of particles decreased for more negative pressure, though the effect of traffic motion was more profound [179]. Concentrations of tracer gas reduced up to 1000-fold when 10 Pa pressure was applied [162]. An operating room performed effectively with 20 Pa positive pressure scenario [180]. Hayden and colleagues however mentioned that >30 Pa pressure differences were maintained during door opening [181]. Two pandemic studies have also reported the effectiveness of negative pressure scenario [182–184].

2. Anteroom

A properly configured anteroom is an effective means to maintaining pressure differentials and creating containment [134,149,169,179]. However, it is very critical to identify a well-designed anteroom. For example, Kokkonen and colleagues (2014) depicted that an under-ventilated anteroom could not effectively remove impurities and pathogens from the isolation room [185]. No statistical significance was found in the escape of particles from AIIRs with and without anterooms due to small size of the anteroom and the lack of separate supply/exhaust vents [186]. Positive pressure anterooms have been shown to be equally or more effective than traditional negative (neutral) anteroom as they break the flow from clean to dirty spaces [187]. Air exchange across the door is inversely proportional to the size of anteroom as it can effectively control the turbulence induced by door opening [181]. Researchers have studied the effect of a shared anteroom and suggested that patients with dissimilar diseases shall not be admitted to such isolation room as cross contamination is likely to happen [159,188].

Anterooms seem to be effective in containment and removal of pathogens in HCFs though they are not required by ASHRAE 170. If the presence of the anteroom is deemed required by future versions of ASHRAE 170, further research must be conducted to identify the acceptable environmental parameters

such as pressure relationship, temperature, RH, and ventilation rates in the anteroom. The current state of knowledge does not offer much about specific requirements for a 'required anteroom' [153,187].

3. Temperature and Relative Humidity

Introduction

Maintaining regulated temperature and relative humidity requirements beyond general thermal comfort requirements has a significant impact on building operations and utility costs. Often chiller plants are required to operate less efficiently to provide colder chilled water for dehumidification and steam plants, or more recently atomizing systems, are operated for humidification that consume energy and maintenance staff time. Further, different spaces have differing requirements for humidification requiring additional humidification systems to meet specific room requirements. Confirming the value and certainty of why these requirements are in place is critical in order to justify the expense to HCF owners and operators.

Modern humans spend 90% of their time in indoor environments where modern buildings are designed to support human activities and protect them from extremes. Buildings' performance is measured by how effectively the building functions to support its occupants [189]. Temperature control and relative humidity (RH) in HCF are important for the health and well-being of patients [190,191]. Also, they are important to keep the staff members comfortable to continue to provide a high quality care and service [192,193]. Most studies do not account for the duration of time spent in the space in relation to the environmental conditions [6,47,48,191,194]. There is little to no conclusive evidence suggesting a defined minimum or maximum relative humidity and temperature range that provide control for comfort, asepsis and odor [5,195]. A comfortable thermal environment for patients in an HCF helps stabilize their mood and affects their satisfaction level with surgical care. Whereas for the staff, thermal comfort has a direct impact on their working conditions, health and safety [6]. Thermal neutrality is sustained when the

amount of heat generated by human metabolism is allowed to evaporate, maintaining thermal equilibrium with the indoor environment [196,197].

Descriptive Statistics

ASHRAE Standard 170 contains 159 requirements pertaining to temperature and RH in HCFs. Evidence was found for 16 requirements (20%) indicating limited research with related measurements. Further, quality of evidence and distribution of data is shown in **Figure *5*** and **Figure *6*** with a mean/median/mode of 4.3/4/3 and 4.3/4.5/5 for temperature and RH, respectively. Overall, no temperature and RH range were required for 65 requirements (41%) (e.g. toilet rooms, etc.).

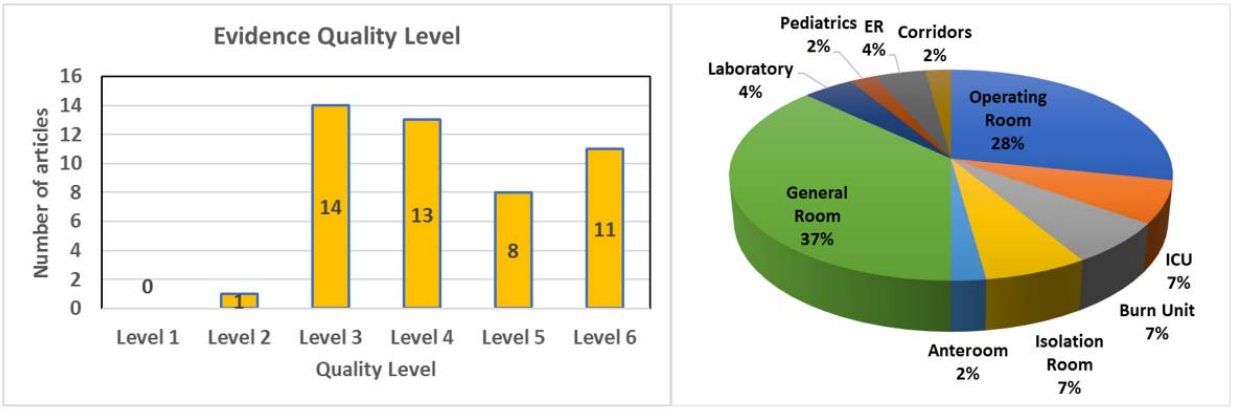

Figure 5 Evidence Quality Level (left) and Distribution of Evidence (right) for Temperature Articles

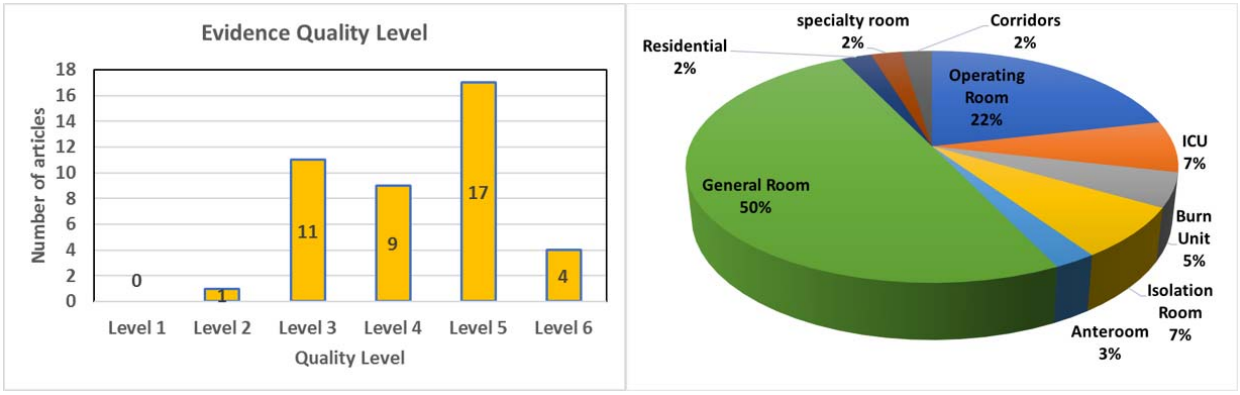

Figure 6 Evidence Quality Level (left) and Distribution of Evidence (right) for Relative Humidity Articles

Summary of Evidence

Operating room environment's complexity and sensitivity makes theoretical and experimental investigations very difficult and, moreover, experimental assessment at the time of an ongoing surgery has a serious threat to the patient and also has many ethical problems [198,199]. The thermal environment also affects the working conditions of the health care personnel who work in these environments and the sleep quality and quantity as well as the overall satisfaction of the patients [200,201]. Thermal comfort of surgical staff was evaluated both subjectively (e.g. survey) and through objective data collection. Results show that the level of stress and thermal comfort of occupants as well as skin temperature vary greatly from surgeon to nurse [202]. Another study conducted in Polish ORs revealed varying thermal sensation among the surgical staff where the surgeons and scrub nurses generally feel warm [203]. Experiments followed by a survey in the Montreal General Hospital offered very similar results; surgeons feel hot, nurses feel cool to cold, and patients feel cold to very cold. Worthy to note, a discrepancy was found between thermostat and the actual air temperature, perhaps due to a calibration problem [204]. Temperature between 24°C (75°F) and 26°C (79°F) in an operating room is suitable for patients with low levels of activity, whereas temperatures below 21°C (70°F) puts the patients at risk of becoming hypothermic [205]. Also, lower temperatures can increase restlessness, increase pain and shivering, increase inattentiveness, increase muscular and joint tension and decrease overall satisfaction for the patient during and after surgery [70]. For the surgical staff, a temperature over 23°C (73°F) is usually intolerable. In addition, it has been noted that the surgical lights have a significant influence on the thermal comfort of the staff [197]. Occupants with clothing flexibility (e.g. circulating nurse) generally adapt themselves to the environment by increasing or decreasing clothing levels [206,207]. One study correlated the variations of temperature in the OR to the number of occupants and suggested that the traffic must be controlled [208]. The posture of the surgical team while performing surgeries also has an impact on the varied thermal comfort within the space [209].

The recommended levels of relative humidity range from 30-60%, due to flammable anesthetic gases and the frequent use of volatile liquids, and to prevent the accumulation of static electricity [210]. The FDA's Device Recall and Malfunction databases documented equipment failure due to electrostatic charges as a result of <30% RH [211]. A study done in Gaza Strip showed that the neonatal care unit RH ranges from 30% to 50% with desirable comfort [212].

Burn units have several unique features and challenges to achieve the set point temperature and relative humidity range. These spaces are usually kept at higher temperature and humidity levels in order to prevent excess moisture loss from the patient wounds and to minimize medical complications [213,214]. Low temperature (<15°C, 60°F) in Emergency room increased the risk for cerebrovascular diseases, hyper-intensive diseases and asthma [215]. Around 26°C (78°F) was associated with the lowest risk. Another significant component related to comfort of the patients is the temperature range adjustment around the patient bed. The typical activities happening around the bed involves wound dressing change and it is preferred to raise the temperature around the patient by 10°F to 15°F. The effect of the reduced temperature difference between the air and the wound temperature improved the patient's comfort [213,216].

Several studies have investigated the flow induced by buoyancy and door motion [217,218]. The setting is particularly important where temperature gradients across the door can be high [164,173,217–219]. Temperature difference across the door could create perturbations in the room airflow, which leads to increased risks in pathogen transmission in and out of the room [129,137,220]. As a result, non-overlapping ranges of temperature for adjacent spaces shall be avoided. Further, temperature and relative humidity are known to affect the survival of viruses, bacteria and different types of fungi within a space [36,192,221]. A study by Harper evaluated the survival of four viruses aerosolized at varying temperatures and RHs. Vaccinia, influenza, and Venezuelan equine encephalomyelitis viruses survived better at low relative humidity (17% to 25%), whereas polio viruses showed greatest survival at high RH (80% to 81%) [222]. The

survival of three aerosolized human respiratory viruses (adenoviruses 4 and 7 and parainfluenza 3) studied in static chambers at three RH levels (20%, 50%, 80%) depicted that the adenoviruses survived better at 80% RH, whereas the parainfluenza virus survived better at 20% RH [223]. In general, studies show that the most unfavorable survival RH for micro-organisms is between 40%-60% [224–226]. A recent study examined all the environmental parameters of a recently built hospital premise against direct patient outcome data (i.e. rate of infection) and found that RH is the only significant indicator of infection [227,228]. It was shown that RH lower than 40% results in farther migration of droplets produced by sneeze [229]. Kowalski and Bahnfleth (1998) reported that spores can grow and multiply in ventilation ducts if not properly controlled [131].

4. Filtration, Recirculation and Direct Exhaust

Introduction

Filtration, recirculation, and direct exhaust requirements are significant for HCF design, construction, and operations. Filter replacements are costly and a time-consuming maintenance item. Based on the Authors' experiences, about 30% of the air flow in a typical HCF is installed due to recirculation requirements rather than ventilation or thermal comfort requirements. High recirculation rates result in consuming reheat energy. Separate direct exhaust systems add complexity and cost in both design and operations of healthcare facilities.

Particles which may contain or carry microorganisms, pathogens and bacteria are ubiquitous in hospitals. Outside air may also contain contaminants and allergens. Thus, designers aim to reduce contaminant level through filtration. It is recommended to have a high rate of flow with no recirculation of air to remove the droplet nuclei which can remain suspended in the air for an hour or more [230]. The Centers for Disease Control (CDC) recommends to admit infected patients to rooms without air recirculation [231]. Using clean outside air is not always cost and energy efficient [232]. Hence, recirculation

of inside air becomes a viable option [233,234]. For example, using HEPA filters can reduce contaminant level up to 99.97% [235,236]. Using proper filtration on return air was shown to produce practically identical air quality to the outside air [131]. In terms of energy saving, it is better to use HEPA filters for cold and hot days and preferably not during mild days or in dry climates [195]. However, the use of filters is associated with high maintenance and pressure drop and consequently electrical consumption of the fans. There is a scarcity of evidence pertaining to filtration and recirculation. Out of the total of 190 requirements listed in Standard 170, scientific evidence was found for only one-third of these requirements. Furthermore, research with original measurements is scarce for this category where the majority of publications were other guidelines, standards, or opinion papers. Mean/median/mode of the evidence were 3.5/3/3 and 4.5/5/5 for filtration and recirculation, respectively.

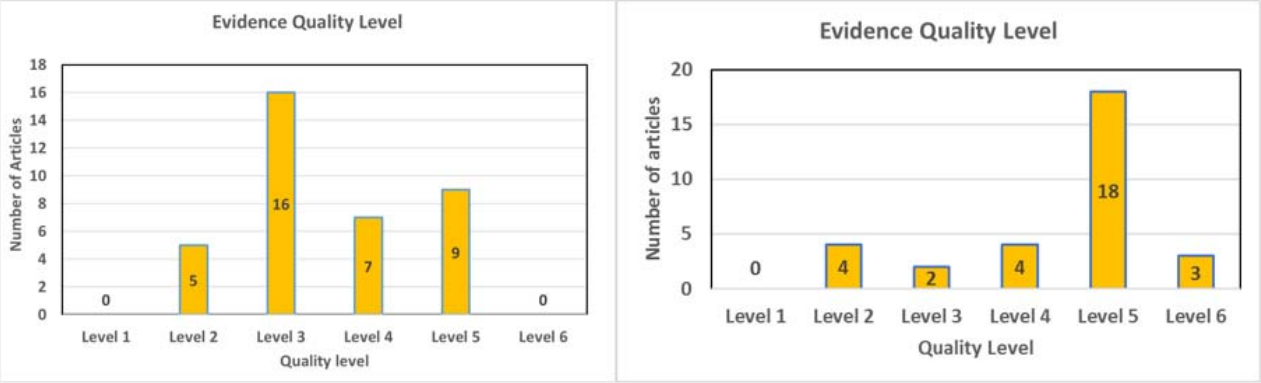

Figure 7 Evidence Quality Level (left) for Filtration and Recirculation (right)

5. Recirculation

It is accepted that an airborne infection route exists but one should determine the magnitude of its role in generating diseases [237]. For instance, tuberculosis (TB) particles are droplet nuclei with 1 to 5 µm in diameter that are unlikely to settle and mostly are removed from air through ventilation and filtration [49,238,239]. Many case studies and retrospective observations associated an outbreak to air recirculation between two otherwise separate spaces [240,241], or lack of proper filtration on the return air [242,243]. For disease with airborne route of transmission, recirculation of air could culminate in disease epidemic

[49,244]. Recirculation of air from spaces with dangerous medical gas concentrations (e.g. anesthesia gases, etc.) is also prohibited by federal and state regulations [245]. Other ventilation standards, such as the German Standard (DIN 1946-4), don't allow recirculation between medical spaces because the efficacy of filtration is considered too low to capture small pathogens [246].

There are not very many studies that directly measured the effect of recirculation on infection control in ORs. Ulrich showed that having recirculation of air along with filtration reduced the number of bacteria inside the OR [245]. One study compared a 100% outdoor air with 83% recirculation air in an OR and showed the latter was cleaner [247]. Another work shows that the use of split unit with 100% recirculation increased contaminant level in an OR [88].

It is important to improve indoor air quality but at the same time not over consume energy. Woods et al.[247] developed energy and economic models to identify the factors that contribute to the performance of operating rooms in their air quality. The results show that the direct costs of the HVAC systems were a significant percentage of the annual energy costs for operating rooms. Also, through changing the ventilation control systems, significant reduction in energy consumption was achievable. They believed that these changes should be implemented in a way that it has no adverse effect on the patient health. However, there were no measurements of the patient's health and the risk of infection in this study and it was purely an analysis of energy efficiency and cost.

Dragan did an economic evaluation to compare several different HVAC systems that minimize the risk of infection to the cost of tuberculosis treatment and concluded that HVAC saving do not outweigh the cost of TB treatment, and thus, recommended direct exhaust [232]. Rahimi et al. constructed a room at full scale length which was equipped with radiator and air circulating mechanism and found potential for energy savings [248]. A ventilation system with local recirculation diffusers reduced the annual energy consumption compared to traditional mechanical ventilation systems [249].

Filtration

Filtration can reduce some airborne pathogens [138,250]. The recommended filters used in hospitals should be durable and airtight fit to prevent air leakage. There should be a pre-filter upstream of air conditioning equipment. Also having enough space for maintaining the system is necessary.

1. Filtration in operating room (OR)

Reducing surgical site infections (SSI) is important since it accounts for 14% to 17% of hospital acquired infections [251]. The committee on operating room environment of the American College of Surgeons [252] advised the use of HEPA filters as standards for all operating rooms [253]. Tang et al. recommended on controlling aerosol transmitted infections in hospitals by using built-in filters in surgical masks [254]. Olmsted et al. (2008) recommended the use of a portable anteroom system combined with HEPA unit (PAS-HEPA) outside the OR [255]. The rate of infection during surgery was kept in the standard range via HEPA filtration [256].

Research on 2,519 burn patients were conducted by McMnus and colleagues provides strong evidence that single-bed isolation rooms in combination with air filtration substantially reduce the incidence of infection to gram-negative bacteremia (GNB) and mortality [257].

Bone marrow transplant (BMT) units in a University of Minnesota hospital built in 1986, has three different filters: 1- rough filter 40% (ASHRAE 52-76), 2- 95% bag filter (ASHRAE 52-76) and 3- HEPA final filters [258]. It was found that the number of small particles (0.3-0.5 µm) was a function of the filtration and number of big particles (>5 µm) was a function of occupants. Smaller sized particle counts (0.3-0.5 µm) were substantially lower for BMT units equipped with HEPA filter. Another study also showed that HEPA Filters led to a significant reduction in the number of nosocomial infection for highly immunocompromised patients [259]. Minimum efficiency reporting value (MERV) 13-16 were found to be more effective in reducing infectious disease compared to MERV 11[260]. A well-mixed condition was

assumed in the space and the effect of filtration was assessed [169,261]. There was no significant difference between removal rates of MERV 15 and HEPA filters [169]. Kowalski et al.[250] also found that for removing 1 µm and larger common spores 90% efficient filters are as effective as HEPA filters. Miller-Leiden et al.[244] showed that for removing aerosol with 0.7 µm and 1.3 µm non-HEPA units works as well as HEPA units. Sometimes portable HEPA filters are used when it is needed to temporarily recirculate air in rooms with no general ventilation. If they are , all room air should be recirculated through the HEPA filter in a way that it can ventilate the room with more than 12 air changes per hour [47,262].

There is a lack of evidence on the use of antimicrobial agents on duct coating and air filters [169]. However, some support the use of antimicrobial agents on filters [263,264], while others found insignificant difference [265,266]. Verdenelli et al. showed reduction in bacterial and fungal growth on filters when filters were treated with antimicrobial agents. Research conducted by different research groups on vulnerable patients showed that single rooms with air filtration reduced the risk of infection and mortality substantially [257,267–269]. UVGI alone is not enough to bring the infection level down and should not replace HEPA filter [47,270]. Ryan et al. however, found that installation of UVGI in the HVAC systems equipped with 95% filters helped reduce ventilator-associated pneumonia VAP and tracheal colonization [271].

HEPA filters can reduce the fungal spore and pathogens counts [4,136,262,272–276]. However, if not available, portable HEPA units can be used [14,275,277–280]. They can be noisy and expensive [280]. Miller et al. found that ceiling mounted air filters (CMAFs) outperform portable air filters (PAFs) [244]. On the other hand, permanent filters can shelter micro-organisms [281,282]. Therefore, the device itself can become the source of contamination[283–288]. PAFs use electrostatic and non-thermal plasma techniques to remove particles [136,262,288–290]. Qian et al. tested the performance of portable HEPA and concluded that having portable HEPA filters improve global airflow mixing by interacting with the airflow pattern [14].

Clean air should not be confused with non-aspirating air. Non-aspirating or laminar flow is characteristic of a flow that is unidirectional. However, clean air is the air that is filtered at the point of dissemination [253]. Non-aspirating air flow combined with HEPA filters, bring the contamination level down and is recommended for ORs and immunocompromised patients room[5,65,136,259,291–293]. Non-aspirating with HEPA filters had no advantages over conventional ventilation system in reducing infection after hip replacement surgery [65,138,253,294,295]. Studies have shown that infection rates correlated with the number of personnel in the room and the duration of the surgery [296,297].

In the study that was done by Sheretz et al.[65], the use of whole-wall HEPA filtration units with horizontal laminar flow (LAF) in patient rooms reduced the number of Aspergillus organisms in the air to 0.009 colony-forming units/m^3, which was significantly lower than in all other areas of the hospital ($p \leq 0.03$). Although bone marrow transplant recipients had an order-of-magnitude greater risk of nosocomial Aspergillus infection than other immunocompromised hosts, they found that using HEPA filters with horizontal laminar airflow (HEPA-LAF) could reduce this risk [65]. Passweg et al. [267] also had the same result that the use of HEPA and/or LAF reduced the contamination and the mortality rate and increase the survival of bone marrow transplant and leukemia patients.

Conclusions

All of the 886 requirements are found in the spreadsheet in Appendix A, which also contains the research team's conclusions. The authors of this report were requested to make a professional judgement on whether the 886 requirements of Standard 170 could be defined as **a basic necessity, an enhanced requirement, require a change to the standard, are procedural, or require further investigation**.

Two hundred, nine (209) of the 886 requirements (23.6%) were defined as **basic necessities**. These included items determined to be included in rational or clinical inclusion or have a sufficient quantity of evidence to support the requirement.

Six (6) of 886 requirements (0.7%) had limited evidence and/or limited quality, which put them in the **enhanced categories**. Others are considered good O&M practices such as placing pressure sensors across filters to aid filter changes, but in and of themselves don't impact patient care.

Eight (8) of the 886 requirements (0.9%) are **recommended to be changed**. Changes include references to ASHRAE standards 62.1 and 188 and NFPA 99 rather than repeating language in standard 170. Technical changes include: increasing the temperature of Wound Intensive Care spaces to greater than 75°F (24°C) found in Table 7-1. Requirement 7.2.3.b, exhaust grilles or registers shall be located near the patient room door, should be changed due to evidence found. The requirement (7.4.1.a.ii) for the average velocity of the surgery diffusers to be 25 to 35 cfm/ft2 (127 to 178 L/sec/m2) should be changed due to evidence found.

Twelve (12) of the 886 requirements (1.4%) are listed as **procedural** that include such items as conducting an infection control risk assessment per section 8.4.

Six hundred, fifty-one (651) of the 886 requirements (70.9%) had to be categorized as **needing further research**. Most of the requirements had no research found that even remotely pertained to the requirements. Some requirements had relevant but inconclusive evidence that was insufficient to move it from Further Investigation to Enhanced Requirement.

There are 60 requirements related to laboratories in Table 7-1 that should be highlighted. A reference to ANSI Z-9.5-2012 Guidelines should be considered in order to achieve consistency with the ASHRAE Technical Committee 9.10 Laboratory Systems. However, the authors and PMS are unsure if this ANSI

standard provides enough guidance as a standard and suggest that laboratories themselves should have further research.

Finally, some requirements contained contradictory evidence, which made a recommendation impossible. For example, requirement 7.2.1.d states that exhaust air grilles or registers in the patient room shall be located directly above the patient bed on the ceiling or on the wall near the head of the bed unless it can be demonstrated that such a location is not practical. Four different sources supported this requirement and four different sources disputed the requirement as well as one relevant but inconclusive source.

The quality of evidence was also assessed based on the quality assessment matrix (Table 1). The overall quality of evidence is depicted in Figure 8, with a mean/median/mode of 3.8/4/3 suggesting that evidence with direct measurements are very scarce (11%). Nearly 30% of the reviewed evidence did not have original findings; they either reviewed original studies or were another guideline/instruction. The vast majority of research was carried out either in controlled environments (e.g. test chambers) or using computer simulations (quality levels 3 and 4).

For some topics such as boundary conditions, and pressurization, studies in real conditions were less scarce due to feasibility of conducting real time experiments and observational studies. Other domains (such as recirculation and filtration), however, are heavily based on common understandings and speculations. This is because testing the efficiency of the recirculation system in a real environment may jeopardize patients' health and safety outcomes and, thus, will not be approved by the Internal Review Board (IRB) panels.

High quality evidence for these domains typically dates back to a few decades ago where fewer restrictions were in place. With the advancement in computer and software technology, recent investigations lean towards computer simulations. As observed by other researchers, there is

insufficient data and research to specify many aspects of the ventilation system in healthcare facilities and this trend has been consistently observed by other researchers [23,45,107,134,210,298].

The conclusions of this present study are presented below with respect to the identified research questions.

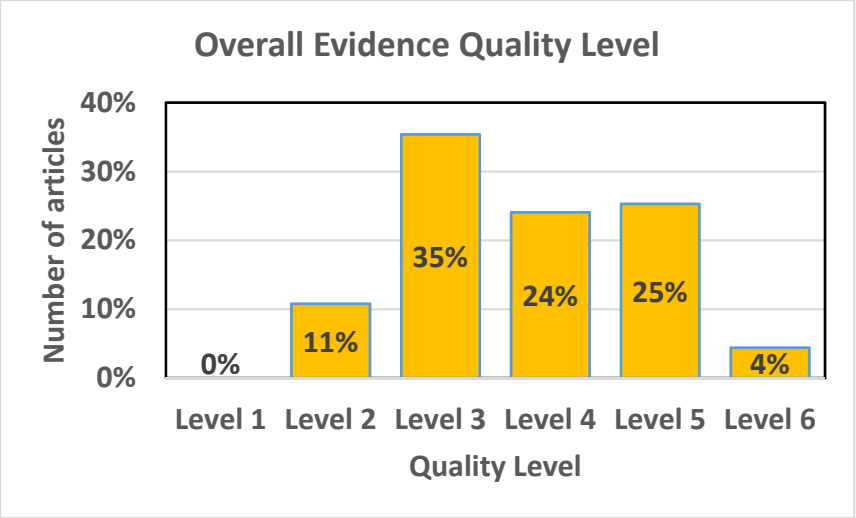

Figure 8 Overall Evidence Quality Level

Ventilation Rate and Boundary Conditions

Theoretically and using the well-mixed condition, one can show that the overall concentration of pathogens can be lowered by increasing the ventilation rate. This phenomenon, however, is an asymptotic trend where insignificant improvements are achieved at very high ventilation rates. New advances in computer models and more robust experiment methods, demonstrate that local air quality indexes can be effectively controlled by the boundary conditions. In a generic room, it was shown that 6 ACH is sufficient to dilute contaminants and excessively higher rates can even result in unfavorable outcomes. Specifically, increasing the ventilation rate of a mixing ventilation system lowers the removal efficiency of larger particles (>10µm). Also, higher rates have been shown to create turbulence when colliding with a surface (e.g. surgical lights), or convective induced flows (human body heat plume), and

thus introduce further risks of pathogen transmission in the OR. Ventilation rate in ORs has been widely studied ranging from 0.3 to 600 ACH and a range of 15-30 ACH was shown to be effective. These findings may not necessarily contribute the “minimum ventilation rate” issue that must hold even during non-occupancy. Similarly, ventilation rate to provide desired thermal comfort does not necessitate a “minimum” ventilation rate as many of the modern HVAC systems regulate the amount of supply air based on the occupancy level.

Results for the boundary conditions of a generic room are very inconsistent and somewhat conflicting. Studies were found for and against mixing ventilation, displacement ventilation, and downward ventilation in healthcare facilities. The reason for this inconsistency is three-fold: 1) experiments are not done in real/actual conditions; they have been conducted in controlled environments using simplifying assumptions. These assumptions, however, vary from work to work, and thus the results differ. 2) There are too many confounding variables that cannot be controlled. For example, human traffic is shown to easily perturb the air motion introduced by the ventilation system [299–301]. 3) The ratio of infection transmission is relatively small (SSI occurs in less than 2% of all operations) such that any statistical inference is difficult.

The use of LAF has been recently questioned and shown ineffective because 1) it results in exceedingly low intra-operative tissue temperature in the surgical wound. A cold wound is more susceptible to infection. 2) the assumption of laminar airflow can be easily nullified by the motion of surgical staff. Regardless of the reason, data against LAF is more solid.

Boundary conditions specified in Standard 170 for AIIR are supported by evidence. A ceiling level supply with either ceiling or floor level exhaust near the patient’s head is recommended.

Pressurization and Anteroom as means for pathogen containment

Results show that pressurization is an effective strategy in containing pathogens and lack of pressure relationship is associated with disease transmission. The current required pressure difference (2.5 Pa) is sufficient when the door is closed, and it was shown the risk of air mixing diminishes with 4 Pa. It seems that the problem is not the magnitude of pressure difference, it is the door opening that results in air mixing. Air mixing across the door occurs even in the presence of high pressure differentials. The risk of contaminant transmission decreases with higher pressure differentials but is not eliminated. Thus, an intermediate space is required to control the air mixing volume. The use of anterooms as a space to minimize cross-contamination is highly supported by evidence. However, since anterooms are not currently required by ASHRAE 170, other requirements such as ventilation rate, temperature range, pressure relationship, and boundary conditions must be identified. There is evidence that low ventilation rates in the anteroom result in the accumulation of impurities.

Temperature and Relative Humidity

Temperature and Relative humidity are important for two main reasons. 1) Viability of viruses, bacteria and spores is greatly dependent on temperature and RH. 2) Temperature and RH determine the overall comfort of occupants. The former has been extensively studied [221]. The latter, however, is a complex problem due to the vast variety of metabolic rates and clothing values. Hence, it seems that further research is required to propose interventions and solutions to this problem. A recent comprehensive study found that the only significant environmental parameter on patient outcome is RH. Lower HAIs were reported for RH>40%. However, from the practitioners' point of view and depending on the geographic location this number can be costly to achieve. Evidence also demonstrate higher chances of cross-contamination when in the presence of large temperature differences across the door. Perhaps, temperature ranges could be studied from the aspect of space adjacency.

Filtration, Recirculation, and Direct Exhaust

Articles regarding filtration and recirculation are very scarce and there are not very many points to conclude from the evidence. Despite that, filtration as a removal strategy has consistently shown to be effective. Further research must be conducted to measure efficacy of filtration with respect to the extra cost and energy burdens. Also, there is strong evidence that the contaminated air (e.g. return from AIIR) results in disease transmission if introduced to other spaces. In the context of Standard 170, not all the spaces in this category are known to carry harmful pathogens and are not necessarily supported by the evidence. Recirculation seems to be very controversial; on one hand, its efficiency in reducing energy consumption by reusing the return air is unclear especially when considering potential infection transmission costs. On the other hand, outside air being 'cleaner' than the return air is not always proven true as it is often location dependent and can change over time. This category of requirements lacks research findings to support them therefore there is a broad spectrum of research to be conducted.

Future Work

One key takeaway of this research project is clarification on what is known and unknown for the healthcare industry related to Standard 170, and information practicing engineers need to enhance the certainty of their designs. The following paragraphs provide high level descriptions and scopes of future ASHRAE research projects that the authors think would provide value and would answer critical questions as to the effectiveness of Standard 170. The first three projects likely could be funded by a single source, but the last two may have very large scopes where multiple sources could each fund a portion of the effort.

Thermal Comfort Clo & Met Values

ASHRAE 170 and ASHRAE 55 Standard for Thermal Environmental Conditions for Human Occupancy have been used for many years in the design of buildings including healthcare facilities. Standard 170 defines ranges for environmental factors that impact thermal comfort, Standard 55 calculation methods are utilized to validate thermal comfort. Unfortunately, many healthcare spaces have unique requirements and functions that fall outside the scope of Standard 55, specifically clothing (Clo) values between 0 and 1.5, and metabolic (Met) values between 1.0 and 2.0. Healthcare workers complete many tasks wearing personal protective equipment (PPE) that exceeds a 1.5 clo value and complete many strenuous tasks that exceed metabolic values greater than 2.0 or walking at 2 miles per hour (3.2 km/h).

A future study should focus on surveying healthcare worker clothing for differing procedure types and measuring metabolic rates of typical healthcare worker tasks.

The thermal comfort of visitors is an additional topic of study. Visitors might complain of being too cold overnight as couches slept on by visitors in patient rooms may be immediately adjacent to the window. Poor thermal performance of windows and inadequate perimeter heating may cause radiant

asymmetry, which leads to discomfort. Perimeter slot diffusers may be used to provide perimeter heat but could dump air on visitors. A CFD study of the combinations of typical patient rooms, envelope parameters, and HVAC systems in various climates may lead to a set of criteria required to ensure visitor thermal comfort.

Separation Distances

Several ASHRAE 170 requirements include specific separation distances such as 25 ft (7.6 m) between cooling tower plumes and outdoor intakes as one example. Many projects potentially put patients at risk where the separation distances are insufficient, and others potentially create unnecessary design challenges where there is no concern even at a lesser distance. From the authors' experiences, there are often wind tunnel and CFD models that have been created for healthcare facilities to determine placement of intakes and exhausts. However, not every project has this level of analysis, so a code mandated separation distance is valuable to practicing engineers. Yet, maybe we can learn from what has already been done.

A research project that specifies pathogens of concern and a corresponding maximum travel distance should be specified. Essentially a source concentration measured in colony forming units (CFU), and a maximum intake CFU concentration should be determined.

Then, existing CFD and wind tunnel models should be retested to determine statistically what a reasonable separation distance should be for the standard. Within this study should also be a sensitivity analysis that may generate a future path for engineers to obtain a variance on the prescribed distance by conducting a project specific analysis.

Finally, an additional compliance path and research project might be to investigate air cleaning technologies (filters, UV, etc.) that can be used to achieve a CFU concentration through treatment rather than separation.

Impact of Door Opening on Pressure Differentials

During the clinical inclusion phase of this RP it was discovered that operating room doors open on average once every 90-120 seconds during a procedure [302,303]. There are a variety of reasons for the door opening frequency, but the question becomes "is the pressure differential maintained at this frequency?" Spaces that have pressure differentials should be monitored across several healthcare facilities to determine if pressurization is being maintained and is therefore an effective regulation. This would include operating rooms, procedures rooms, protective environment rooms, and airborne infectious isolation rooms. Anecdotally, the research team has heard that control systems use door sensors to temporarily disable a room pressure differential alarm for 60-120 seconds to prevent the generation of thousands of differential pressure alarms by the building automation system that buildings operators would have to acknowledge. Based on recent project experience for two large academic medical centers, an alarm is generated every 2-4 minutes, 24 hours per day, 7 days per week. This is leading to building operators missing important alarms because of the large quantity of similar alarms to process in a limited time[304].

Big Data Operating Room Air Change Analysis

The debate about the appropriate number of air changes in operating rooms has been going on for years with no effective way of comparing air change rates versus patient outcomes. CFD models have shown mixed results, but ultimately are all inconclusive because the flow of particles does not necessarily correspond to patient outcomes. There is no simple way of comparing patient outcomes and air change rates because it will likely be impossible to get institutional review board approval to allow variable air change rates that may impact morbidity and mortality of a patient.

As an alternative, a major data collection effort could yield statistically significant results to determine the impact of air changes. There are tens of thousands of operating rooms functioning across the

country that operate at a variety of air change rates. Operating rooms in California can operate at 12 ACH when supplied with 100% fresh air. Operating rooms designed to older codes allow 15 ACH, many operate at 20, 25, and 30 ACH. If a statistically significant amount of data can be collected from thousands of operating rooms across hundreds of procedures per operating room that can account for patient factors, demographics, etc., then it might be possible to determine if there were differences in infection rates that are statistically linked to the air change rate. Scale is also important to make the data anonymous and secure for contributing hospitals.

The first phase of the research project would likely just be to design the experiment and the parameters to make such a study statistically significant. The funding for a project of this scale will need to come from multiple sources, but it is potentially the only path forward for determining the impact of this significant factor in healthcare facility first and operating costs.

Tie Breakers

Evidence was found for several Standard 170 requirements that demonstrated contradictions and resulted in an inconclusive result as part of this research project. For example, requirement 7.2.1.d states that exhaust air grilles or registers in the patient room shall be located directly above the patient bed on the ceiling or on the wall near the head of the bed unless it can be demonstrated that such a location is not practical. Four different sources supported this requirement and four different sources disputed the requirement as well as one relevant but inconclusive source.

Individual research projects should be funded to revisit the evidence and potentially repeat the experiments to develop a more conclusive result.

Cost Benefit Analysis

Many standards use a cost benefit analysis to determine whether a requirement is a reasonable minimum expectation for the system being regulated. One of the most scrutinized ASHRAE documents in this regard is Standard 90.1, which is referenced in many energy codes around the world. Consequently, the 90.1 committee typically follows the Scalar Method when evaluating addenda to the standard.

Similarly, Standard 170 Addenda may have a cost and benefit, that should be considered however the calculation is likely more complex than the Scalar Method. We must always remember that we are dealing with the health of people. So, the calculation would need to consider potential for impacts on patient outcomes and not just the incidental costs associated with the addenda. A research project should be created to develop a calculation method and tool that the standard 170 committee can use to weigh future addenda.

Ventilation Rate Procedure for Contaminant Exposure

A key variable that is omitted from Standard 170 is the exposure to contaminants, and its impact on occupant health and safety and subsequently mechanical system design. Depending on the type and rate of contaminant exposure it is possible that different requirements should be imposed upon the mechanical system design. These requirements could be less stringent or more stringent depending on the situation. Currently ASHRAE 170 only sets a minimum prescriptive requirement and does not allow for deviation regardless of other enhancements. For example, HEPA filters are often applied in lieu of the filters defined in Table 6.4. The air quality within the spaces served by the HEPA filter will have fewer particles and potentially increased air quality, which is comparable to some level of increased air changes. To put it another way, can an AHU serving operating rooms with a MERV 7 prefilter, MERV 14 Final Filter, and 20 air changes per hour have reduced air changes per hour if a HEPA filter is applied?

To enable this type of discussion, a method of establishing equivalency between all the factors impacting air quality would need to be created. Recommended is the use of synthetic aerosols in actual healthcare spaces (or full-scale mock-up spaces) to determine contaminant removal equivalencies. For each test, a polyaliphatic-olefin (PAO) mineral oil can be aerosolized to simulate the respiratory production of an infectious patient. The aerosol may consist of 0.1-10.0μm particles consistent with viral droplets and desiccated droplet nuclei and may be released at the approximate height of a patient at rest. Validated CFD models should also be created based on the measured data to assist the design process for rooms that are somewhat different than the measured rooms. The test rooms should be either in a full-scale mockup or in a real hospital.

A performance-based approach would enable lower cost infrastructure for healthcare institutions, and potentially improved outcomes based on designing ventilation systems to meet a particular need.

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
1	Purpose	Purpose	Section Header									HEAD	
2	Scope	Scope	Section Header									HEAD	
3	Definitions	Definitions	Section Header									HEAD	
4	Compliance	Compliance	Section Header									HEAD	
4	Compliance	Compliance shall follow the compliance methods stated in Section 4.	Rational									RATIONAL	Procedural
5	Planning	Planning	Section Header									HEAD	
5.i	Planning	Owners/managers shall prepare a detailed space program including the clinical services expected, expected equipment for each space, and any special temperature, humidity, and pressure control.	Rational									RATIONAL	Basic Necessity
5.ii	Planning	The detailed space program shall be prepared in the planning phase of the design.	Rational									RATIONAL	Basic Necessity
6	Systems and Equipment	Systems and Equipment	Section Header									HEAD	
6	Systems and Equipment	Air-handling and distribution systems are required to provide health care facilities not only with a comfortable environment but also with ventilation to dilute and remove contaminants, to provide conditioned air, and to assist in controlling the transmission of airborne infection. In order to meet these requirements, air-handling and distribution systems shall be designed according to the requirements of this standard.	Rational	Most healthcare facilities due to their size and loads will require an HVAC system to provide thermal comfort and ventilation. The efficacy of HVAC and mitigating transmission of airborne infection will be addressed in the Evidence section.								RATIONAL	Further Investigation
6.1	Utilities	Utilities	Section Header									HEAD	
6.1.1.a	Ventilation Upon Loss of electrical Power	The space ventilation and pressure relationship requirements per Table 7.1 for AII rooms shall be maintained, even in the event of loss of normal electrical power	Rational	This requirement assumes patients occupying AII rooms are a risk to others and that ventilation and air flow rates reduce that risk. Backup power would be required to achieve this risk mitigation. The airflow rates and pressure relationship are addressed separately.								RATIONAL	Basic Necessity
6.1.1.b	Ventilation Upon Loss of electrical Power	The space ventilation and pressure relationship requirements per Table 7.1 for PE rooms shall be maintained, even in the event of loss of normal electrical power	Rational	This requirement assumes patients occupying PE rooms are at risk from others and that ventilation and air flow rates reduce that risk. Backup power would be required to achieve this risk mitigation. The airflow rates and pressure relationship are addressed separately.								RATIONAL	Basic Necessity
6.1.1.c	Ventilation Upon Loss of electrical Power	The space ventilation and pressure relationship requirements per Table 7.1 for Operating rooms(Class B and C surgery) and delivery rooms (Caesarean) shall be maintained, even in the event of loss of normal electrical power	Rational	This requirement assumes patients occupying ORs rooms are at risk and that ventilation and air flow rates reduce that risk. Backup power would be required to achieve this risk mitigation. The airflow rates and pressure relationship are addressed separately.								RATIONAL	Basic Necessity
6.1.2	Heating and Cooling Sources		Rational									HEAD	
6.1.2.1.i	Heating and Cooling Sources	Provide heat sources and essential accessories in number and arrangement sufficient to accommodate the facility need (reserve capacity), even when any one of the heat sources or essential accessories is not operating due to a breakdown or routine maintenance.	Rational	Hospitals are critical facilities that need to maintain functionality even during utility outages. N+1 heating capacity is a common means of achieving resilience.								RATIONAL	Basic Necessity
6.1.2.1.ii	Heating and Cooling Sources	The capacity of the remaining source(s) shall be sufficient to provide for domestic hot water,sterilization, and dietary purposes and to provide heating for operating, delivery, birthing, labor, recovery, emergency,intensive care, nursery, and inpatient rooms.	Rational	The identified end-uses for heating are necessary for building occupants to maintain thermal comfort per ASHRAE 55 as many occupants in these areas cannot be easily moved upon loss of heating.		The identified end-uses for heating are necessary to enable staff to provide care.						RATIONAL	Basic Necessity
6.1.2.1.iii	Heating and Cooling Sources	Fuel sufficient to support the owner's facility operation plan upon loss of fuel service shall be provided on site.	Rational	A possible cause of loss of heating is that the electric or natural gas utility has an outage. To mitigate the impact of this outage hospitals store fuel oil on-site to fuel generators and/or boilers to provide heat.								RATIONAL	Basic Necessity
6.1.2.1.iv	Exception	Reserve capacity is not required if the ASHRAE 99% heating dry-bulb temperature for the facility is greater than or equal to 25°F (–4°C)	Rational	Upon loss of the heating system in a warmer climate it is unlikely that a space will become too cold considering the insulation values of the envelope and internal heat gains. The time it takes to fall out of compliance with ASHRAE 55 is likley long enough to for maintenance staff to restore heating or provide an alternate means of heat.								RATIONAL	Basic Necessity
6.1.2.2	Heating and Cooling Sources	For central cooling systems greater than 400 tons (1407 kW) peak cooling load, the number and arrangement of cooling sources and essential accessories shall be sufficient to support the owner's facility operation plan upon a breakdown or routine maintenance of any one of the cooling sources.	Rational	Hospitals are critical facilities that need to maintain functionality even during utility outages. N+1 cooling capacity is a common means of achieving resilience.		Significant quantities of medical records on stored in IT systems that need to be cooled.						RATIONAL	Basic Necessity
6.2	Air-Handling Unit Desigr	Air-Handling-Unit Desigr	Section Header									HEAD	
6.2.1.i	Air-Handling Unit Casing	The casing of the air-handling unit shall be designed to prevent water intrusion, resist corrosion, and permit access for inspection and maintenance.	Rational	The requirements of section 6.1 are more likely to be achieved with AHUs kept in proper working order. Inspection access is necessary to ensure that the AHU is in fact not going to suddenly fail. Scheduled maintenance can be timed so that clinical functions are not impacted.	ASHRAE 62.1							RATIONAL	Basic Necessity
6.2.1.ii	Air-Handling Unit Casing	All airstream surfaces of air-handling units shall comply with Section 5.4 of ANSI/ASHRAE Standard 62.1.	Rational	The identified section of ASHRAE 62.1-2013 supports the long term effective operation of AHUs.								RATIONAL	Basic Necessity
6.3	Outdoor Air Intakes & Exhaust discharges	Outdoor Air Intakes and Exhaust Discharges	Section Header									HEAD	
6.3.1	Outdoor Air Intakes	Outdoor Air Intakes											
6.3.1.1.i	General	Outdoor air intakes for air-handling units shall be located a minimum of 25 ft (8 m) from cooling towers and all exhaust and vent discharges.	Rational/Evidence	A separation to prevent reentrainment for air quality is rational. The separation distance shall be validated separately.					1,2			MISC	Further Investigation
6.3.1.1.ii	General	Outdoor air intakes shall be located such that the bottom of the air intake is at least 6 ft (2 m) above grade	Rational/Evidence	Air intakes above grade may prevent vermin and ground level particles from entering the AHU. The distance above grade shall be validated separately.					1,2			MISC	Further Investigation
6.3.1.1.iii	General	New facilities with moderate-to-high risk of natural or man-made extraordinary incidents shall locate air intakes away from public access.	Rational	This requirement is rational, but a process for identifying risk needs to be defined.								RATIONAL	Basic Necessity
6.3.1.1.iv	General	All intakes shall be designed to prevent entrainment of wind driven rain.	Rational	This requirement prevents potential corrosion of the AHU and a reservoir for pathogens being present. Cross reference ASHRAE 62.1-2013 section 5.5.2	ASHRAE 62.1							RATIONAL	Basic Necessity
6.3.1.1.v	General	All intakes shall contain features for draining away precipitation.	Rational	This requirement prevents potential corrosion of the AHU and a reservoir for pathogens being present. Cross reference ASHRAE 62.1-2013 section 5.5.3	ASHRAE 62.1							RATIONAL	Basic Necessity
6.3.1.1.vi	General	All intakes shall be shall be equipped with a bird screen of mesh no smaller than 0.5 in. (13 mm).	Rational	Birds and related debris (twigs, feces, etc.) need to be kept out of AHU's to prevent clogging and as a source of pathogens. Cross reference ASHRAE 62.1-2013 section 5.5.3	ASHRAE 62.1							RATIONAL	Basic Necessity
6.3.1.2.i	Relief Air	Relief air is exempt from the 25-foot (8-metre) separation requirement. Relief air is defined as the Class 1 air that could be returned to the air-handling unit from the occupied spaces but is being discharged to the outdoors to maintain building pressurization (such as during air-side economizer operation).	Rational/Evidence	Relief air quality is assumed equivalent of return air.	ASHRAE 62.1				1,2			MISC	Further Investigation
6.3.1.2.ii	Roof Locations	Intakes on top of buildings shall be located with the bottom of the air intake a minimum of 3 ft (1 m) above roof level.	Rational/Evidence	Air intakes above root level may prevent vermin and particles from entering the AHU. Depending on the location of the facility, snow accumulation may be a factor in the height of the intake. The distance above grade shall be validated separately.	International Mechanical Code				1,2			MISC	Further Investigation
6.3.1.3.i	Areaways	In the case of an areaway, the bottom of the air intake opening shall be at least 6 ft (2 m) above grade.	Rational/Evidence	Air intakes above grade may prevent vermin and ground level particles from entering the AHU. The distance above grade shall be validated separately.				not found				MISC	Further Investigation
6.3.1.3.ii	Areaways	The bottom of the air intake opening from the areaway into the building shall be at least 3 ft (1 m) above the bottom of the areaway.	Rational/Evidence	Air intakes above the bottom of the area well may prevent vermin, particles, and water from entering the AHU. Depending on the location of the facility, snow accumulation may be a factor in the height of the intake. The distance above the bottom of the intake shall be validated separately.				not found				MISC	Further Investigation

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
6.3.2	Exhaust Discharges	Exhaust discharge outlets that discharge air from AII rooms shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.1	Exhaust Discharges	Exhaust discharge outlets that discharge air from bronchoscopy rooms shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.2	Exhaust Discharges	Exhaust discharge outlets that discharge air from emergency department waiting rooms shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.3	Exhaust Discharges	Exhaust discharge outlets that discharge air from nuclear medicine laboratories shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.4	Exhaust Discharges	Exhaust discharge outlets that discharge air from radiology waiting rooms shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.5	Exhaust Discharges	Exhaust discharge outlets that discharge air from laboratory chemical fumehoods shall be designed so that all ductwork within the building (except for ductwork located within mechanical equipment rooms) is under negative pressure.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.								RATIONAL	Basic Necessity
6.3.2.6	Exception	Positive-pressure exhaust ductwork located within mechanical equipment rooms shall be sealed in accordance with SMACNA duct leakage Seal Class A.	Rational	Prevents air from leaking to surround spaces with potential pathogens or odors.	SMACNA							RATIONAL	Basic Necessity
6.3.2.7	Exhaust Discharges	Exhaust discharge outlets that discharge air from AII rooms shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.8	Exhaust Discharges	Exhaust discharge outlets that discharge air from bronchoscopy rooms shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.	Std 170 Adendum M			not found				MISC	Further Investigation
6.3.2.9	Exhaust Discharges	Exhaust discharge outlets that discharge air from emergency department waiting rooms shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.10	Exhaust Discharges	Exhaust discharge outlets that discharge air from nuclear medicine laboratories shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.11	Exhaust Discharges	Exhaust discharge outlets that discharge air from radiology waiting rooms shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.12	Exhaust Discharges	Exhaust discharge outlets that discharge air from laboratory chemical fumehoods shall discharge in a vertical direction at least 10 ft (3 m) above roof level.	Rational/Evidence	A distance above roof level ensures a level of dilution. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.13	Exhaust Discharges	Exhaust discharge outlets that discharge air from AII rooms shall be located not less than 10 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.14	Exhaust Discharges	Exhaust discharge outlets that discharge air from bronchoscopy rooms shall be located not less than 10 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.15	Exhaust Discharges	Exhaust discharge outlets that discharge air from emergency department waiting rooms shall be located not less than 10 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.16	Exhaust Discharges	Exhaust discharge outlets that discharge air from nuclear medicine laboratories shall be located not less than 10 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.17	Exhaust Discharges	Exhaust discharge outlets that discharge air from radiology waiting rooms shall be located not less than 1 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.18	Exhaust Discharges	Exhaust discharge outlets that discharge air from laboratory chemical fumehoods shall be located not less than 10 ft horizontally from air intakes, openable windows/doors, or areas that are normally accessible to the public or maintenance personnel and that are higher in elevation than the exhaust discharge.	Rational/Evidence	This requirement prevents reentrainment of contaminated exhaust. The distance shall be validated separately.				not found				MISC	Further Investigation
6.3.2.19	Exhaust Discharges	Exhaust discharge outlets that discharge air from AII rooms shall be located such that they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.3.2.20	Exhaust Discharges	Exhaust discharge outlets that discharge air from bronchoscopy rooms shall be located such that they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.3.2.21	Exhaust Discharges	Exhaust discharge outlets that discharge air from emergency department waiting rooms shall be located such that they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.3.2.22	Exhaust Discharges	Exhaust discharge outlets that discharge air from nuclear medicine laboratories shall be located such that they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.3.2.23	Exhaust Discharges	Exhaust discharge outlets that discharge air from radiology waiting rooms shall be located such that they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.3.2.24	Exhaust Discharges	Exhaust discharge outlets that discharge air from laboratory chemical fumehoods shall be located such th they minimize the recirculation of exhausted air back into the building.	Rational	This requirement reduces reentrainment of contaminated exhaust. This requirement is vague.								RATIONAL	Basic Necessity
6.4	Filtration	Filtration	Section Header									HEAD	
6.4.i	Filtration	Filter banks shall be provided in accordance with Table 6.4.	Rational	See comments in Table 6.4 section								RATIONAL	Basic Necessity
6.4.ii	Filtration	Each filter bank with an efficiency of greater than MERV 12 shall be provided with an installed manometer or differential pressure measuring device that is readily accessible and provides a reading of differential static pressure across the filter to indicate when the filter needs to be changed.	Rational	Supports maintenance staff to provide effective preventative maintenance to ensure filters aren't overloaded or replaced too frequently.	FGI (2010) CDC (2003)							RATIONAL	Enhanced Requirement
6.4.iii	Filtration	All of the air provided to a space shall be filtered in accordance with Table 6.4, except as otherwise indicated in Section 7.1 for spaces that allow recirculating HVAC room units.	Rational									RATIONAL	Basic Necessity
Table 6.4	Minimum Filter Efficiencies	Minimum Filter Efficiencies	Section Header									HEAD	
6.4.t.1	Minimum Filter Efficiencies	Filter Bank No. 1 at Operating rooms (Class B and C surgery) shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.	Coil fouling research. ASHRAE 52.2 research FGI has additional requirements on filters.							RATIONAL	Basic Necessity
6.4.t.2	Minimum Filter Efficiencies	Filter Bank No. 1 at Inpatient and ambulatory diagnostic and therapeutic radiology rooms shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.3	Minimum Filter Efficiencies	Filter Bank No. 1 at Inpatient delivery and recovery spaces shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.4	Minimum Filter Efficiencies	Filter Bank No. 2 at Operating rooms (Class B and C surgery) shall have a minimum filter efficiency of MERV 14	Clinical/Evidence						260, 243, 269	295, 296	136, 169, 249, 250, 251, 252, 253, 254, 257, 258, 259,262, 263, 264, 265, 291, 292, 293	Q8	Basic Necessity
6.4.t.5	Minimum Filter Efficiencies	Filter Bank No. 2 at Inpatient and ambulatory diagnostic and therapeutic radiology rooms shall have a minimum filter efficiency of MERV 14	Clinical/Evidence								255	Q8	Further Investigation
6.4.t.6	Minimum Filter Efficiencies	Filter Bank No. 2 at Inpatient delivery and recovery spaces shall have a minimum filter efficiency of MERV 14	Clinical/Evidence					not found				Q8	Further Investigation
6.4.t.7	Minimum Filter Efficiencies	Filter Bank No. 1 at Inpatient care, treatment, and diagnosis, and those spaces providing direct service or clean supplies and clean processing shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.8	Minimum Filter Efficiencies	Filter Bank No. 1 at AII (rooms) shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.9	Minimum Filter Efficiencies	Filter Bank No. 2 at Inpatient care, treatment, and diagnosis, and those spaces providing direct service or clean supplies and clean processing shall have a minimum filter efficiency of MERV 14	Clinical/Evidence					not found				Q8	Further Investigation
6.4.t.10	Minimum Filter Efficiencies	Filter Bank No. 2 at AII (rooms) shall have a minimum filter efficiency of MERV 14	Clinical/Evidence						270, 271,272, 273, 274, 275, 276			Q8	Basic Necessity
6.4.t.11	Minimum Filter Efficiencies	Filter Bank No. 1 at Protective environment (PE) rooms shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.12	Minimum Filter Efficiencies	Filter Bank No. 2 at Protective environment (PE) rooms shall use HEPA filters	Clinical/Evidence						65, 256, 257		266, 267, 268	Q8	Basic Necessity
6.4.t.13	Notes	As an alternative, MERV-14 rated filters may be used in filter Bank No. 2 if a tertiary terminal HEPA filter is provided for protective environment (PE) rooms.	Clinical/Evidence						65, 256, 257		266, 267, 268	Q8	Enhanced Requirement
6.4.t.14	Minimum Filter Efficiencies	Filter Bank No. 1 at Laboratories shall have a minimum filter efficiency of MERV 13	Clinical/Evidence					not found				Q8	Enhanced Requirement
6.4.t.15	Minimum Filter Efficiencies	Filter Bank No. 1 at Procedure rooms (Class A surgery), and associated semi-restricted spaces shall have a minimum filter efficiency of MERV 13	Clinical/Evidence						243, 260, 269	295, 296	136, 169, 249, 250, 251, 252, 253, 254, 257, 258, 259,262, 263, 264, 265, 291, 292, 293	Q8	Basic Necessity
6.4.t.16	Minimum Filter Efficiencies	Filter Bank No. 1 at Administrative rooms shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
6.4.t.17	Minimum Filter Efficiencies	Filter Bank No. 1 at Bulk storage spaces shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.18	Minimum Filter Efficiencies	Filter Bank No. 1 at Soiled holding spaces shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.19	Minimum Filter Efficiencies	Filter Bank No. 1 at Food preparation spaces shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.20	Minimum Filter Efficiencies	Filter Bank No. 1 at Laundries shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.21	Minimum Filter Efficiencies	Filter Bank No. 1 at All other outpatient spaces shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.22	Minimum Filter Efficiencies	Filter Bank No. 1 at Nursing facilities shall have a minimum filter efficiency of MERV 13	Clinical/Evidence					not found				Q8	Enhanced Requirement
6.4.t.23	Minimum Filter Efficiencies	Filter Bank No. 1 at Psychiatric hospitals shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.t.24	Minimum Filter Efficiencies	Filter Bank No. 1 at Resident care, treatment, and support areas in inpatient hospice facilities shall have a minimum filter efficiency of MERV 13	Clinical/Evidence					not found				Q8	Enhanced Requirement
6.4.t.25	Minimum Filter Efficiencies	Filter Bank No. 1 at Resident care, treatment, and support areas in assisted living facilities shall have a minimum filter efficiency of MERV 7	Rational	A prefilter is a means to keep heating and cooling coils clean and providing proper thermal comfort.								RATIONAL	Basic Necessity
6.4.t.26	Minimum Filter Efficiencies	Filter Bank No. 2 at Laboratories do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.27	Minimum Filter Efficiencies	Filter Bank No. 2 at Procedure rooms (Class A surgery), and associated semi-restricted spaces do not have a requirement for minimum filter efficiency.	Clinical/Evidence						243, 260, 269	295, 296	136, 169, 249, 250, 251, 252, 253, 254, 257, 258, 259,262, 263, 264, 265, 291, 292, 293	Q8	Further Investigation
6.4.t.28	Minimum Filter Efficiencies	Filter Bank No. 2 at Administrative rooms do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.29	Minimum Filter Efficiencies	Filter Bank No. 2 at Bulk storage spaces do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.30	Minimum Filter Efficiencies	Filter Bank No. 2 at Soiled holding spaces do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.31	Minimum Filter Efficiencies	Filter Bank No. 2 at Food preparation spaces do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.32	Minimum Filter Efficiencies	Filter Bank No. 2 at Laundries do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.33	Minimum Filter Efficiencies	Filter Bank No. 2 at All other outpatient spaces do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.34	Minimum Filter Efficiencies	Filter Bank No. 2 at Nursing facilities do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.35	Minimum Filter Efficiencies	Filter Bank No. 2 at Psychiatric hospitals do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.36	Minimum Filter Efficiencies	Filter Bank No. 2 at Resident care, treatment, and support areas in inpatient hospice facilities do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
6.4.t.37	Minimum Filter Efficiencies	Filter Bank No. 2 at Resident care, treatment, and support areas in assisted living facilities do not have a requirement for minimum filter efficiency.	Clinical/Evidence					not found				Q8	Basic Necessity
b	Notes	Additional prefilters may be used to reduce maintenance for filters with efficiencies higher than MERV 7.	Rational	A prefilter is a means to reduce loading on higher efficiency filters that are more costly as some of the contaminants will be picked up by the prefilter.								RATIONAL	Basic Necessity
6.4.1	First Filter Bank	Filter Bank No. 1 shall be placed upstream of the heating and cooling coils such that all mixed air is filtered.	Rational	A prefilter is a means to keep heating and cooling coils clean and functioning properly.								RATIONAL	Basic Necessity
6.4.2.i	Second Filter Bank	Filter Bank No. 2 shall be installed downstream of all wet-air cooling coils and the supply fan.	Clinical/Evidence					not found				Q8	Further Investigation
6.4.2.ii	Second Filter Bank	All second filter banks shall have sealing interface surfaces.	Rational	This prevents leakage and ensures effectiveness of filtration.								RATIONAL	Basic Necessity
6.4.3.i	Filter Bank Blank-Off Panels	Filter bank blank-off panels shall be permanently attached to the filter bank frame constructed of rigid materials.	Rational	Ensures that air flow moves through filters								RATIONAL	Basic Necessity
6.4.3.ii	Filter Bank Blank-Off Panels	Filter bank blank-off panels shall have sealing surfaces equal to or greater than the filter media installed within the filter bank frame.	Rational	Ensures that air flow moves through filters This prevents leakage and ensures effectiveness of filtration.								RATIONAL	Basic Necessity
6.4.4.i	Filter Frames	Filter frames shall be durable and proportioned to provide an airtight fit with the enclosing ductwork.	Rational	This requirement ensures that there is minima unfiltered air leakage.								RATIONAL	Basic Necessity
6.4.4.ii	Filter Frames	All joints between filter segments and enclosing ductwork shall have gaskets or seals to provide a positive seal against air leakage.	Rational									RATIONAL	Basic Necessity
6.5	Heating and Cooling Systems	Heating and Cooling Systems	Section Header									HEAD	
6.5.1	Cooling Coils and Drain Pans	Cooling coils and drain pans shall comply with the requirements of ANSI/ASHRAE Standard 62.1.	Rational	Requirements of ASHRAE 62.1-2013 section 5.10 are rational.	ASHRAE 62.1							RATIONAL	Basic Necessity
6.5.2	Radiant Cooling Systems	If radiant cooling panels are utilized, the chilled-water temperature shall always remain above the dew-point temperature of the space.	Rational	Prevents condensation, which may cause water damage and potential falls.								RATIONAL	Basic Necessity
6.5.3.i	Radiant Heating Systems	If radiant heating is provided for an AII room, either flat and smooth radiant ceiling or wall panels with exposed cleanable surfaces or radiant floor heating shall be used.	Rational	Simplifies the cleaning procedure for cleaning staff.								RATIONAL	Basic Necessity
6.5.3.ii	Radiant Heating Systems	If radiant heating is provided for a protective environment room, either flat and smooth radiant ceiling or wall panels with exposed cleanable surfaces or radiant floor heating shall be used.	Rational	Simplifies the cleaning procedure for cleaning staff.								RATIONAL	Basic Necessity
6.5.3.iii	Radiant Heating Systems	If radiant heating is provided for a wound intensive-care unit (burn unit), either flat and smooth radiant ceiling or wall panels with exposed cleanable surfaces or radiant floor heating shall be used.	Rational	Simplifies the cleaning procedure for cleaning staff.								RATIONAL	Basic Necessity
6.5.3.iv	Radiant Heating Systems	If radiant heating is provided for an operating room, either flat and smooth radiant ceiling or wall panels with exposed cleanable surfaces or radiant floor heating shall be used.	Rational	Simplifies the cleaning procedure for cleaning staff.								RATIONAL	Basic Necessity
6.5.3.v	Radiant Heating Systems	If radiant heating is provided for a procedure room (for any class of surgery), either flat and smooth radiant ceiling or wall panels with exposed cleanable surfaces or radiant floor heating shall be used.	Rational	Simplifies the cleaning procedure for cleaning staff.								RATIONAL	Basic Necessity
6.5.3.vi	Radiant Heating Systems	Gravity-type heating or cooling units, such as radiators or convectors, shall not be used in operating rooms and other special-care areas.	Rational/Clinical/Evidence	Potential reservoir for pathogens as it's more difficult to clean. Evidence needed.				not found				MISC	Further Investigation
6.5.4.i	Cooling Towers	Cooling towers shall be located so that drift is directed away from air-handling unit intakes.	Rational	Cooling towers are known to contain pathogens such as legionella. Situations where wind blows in multiple directions may prove challenging. The effectiveness of drift eliminators shall be documented.								RATIONAL	Change
6.5.4.ii	Cooling Towers	Cooling towers shall meet requirements of Section 6.3.2.	Evidence	Validate that separation distances are sufficient for cooling towers.	ASHRAE 170			not found				MISC	Basic Necessity
6.6	Humidifiers	Humidifiers	Section Header									HEAD	
6.6.i	Humidifiers	When outdoor humidity and internal moisture sources are not sufficient to meet the requirements of Table 7.1, humidification shall be provided by means of the health-care facility air-handling systems.	Rational/Clinical/Evidence	Humidification may support thermal comfort. Additional clinical requirements shall supersede humidification needs.				not found				NO	Basic Necessity
6.6.ii	Humidifiers	Locate humidifiers within air-handling units or ductwork to avoid moisture accumulation in downstream components, including filters and insulation.	Rational	Filters that get wet may degrade.								RATIONAL	Basic Necessity
6.6.iii	Humidifiers	Steam humidifiers shall be used.	Rational	This is inconsistent with the requirements of ASHRAE 62.1-2013 section 5.12	Addendum M not published yet.							RATIONAL	Change
6.6.iv	Humidifiers	Chemical additives used for steam humidifiers serving health care facilities shall comply with FDA requirements.	Clinical/Evidence	Chemical treatment for steam systems prevents corrosion and clogging of tubes. The chemicals may be introduced into the air stream through humidification. The FDA document cross referenced does not specifically call out steam in air. Additional support needed.	FDA			not found				NO	Further Investigation
6.6.v	Humidifiers	A humidity sensor shall be provided, located at a suitable distance downstream from the steam injection source.	Rational	This is required to ensure control of desired humidity level. The distance downstream from the humidifiers is vague, but implies a desire for a well mixed uniform flow.								RATIONAL	Basic Necessity
6.6.vi	Humidifiers	Controls shall be provided to limit duct humidity to a maximum value of 90% RH when the humidifier is operating.	Rational	Too high moisture may cause condensation and damage to ductwork, filters, etc.	85% from manufacturer. Specify location (AHU or duct)							RATIONAL	Basic Necessity
6.6.vii	Humidifiers	Humidifier steam control valves shall be designed so that they remain off whenever the air-handling unit is not in operation.	Rational	This prevents waste of steam and energy as well as risk of damaging the AHU.								RATIONAL	Basic Necessity
6.6.viii	Humidifiers	Duct takeoffs shall not be located within the humidifier's absorption distance.	Rational	This requirement ensures desired humidity levels are achieved.								RATIONAL	Basic Necessity
6.7	Air Distribution	Air Distribution	Section Header									HEAD	
6.7.1.i	General	Maintain the pressure relationships required in Table 7.1 in all modes of HVAC system operation, except as noted in the table.	Rational									RATIONAL	Basic Necessity
6.7.1.ii	General	Spaces listed in Table 7.1 that have required pressure relationships shall be served by fully ducted return systems or fully ducted exhaust systems.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.	Plenum return for clinics with procedure room							RATIONAL	Basic Necessity
6.7.1.iii	General	Recovery rooms shall be served by fully ducted return or exhaust systems.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.								RATIONAL	Basic Necessity

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
6.7.1.iv	General	Critical- and intensive-care areas shall be served by fully ducted return or exhaust systems.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.								RATIONAL	Basic Necessity
6.7.1.v	General	Intermediate-care areas shall be served by fully ducted return or exhaust systems.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.								RATIONAL	Basic Necessity
6.7.1.vi	General	Wound intensive-care units (burn units) shall be served by fully ducted return or exhaust systems.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.								RATIONAL	Basic Necessity
6.7.1.vii	General	In inpatient facilities, patient-care areas shall utilize ducted systems for return and exhaust air.	Rational	This requirement is in place to achieve controllability of the pressure relationships in specified rooms.								RATIONAL	Basic Necessity
6.7.1.viii	General	Where space pressure relationships are required, the air distribution system design shall maintain them, taking into account recommended maximum filter loading, heating-season lower airflow operation, and cooling-season higher airflow operation.	Rational	Design guidance for engineer								RATIONAL	Basic Necessity
6.7.1.ix	General	Airstream surfaces of the air distribution system downstream of Filter Bank No. 2, shall comply with Section 5.4 of ANSI/ASHRAE Standard 62.1.	Rational	The identified section of ASHRAE 62.1-2013 supports the long term effective operation of AHUs.	ASHRAE 62.1							RATIONAL	Basic Necessity
6.7.1.x	General	The air distribution system shall be provided with access doors, panels, or other means to allow convenient access for inspection and cleaning.	Rational	Access for maintenance and cleaning								RATIONAL	Basic Necessity
6.7.2.i	Air Distribution Devices	Surfaces of air distribution devices shall be suitable for cleaning.	Rational	Air distribution devices may experience lint build up and will require periodic cleaning.								RATIONAL	Basic Necessity
6.7.2.ii	Air Distribution Devices	Supply air outlets in accordance with Table 6.7.2 shall be used.	Evidence		Handbook of Fundamentals			not found				NO	Further Investigation
6.7.2.ii	Air Distribution Devices	The supply diffusers in operating rooms (Classes B and C surgeries) shall be designed and installed to allow for internal cleaning.	Rational	Air distribution devices may experience lint build up and will require periodic cleaning.								RATIONAL	Basic Necessity
6.7.2.iv	Air Distribution Devices	Psychiatric, seclusion, and holding-patient rooms shall be designed with security diffusers, grilles, and registers.	Clinical	This requirement is for patient safety.								CLINIC	Basic Necessity
6.7.3	Smoke Barriers	Where smoke barriers are required, heating, ventilating, and air-conditioning zones shall be coordinated with compartmentation to minimize ductwork penetrations of fire and smoke barriers.	Rational	Vague requirement to enhance life safety.								RATIONAL	Basic Necessity
6.7.4.i	Smoke and fire Dampers	Maintenance access shall be provided at all dampers.	Rational	Dampers may wear out and get stuck over time. Maintenance access is required to ensure operability.								RATIONAL	Basic Necessity
6.7.4.ii	Smoke and fire Dampers	All damper locations shall be shown on design drawings.	Rational	This is required for code reviewers and owners to ensure proper placement prior to installation.								RATIONAL	Basic Necessity
6.7.4.iii	Smoke and fire Dampers	Air-handling systems shall be arranged such that damper activation will not damage ducts.	Rational	Upon closing of fire dampers the fan will continue to increase pressure. Either design duct to a pressure class to support this pressure or add a pressure sensor that shuts down the fan.								RATIONAL	Basic Necessity
6.7.5.i	Duct Penetrations	Ducts that penetrate construction intended to protect against x-ray, magnetic, radio frequency interference (RFI), or other radiation shall not impair the effectiveness of the protection.	Rational	Life safety requirement								RATIONAL	Basic Necessity
6.7.5.ii	Duct Penetrations	Treatment of the penetrations shall not impair the ventilation of the space served.	Rational	Ensures ventilation effectiveness								RATIONAL	Basic Necessity
6.7.2.1	Supply Air Outlets	The supply air outlet classifications are Primary supply diffusers Group E, nonaspirating additional supply diffusers, Group E for Operating rooms, procedure rooms (all class A, B, and C surgeries)	Evidence	Goal is to prevent mixing of contaminants in space. Move contaminants to ground. Effectiveness needs to be supported by evidence.	2013 ASHRAE Handbook—Fundamentals, Chapter 20 (see ASHRAE [2013b] in Informative Appendix B).				64, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75	79, 80, 81, 82, 83, 84	61, 62, 63, 76, 77, 78, 85, 86, 87, 88	Q2	Further Investigation
6.7.2.2	Supply Air Outlets	The supply air outlet classifications are Group E, nonaspirating for Protective environment (PE) rooms	Evidence						135, 136		137	Q2	Further Investigation
6.7.2.3	Supply Air Outlets	The supply air outlet classifications are Group E, nonaspirating for Wound intensive-care units (bum units)	Evidence								89	Q2	Further Investigation
6.7.2.4	Supply Air Outlets	The supply air outlet classifications are Group E, nonaspirating for Trauma rooms (crisis or shock)	Evidence					not found				Q2	Further Investigation
6.7.2.5	Supply Air Outlets	The supply air outlet classifications are Group A or Group E for AII rooms	Evidence						22, 113, 114, 115, 116, 117, 118		110, 98	Q2	Basic Necessity
6.7.2.6	Supply Air Outlets	The supply air outlet classifications are Group A, Group D, or Group E for Single-bed patient rooms	Evidence						23, 26, 27, 28, 29, 30, 31	33, 34, 35	32, 37, 38, 39, 40, 41, 42, 43, 44, 45	Q2	Further Investigation
6.7.2.7	Supply Air Outlets	The supply air outlet classifications are Group A or Group E for All other patient-care spaces	Evidence					not found				Q2	Further Investigation
6.7.2.8	Supply Air Outlets	The supply air outlet classifications are not required for All other spaces	Evidence					not required				Q2	Further Investigation
b	Notes	Surgeons may require alternate air distribution systems for some specialized surgeries. Such systems shall be considered acceptable if they meet or exceed the requirements of this standard.	Evidence					not found				NO	Enhanced Requirement
c.i	Notes	For air distribution systems using Group D diffusers, the system shall be designed according to "Design Guidelines" in Chapter 7 of ASHRAE System Performance Evaluation and Design.Guidelines for Displacement Ventilation.	Evidence					not found				Q2	Basic Necessity
c.ii	Notes	For air distribution systems using Group D diffusers, the supply diffuser shall be located where it cannot be permanently blocked (e.g., opposite the foot of the bed.)	Rational	Blocking the diffuser will prevent proper distribution of ventilation and heating/cooling air.								RATIONAL	Basic Necessity
c.iii	Notes	For air distribution systems using Group D diffusers, the room return/exhaust grille shall be located in the ceiling, approximately above the head of the patient bed.	Evidence							33, 34, 35		Q2	Basic Necessity
c.iv	Notes	For air distribution systems using Group D diffusers, the transfer grille to the toilet room shall be located above the occupied zone.	Evidence					not found				Q2	Further Investigation
6.8	**Energy Recovery Systems**	**Energy Recovery Systems**	Section Header									HEAD	
6.8.i	General	Energy recovery systems shall be located upstream of Filter Bank No. 2.	Evidence					not found				MISC	Basic Necessity
6.8.ii	General	If energy recovery systems are utilized, the systems shall not allow for any amount of cross-contamination of exhaust air back to the supply airstream via purge, leakage, carryover, or transfer except as allowed in Section 6.8.3.	Rational/Evidence	A potential for odors and pathogen transfer exists in wheel type heat recovery systems. Fans can be arranged to prevent cross contamination into the supply air stream.				not found				NO	Basic Necessity
6.8.2	Airborne Infectious Isolation Room Exhaust	Airborne infectious isolation room exhaust systems serving AII rooms or combination AII/PE rooms shall not be utilized for energy recovery.	Evidence					not found				Q7	Further Investigation
Exception		Airborne infectious isolation room exhaust systems serving AII rooms or combination AII/PE rooms may be served by an energy recovery system where the supply airstream components and the exhaust airstream components are fully separated by an air gap of adequate distance to prevent cross contamination that is open to the atmosphere (e.g., run-around pumped coils	Evidence						239, 240	49, 237, 236		Q7	Further Investigation
6.8.3	Energy Recovery with Leakage Potential	If energy recovery systems with leakage potential are utilized, they shall be arranged to minimize the potential to transfer exhaust air directly back into the supply airstream.	Evidence					not found				ER	Further Investigation
6.8.3.1	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall be designed to have no more than 5% of the total supply airstream consisting of exhaust air.	Evidence					not found				ER	Further Investigation
6.8.3.2	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of ER waiting rooms	Evidence					not found				ER	Further Investigation
6.8.3.3	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of triage	Evidence					not found				ER	Further Investigation
6.8.3.4	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of ER decontamination	Evidence					not found				ER	Further Investigation
6.8.3.5	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of radiology waiting rooms	Evidence					not found				ER	Further Investigation
6.8.3.6	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of darkroom	Evidence					not found				ER	Further Investigation
6.8.3.7	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of bronchoscopy sputum collection and pentamidine administration	Evidence					not found				ER	Further Investigation
6.8.3.8	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of laboratory fume hood	Evidence					not found				ER	Further Investigation
6.8.3.9	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of directly ducted laboratory equipment exhaust	Evidence					not found				ER	Further Investigation
6.8.3.10	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of waste anesthesia gas disposal	Evidence					not found				ER	Further Investigation
6.8.3.11	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of autopsy	Evidence					not found				ER	Further Investigation
6.8.3.12	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of nonrefrigerated body holding	Evidence					not found				ER	Further Investigation
6.8.3.13	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of endoscope cleaning	Evidence					not found				ER	Further Investigation
6.8.3.14	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of central medical and surgical supply soiled or decontamination room	Evidence					not found				ER	Further Investigation
6.8.3.15	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of laundry general	Evidence					not found				ER	Further Investigation

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
6.8.3.16	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of hazardous material storage	Evidence					not found				ER	Further Investigation
6.8.3.17	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of dialyzer reprocessing room	Evidence					not found				ER	Further Investigation
6.8.3.18	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of nuclear medicine hot lab	Evidence					not found				ER	Further Investigation
6.8.3.19	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of nuclear medicine treatment room	Evidence					not found				ER	Further Investigation
6.8.3.20	Energy Recovery with Leakage Potential	Energy recovery systems with leakage potential shall not be utilized from the exhaust airstream of any other space identified by the authority having jurisdiction or the ICRA team	Evidence					not found				ER	Further Investigation
6.9	Insulation and Duct Lining	Insulation and Duct Lining	Section Header									HEAD	
6.9.a.ii	Insulation and Duct Lining	An exterior vapor barrier shall be provided for insulation on cold surfaces.	Rational	Mitigates mold growth inside walls.								RATIONAL	Basic Necessity
6.9.a.i	Insulation and Duct Lining	A vapor barrier is not required for insulation materials that do not absorb or transmit moisture.	Rational	Certain insulation types also act as a vapor barrier								RATIONAL	Basic Necessity
6.9.b	Insulation and Duct Lining	Existing insulation and duct lining accessible during a renovation project shall be inspected, repaired, and/or replaced as appropriate.	Rational	Degraded insulation and lining may enter the air stream.								RATIONAL	Basic Necessity
6.9.c.i	Insulation and Duct Lining	Duct lining shall not be used in ductwork located downstream of Filter Bank No. 2.	Rational	The lining may degrade over time and enter the air stream.								RATIONAL	Basic Necessity
6.9.c.ii	Insulation and Duct Lining	Duct lining with an impervious cover may be allowed in terminal units, sound attenuators, and air distribution devices downstream of Filter Bank No.2.	Rational	These components typically arrive from the factory lined, and would be challenging to wrap on site.								RATIONAL	Basic Necessity
6.9.c.iii	Insulation and Duct Lining	This lining and cover shall be factory installed.	Rational	These components typically arrive from the factory lined, and would be challenging to wrap on site.								RATIONAL	Basic Necessity
6.9.d	Insulation and Duct Lining	Duct lining shall not be installed within 15 ft (4.57 m) downstream of humidifiers.	Rational	Moisture may build up on the duct lining causing it to degrade or allow mold growth.								RATIONAL	Basic Necessity
7	Space Ventilation	Space Ventilation	Section Header									HEAD	
7.i	Space Ventilation	The ventilation requirements of this standard are minimums that provide control of environmental comfort, asepsis, and odor in health care facilities.	Rational/Clinical/Evidence					not required				NO	Further Investigation
7.ii	Space Ventilation	Because they are minimum requirements and because of the diversity of the population and variations in susceptibility and sensitivity, these requirements do not provide assured protection from discomfort, airborne transmission of contagions, and odors.	Rational									RATIONAL	Basic Necessity
Table 7.1.	Design Parameters	Design Parameters	Section Header									HEAD	
1	Design Parameters	The pressure relationship of Operating room (Class B and C) to adjacent areas is Positive.	Clinical/Evidence						53, 148, 162, 163, 167, 168, 180,		164, 165, 166, 168, 170, 171, 177, 178, 181	Q3	Basic Necessity
1	Design Parameters	The pressure relationship of Operating/surgical cystoscopic rooms to adjacent areas is Positive.	Clinical/Evidence						53, 148, 162, 163, 167, 168, 180,		164, 165, 166, 168, 170, 171, 177, 178, 181	Q3	Basic Necessity
1	Design Parameters	The pressure relationship of Delivery room (Caesarean) to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
1	Design Parameters	The pressure relationship of Substerile service area to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-1	Design Parameters	The pressure relationship of Recovery room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-2	Design Parameters	The pressure relationship of Critical and intensive care to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-3	Design Parameters	The pressure relationship of Intermediate care to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-4	Design Parameters	The pressure relationship of Wound intensive care (burn unit) to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-5	Design Parameters	The pressure relationship of Newborn intensive care to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-6	Design Parameters	The pressure relationship of Treatment room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-7	Design Parameters	The pressure relationship of Trauma room (crisis or shock) to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-8	Design Parameters	The pressure relationship of Medical/anesthesia gas storage to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-9	Design Parameters	The pressure relationship of Laser eye room to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-10	Design Parameters	The pressure relationship of ER waiting rooms to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-11	Design Parameters	The pressure relationship of Triage to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-12	Design Parameters	The pressure relationship of ER decontamination to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-13	Design Parameters	The pressure relationship of Radiology waiting rooms to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-14	Design Parameters	The pressure relationship of Procedure room (Class A surgery) to adjacent areas is Positive.	Clinical/Evidence						53, 148, 162, 163, 167, 168, 180,		164, 165, 166, 168, 170, 171, 177, 178, 181	Q3	Basic Necessity
7.i-15	Design Parameters	The pressure relationship of Emergency department exam/treatment room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-16	Design Parameters	The pressure relationship of Patient room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-17	Design Parameters	The pressure relationship of Nourishment area or room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-18	Design Parameters	The pressure relationship of Toilet room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Basic Necessity
7.i-19	Design Parameters	The pressure relationship of Newborn nursery suite to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-20	Design Parameters	The pressure relationship of Protective environment room to adjacent areas is Positive.	Clinical/Evidence						136			Q3	Basic Necessity
7.i-21	Design Parameters	The pressure relationship of AII room to adjacent areas is Negative.	Clinical/Evidence						112, 150, 151, 152, 153, 154, 155, 156, 157, 158, 160,179, 182, 183, 184		159, 161, 164, 165, 166, 169, 170, 171	Q3	Basic Necessity
7.i-22	Design Parameters	The pressure relationship of Combination AII/PE room to adjacent areas is Positive.	Clinical/Evidence						136			Q3	Basic Necessity
7.i-23	Design Parameters	The pressure relationship of AII anteroom to adjacent areas is stated in Section 7.2 and its subsections.	Clinical/Evidence								134, 148, 149, 169, 179	Q4	Further Investigation
7.i-24	Design Parameters	The pressure relationship of PE anteroom to adjacent areas is stated in Section 7.2 and its subsections.	Clinical/Evidence								134, 148, 149, 169, 179	Q4	Further Investigation
7.i-25	Design Parameters	The pressure relationship of Combination A1I/PE anteroom to adjacent areas is stated in Section 7.2 and its subsections.	Clinical/Evidence								134, 148, 149, 169, 179	Q4	Further Investigation
7.i-26	Design Parameters	The pressure relationship of Labor/delivery/recovery/postpartum (LDRP) to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-27	Design Parameters	The pressure relationship of Labor/delivery/recovery (LDR) to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-28	Design Parameters	The pressure relationship of Patient Corridor to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-29	Design Parameters	The pressure relationship of Resident room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-30	Design Parameters	The pressure relationship of Resident gathering/activity/dining to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-31	Design Parameters	The pressure relationship of Resident unit corridor to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-32	Design Parameters	The pressure relationship of Physical therapy to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-33	Design Parameters	The pressure relationship of Occupational therapy to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-34	Design Parameters	The pressure relationship of Bathing room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-35	Design Parameters	The pressure relationship of X-ray (diagnostic and treatment) to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-36	Design Parameters	The pressure relationship of X-ray (surgery/critical care and catheterization) to adjacent areas is Positive.	Clinical/Evidence								148	Q3	Further Investigation
7.i-37	Design Parameters	The pressure relationship of Darkroom to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-38	Design Parameters	The pressure relationship of Bronchoscopy, sputum collection, and pentamidine administration to adjacent areas is Negative.	Clinical/Evidence						176			Q3	Basic Necessity
7.i-39	Design Parameters	The pressure relationship of Laboratory, general to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-40	Design Parameters	The pressure relationship of Laboratory, bacteriology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-41	Design Parameters	The pressure relationship of Laboratory, biochemistry to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-42	Design Parameters	The pressure relationship of Laboratory, cytology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-43	Design Parameters	The pressure relationship of Laboratory, glasswashing to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-44	Design Parameters	The pressure relationship of Laboratory, histology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-45	Design Parameters	The pressure relationship of Laboratory, microbiology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-46	Design Parameters	The pressure relationship of Laboratory, nuclear medicine to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-47	Design Parameters	The pressure relationship of Laboratory, pathology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-48	Design Parameters	The pressure relationship of Laboratory, serology to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-49	Design Parameters	The pressure relationship of Laboratory, sterilizing to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-50	Design Parameters	The pressure relationship of Laboratory, media transfer to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-51	Design Parameters	The pressure relationship of Nonrefrigerated body-holding room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Basic Necessity
7.i-52	Design Parameters	The pressure relationship of Autopsy room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Basic Necessity
7.i-53	Design Parameters	The pressure relationship of Pharmacy to adjacent areas is Positive.	Clinical/Evidence								141	Q3	Further Investigation
7.i-54	Design Parameters	The pressure relationship of Examination room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-55	Design Parameters	The pressure relationship of Medication room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-56	Design Parameters	The pressure relationship of Gastrointestinal endoscopy procedure room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-57	Design Parameters	The pressure relationship of Endoscope cleaning to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-58	Design Parameters	The pressure relationship of Treatment room to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-59	Design Parameters	The pressure relationship of Hydrotherapy to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-60	Design Parameters	The pressure relationship of Physical therapy to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
7.i-61	Design Parameters	The pressure relationship of Sterilizer equipment room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-62	Design Parameters	The pressure relationship of Soiled or decontamination room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-63	Design Parameters	The pressure relationship of Clean workroom to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-64	Design Parameters	The pressure relationship of Sterile storage to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-65	Design Parameters	The pressure relationship of Food preparation center to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-66	Design Parameters	The pressure relationship of Ware washing to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-67	Design Parameters	The pressure relationship of Dietary storage to adjacent areas is not required.	Clinical/Evidence					not required				Q3	Further Investigation
7.i-68	Design Parameters	The pressure relationship of Laundry, general to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-69	Design Parameters	The pressure relationship of Soiled linen sorting and storage to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-70	Design Parameters	The pressure relationship of Clean linen storage to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-71	Design Parameters	The pressure relationship of Linen and trash chute room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-72	Design Parameters	The pressure relationship of Bedpan room to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-73	Design Parameters	The pressure relationship of Bathroom to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-74	Design Parameters	The pressure relationship of Janitor's closet to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-75	Design Parameters	The pressure relationship of Soiled workroom or soiled holding to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-76	Design Parameters	The pressure relationship of Clean workroom or clean holding to adjacent areas is Positive.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-77	Design Parameters	The pressure relationship of Hazardous material storage to adjacent areas is Negative.	Clinical/Evidence					not found				Q3	Further Investigation
7.i-78	Design Parameters	The minimum outdoor ach of Operating room (Class B and C) is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-79	Design Parameters	The minimum outdoor ach of Operating/surgical cystoscopic rooms is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-80	Design Parameters	The minimum outdoor ach of Delivery room (Caesarean) is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-81	Design Parameters	The minimum outdoor ach of Substerile service area is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-82	Design Parameters	The minimum outdoor ach of Recovery room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-83	Design Parameters	The minimum outdoor ach of Critical and intensive care is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-84	Design Parameters	The minimum outdoor ach of Intermediate care is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-85	Design Parameters	The minimum outdoor ach of Wound intensive care (bum unit) is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-86	Design Parameters	The minimum outdoor ach of Newborn intensive care is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-87	Design Parameters	The minimum outdoor ach of Treatment room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-88	Design Parameters	The minimum outdoor ach of Trauma room (crisis or shock) is 3.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-89	Design Parameters	The minimum outdoor ach of Medical/anesthesia gas storage is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-90	Design Parameters	The minimum outdoor ach of Laser eye room is 3.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-91	Design Parameters	The minimum outdoor ach of ER waiting rooms is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-92	Design Parameters	The minimum outdoor ach of Triage is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-93	Design Parameters	The minimum outdoor ach of ER decontamination is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-94	Design Parameters	The minimum outdoor ach of Radiology waiting rooms is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-95	Design Parameters	The minimum outdoor ach of Procedure room (Class A surgery) is 3.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-96	Design Parameters	The minimum outdoor ach of Emergency department exanVtreatment room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-97	Design Parameters	The minimum outdoor ach of Patient room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-98	Design Parameters	The minimum outdoor ach of Nourishment area or room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-99	Design Parameters	The minimum outdoor ach of Toilet room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-100	Design Parameters	The minimum outdoor ach of Newborn nursery suite is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-101	Design Parameters	The minimum outdoor ach of Protective environment room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-102	Design Parameters	The minimum outdoor ach of AII room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-103	Design Parameters	The minimum outdoor ach of Combination AII/PE room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-104	Design Parameters	The minimum outdoor ach of All anteroom is not required.	Clinical/Evidence					not required				Q4	Further Investigation
7.i-105	Design Parameters	The minimum outdoor ach of PE anteroom is not required.	Clinical/Evidence					not required				Q4	Further Investigation
7.i-106	Design Parameters	The minimum outdoor ach of Combination AII/PE anteroom is not required.	Clinical/Evidence					not required				Q4	Further Investigation
7.i-107	Design Parameters	The minimum outdoor ach of Labor/delivery/recovery/postpartum (LDRP) is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-108	Design Parameters	The minimum outdoor ach of Labor/delivery/recovery (LDR) is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-109	Design Parameters	The minimum outdoor ach of Patient Corridor is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-110	Design Parameters	The minimum outdoor ach of Resident room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-111	Design Parameters	The minimum outdoor ach of Resident gathering/activity/dining is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-112	Design Parameters	The minimum outdoor ach of Resident unit corridor is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-113	Design Parameters	The minimum outdoor ach of Physical therapy is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-114	Design Parameters	The minimum outdoor ach of Occupational therapy is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-115	Design Parameters	The minimum outdoor ach of Bathing room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-116	Design Parameters	The minimum outdoor ach of X-ray (diagnostic and treatment) is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-117	Design Parameters	The minimum outdoor ach of X-ray (surgery/critical care and catheterization) is 3.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-118	Design Parameters	The minimum outdoor ach of Darkroom is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-119	Design Parameters	The minimum outdoor ach of Bronchoscopy, sputum collection, and pentamidine administration is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-120	Design Parameters	The minimum outdoor ach of Laboratory, general is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-121	Design Parameters	The minimum outdoor ach of Laboratory, bacteriology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-122	Design Parameters	The minimum outdoor ach of Laboratory, biochemistry is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-123	Design Parameters	The minimum outdoor ach of Laboratory, cytology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-124	Design Parameters	The minimum outdoor ach of Laboratory, glasswashing is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-125	Design Parameters	The minimum outdoor ach of Laboratory, histology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-126	Design Parameters	The minimum outdoor ach of Laboratory, microbiology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-127	Design Parameters	The minimum outdoor ach of Laboratory, nuclear medicine is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-128	Design Parameters	The minimum outdoor ach of Laboratory, pathology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-129	Design Parameters	The minimum outdoor ach of Laboratory, serology is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-130	Design Parameters	The minimum outdoor ach of Laboratory, sterilizing is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-131	Design Parameters	The minimum outdoor ach of Laboratory, media transfer is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-132	Design Parameters	The minimum outdoor ach of Nonrefrigerated body-holding room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-133	Design Parameters	The minimum outdoor ach of Autopsy room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-134	Design Parameters	The minimum outdoor ach of Pharmacy is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-135	Design Parameters	The minimum outdoor ach of Examination room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-136	Design Parameters	The minimum outdoor ach of Medication room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-137	Design Parameters	The minimum outdoor ach of Gastrointestinal endoscopy procedure room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-138	Design Parameters	The minimum outdoor ach of Endoscope cleaning is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-139	Design Parameters	The minimum outdoor ach of Treatment room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-140	Design Parameters	The minimum outdoor ach of Hydrotherapy is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-141	Design Parameters	The minimum outdoor ach of Physical therapy is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-142	Design Parameters	The minimum outdoor ach of Sterilizer equipment room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-143	Design Parameters	The minimum outdoor ach of Soiled or decontamination room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-144	Design Parameters	The minimum outdoor ach of Clean workroom is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-145	Design Parameters	The minimum outdoor ach of Sterile storage is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-146	Design Parameters	The minimum outdoor ach of Food preparation center is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-147	Design Parameters	The minimum outdoor ach of Ware washing is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-148	Design Parameters	The minimum outdoor ach of Dietary storage is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-149	Design Parameters	The minimum outdoor ach of Laundry, general is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-150	Design Parameters	The minimum outdoor ach of Soiled linen sorting and storage is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-151	Design Parameters	The minimum outdoor ach of Clean linen storage is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-152	Design Parameters	The minimum outdoor ach of Linen and trash chute room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-153	Design Parameters	The minimum outdoor ach of Bedpan room is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-154	Design Parameters	The minimum outdoor ach of Bathroom is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-155	Design Parameters	The minimum outdoor ach of Janitor's closet is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-156	Design Parameters	The minimum outdoor ach of Soiled workroom or soiled holding is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-157	Design Parameters	The minimum outdoor ach of Clean workroom or clean holding is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-158	Design Parameters	The minimum outdoor ach of Hazardous material storage is not required.	Clinical/Evidence					not required				Q1	Further Investigation
7.i-159	Design Parameters	The minimum total ach of Operating room (Class B and C) is 20.	Clinical/Evidence						104, 105	106, 107	77,90, 91, 92, 92, 94, 95, 96, 97, 98, 99, 100	Q1	Further Investigation
7.i-160	Design Parameters	The minimum total ach of Operating/surgical cystoscopic rooms is 20.	Clinical/Evidence								77,90, 91, 92, 92, 94, 95, 96, 97, 98, 99, 100	Q1	Further Investigation
7.i-161	Design Parameters	The minimum total ach of Delivery room (Caesarean) is 20.	Clinical/Evidence					not found				Q1	Further Investigation

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
7.i-162	Design Parameters	The minimum total ach of Substerile service area is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-163	Design Parameters	The minimum total ach of Recovery room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-164	Design Parameters	The minimum total ach of Critical and intensive care is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-165	Design Parameters	The minimum total ach of Intermediate care is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-166	Design Parameters	The minimum total ach of Wound intensive care (bum unit) is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-167	Design Parameters	The minimum total ach of Newborn intensive care is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-168	Design Parameters	The minimum total ach of Treatment room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-169	Design Parameters	The minimum total ach of Trauma room (crisis or shock) is 15.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-170	Design Parameters	The minimum total ach of Medical/anesthesia gas storage is 8.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-171	Design Parameters	The minimum total ach of Laser eye room is 15.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-172	Design Parameters	The minimum total ach of ER waiting rooms is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-173	Design Parameters	The minimum total ach of Triage is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-174	Design Parameters	The minimum total ach of ER decontamination is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-175	Design Parameters	The minimum total ach of Radiology waiting rooms is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-176	Design Parameters	The minimum total ach of Procedure room (Class A surgery) is 15.	Clinical/Evidence								77,90, 91, 92, 92, 94, 95, 96, 97, 98, 99, 100	Q1	Further Investigation
7.i-177	Design Parameters	The minimum total ach of Emergency department exam/treatment room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-178	Design Parameters	The minimum total ach of Patient room is 4.	Clinical/Evidence						33, 35, 46, 52, 53, 59, 60	31, 54, 55, 56, 57, 58	32, 47, 48, 49, 50, 51,	Q1	Further Investigation
7.i-179	Design Parameters	The minimum total ach of Nourishment area or room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-180	Design Parameters	The minimum total ach of Toilet room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-181	Design Parameters	The minimum total ach of Newborn nursery suite is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-182	Design Parameters	The minimum total ach of Protective environment room is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-183	Design Parameters	The minimum total ach of AII room is 12.	Clinical/Evidence						127	113, 115, 117, 125	9, 126, 128, 129. 130, 131, 132, 133, 134	Q1	Further Investigation
7.i-184	Design Parameters	The minimum total ach of Combination AII/PE room is 12.	Clinical/Evidence						127	113, 115, 117, 125	9, 126, 128, 129. 130, 131, 132, 133, 134	Q1	Further Investigation
7.i-185	Design Parameters	The minimum total ach of All anteroom is 10.	Clinical/Evidence								181, 185, 186	Q4	Further Investigation
7.i-186	Design Parameters	The minimum total ach of PE anteroom is 10.	Clinical/Evidence								185, 186	Q4	Further Investigation
7.i-187	Design Parameters	The minimum total ach of Combination A1I/PE anteroom is 10.	Clinical/Evidence								185, 186	Q4	Further Investigation
7.i-188	Design Parameters	The minimum total ach of Labor/delivery/recovery/postpartum (LDRP) is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-189	Design Parameters	The minimum total ach of Labor/delivery/recovery (LDR) is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-190	Design Parameters	The minimum total ach of Patient Corridor is 2.	Clinical/Evidence								139, 140, 146	Q1	Further Investigation
7.i-191	Design Parameters	The minimum total ach of Resident room is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-192	Design Parameters	The minimum total ach of Resident gathering/activity/dining is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-193	Design Parameters	The minimum total ach of Resident unit corridor is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-194	Design Parameters	The minimum total ach of Physical therapy is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-195	Design Parameters	The minimum total ach of Occupational therapy is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-196	Design Parameters	The minimum total ach of Bathing room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-197	Design Parameters	The minimum total ach of X-ray (diagnostic and treatment) is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-198	Design Parameters	The minimum total ach of X-ray (surgery/critical care and catheterization) is 15.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-199	Design Parameters	The minimum total ach of Darkroom is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-200	Design Parameters	The minimum total ach of Bronchoscopy, sputum collection, and pentamidine administration is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-201	Design Parameters	The minimum total ach of Laboratory, general is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-202	Design Parameters	The minimum total ach of Laboratory, bacteriology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-203	Design Parameters	The minimum total ach of Laboratory, biochemistry is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-204	Design Parameters	The minimum total ach of Laboratory, cytology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-205	Design Parameters	The minimum total ach of Laboratory, glasswashing is 10.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-206	Design Parameters	The minimum total ach of Laboratory, histology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-207	Design Parameters	The minimum total ach of Laboratory, microbiology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-208	Design Parameters	The minimum total ach of Laboratory, nuclear medicine is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-209	Design Parameters	The minimum total ach of Laboratory, pathology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-210	Design Parameters	The minimum total ach of Laboratory, serology is 6.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-211	Design Parameters	The minimum total ach of Laboratory, sterilizing is 10.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-212	Design Parameters	The minimum total ach of Laboratory, media transfer is 4.	Clinical/Evidence								142, 143, 144, 145	Q1	Further Investigation
7.i-213	Design Parameters	The minimum total ach of Nonrefrigerated body-holding room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-214	Design Parameters	The minimum total ach of Autopsy room is 12.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-215	Design Parameters	The minimum total ach of Pharmacy is 4.	Clinical/Evidence								141	Q1	Further Investigation
7.i-216	Design Parameters	The minimum total ach of Examination room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-217	Design Parameters	The minimum total ach of Medication room is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-218	Design Parameters	The minimum total ach of Gastrointestinal endoscopy procedure room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-219	Design Parameters	The minimum total ach of Endoscope cleaning is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-220	Design Parameters	The minimum total ach of Treatment room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-221	Design Parameters	The minimum total ach of Hydrotherapy is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-222	Design Parameters	The minimum total ach of Physical therapy is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-223	Design Parameters	The minimum total ach of Sterilizer equipment room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-224	Design Parameters	The minimum total ach of Soiled or decontamination room is 6.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-225	Design Parameters	The minimum total ach of Clean workroom is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-226	Design Parameters	The minimum total ach of Sterile storage is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-227	Design Parameters	The minimum total ach of Food preparation center is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-228	Design Parameters	The minimum total ach of Ware washing is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-229	Design Parameters	The minimum total ach of Dietary storage is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-230	Design Parameters	The minimum total ach of Laundry, general is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-231	Design Parameters	The minimum total ach of Soiled linen sorting and storage is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-232	Design Parameters	The minimum total ach of Clean linen storage is 2.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-233	Design Parameters	The minimum total ach of Linen and trash chute room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-234	Design Parameters	The minimum total ach of Bedpan room is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-235	Design Parameters	The minimum total ach of Bathroom is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-236	Design Parameters	The minimum total ach of Janitor's closet is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-237	Design Parameters	The minimum total ach of Soiled workroom or soiled holding is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-238	Design Parameters	The minimum total ach of Clean workroom or clean holding is 4.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-239	Design Parameters	The minimum total ach of Hazardous material storage is 10.	Clinical/Evidence					not found				Q1	Further Investigation
7.i-240	Design Parameters	All room air exhausted directly to outdoors is not required for Operating room (Class B and C).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-241	Design Parameters	All room air exhausted directly to outdoors is not required for Operating/surgical cystoscopic rooms.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-242	Design Parameters	All room air exhausted directly to outdoors is not required for Delivery room (Caesarean).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-243	Design Parameters	All room air exhausted directly to outdoors is not required for Substerile service area.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-244	Design Parameters	All room air exhausted directly to outdoors is not required for Recovery room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-245	Design Parameters	All room air exhausted directly to outdoors is not required for Critical and intensive care.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-246	Design Parameters	All room air exhausted directly to outdoors is not required for Intermediate care.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-247	Design Parameters	All room air exhausted directly to outdoors is not required for Wound intensive care (bum unit).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-248	Design Parameters	All room air exhausted directly to outdoors is not required for Newborn intensive care.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-249	Design Parameters	All room air exhausted directly to outdoors is not required for Treatment room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-250	Design Parameters	All room air exhausted directly to outdoors is not required for Trauma room (crisis or shock).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-251	Design Parameters	All room air exhausted directly to outdoors is required for Medical/anesthesia gas storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-252	Design Parameters	All room air exhausted directly to outdoors is not required for Laser eye room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-253	Design Parameters	All room air exhausted directly to outdoors is required for ER waiting rooms.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-254	Design Parameters	All room air exhausted directly to outdoors is required for Triage.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-255	Design Parameters	All room air exhausted directly to outdoors is required for ER decontamination.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-256	Design Parameters	All room air exhausted directly to outdoors is required for Radiology waiting rooms.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-257	Design Parameters	All room air exhausted directly to outdoors is not required for Procedure room (Class A surgery).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-258	Design Parameters	All room air exhausted directly to outdoors is not required for Emergency department exanVtrcatmcnt room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-259	Design Parameters	All room air exhausted directly to outdoors is not required for Patient room.	Clinical/Evidence					not required				Q7	Further Investigation

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7.i-260	Design Parameters	All room air exhausted directly to outdoors is not required for Nourishment area or room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-261	Design Parameters	All room air exhausted directly to outdoors is required for Toilet room.	Clinical/Evidence									Q7	Further Investigation
7.i-262	Design Parameters	All room air exhausted directly to outdoors is not required for Newborn nursery suite.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-263	Design Parameters	All room air exhausted directly to outdoors is not required for Protective environment room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-264	Design Parameters	All room air exhausted directly to outdoors is required for All room.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-265	Design Parameters	All room air exhausted directly to outdoors is required for Combination All/PE room.	Clinical/Evidence						245	246	243, 244	Q7	Further Investigation
7.i-266	Design Parameters	All room air exhausted directly to outdoors is required for All anteroom.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-267	Design Parameters	All room air exhausted directly to outdoors is not required for PE anteroom.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-268	Design Parameters	All room air exhausted directly to outdoors is required for Combination A1I/PE anteroom.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-269	Design Parameters	All room air exhausted directly to outdoors is not required for Labor/delivery/recovery/postpartum (LDRP).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-270	Design Parameters	All room air exhausted directly to outdoors is not required for Labor/delivery/recovery (LDR).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-271	Design Parameters	All room air exhausted directly to outdoors is not required for Patient Corridor.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-272	Design Parameters	All room air exhausted directly to outdoors is not required for Resident room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-273	Design Parameters	All room air exhausted directly to outdoors is not required for Resident gathering/activity/dining.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-274	Design Parameters	All room air exhausted directly to outdoors is not required for Resident unit corridor.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-275	Design Parameters	All room air exhausted directly to outdoors is not required for Physical therapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-276	Design Parameters	All room air exhausted directly to outdoors is not required for Occupational therapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-277	Design Parameters	All room air exhausted directly to outdoors is required for Bathing room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-278	Design Parameters	All room air exhausted directly to outdoors is not required for X-ray (diagnostic and treatment).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-279	Design Parameters	All room air exhausted directly to outdoors is not required for X-ray (surgery/critical care and catheterization).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-280	Design Parameters	All room air exhausted directly to outdoors is required for Darkroom.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-281	Design Parameters	All room air exhausted directly to outdoors is required for Bronchoscopy, sputum collection, and pentamidine administration.	Clinical/Evidence						176			Q7	Basic Necessity
7.i-282	Design Parameters	All room air exhausted directly to outdoors is not required for Laboratory, general.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-283	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, bacteriology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-284	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, biochemistry.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-285	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, cytology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-286	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, glasswashing.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-287	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, histology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-288	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, microbiology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-289	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, nuclear medicine.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-290	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, pathology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-291	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, serology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-292	Design Parameters	All room air exhausted directly to outdoors is required for Laboratory, sterilizing.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-293	Design Parameters	All room air exhausted directly to outdoors is not required for Laboratory, media transfer.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-294	Design Parameters	All room air exhausted directly to outdoors is required for Nonrefrigerated body-holding room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-295	Design Parameters	All room air exhausted directly to outdoors is required for Autopsy room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-296	Design Parameters	All room air exhausted directly to outdoors is not required for Pharmacy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-297	Design Parameters	All room air exhausted directly to outdoors is not required for Examination room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-298	Design Parameters	All room air exhausted directly to outdoors is not required for Medication room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-299	Design Parameters	All room air exhausted directly to outdoors is not required for Gastrointestinal endoscopy procedure room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-300	Design Parameters	All room air exhausted directly to outdoors is required for Endoscope cleaning.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-301	Design Parameters	All room air exhausted directly to outdoors is not required for Treatment room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-302	Design Parameters	All room air exhausted directly to outdoors is not required for Hydrotherapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-303	Design Parameters	All room air exhausted directly to outdoors is not required for Physical therapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-304	Design Parameters	All room air exhausted directly to outdoors is required for Sterilizer equipment room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-305	Design Parameters	All room air exhausted directly to outdoors is required for Soiled or decontamination room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-306	Design Parameters	All room air exhausted directly to outdoors is not required for Clean workroom.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-307	Design Parameters	All room air exhausted directly to outdoors is not required for Sterile storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-308	Design Parameters	All room air exhausted directly to outdoors is not required for Food preparation center.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-309	Design Parameters	All room air exhausted directly to outdoors is required for Ware washing.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-310	Design Parameters	All room air exhausted directly to outdoors is not required for Dietary storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-311	Design Parameters	All room air exhausted directly to outdoors is required for Laundry, general.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-312	Design Parameters	All room air exhausted directly to outdoors is required for Soiled linen sorting and storage.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-313	Design Parameters	All room air exhausted directly to outdoors is not required for Clean linen storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-314	Design Parameters	All room air exhausted directly to outdoors is required for Linen and trash chute room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-315	Design Parameters	All room air exhausted directly to outdoors is required for Bedpan room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-316	Design Parameters	All room air exhausted directly to outdoors is required for Bathroom.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-317	Design Parameters	All room air exhausted directly to outdoors is required for Janitor's closet.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-318	Design Parameters	All room air exhausted directly to outdoors is required for Soiled workroom or soiled holding.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-319	Design Parameters	All room air exhausted directly to outdoors is not required for Clean workroom or clean holding.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-320	Design Parameters	All room air exhausted directly to outdoors is required for Hazardous material storage.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-321	Design Parameters	Air recirculated by means of room units is not allowed for Operating room (Class B and C).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-322	Design Parameters	Air recirculated by means of room units is not allowed for Operating/surgical cystoscopic rooms.	Clinical/Evidence						88, 281,282, 283, 284, 285, 286, 287, 288,	275, 276, 277, 278, 279, 280,	247,248	Q7	Further Investigation
7.i-323	Design Parameters	Air recirculated by means of room units is not allowed for Delivery room (Caesarean).	Clinical/Evidence						281,282, 283, 284, 285, 286, 287, 288,	276, 277, 278, 279, 280	247,248	Q7	Further Investigation
7.i-324	Design Parameters	Air recirculated by means of room units is not allowed for Substerile service area.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-325	Design Parameters	Air recirculated by means of room units is not allowed for Recovery room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-326	Design Parameters	Air recirculated by means of room units is not allowed for Critical and intensive care.	Clinical/Evidence						281,282, 283, 284, 285, 286, 287, 288,	276, 277, 278, 279, 280	247,248	Q7	Further Investigation
7.i-327	Design Parameters	Air recirculated by means of room units is allowed for Intermediate care.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-328	Design Parameters	Air recirculated by means of room units is not allowed for Wound intensive care (bum unit).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-329	Design Parameters	Air recirculated by means of room units is not allowed for Newborn intensive care.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-330	Design Parameters	Air recirculated by means of room units is allowed for Treatment room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-331	Design Parameters	Air recirculated by means of room units is not allowed for Trauma room (crisis or shock).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-332	Design Parameters	Air recirculated by means of room units is allowed for Medical/anesthesia gas storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-333	Design Parameters	Air recirculated by means of room units is not allowed for Laser eye room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-334	Design Parameters	Air recirculated by means of room units is allowed for ER waiting rooms.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-335	Design Parameters	Air recirculated by means of room units is allowed for Triage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-336	Design Parameters	Air recirculated by means of room units is not allowed for ER decontamination.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-337	Design Parameters	Air recirculated by means of room units is allowed for Radiology waiting rooms.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-338	Design Parameters	Air recirculated by means of room units is not allowed for Procedure room (Class A surgery).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-339	Design Parameters	Air recirculated by means of room units is allowed for Emergency department exanVtrcatmnent room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-340	Design Parameters	Air recirculated by means of room units is allowed for Patient room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-341	Design Parameters	Air recirculated by means of room units is allowed for Nourishment area or room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-342	Design Parameters	Air recirculated by means of room units is not allowed for Toilet room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-343	Design Parameters	Air recirculated by means of room units is not allowed for Newborn nursery suite.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-344	Design Parameters	Air recirculated by means of room units is not allowed for Protective environment room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-345	Design Parameters	Air recirculated by means of room units is not allowed for AII room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-346	Design Parameters	Air recirculated by means of room units is not allowed for Combination AII/PE room.	Clinical/Evidence						239, 240		49, 237, 238	Q7	Basic Necessity
7.i-347	Design Parameters	Air recirculated by means of room units is not allowed for All anteroom.	Clinical/Evidence						159, 188			Q4	Basic Necessity
7.i-348	Design Parameters	Air recirculated by means of room units is not allowed for PE anteroom.	Clinical/Evidence						159, 188			Q4	Basic Necessity
7.i-349	Design Parameters	Air recirculated by means of room units is not allowed for Combination A1I/PE anteroom.	Clinical/Evidence						159, 188			Q4	Basic Necessity
7.i-350	Design Parameters	Air recirculated by means of room units is allowed for Labor/delivery/recovery/postpartum (LDRP).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-351	Design Parameters	Air recirculated by means of room units is allowed for Labor/delivery/recovery (LDR).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-352	Design Parameters	Air recirculated by means of room units is allowed for Patient Corridor.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-353	Design Parameters	Air recirculated by means of room units is allowed for Resident room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-354	Design Parameters	Air recirculated by means of room units is allowed for Resident gathering/activity/dining.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-355	Design Parameters	Air recirculated by means of room units is allowed for Resident unit corridor.	Clinical/Evidence					not found				Q7	Further Investigation

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7.i-356	Design Parameters	Air recirculated by means of room units is allowed for Physical therapy.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-357	Design Parameters	Air recirculated by means of room units is allowed for Occupational therapy.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-358	Design Parameters	Air recirculated by means of room units is not allowed for Bathing room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-359	Design Parameters	Air recirculated by means of room units is allowed for X-ray (diagnostic and treatment).	Clinical/Evidence					not required				Q7	Further Investigation
7.i-360	Design Parameters	Air recirculated by means of room units is not allowed for X-ray (surgery/critical care and catheterization).	Clinical/Evidence					not found				Q7	Further Investigation
7.i-361	Design Parameters	Air recirculated by means of room units is not allowed for Darkroom.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-362	Design Parameters	Air recirculated by means of room units is not allowed for Bronchoscopy, sputum collection, and pentamidine administration.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-363	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, general.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-364	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, bacteriology.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-365	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, biochemistry.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-366	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, cytology.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-367	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, glasswashing.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-368	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, histology.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-369	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, microbiology.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-370	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, nuclear medicine.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-371	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, pathology.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-372	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, serology.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-373	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, sterilizing.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-374	Design Parameters	Air recirculated by means of room units is allowed for Laboratory, media transfer.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-375	Design Parameters	Air recirculated by means of room units is not allowed for Nonrefrigerated body-holding room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-376	Design Parameters	Air recirculated by means of room units is not allowed for Autopsy room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-377	Design Parameters	Air recirculated by means of room units is allowed for Pharmacy.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-378	Design Parameters	Air recirculated by means of room units is allowed for Examination room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-379	Design Parameters	Air recirculated by means of room units is allowed for Medication room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-380	Design Parameters	Air recirculated by means of room units is not allowed for Gastrointestinal endoscopy procedure room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-381	Design Parameters	Air recirculated by means of room units is not allowed for Endoscope cleaning.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-382	Design Parameters	Air recirculated by means of room units is allowed for Treatment room.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-383	Design Parameters	Air recirculated by means of room units is allowed for Hydrotherapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-384	Design Parameters	Air recirculated by means of room units is allowed for Physical therapy.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-385	Design Parameters	Air recirculated by means of room units is not allowed for Sterilizer equipment room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-386	Design Parameters	Air recirculated by means of room units is not allowed for Soiled or decontamination room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-387	Design Parameters	Air recirculated by means of room units is not allowed for Clean workroom.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-388	Design Parameters	Air recirculated by means of room units is allowed for Sterile storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-389	Design Parameters	Air recirculated by means of room units is not allowed for Food preparation center.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-390	Design Parameters	Air recirculated by means of room units is not allowed for Ware washing.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-391	Design Parameters	Air recirculated by means of room units is not allowed for Dietary storage.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-392	Design Parameters	Air recirculated by means of room units is not allowed for Laundry, general.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-393	Design Parameters	Air recirculated by means of room units is not allowed for Soiled linen sorting and storage.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-394	Design Parameters	Air recirculated by means of room units is allowed for Clean linen storage.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-395	Design Parameters	Air recirculated by means of room units is not allowed for Linen and trash chute room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-396	Design Parameters	Air recirculated by means of room units is not allowed for Bedpan room.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-397	Design Parameters	Air recirculated by means of room units is not allowed for Bathroom.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-398	Design Parameters	Air recirculated by means of room units is not allowed for Janitor's closet.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-399	Design Parameters	Air recirculated by means of room units is not allowed for Soiled workroom or soiled holding.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-400	Design Parameters	Air recirculated by means of room units is allowed for Clean workroom or clean holding.	Clinical/Evidence					not required				Q7	Further Investigation
7.i-401	Design Parameters	Air recirculated by means of room units is not allowed for Hazardous material storage.	Clinical/Evidence					not found				Q7	Further Investigation
7.i-402	Design Parameters	Design relative humidity (%) of Operating room (Class B and C) is 20-60 %.	Clinical/Evidence							209, 210	6, 67, 208	Q6	Further Investigation
7.i-403	Design Parameters	Design relative humidity (%) of Operating/surgical cystoscopic rooms is 20-60 %.	Clinical/Evidence								207	Q6	Further Investigation
7.i-404	Design Parameters	Design relative humidity (%) of Delivery room (Caesarean) is 20-60 %.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-405	Design Parameters	Design relative humidity (%) of Substerile service area is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-406	Design Parameters	Design relative humidity (%) of Recovery room is 20-60 %.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-407	Design Parameters	Design relative humidity (%) of Critical and intensive care is 30-60 %.	Clinical/Evidence						210			Q6	Basic Necessity
7.i-408	Design Parameters	Design relative humidity (%) of Intermediate care is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-409	Design Parameters	Design relative humidity (%) of Wound intensive care (bum unit) is 40-60 %.	Clinical/Evidence						210		213, 214	Q6	Basic Necessity
7.i-410	Design Parameters	Design relative humidity (%) of Newborn intensive care is 30-60 %.	Clinical/Evidence								210	Q6	Further Investigation
7.i-411	Design Parameters	Design relative humidity (%) of Treatment room is 20-60 %.	Clinical/Evidence							210		Q6	Further Investigation
7.i-412	Design Parameters	Design relative humidity (%) of Trauma room (crisis or shock) is 20-60 %.	Clinical/Evidence							210		Q6	Further Investigation
7.i-413	Design Parameters	Design relative humidity (%) of Medical/anesthesia gas storage is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-414	Design Parameters	Design relative humidity (%) of Laser eye room is 20-60 %.	Clinical/Evidence							210		Q6	Further Investigation
7.i-415	Design Parameters	Design relative humidity (%) of ER waiting rooms is less than 65%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-416	Design Parameters	Design relative humidity (%) of Triage is less than 60%.	Clinical/Evidence								177	Q6	Further Investigation
7.i-417	Design Parameters	Design relative humidity (%) of ER decontamination is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-418	Design Parameters	Design relative humidity (%) of Radiology waiting rooms is less than 60%.	Clinical/Evidence								191	Q6	Further Investigation
7.i-419	Design Parameters	Design relative humidity (%) of Procedure room (Class A surgery) is 20-60 %.	Clinical/Evidence							209, 210	6, 67, 208	Q6	Change
7.i-420	Design Parameters	Design relative humidity (%) of Emergency department exanVtrcatmcnt room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-421	Design Parameters	Design relative humidity (%) of Patient room is less than 60%.	Clinical/Evidence								227, 228, 229	Q6	Further Investigation
7.i-422	Design Parameters	Design relative humidity (%) of Nourishment area or room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-423	Design Parameters	Design relative humidity (%) of Toilet room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-424	Design Parameters	Design relative humidity (%) of Newborn nursery suite is 30-60 %.	Clinical/Evidence								211	Q6	Further Investigation
7.i-425	Design Parameters	Design relative humidity (%) of Protective environment room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-426	Design Parameters	Design relative humidity (%) of AII room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-427	Design Parameters	Design relative humidity (%) of Combination AII/PE room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-428	Design Parameters	Design relative humidity (%) of All anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-429	Design Parameters	Design relative humidity (%) of PE anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-430	Design Parameters	Design relative humidity (%) of Combination A1I/PE anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-431	Design Parameters	Design relative humidity (%) of Labor/delivery/recovery/postpartum (LDRP) is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-432	Design Parameters	Design relative humidity (%) of Labor/delivery/recovery (LDR) is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-433	Design Parameters	Design relative humidity (%) of Patient Corridor is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-434	Design Parameters	Design relative humidity (%) of Resident room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-435	Design Parameters	Design relative humidity (%) of Resident gathering/activity/dining is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-436	Design Parameters	Design relative humidity (%) of Resident unit corridor is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-437	Design Parameters	Design relative humidity (%) of Physical therapy is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-438	Design Parameters	Design relative humidity (%) of Occupational therapy is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-439	Design Parameters	Design relative humidity (%) of Bathing room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-440	Design Parameters	Design relative humidity (%) of X-ray (diagnostic and treatment) is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-441	Design Parameters	Design relative humidity (%) of X-ray (surgery/critical care and catheterization) is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-442	Design Parameters	Design relative humidity (%) of Darkroom is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-443	Design Parameters	Design relative humidity (%) of Bronchoscopy, sputum collection, and pentamidine administration is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-444	Design Parameters	Design relative humidity (%) of Laboratory, general is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-445	Design Parameters	Design relative humidity (%) of Laboratory, bacteriology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-446	Design Parameters	Design relative humidity (%) of Laboratory, biochemistry is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-447	Design Parameters	Design relative humidity (%) of Laboratory, cytology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-448	Design Parameters	Design relative humidity (%) of Laboratory, glasswashing is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-449	Design Parameters	Design relative humidity (%) of Laboratory, histology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-450	Design Parameters	Design relative humidity (%) of Laboratory, microbiology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-451	Design Parameters	Design relative humidity (%) of Laboratory, nuclear medicine is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-452	Design Parameters	Design relative humidity (%) of Laboratory, pathology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-453	Design Parameters	Design relative humidity (%) of Laboratory, serology is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-454	Design Parameters	Design relative humidity (%) of Laboratory, sterilizing is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-455	Design Parameters	Design relative humidity (%) of Laboratory, media transfer is not required.	Clinical/Evidence					not required				Q6	Further Investigation

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7.i-456	Design Parameters	Design relative humidity (%) of Nonrefrigerated body-holding room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-457	Design Parameters	Design relative humidity (%) of Autopsy room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-458	Design Parameters	Design relative humidity (%) of Pharmacy is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-459	Design Parameters	Design relative humidity (%) of Examination room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-460	Design Parameters	Design relative humidity (%) of Medication room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-461	Design Parameters	Design relative humidity (%) of Gastrointestinal endoscopy procedure room is 20-60 %.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-462	Design Parameters	Design relative humidity (%) of Endoscope cleaning is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-463	Design Parameters	Design relative humidity (%) of Treatment room is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-464	Design Parameters	Design relative humidity (%) of Hydrotherapy is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-465	Design Parameters	Design relative humidity (%) of Physical therapy is less than 65%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-466	Design Parameters	Design relative humidity (%) of Sterilizer equipment room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-467	Design Parameters	Design relative humidity (%) of Soiled or decontamination room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-468	Design Parameters	Design relative humidity (%) of Clean workroom is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-469	Design Parameters	Design relative humidity (%) of Sterile storage is less than 60%.	Clinical/Evidence					not found				Q6	Further Investigation
7.i-470	Design Parameters	Design relative humidity (%) of Food preparation center is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-471	Design Parameters	Design relative humidity (%) of Ware washing is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-472	Design Parameters	Design relative humidity (%) of Dietary storage is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-473	Design Parameters	Design relative humidity (%) of Laundry, general is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-474	Design Parameters	Design relative humidity (%) of Soiled linen sorting and storage is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-475	Design Parameters	Design relative humidity (%) of Clean linen storage is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-476	Design Parameters	Design relative humidity (%) of Linen and trash chute room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-477	Design Parameters	Design relative humidity (%) of Bedpan room is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-478	Design Parameters	Design relative humidity (%) of Bathroom is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-479	Design Parameters	Design relative humidity (%) of Janitor's closet is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-480	Design Parameters	Design relative humidity (%) of Soiled workroom or soiled holding is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-481	Design Parameters	Design relative humidity (%) of Clean workroom or clean holding is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-482	Design Parameters	Design relative humidity (%) of Hazardous material storage is not required.	Clinical/Evidence					not required				Q6	Further Investigation
7.i-483	Design Parameters	Design temperature of Operating room (Class B and C) is 68-75 °F.	Clinical/Evidence						203		6, 21, 67, 208	Q5	Further Investigation
7.i-484	Design Parameters	Design temperature of Operating/surgical cystoscopic rooms is 68-75 °F.	Clinical/Evidence						203		6, 21, 67, 208	Q5	Further Investigation
7.i-485	Design Parameters	Design temperature of Delivery room (Caesarean) is 68-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-486	Design Parameters	Design temperature of Substerile service area is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-487	Design Parameters	Design temperature of Recovery room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-488	Design Parameters	Design temperature of Critical and intensive care is 70-75 °F.	Clinical/Evidence								39	Q5	Further Investigation
7.i-489	Design Parameters	Design temperature of Intermediate care is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-490	Design Parameters	Design temperature of Wound intensive care (bum unit) is 70-75 °F.	Clinical/Evidence							214	205,216	Q5	Change
7.i-491	Design Parameters	Design temperature of Newborn intensive care is 72-78 °F.	Clinical/Evidence								211	Q5	Further Investigation
7.i-492	Design Parameters	Design temperature of Treatment room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-493	Design Parameters	Design temperature of Trauma room (crisis or shock) is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-494	Design Parameters	Design temperature of Medical/anesthesia gas storage is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-495	Design Parameters	Design temperature of Laser eye room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-496	Design Parameters	Design temperature of ER waiting rooms is 70-75 °F.	Clinical/Evidence								215	Q5	Further Investigation
7.i-497	Design Parameters	Design temperature of Triage is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-498	Design Parameters	Design temperature of ER decontamination is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-499	Design Parameters	Design temperature of Radiology waiting rooms is 70-75 °F.	Clinical/Evidence						191			Q5	Further Investigation
7.i-500	Design Parameters	Design temperature of Procedure room (Class A surgery) is 70-75 °F.	Clinical/Evidence						203		6, 21, 67, 208	Q5	Further Investigation
7.i-501	Design Parameters	Design temperature of Emergency department exanVtreatment room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-502	Design Parameters	Design temperature of Patient room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-503	Design Parameters	Design temperature of Nourishment area or room is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-504	Design Parameters	Design temperature of Toilet room is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-505	Design Parameters	Design temperature of Newborn nursery suite is 72-78 °F.	Clinical/Evidence								211	Q5	Further Investigation
7.i-506	Design Parameters	Design temperature of Protective environment room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-507	Design Parameters	Design temperature of AII room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-508	Design Parameters	Design temperature of Combination AII/PE room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-509	Design Parameters	Design temperature of All anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-510	Design Parameters	Design temperature of PE anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-511	Design Parameters	Design temperature of Combination A1I/PE anteroom is not required.	Clinical/Evidence					not found				Q4	Further Investigation
7.i-512	Design Parameters	Design temperature of Labor/delivery/recovery/postpartum (LDRP) is 70-75 °F.	Clinical/Evidence									Q5	Further Investigation
7.i-513	Design Parameters	Design temperature of Labor/delivery/recovery (LDR) is 70-75 °F.	Clinical/Evidence									Q5	Further Investigation
7.i-514	Design Parameters	Design temperature of Patient Corridor is not required.	Clinical/Evidence					not required			164, 173, 217, 218, 219	Q5	Further Investigation
7.i-515	Design Parameters	Design temperature of Resident room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-516	Design Parameters	Design temperature of Resident gathering/activity/dining is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-517	Design Parameters	Design temperature of Resident unit corridor is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-518	Design Parameters	Design temperature of Physical therapy is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-519	Design Parameters	Design temperature of Occupational therapy is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-520	Design Parameters	Design temperature of Bathing room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-521	Design Parameters	Design temperature of X-ray (diagnostic and treatment) is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-522	Design Parameters	Design temperature of X-ray (surgery/critical care and catheterization) is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-523	Design Parameters	Design temperature of Darkroom is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-524	Design Parameters	Design temperature of Bronchoscopy, sputum collection, and pentamidine administration is 68-73 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-525	Design Parameters	Design temperature of Laboratory, general is 70-75 °F.	Clinical/Evidence								21, 43, 142	Q5	Further Investigation
7.i-526	Design Parameters	Design temperature of Laboratory, bacteriology is 70-75 °F.	Clinical/Evidence								21, 43, 142	Q5	Further Investigation
7.i-527	Design Parameters	Design temperature of Laboratory, biochemistry is 70-75 °F.	Clinical/Evidence						67, 208, 6,		21, 43, 142	Q5	Further Investigation
7.i-528	Design Parameters	Design temperature of Laboratory, cytology is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-529	Design Parameters	Design temperature of Laboratory, glasswashing is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-530	Design Parameters	Design temperature of Laboratory, histology is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-531	Design Parameters	Design temperature of Laboratory, microbiology is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-532	Design Parameters	Design temperature of Laboratory, nuclear medicine is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-533	Design Parameters	Design temperature of Laboratory, pathology is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-534	Design Parameters	Design temperature of Laboratory, serology is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-535	Design Parameters	Design temperature of Laboratory, sterilizing is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-536	Design Parameters	Design temperature of Laboratory, media transfer is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-537	Design Parameters	Design temperature of Nonrefrigerated body-holding room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-538	Design Parameters	Design temperature of Autopsy room is 68-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-539	Design Parameters	Design temperature of Pharmacy is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-540	Design Parameters	Design temperature of Examination room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-541	Design Parameters	Design temperature of Medication room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-542	Design Parameters	Design temperature of Gastrointestinal endoscopy procedure room is 68-73 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-543	Design Parameters	Design temperature of Endoscope cleaning is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-544	Design Parameters	Design temperature of Treatment room is 70-75 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-545	Design Parameters	Design temperature of Hydrotherapy is 72-80 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-546	Design Parameters	Design temperature of Physical therapy is 72-80 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-547	Design Parameters	Design temperature of Sterilizer equipment room is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-548	Design Parameters	Design temperature of Soiled or decontamination room is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-549	Design Parameters	Design temperature of Clean workroom is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-550	Design Parameters	Design temperature of Sterile storage is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-551	Design Parameters	Design temperature of Food preparation center is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-552	Design Parameters	Design temperature of Ware washing is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-553	Design Parameters	Design temperature of Dietary storage is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-554	Design Parameters	Design temperature of Laundry, general is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-555	Design Parameters	Design temperature of Soiled linen sorting and storage is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-556	Design Parameters	Design temperature of Clean linen storage is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation

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7.i-557	Design Parameters	Design temperature of Linen and trash chute room is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-558	Design Parameters	Design temperature of Bedpan room is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-559	Design Parameters	Design temperature of Bathroom is 72-78 °F.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-560	Design Parameters	Design temperature of Janitor's closet is not required.	Clinical/Evidence					not found				Q5	Further Investigation
7.i-561	Design Parameters	Design temperature of Soiled workroom or soiled holding is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-562	Design Parameters	Design temperature of Clean workroom or clean holding is not required.	Clinical/Evidence					not required				Q5	Further Investigation
7.i-563	Design Parameters	Design temperature of Hazardous material storage is not required.	Clinical/Evidence					not required				Q5	Further Investigation
Table 7.1	Notes	Notes for Table 7.1	Section Header									HEAD	
a.i	Notes	Recirculating devices with HEPA filters shall be permitted in existing facilities as interim, supplemental environmental controls to meet requirements for the control of airborne infectious agents.	Evidence					not found				Q7	Further Investigation
a.ii	Notes	The design of either portable or fixed (recirculating) systems should prevent stagnation and short circuiting of airflow.	Rational	To ensure ventilation effectiveness velocity and location of diffusers needs to be coordinated to meet the thermal load and comfort								RATIONAL	Basic Necessity
a.iii	Notes	The design of such systems shall also allow for easy access for scheduled preventative maintenance and cleaning.	Rational	All mechanical systems require maintenance and eventual replacement.								RATIONAL	Basic Necessity
b	Notes	Pharmacy compounding areas may have additional air change, differential pressure, and filtering requirements beyond the minimum of this table depending on the type of pharmacy, the regulatory X requirements which may include adoption of USP 797), the associated level of risk of the work (sec USP [2013] in Informative Appendix B), and the equipment utilized in the space	Clinical		USP 797, USP 800							CLINIC	Procedural
c	Notes	The term trauma room as used herein is a first-aid room and/or emergency room used for general initial treatment of accident victims. The operating room within the trauma center that is routinely used for emergency surgery is considered to be an operating room by this standard.	Clinical									CLINIC	Procedural
d	Notes	Pressure relationships need not be maintained when the room is unoccupied.	Evidence					not found				Q3	Further Investigation
g	Notes	All air need not be exhausted if darkroom equipment has a scavenging exhaust duct attached and meets ventilation standards regarding NIOSH, OSHA, and local employee exposure limits.	Clinical/Evidence					not found				Q7	Basic Necessity
h	Notes	A nonrefrigerated body-holding room is applicable only to facilities that do not perform autopsies on-site and use the space for short periods while waiting for the body to be transferred.	Clinical									CLINIC	Procedural
i.i	Notes	Minimum total air changes per hour (ach) shall be that required to provide proper makeup air to kitchen exhaust systems as specified in ANSI/ASHRAE Standard 154.	Rational	Exhaust volume is to maintain safety by removing smoke, moisture and heat from kitchen cooking areas.	ASHRAE standard 154							RATIONAL	Basic Necessity
i.ii	Notes	In some cases, excess exfiltration or infiltration to or from exit corridors compromises the exit corridor restrictions of NFPA 90A, the pressure requirements of NFPA 96, or the maximum defined in the table.	Rational	Vague guidance. Does Standard 170 or 154 override NFPA or vice versa.	NFPA 90A, 96							RATIONAL	Basic Necessity
i.iii	Notes	During operation, a reduction to the number of air changes to any extent required for odor control shall be permitted when the space is not in use. (See FGI [2010] in Informative Appendix B.)	Rational	VAV kitchen hoods with demand control ventilation are common energy conservation measures that modulate flow to maintain safe exhaust.								RATIONAL	Basic Necessity
j.i	Notes	In some areas with potential contamination and/or odor problems, exhaust air shall be discharged directly to the outdoors and not recirculated to other areas.	Rational	Contaminant and odors shall be removed from building via exhaust.								RATIONAL	Basic Necessity
j.ii	Notes	Individual circumstances may require special consideration for air exhausted to the outdoors.	Rational	Allows engineer flexibility to exhaust spaces that do not always require exhaust, but special circumstances exist.								RATIONAL	Basic Necessity
j.iii	Notes	To satisfy exhaust needs, constant replacement air from the outdoors is necessary when the system is in operation.	Rational	This is required to prevent the building from being negative pressure and to maintain control of air flow.								RATIONAL	Basic Necessity
k	Notes	The RH ranges listed are the minimum and/or maximum allowable at any point within the design temperature range required for that space.	Rational	Design guidance for engineer								RATIONAL	Basic Necessity
l.i	Notes	Systems shall be capable of maintaining the rooms within the temperature range during normal operation.	Rational	Design guidance for engineer								RATIONAL	Basic Necessity
l.ii	Notes	Lower or higher temperature shall be permitted when patients' comfort and/or medical conditions require those conditions.	Clinical/Evidence						210		129, 127, 164, 173, 217, 218, 219,220	Q5	Further Investigation
m	Notes	National Institute for Occupational Safety and Health (NIOSH) criteria documents regarding occupational exposure to waste anesthetic gases and vapors, and control of occupational exposure to nitrous oxide indicate a need for both local exhaust (scavenging) systems and general ventilation of the areas in which the respective gases are utilized. Refer to NFPA 99 for other requirements	Clinical/Evidence		NFPA 99			not found				NO	Change
n.i	Notes	If pressure-monitoring device alarms are installed, allowances shall be made to prevent nuisance alarms.	Rational	Vague operational guidance								RATIONAL	Basic Necessity
n.ii	Notes	Short-term excursions from required pressure relationships shall be allowed while doors are moving or temporarily open.	Rational	Pressurization calculations assume doors are normally closed and are not propped open.								RATIONAL	Basic Necessity
n.iii	Notes	Simple visual methods such as smoke trail, ball-in-tube, or flutter strip shall be permitted for verification of airflow direction.	Rational	Operational test methods								RATIONAL	Basic Necessity
o	Notes	Surgeons or surgical procedures may require room temperatures, ventilation rates, humidity ranges, and/or air distribution methods that exceed the minimum indicated ranges.	Clinical/Evidence						189, 192, 193, 198, 199, 200, 201	206, 207	70, 190, 191, 194,202, 203, 204, 208	Q5	Further Investigation
p.i	Notes	Treatment rooms used for bronchoscopy shall be treated as bronchoscopy rooms.	Clinical/Evidence	Allows operational flexibility				not found				NO	Procedural
p.ii	Notes	Treatment rooms used for procedures with nitrous oxide shall contain provisions for exhausting anesthetic waste gases.	Clinical/Evidence					not found				Q7	Change
q.i	Notes	In a recirculating ventilation system, HEPA filters shall be permitted instead of exhausting the air from these spaces to the outdoors provided that the return air passes through the HEPA filters before it is introduced into any other spaces.	Evidence						195, 232, 233, 234,		14, 131, 235, 236, 276, 277, 278, 279, 280	Q8	Basic Necessity
q.ii	Notes	The entire minimum total air changes per hour of recirculating airflow shall pass through HEPA filters.	Evidence						47, 261			Q8	Basic Necessity
q.iii	Notes	When these areas are open to larger, nonwaiting spaces, the exhaust air volume shall be calculated based on the seating area of the waiting area.	Rational	Enigneering guidance. Boundary area for calculating air flow volume.								RATIONAL	Basic Necessity
s	Notes	For intermediate care, labor/delivery/recovery rooms, and labor/delivery/recovery/postpartum rooms, four total ach shall be permitted when supplemental heating and/or cooling systems (radiant heating and cooling, baseboard heating, etc.) are used.	Rational	Reduced air change rate needed to meet thermal comfort requirements.								RATIONAL	Basic Necessity
t.i	Notes	The protective environment airflow design specifications protect the patient from common environmental airborne infectious microbes (i.e., Aspergillus spores). Recirculation HEPA filters shall be permitted to increase the equivalent room air exchanges; however, the outdoor air changes are still required.	Evidence						256, 257, 65, 266			Q7	Basic Necessity
t.ii	Notes	Constant-volume airflow is required for consistent ventilation for the protected environment.	Evidence	Fixed offset. Don't adjust for doors opening. Clarification of intent required.					136		141	Q3	Basic Necessity
t.iii	Notes	The pressure relationship to adjacent areas shall remain unchanged if the PE room is utilized as a normal patient room.	Clinical/Evidence					not found				Q3	Further Investigation
t.iv	Notes	Rooms with reversible airflow provisions for the purpose of switching between protective environment and AII functions shall not be permitted.	Clinical/Evidence					not found				MISC	Further Investigation
u.i	Notes	The AII room described in this standard shall be used for isolating the airborne spread of infectious diseases, such as measles, varicella, or tuberculosis.	Clinical/Evidence					not found				NO	Further Investigation
u.ii	Notes	Supplemental recirculating devices using HEPA filters shall be permitted in the AII room to increase the equivalent room air exchanges; however, the minimum outdoor air changes of Table 7.1 are still required.	Evidence					not found				Q1	Further Investigation
u.iii	Notes	AII rooms that are retrofitted from standard patient rooms from which it is impractical to exhaust directly outdoors may be recirculated with air from the AII room, provided that air first passes through a HEPA filter.	Rational/Evidence	The volume of ductwork needed for AII rooms is larger than standard patient rooms and may not fit within the floor to floor height.				not found				misc	Further Investigation
u.iv	Notes	When the AII room is not utilized for airborne infection isolation, the pressure relationship to adjacent areas, when measured with the door closed, shall remain unchanged and the minimum total air change rate shall be 6 ACH.	Evidence					not found				misc	Further Investigation
u.v	Notes	Switching controls for reversible airflow provisions shall not be permitted.	Evidence					not found				misc	Further Investigation
v	Notes	When required, appropriate hoods and exhaust devices for the removal of noxious gases or chemical vapors shall be provided in accordance with NFPA 99.	Rational	Life safety measure	NFPA 99							RATIONAL	Basic Necessity
w	Notes	The requirement that all room air is exhausted directly to outdoors applies only to radiology waiting room programmed to hold patients who are waiting for chest x-rays for diagnosis of respiratory disease.	Clinical/Evidence					not found				misc	Further Investigation

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
x	Notes	If the planned space is designated in the organization's operational plan to be utilized for both bronchoscopy and gastrointestinal endoscopy, the design parameters for "bronchoscopy, sputum collectio and pentamidine administration" shall be used.	Clinical/Evidence					not found				misc	Further Investigation
y	Notes	For single-bed patient rooms using Group D diffusers, a minimum of six total ach shall be provided and calculated based on the volume from finished floor to 6 ft (1.83 m) above the floor.	Rational/Evidence	Displacement ventilation stratifies a space and does not condition the entire volume. Air change rate and conditioned volume to be validated.				not found				Q1	Further Investigation
7.1	**General Requirements**	**General Requirements**	Section Header									HEAD	
7.1.a	General Requirements	Spaces shall be ventilated according to Table 7.1	Rational									RATIONAL	Procedural
7.1.a.1.i	General Requirements	Design of the ventilation system shall provide air movement that is generally from clean to less clean areas.	Evidence						44, 45, 147			Q2	Basic Necessity
7.1.a.1.ii	General Requirements	If any form of variable-air-volume or load-shedding system is used for energy conservation, it shall not compromise the pressure balancing relationships or the minimum air changes required by the table.	Rational	Controls requirement. Pressure relationships addressed separately.								RATIONAL	Basic Necessity
7.1.a.2.i	General Requirements	The ventilation rates in this table are intended to provide for comfort as well as for asepsis and odor control in areas of a health care facility that directly affect patient care.	Rational/Clinical/Evidence					not found				NO	Further Investigation
7.1.a.2.ii	General Requirements	Ventilation rates for many areas not specified in here can be found in ANSI/ASHRAE Standard 62.1.	Rational	Cross reference to ASHRAE 62.1	ASHRAE 62.1							RATIONAL	Basic Necessity
7.1.a.2.iii	General Requirements	Where areas with prescribed rates in both Standard 62.1 and Table 7.1 of this standard exist, the higher of the two air change rates shall be used.	Evidence	Assumption that more air flow is better.				not found				NO	Procedural
7.1.a.3.i	General Requirements	For design purposes, the minimum number of total air changes indicated shall be either supplied for positive pressure rooms or exhausted for negative pressure rooms.	Rational	Design guidance for engineer.								RATIONAL	Basic Necessity
7.1.a.3.ii	General Requirements	Spaces that are required in Table 7.1 to be at a negative pressure relationship and are not required to be exhausted shall utilize the supply airflow rate to compute the minimum total air changes per hour required.	Rational	Design guidance for engineer.								RATIONAL	Basic Necessity
7.1.a.3.iii	General Requirements	For spaces that require a positive or negative pressure relationship, the number of air changes can be reduced when the space is unoccupied, provided that the required pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is re-established anytime the space becomes occupied	Evidence	Operational guidance for facility manager				not found				Q3	Further Investigation
7.1.a.3.iv	General Requirements	Air change rates in excess of the minimum values are expected in some cases in order to maintain room temperature and humidity conditions based upon the space cooling or heating load.	Rational	Thermal load calculations per 2015 ASHRAE Fundamentals may require more ventilation to meet thermal comfort requirements.					222, 223, 224, 225, 226			RATIONAL	Basic Necessity
7.1.a.4	General Requirements	The entire minimum outdoor air changes per hour required by Table 7.1 for the space shall meet the filtration requirements of Section 6.4.	Evidence	Design guidance for engineer.				not found				NO	Further Investigation
7.1.a.5.i	General Requirements	For spaces where Table 7.1 permits air to be recirculated by room units, the portion of the minimum total air changes per hour required for a space that is greater than the minimum outdoor air changes per hour required component may be provided by recirculating room HVAC units.	Rational	Design guidance for engineer.								RATIONAL	Basic Necessity
7.1.a.5.ii	General Requirements	Such recirculating room HVAC units shall not receive nonfiltered, nonconditioned outdoor air.	Evidence						47, 261			Q8	Basic Necessity
7.1.a.5.iii	General Requirements	Such recirculating room HVAC units shall serve only a single space.	Evidence					not found				Q7	Further Investigation
7.1.a.5.iv	General Requirements	Such recirculating room HVAC units shall provide a minimum MERV 6 filter for airflow passing over any surface that is designed to condense water.	Rational	Prefilter keep coils clean and functional.								RATIONAL	Basic Necessity
7.1.a.5.v	General Requirements	This filter shall be located upstream of any such cold surface, so that all of the air passing over the cold surface is filtered.	Rational	Prefilter keep coils clean and functional.								RATIONAL	Basic Necessity
7.1.a.6	General Requirements	For air-handling systems serving multiple spaces, system minimum outdoor air quantity shall be calculated utilizing one of the following methods:	Rational	Design guidance for engineer is vague.								RATIONAL	Basic Necessity
7.1.a.6.i	General Requirements	System minimum outdoor air quantity for an air-handling system shall be calculated as the sum of the individual space requirements as defined by this standard.	Rational	Design guidance for engineer is vague.								RATIONAL	Basic Necessity
7.1.a.6.ii	General Requirements	System minimum outdoor air quantity shall be calculated by the Ventilation Rate Procedure (multiple zone formula) of ASHRAE Standard 62.1. The minimum outdoor air change rate listed in this standard shall be interpreted as the Voz (zone outdoor airflow) for purposes of this calculation.	Rational	Design guidance for engineer is vague.	ASHRAE 62.1							RATIONAL	Basic Necessity
7.1.b	General Requirements	Air filtration for spaces shall comply with Table 6.4.	Evidence	Design guidance for engineer				not found				NO	Procedural
7.1.c	General Requirements	Supply air outlets for spaces shall comply with Table 6.7.2.	Evidence	Design guidance for engineer				not found				NO	Procedural
7.1.d	General Requirements	In AII rooms, protective environment rooms, wound intensive-care units (burn units), and operating and procedure rooms (for all classes of surgery), heating with supply air or radiant panels that meet the requirements of Section 6.5.3 shall be provided.	Clinical/Evidence	Design guidance for engineer.					46			Q2	Basic Necessity
7.2	**Additional Room Specific Requirements**	**Additional Room-Specific Requirements**	Section Header									HEAD	
7.2.1	Airborne Infection Isolation (AII) Rooms	Ventilation for AII rooms shall meet the following requirements whenever an infectious patient occupies the room:	Clinical									CLINIC	Procedural
7.2.1.a.i	Airborne Infection Isolation (AII) Rooms	Each AII room shall comply with requirements of Tables 6.4, 6.7.2, and 7.1.	Rational	Redundan								RATIONAL	Basic Necessity
7.2.1.a.ii	Airborne Infection Isolation (AII) Rooms	AII rooms shall have a permanently installed device and/or mechanism to constantly monitor the differential air pressure between the room (when occupied by patients with a suspected airborne infectiou disease) and the corridor, whether or not there is an anteroom.	Rational	Required for controls to maintain the desired pressure relationship								RATIONAL	Basic Necessity
7.2.1.a.iii	Airborne Infection Isolation (AII) Rooms	A local visual means shall be provided to indicate whenever negative differential pressure is not maintained.	Rational	Notifies staff observing patient room not being in compliance in order to alert building operators.								RATIONAL	Basic Necessity
7.2.1.b.i	Airborne Infection Isolation (AII) Rooms	All air from the AII room shall be exhausted directly to the outdoors.	Clinical/Evidence	Exhaust is assumed contaminated. Cross contamination should be prevented.					49, 239, 240, 243			Q7	Basic Necessity
7.2.1.b.ii	Exception	AII rooms that are retrofitted from standard patient rooms from which it is impractical to exhaust directly outdoors may be provided with recirculated air from the room's exhaust on the condition that the air first passes through a HEPA filter.	Rational	The volume of ductwork needed for AII rooms is larger than standard patient rooms and may not fit within the floor to floor height.								RATIONAL	Basic Necessity
7.2.1.c	Airborne Infection Isolation (AII) Rooms	All exhaust air from the AII rooms, associated anterooms, and associated toilet rooms shall be discharged directly to the outdoors without mixing with exhaust air from any other non-AII room or exhaust system.	Evidence								49, 239, 240, 243	Q4	Further Investigation
7.2.1.d	Airborne Infection Isolation (AII) Rooms	Exhaust air grilles or registers in the patient room shall be located directly above the patient bed on the ceiling or on the wall near the head of the bed unless it can be demonstrated that such a location is not practical.	Clinical/Evidence						22, 113, 114, 115	120, 121, 122,123	124	Q2	Further Investigation
7.2.1.e	Airborne Infection Isolation (AII) Rooms	The room envelope shall be sealed to limit leakage airflow at 0.01 in. wc (2.5 Pa) differential pressure across the envelope.	Rational	Required to ensure room pressurization requirements. Pressure differential needs to be validated.								RATIONAL	Basic Necessity
7.2.1.f.ii	Airborne Infection Isolation (AII) Rooms	Differential pressure between AII rooms and adjacent spaces that are not AII rooms shall be a minimum o 0.01 in. wc (-2.5 Pa).	Clinical/Evidence							173	126, 164, 171, 172, 174, 175, 179	Q3	Further Investigation
7.2.1.f.i	Airborne Infection Isolation (AII) Rooms	Spaces such as the toilet room and the anteroom (if present) that are directly associated with the AII room and open directly into the AII room are not required to be designed with a minimum pressure difference from the AII room but are still required to maintain the pressure relationships to adjacent areas specified i Table 7.1.	Rational	Maintaining a pressure differential between these spaces is not practicable.								RATIONAL	Basic Necessity
7.2.1.g	Airborne Infection Isolation (AII) Rooms	When an anteroom is provided, the pressure relationships shall be as follows: (1) the AII room shall be at a negative pressure with respect to the anteroom, and (2) the anteroom shall be at a negative pressure with respect to the corridor.	Rational	Ensure air flow from corriodor to anteroom to AII room. Air flow direction and pressure difference needs to be validated separately.								RATIONAL	Basic Necessity
7.2.2	Protective Environment (PE) Rooms	Protective Environment (PE) Rooms	Section Header									HEAD	
7.2.2.a	Protective Environment (PE) Rooms	The room envelope shall be sealed to limit leakage airflow at 0.01 in. wc (2.5 Pa) differential pressure across the envelope.	Rational	Minimizing leakage is critical to maintaining controllability of the system to achieve desired pressure differentials.								RATIONAL	Basic Necessity
7.2.2.b.i	Protective Environment (PE) Rooms	Each PE room shall comply with the requirements of Tables 6.4, 6.7.2, and 7.1.	Rational	Cross reference	ASHRAE 170							RATIONAL	Basic Necessity
7.2.2.b.ii	Protective Environment (PE) Rooms	PE rooms shall have a permanently installed device and/or mechanism to constantly monitor the differential air pressure between the room and the corridor when occupied by patients requiring a protective environment regardless of whether there is an anteroom.	Rational	Required to provide feedback to HVAC controls to maintain desired pressure differential.								RATIONAL	Basic Necessity
7.2.2.b.iii	Protective Environment (PE) Rooms	A local visual means shall be provided to indicate whenever positive differential pressure is not maintained.	Rational	Notifies staff observing patient room not being in compliance in order to alert building operators.								RATIONAL	Basic Necessity
7.2.2.c.1.i	Protective Environment (PE) Rooms	In protective environment room, supply air diffusers shall be above the patient bed unless it can be demonstrated that such a location is not practical.	Rational/Clinical/Evidence	Obstructions may be present in existing buildings that have program changes to PE rooms. Impact of diffuser location requires evidence.					135, 136			Q2	Basic Necessity
7.2.2.c.1.ii	Protective Environment (PE) Rooms	Diffuser design shall limit air velocity at the patient bed to reduce patient discomfort. (See ASHRAE Standard 55 [2010a] in Informative Appendix B.)	Rational	Drafts may cause thermal discomfort	ASHRAE 55							RATIONAL	Basic Necessity
7.2.2.c.1.iii	Protective Environment (PE) Rooms	Diffuser design shall limit air velocity at the patient bed to reduce patient discomfort.	Rational	Drafts may cause thermal discomfort								RATIONAL	Basic Necessity
7.2.2.c.2	Protective Environment (PE) Rooms	Return/exhaust grilles or registers shall be located near the patient room door.	Clinical/Evidence					not found				Q2	Further Investigation
7.2.2.d.i	Protective Environment (PE) Rooms	Differential pressure between PE rooms and adjacent spaces that are not PE rooms shall be a minimum of +0.01 in. wc (+2.5 Pa).	Evidence								126, 162, 164, 171, 172, 174,	Q3	Further Investigation

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7.2.2.d.ii	Protective Environment (PE) Rooms	Spaces such as the toilet room and the anteroom (if present) that are directly associated with the PE room and open directly into the PE room are not required to be designed with a minimum pressure difference from the PE room but are still required to maintain the pressure relationships to adjacent areas specified in Table 7.1.	Rational	Without doors between spaces it is impractical to maintain pressure differentials between spaces.								RATIONAL	Basic Necessity
7.2.2.e	Protective Environment (PE) Rooms	PE rooms retrofitted from standard patient rooms may be ventilated with recirculated air, provided that air first passes through a HEPA filter and the room complies with parts "a" through "d" of Section 7.2.2.	Clinical/Evidence					not found				MISC	Further Investigation
7.2.2.f	Protective Environment (PE) Rooms	When an anteroom is provided, the pressure relationships shall be as follows: (1) the PE room shall be at a positive pressure with respect to the anteroom and (2) the anteroom shall be at a positive pressure with respect to the corridor.	Clinical/Evidence	Ensure air flow from PE room to anteroom to corridor.					185	187		Q4	Further Investigation
7.2.3	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	Section Header									HEAD	
7.2.3.a	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	Supply air diffusers shall be located above the patient bed.	Evidence	Provides cleanest air to patient. Effectiveness to be validated with evidence.							116, 117, 118, 119, 120	Q2	Further Investigation
7.2.3.b	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	Exhaust grilles or registers shall be located near the patient room door.	Rational/Evidence	Distance from the supply air diffuser ensure short circuiting does not occur. Supply and exhaust locations shall be validated independently.						117, 119		Q2	Change
7.2.3.c	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	The pressure relationship to adjacent areas for the required anteroom shall be one of the following:	Rational									RATIONAL	Basic Necessity
7.2.3.c.i	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	The anteroom shall be at a positive pressure with respect to both the AII/PE room and the corridor or common space.	Clinical/Evidence						187			Q4	Further Investigation
7.2.3.c.ii	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	The anteroom shall be at a negative pressure with respect to both the AII/PE room and the corridor or common space.	Clinical/Evidence						185	187		Q4	Further Investigation
7.2.3.d.i	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	AII/PE rooms shall have two permanently installed devices and/or mechanisms to constantly monitor the differential air pressure. One device and/or mechanism shall monitor the pressure differential between the AII/PE room and the anteroom. The second device and/or mechanism shall monitor the pressure differential between the anteroom and the corridor or common space	Rational	Required for building controls and verifying compliance with standard. Pressure differentials requirements shall be validated separately.								RATIONAL	Basic Necessity
7.2.3.d.ii	Combination Airborne Infectious Isolation/Protective Environment (AII/PE) Rooms.	For each device and/or mechanism, a local visual means shall be provided to indicate whenever differential pressure is not maintained.	Rational	Provides building occupants feedback to ensure systems are maintaining desired setpoints.								RATIONAL	Basic Necessity
7.3	Critical-Care Units	Critical Care Units	Section Header									HEAD	
7.3.1	Wound Intensive-Care Units (Burn Units)	Burn-unit patient rooms that require humidifiers to comply with Table 7.1 shall be provided with individual humidity control.	Clinical/Evidence		ASHRAE 170 Table 7.1						205, 214	Q6	Further Investigation
7.4	Surgery Rooms	Surgery Rooms	Section Header									HEAD	
7.4.1.i	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times.	Clinical/Evidence						53, 148, 162, 163, 167, 168, 180		164, 165, 166, 168, 170, 171, 177, 178, 181	Q3	Basic Necessity
7.4.1.ii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	A pressure differential shall be maintained at a value of at least +0.01 in. wc (2.5 Pa).	Clinical/Evidence							180	162, 181	Q3	Further Investigation
7.4.1.iii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	Each room shall have individual temperature control.	Rational	Required when room used for multiple types of surgery.								RATIONAL	Basic Necessity
7.4.1.a.i	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	These rooms shall be provided with primary supply diffusers that are designed as follows: the airflow shall be unidirectional, downwards.	Clinical/Evidence						136,137			Q2	Basic Necessity
7.4.1.a.ii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	The average velocity of the diffusers shall be 25 to 35 cfm/ft2 (127 to 178 L/s/m2).	Clinical/Evidence	Where is this measured? Cross reference to definitions. Evidence needed to support velocity.						101, 102, 19	95, 103	Q2	Change
7.4.1.a.iii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	The diffusers shall be concentrated to provide an airflow pattern over the patient and surgical team.	Clinical/Evidence						62, 63			Q2	Basic Necessity
7.4.1.b.i	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	The area of the primary supply diffuser array shall extend a minimum of 12 in. (305 mm) beyond the footprint of the surgical table on each side.	Clinical/Evidence								111	Q2	Further Investigation
7.4.1.b.ii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	No more than 30% of the primary supply diffuser array area shall be used for nondiffuser uses such as lights, gas columns, etc.	Clinical/Evidence	Provides space for boom. Percentage to be validated separately.							78, 95, 96, 97, 110	Q2	Further Investigation
7.4.1.b.iii	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	Additional supply diffusers may be required to provide additional ventilation to the operating room to achieve the environmental requirements of Table 7.1 relating to temperature, humidity, etc.	Rational	Diffuser area over table may not be large enough to ensure thermal comfort or a properly mixed space.								RATIONAL	Basic Necessity
7.4.1.iv	Operating Rooms (Class B and C), Operating/Surgical Cystoscopic Rooms, and Caesarean Delivery Rooms	The room shall be provided with at least two low sidewall return or exhaust grilles spaced at opposite corners or as far apart as possible, with the bottom of these grilles installed approximately 8 in. (203 mm) above the floor.	Clinical/Evidence								94	Q2	Further Investigation
7.4.1.v	Exception	In addition to the required low return (or exhaust) air grilles, such grilles may be placed high on the walls.	Clinical/Evidence								94	Q2	Further Investigation
7.4.2.i	Sterilization Rooms	Steam that escapes from a steam sterilizer shall be exhausted using an exhaust hood or other suitable means.	Rational	Heat load and moisture may build up in space and should be removed for thermal comfort purposes.								RATIONAL	Basic Necessity
7.4.2.ii	Sterilization Rooms	Ethylene oxide that escapes from a gas sterilizer shall be exhausted using an exhaust hood or other suitable means.	Rational	Ethylene oxide is flammable and should be exhausted to support life safety goals.								RATIONAL	Basic Necessity
7.4.3.i	Imaging Procedure Room	If invasive procedures occur in this type of room, ventilation shall be provided in accordance with the ventilation requirements for procedure rooms (Class A surgery).	Clinical/Evidence					not found				Q1	Further Investigation
7.4.3.ii	Imaging Procedure Room	If anesthetic gases are administered, ventilation shall be provided in accordance with the ventilation requirements for operating rooms (Class B or C surgery).	Clinical/Evidence					not found				Q1	Further Investigation
7.5	Support Rooms	Support Spaces	Section Header									HEAD	
7.5.1.a	Morgue and Autopsy Rooms	Low sidewall exhaust grilles shall be provided unless exhaust air is removed through an autopsy table designed for this purpose.	Clinical/Evidence					not found				Q2	Further Investigation
7.5.1.b	Morgue and Autopsy Rooms	All exhaust air from autopsy, nonrefrigerated body-holding, and morgue rooms shall be discharged directly to the outdoors without mixing with air from any other room or exhaust system.	Clinical/Evidence					not found				Q7	Further Investigation
7.5.1.c	Morgue and Autopsy Rooms	Differential pressure between morgue and autopsy rooms and any adjacent spaces that have other functions shall be a minimum of-0.01 in. wc (-2.5 Pa).	Clinical/Evidence					not found				Q3	Further Investigation
7.5.2.a	Bronchoscopy	Differential pressure between bronchoscopy procedure and sputum induction rooms and any adjacent spaces that have other functions shall be a minimum of -0.01 in. wc (-2.5Pa).	Clinical/Evidence							173		Q3	Further Investigation
7.5.2.b	Bronchoscopy	Local exhaust shall be provided for sputum collection procedures.	Clinical/Evidence								176	Q2	Further Investigation
7.6	Psychiatric Patient Areas	Psychiatric Patient Areas	Section Header									HEAD	
7.6.i	Psychiatric Patient Areas	All exposed equipment located with these spaces shall have enclosures with rounded corners and tamper-resistant fasteners.	Rational	Safety requirement								RATIONAL	Basic Necessity
7.6.ii	Psychiatric Patient Areas	With the exception of HVAC room recirculating units, equipment shall be arranged such that maintenance personnel are not required to enter patient-care spaces for service.	Rational	Typically clinical operations don't allow maintenance staff easy access to patient areas as they are often in use.								RATIONAL	Basic Necessity
8	Planning, Construction, and System Start-up	Planning, Construction, and System Startup	Section Header									HEAD	
8.1	Overview	Overview	Section Header									HEAD	
8.1	Planning, Construction, and System Start-up overview	For HVAC systems serving surgery and critical-care spaces, compliance with this standard requires preparation of an acceptance testing plan.	Rational									RATIONAL	Basic Necessity
8.2	Planning for HVAC Service in a New Facility	Planning for HVAC Service in a New Facility	Section Header									HEAD	
8.2.a	General Mechanical Equipment Rooms	The access to mechanical rooms shall be planned to avoid the intrusion of maintenance personnel into surgical and critical-care patient spaces.	Rational	Typically clinical operations don't allow maintenance staff easy access to patient areas as they are often in use.								RATIONAL	Basic Necessity

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Section	Topic	Statement	Category	Rational Inclusion	Rational Inclusion Source	Clinical Practice	Clinical Inclusion Source	Evidence Availability	Evidence Support the requirement	Evidence Rejects the Requirement	Relevant but Inconclusive Evidence	Research Question	Conclusion
8.2.b.i	Mechanical Room Layout	Mechanical room layout shall include sufficient space for access to equipment for operation, maintenance, and replacement.	Rational	Mechanical systems have a lifetime typically less than the building lifetime. Therefore the systems will need to be maintained and replaced. A pathway for the replacement system must be planned.								RATIONAL	Basic Necessity
8.2.b.ii	Mechanical Room Layout	Floors in mechanical rooms shall be sealed, including sealing around all penetrations, when they are above surgical suites and critical care.	Rational	Leaks are more likely in a mechanical room. The floor must be sealed to prevent water damage to the spaces below.								RATIONAL	Basic Necessity
8.2.c.i	Maintenance/Repair Personnel Access	Safe and practical means of accessing equipment shall be provided.	Rational	Mechanical systems require maintenance and personnel must have access to perform said maintenace.								RATIONAL	Basic Necessity
8.2.c.ii	Maintenance/Repair Personnel Access	Clearance is required at all service points to mechanical equipment to allow personnel access and working space.	Rational	Mechanical systems require maintenance and personnel must have access to perform said maintenace.								RATIONAL	Basic Necessity
8.3	Planning for the HVAC Services in an Existing Facility	**Planning for the HVAC Services in an Existing Facility**	Section Header									HEAD	
8.3	Planning for the HVAC Services in an Existing Facility	If any existing air-handling equipment is reused, the designer shall evaluate the capacity of the equipment to determine whether it will meet the requirements of this standard for the remodeled space.	Rational									RATIONAL	Basic Necessity
8.4	Planning for Infection Control During Remodeling of an Existing Facility	**Planning for Infection Control During Remodeling of an Existing Facility**	Section Header									HEAD	
8.4.i	Planning for Infection Control During Remodeling of an Existing Facility	Prior to beginning modifications or remodeling of HVAC systems in an existing facility, an owner shall conduct an infection control risk assessment (ICRA).	Rational/Clinical/Evidence									NO	Procedural
8.4.ii	Planning for Infection Control During Remodeling of an Existing Facility	The ICRA shall establish those procedures required to minimize the disruption of facility operation and the distribution of dust, odors, and particulates.	Rational/Clinical/Evidence									NO	Procedural
8.5	Documentation of New or Remodeled HVAC Systems	**Documentation of New or Remodeled HVAC Systems**	Section Header									HEAD	
8.5.i	Documentation of New or Remodeled HVAC Systems	Owners shall retain an acceptance testing report for their files.	Rational									RATIONAL	Basic Necessity
8.5.ii	Documentation of New or Remodeled HVAC Systems	In addition, the design shall include requirements for operations and maintenance staff training that is sufficient for the staff to keep all HVAC equipment in a condition that will maintain the original design intent for ventilation.	Rational									RATIONAL	Basic Necessity
8.5.iii	Documentation of New or Remodeled HVAC Systems	Training of operating staff shall include an explanation of the design intent.	Rational									RATIONAL	Basic Necessity
8.5.a	Documentation of New or Remodeled HVAC Systems	The training materials shall include O&M procedures.	Rational									RATIONAL	Basic Necessity
8.5.b	Documentation of New or Remodeled HVAC Systems	The training materials shall include, temperature and pressure control operation in all modes.	Rational									RATIONAL	Basic Necessity
8.5.c	Documentation of New or Remodeled HVAC Systems	The training materials shall include, acceptable tolerances for system temperatures and pressures.	Rational									RATIONAL	Basic Necessity
8.5.d	Documentation of New or Remodeled HVAC Systems	The training materials shall include procedures for operations under emergency power or other abnormal conditions that have been considered in the facility design.	Rational									RATIONAL	Basic Necessity
8.6	Duct Cleanliness	**Duct Cleanliness**	Section Header									HEAD	
8.6.a.i	Duct Cleanliness	The duct system shall be free of construction debris.	Rational		SMACNA							RATIONAL	Basic Necessity
8.6.a.ii	Duct Cleanliness	New supply duct system installations shall comply with level "B", the Intermediate Level of SMACNA Duct Cleanliness for New Construction Guidelines.	Clinical/Evidence	Cross reference to SMACNA	SMACNA			not found				NO	Further Investigation
8.6.b	Duct Cleanliness	The supply diffusers in operating rooms (Class B and C surgery) shall be opened and cleaned before the space is used.	Clinical/Evidence					not found				NO	Further Investigation
8.6.c	Duct Cleanliness	The permanent HVAC systems shall not be operated unless protection from contamination of the air distribution system is provided.	Clinical/Evidence					not found				NO	Further Investigation

Row	Author	Title	Journal	Volume	Number	Month	Pages	Year
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2	Abboud, Cely Saad; Wey, Sergio Barsanti; Baltar, Valeria Trancoso	Risk factors for mediastinitis after cardiac surgery	The Annals of Thoracic Surgery	77	2	February	676--683	2004
3	Abdul Salam, Zakir Hussain; Karlin, Rubiyah Binte; Ling, Moi Lin; Yang, Kok Soong	The impact of portable high-efficiency particulate air filters on the incidence of invasive aspergillosis in a large acute tertiary-care hospital	American Journal of Infection Control	38	4		e1--e7	2010
4	Abraham, J. P.; Plourde, B. D.; Vallez, L. J.	Comprehensive review and study of the buoyant air flow within positive-pressure hospital operating rooms	Numerical Heat Transfer, Part A: Applications	72	1	July	1--20	2017
5	Abundo, Paolo; Rosato, Nicola; Abundo, Marchchchio	A Stochastic Model for Infective Events in Operating Room Caused by Air Contamination	AIP Conference Proceedings				198--210	2008
6	Adams, Noah J.; Johnson, David L.; Lynch, Robert A.	The effect of pressure differential and care provider movement on airborne infectious isolation room containment effectiveness	American Journal of Infection Control	39	2		91--97	2011
7	Adamu, Z. A.; Price, A. D. F.; Cook, M. J.	Performance evaluation of natural ventilation strategies for hospital wards - A case study of Great Ormond Street Hospital	Building and Environment	56			211--222	2012
8	Adamu, Za; Cook, Mj; Price, Adf	Natural Personalised Ventilation-A Novemberel Approach	International Journal of Ventilation	10	3		263--275	2011
9	U.S. Energy Information Administration	Commercial Building Energy Consumption Survey (CBECS)						2012
10	Afram, Abdul; Januaryabi-Sharifi, Farrokh	Theory and applications of HVAC control systems - A review of model predictive control (MPC)	Building and Environment	72			343--355	2014
11	AgaNovemberic, AMarchchch; Cao, Guangyu; Stenstad, Livinger; Skogaas, January Gunnar	Impact of surgical lights on the velocity distribution and airborne contamination level in an operating room with laminar airflow system	Building and Environment	126			42--53	2017
12	Ahmad, Nabeeha; Hussein, Ahmed A.; Cavuoto, Lora; Sharif, Mohamed; Allers, Jenna C.; Hinata, Nobuyuki; Ahmad, Basel; Kozlowski, Justen D.; Hashmi, Zishan; Bisantz, Ann; Guru, Khurshid A.	Ambulatory movements, team dynamics and interactions during robot-assisted surgery	BJU International	118	1		132--139	2016
13	Ahmadi	Lagrangian versus Eulerian Method for Nano-Particles	Modelling and Computation of Nanoparticles in Fluid Flows					2009
14	AIA	Guidelines for design and construction of health care facilities.						2006
15	Ajraoui, S.; Parra-Robles, J.; Marchchchshall, H.; Deppe, M. H.; Clemence, M.; Wild, J. M.	Acquisition of 3He ventilation images, ADC, T 2* and B 1 maps in a single scan with compressed sensing	NMR in Biomedicine	25	1		44--51	2012
16	Al-Benna, Sammy	Infection control in operating theatres.	Journal of perioperative practice	22	10	October	318--22	2012
17	Aliabadi, Amir A.; Rogak, Steven N.; Bartlett, Karen H.; Green, Sheldon I.	Preventing airborne disease transmission: review of methods for ventilation design in health care facilities.	Advances in preventive medicine	2011			1--21	2011
18	Aljeesh, Yousef; Madhoun, Wesam Al; Shamh, Iyad Abu; Arcaya, Marchchchiana	Assessment of Indoor Air Quality in Neonatal Intensive Care Units in Government Hospitals in Gaza Strip , Palestine		6	1		24--30	2016
19	Allen-Bridson, Katherine; Gross, Cindy; Hebden, Joan N.; Morrell, Gloria C.; Wright, Marchchchc Oliver; Horan, Teresa	Healthcare-associated infections studies project: An American Journal of Infection Control and National Healthcare Safety Network data quality collaboration - Ventilator-associated event 1, 2013	American Journal of Infection Control	41	11		1085--1086	2013
20	Allocca, Camille; Chen, Qingyan; Glicksman, Leon R.	Design analysis of single-sided natural ventilation	Energy and Buildings	35	8		785--795	2003
21	Alonso, E.; Aramendi, E.; Gonzalez-Otero, D.; Ayala, U.; Daya, M.; Russell, J. K.	Empirical mode Decemberomposition for chest compression and ventilation detection in cardiac arrest	Computing in Cardiology	41		January	17--20	2014
22	Alvarez, M.; Ponga, B. L.; Rayon, C.; Gala, J. G.; Porto, M. C. R.; Gonzalez, M.; Marchchchtinez-Suarez, J. V.; Rodriguez-Tudela, J. L.	Nosocomial outbreak caused by Scedosporium prolificans (inflatum): Four fatal cases in leukemic patients	Journal of Clinical Microbiology	33	12		3290--3295	1995
23	Al-waked, Rafat	Effect of ventilation strategies on infection control inside operating theatres	Engineering Applications of Computational Fluid Mechanics	4	1		1--16	2010
24	Anderson, Deverick J.; Kirkland, Kathryn B.; Kaye, Keith S.; Thacker, Paul A.; Kanafani, Zeina A.; Auten, Grace; Sexton, Daniel J.	Underresourced Hospital Infection Control and Prevention Programs: Penny Wise, Pound Foolish?	Infection Control & Hospital Epidemiology	28	7		767--773	2007
25	Anderson, J. D.; Bonner, M.; Scheifele, D. W.; Schneider, B. C.	Lack of nosocomial spread of Varicella in a pediatric hospital with negative pressure ventilated patient rooms.	Infection control : IC	6	3		120--121	1985
26	Andersson, Annette Erichsen; Bergh, Ingrid; Karlsson, Jon; Eriksson, Bengt I.; Nilsson, Kerstin	Traffic flow in the operating room: An explorative and descriptive study on air quality during orthopedic trauma implant surgery	American Journal of Infection Control	40	8		750--755	2012
27	Aoki, Hirooki; Ichimura, Shiro; Koshiji, Kohji	Calculation of ventilation threshold using noncontact respirometry	Engineering in Medicine				2273--6	2008
28	Araujo, Ricardo; Cabral, Jo~ao Paulo; Rodrigues, Ac'acio Gonccalves	Air filtration systems and restrictive access conditions improve indoor air quality in clinical units: Penicillium as a general indicator of hospital indoor fungal levels	American Journal of Infection Control	36	2		129--134	2008
29	Araujo, R.; Carneiro, A.; Costa-Oliveira, S.; Pinavaz, C.; Rodrigues, A. G.; GuiMarchchchaes, J. E.	Fungal infections after haematology unit reNovemberation: evidence of clinical, environmental and economical impact	European journal of haematology	80			436--443	2008
30	The American Institute of Architects	Guidelines for Construction and Equipment of Hospital and Medical facilities						1993
31	Arlet, G.; Gluckman, E.; Gerber, F.; Perol, Y.; Hirsch, A.	Measurement of bacterial and fungal air counts in two bone-Marchchchrow transplant units	Journal of Hospital Infection	13	1		63--69	1989
32	Asahara, Akinori; Marchchchuyama, Kishiko; Sato, Akiko; Seto, Kouichi	Pedestrian-movement prediction based on mixed Marchchchkov-chain model					25	2011
33	Ascione, Fabrizio; Bianco, Nicola; De Masi, Rosa Francesca; Vanoli, GiuSeptemberpe Peter	Rehabilitation of the building envelope of hospitals: Achievable energy savings and microclimatic control on varying the HVAC systems in Mediterranean climates	Energy and Buildings	60			125--138	2013
34	Asgharian, Bahman; Price, Owen T.	Deposition of ultrafine (nano) particles in the human lung.	Inhalation toxicology	19	13		1045--1054	2007
35	ASHRAE	HVAC Design Manual for Hospitals and Clinics					298	2003
36	ASHRAE	Ventilation of health care facilities						2008
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38	ASHRAE Standard 170	Ventilation of healthcare facilities	ASHRAE STANDARD 170				1--26	2013
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Row	Author	Title	Journal	Volume	Number	Month	Pages	Year
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41	Atkinson, James; Chartier, Yves; Pessoa-Silva, Carmen Garcia; Jensen, Paul; Li, Yuguo; Seto, Wing-Hong	Natural Ventilation for Infection Control in Health-Care Settings	World Health Organization (WHO)				133 p.	2009
42	Avalos Ramirez, Antonio; Benard, Sandrine; Giroir-Fendler, Anne; Jones, J. Peter; Heitz, Michele	Treatment of air polluted with methanol vapours in biofilters with and without percolationThis article is one of a selection of papers published in this Special Issue on Biological Air Treatment.	Canadian Journal of Civil Engineering	36	12		1911--1918	2009
43	Ayliffe, G. A.	Role of the environment of the operating suite in surgical wound infection.	Reviews of infectious diseases		Suppl 10		S800--4	1991
44	Babb, J. R.; Lynam, P.; Ayliffe, G. A. J.	Risk of airborne transmission in an operating theatre containing four ultraclean air units	Journal of Hospital Infection	31	3	November	159--168	1995
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46	Bache, Sarah E.; Maclean, Michelle; Gettinby, George; Anderson, John G.; Macgregor, Scott J.; Taggart, Ian	Airborne bacterial dispersal during and after dressing and bed changes on burns patients	Burns	41	1		39--48	2015
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48	A, Baillot M, Brünner F, Diepenbrock J., Sander	Pollution of operating room air by anesthetic gases in relation to the air conditioning method and anesthesia techniques	International journal of hygiene and environmental medicine	195	4		299-305	1994
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50	Balocco, Carla	Modelling infection spreading control in a hospital isolation room	Journal of Biomedical Science and Engineering	3	7		653--663	2010
51	Balocco, Carla; Lio, Pietro	Assessing ventilation system performance in isolation rooms	Energy and Buildings	43	1		246--252	2011
52	Barbosa, Bruno Perazzo Pedroso; Brum, Nisio de Carvalho Lobo	Sensitivity Tests of Biological Safety Cabinets' Contaminant Contention to Variations on Indoor Flow Parameters in Biosafety Level Laboratories	Building and Environment	124			1--13	2017
53	Barnes, R. A.; Rogers, T. R.	Control of an outbreak of nosocomial aspergillosis by laminar air-flow isolation	Journal of Hospital Infection	14			89--94	1989
54	Bartley, Judene	Behind the change in ASHRAE/ASHE standard 170	ASHRAE		2		2--4	2011
55	Bartley, J.; Bjerke, N. B.	Infection control considerations in critical care unit design and construction: a systematic risk assessment.	Critical care nursing quarterly	24	3		43--58	2001
56	Bartley, Judene Mueller	APIC State-of-the-Art Report: The role of infection control during construction in health care facilities	American Journal of Infection Control	28	2		156--169	2000
57	Bartley, Judene M.; Olmsted, Russell N.; Haas, Januaryet	Current views of health care design and construction: Practical implications for safer, cleaner environments	American Journal of Infection Control	38	5 SUPPL.		S1--S12	2010
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61	Beauchene, Christian; Laudinet, Nicolas; Choukri, Firas; Rousset, Jean-Luc; Benhamadouche, Sofiane; Larbre, Julyiette; Chaouat, Marchchchc; Benbunan, Marchchchc; Mimoun, Maurice; Lajonchere, Jean-Patrick; Bergeron, Vance; Derouin, Francis	Accumulation and transport of microbial-size particles in a pressure protected model burn unit: CFD simulations and experimental evidence.	BMC infectious diseases	11	1		58	2011
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65	Leung, Michael; Chan, Alan H. S.	Control and management of hospital indoor air quality	Medical science monitor	12	3		SR17--R23	2006
66	Mousavi, Ehsan S.; Grosskopf, Kevin R.	ReNovemberation in hospitals : a case study of source control ventilation in work zones	Advances in Building Energy Research					2018
67	Mousavi, Ehsan S.; Grosskopf, Kevin R. K. R.	Ventilation rates and airflow pathways in patient rooms: A case study of bioaerosol containment and removal	Annals of Occupational Hygiene	59	9		1190--1199	2015
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70	Robertson, Elizabeth Chant; Doyle, M. Elizabeth	ON THE CONTROL OF AIR-BORNE BACTERIA IN OPERATING ROOMS AND HOSPITAL WARDS: A PRELIMINARY REPORT	Annals of surgery	111	3		491	1940
71	Tao, Yao; Inthavong, Kiao; Tu, Jiyuan	A numerical investigation of wind environment around a walking human body	Journal of Wind Engineering and Industrial Aerodynamics	168			9--19	2017
72	Watt, James	The ventilation, heating and lighting of hospital wards					1411--1426	1933
73	Beggs, C.; Knibbs, L. D.; Johnson, G. R.; Morawska, L.	Environmental contamination and hospital-acquired infection: Factors that are easily overlooked	Indoor Air	25	5		462--474	2015
74	Beggs, C. B.	The Airborne Transmission of Infection in Hospital Buildings: Fact or Fiction?	Indoor and Built Environment	12	1		9--18	2003
75	Beggs, Clive B.; Kerr, Kevin G.; Noakes, Catherine J.; Hathway, E. Abigail; Sleigh, P. Andrew	The ventilation of multiple-bed hospital wards: Review and analysis	American Journal of Infection Control	36	4		250--259	2008
76	Beggs, Clive B.; Shepherd, Simon J.; Kerr, Kevin G.	Potential for airborne transmission of infection in the waiting areas of healthcare premises: stochastic analysis using a Monte Carlo model	BMC infectious diseases	10			247	2010
77	Bellardine, C. L.; Ingenito, E. P.	Tracking Severity and Distribution of Lung Disease During Mechanical Ventilation: Applications to Bronchoconstriction and Respiratory Distress Syndrome	Proceedings of the Second Joint EMBSBMES Conference				1474--1475	2002
78	Bellardine, C. L.; Ingenito, E. P.; Hoffman, A.; Lopez, F.; Sanborn, W.; Suki, B.; Lutchen, K. R.	Heterogeneous airway versus tissue mechanics and their relation to gas exchange function during mechanical ventilation	Annals of Biomedical Engineering	33	5		626--641	2005
79	Bellchambers, J.; Harris, J. M.; Cullinan, P.; Gaya, H.; Pepper, J. R.	A prospective study of wound infection in coronary artery surgery	European Journal of Cardio-Thoracic Surgery	15	1	January	45--50	1999
80	Belleri, AnnaMarchchchia; Lollini, Roberto; Dutton, Spencer M.	Natural ventilation design: An analysis of predicted and measured performance	Building and Environment	81			123--138	2014
81	Berg, Regan J.; Inaba, Kenji; Sullivan, Maura; Okoye, Obi; Siboni, Stefano; Minneti, Michael; Teixeira, Pedro G.; Demetriades, Demetrios	The impact of heat stress on operative performance and cognitive function during simulated laparoscopic operative tasks	Surgery (United States)	157	1		87--95	2015
82	Bergeron, V.; Reboux, G.; Poirot, J. L.; Laudinet, N.	Decemberreasing Airborne Contamination Levels in Highâ€Risk Hospital Areas Using a Novemberel Mobile Airâ€Treatment Unit â€¢	Infection Control and Hospital Epidemiology	28	10		1181--1186	2007

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84	Bhat, Vivek; Kelkar, Rohini; Biswas, Sanjay; NataraJanuary, Gita	Ventilator-associated pneumonia: Survey of infection control practices in intensive care units of 15 tertiary care hospitals in Mumbai	American Journal of Infection Control	42	8		935--936	2014
85	Birgand, Gabriel; Toupet, Gaelle; Rukly	Air contamination for predicting wound contamination in clean surgery: A large multicenter study	American Journal of Infection Control	43	5		516--521	2015
86	Bischoff, Werner E.; Tucker, Brian K.; Wallis, Michelle L.; Reboussin, Beth A.; Pfaller, Michael A.; Hayden, Frederick G.; Sherertz, Robert J.	Preventing the airborne spread of Staphylococcus aureus by persons with the common cold: effect of surgical scrubs, gowns, and masks.		28	10		1148--1154	2007
87	Bivolarova, Marchchchiya P.; Melikov, Arsen K.; Mizutani, Chiyomi; Kajiwara, Kanji; Bolashikov, Zhecho D.	Bed-integrated local exhaust ventilation system combined with local air cleaning for improved IAQ in hospital patient rooms	Building and Environment	100			10--18	2016
88	Björkman, Author J Nagaev, I Berg, O G Hughes, D Andersson, D I	Effects of Environment on Compensatory Mutations to Ameliorate Costs of Antibiotic Resistance	Science	287	5457		1479--1482	2000
89	Blom, A. W.; Bowker, K. E.; Wooton, M.; MacGowan, A. P.; Smith, E. J.; Bannister, G. C.	Contamination of wounds by direct inoculation in total hip arthroplasty: a prospective clinical study	Journal of Hospital Infection	40	1	September	79--80	1998
90	Blowers, R.; Crew, B.	Ventilation of operating-theatres.	The Journal of hygiene	58	4		427--448.2	1960
91	Bolashikov, Zhecho D.; Melikov, Arsen K.; Kierat, Wojciech; Popiolek, Zbigniew; Brand, Marchchchek	Exposure of health care workers and occupants to coughed airborne pathogens in a double-bed hospital patient room with overhead mixing ventilation		18	4		602--615	2012
92	Bolister, N. J.; Johnson, H. E.; Wathes, C. M.	The ability of airborne Klebsiella pneumoniae to colonize mouse lungs.	Epidemiology and infection	109	1		121--131	1992
93	Bonnema, Eric; Studer, Daniel; Parker, Andrew; Pless, Shanti; Torcellini, Paul	Large Hospital 50% Energy Savings : Technical Support Document Large Hospital 50% Energy Savings : Technical Support Document	National Renewable Energy Laboratory			September		2010
94	Borges, João Batista, Irina Velikyan, Bengt Långström, Jens Sörensen, Johan Ulin, Enn Marchchchipuu, Mattias Sandström, Charles Widström, and Göran Hedenstiern	Ventilation distribution studies comparing Technegas and Gallgas" using 68GaCl3 as the label."	Journal of nuclear medicine : official publication, Society of Nuclear Medicine	52	2		206--9	2011
95	Borrello, Mike	A Feedback Control Approach to the Estimation of Patient Airway and Leak Flow for Non-Invasive , Positive Pressure Ventilation (NPPV)	American Control Conference (ACC)				3982--3987	2016
96	Bosanquet, D.; Jones, C. N.; Gill, N.; Jarvis, P.; Lewis, M. H.	Laminar flow reduces cases of surgical site infections in vascular patients	Annals of the Royal College of Surgeons of England	95	1		15--19	2013
97	Boswell, T.	Use of HEPA filters to reduce airborne concentrations of Pseudomonas aeruginosa						2006
98	Boswell, T. C.; Fox, P. C.	Reduction in MRSA environmental contamination with a portable HEPA-filtration unit.	Journal of Hospital Infection	63	1		47--54	2006
99	Bouza, E.; Pelaez, T.; Perez-Molina, J.; Marchchchan, M.; Alcala, L.; Padilla, B.; Munioz, P.; Aspergillus Study Team	Demolition of a hospital building by controlled explosion: the impact on filamentous fungal load in internal and external air.	Journal of Hospital Infection	52	4		234--242.	2002
100	Brady, Michael T.	Health care-associated infections in the neonatal intensive care unit	American Journal of Infection Control	33	5		268--275	2005
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102	Brandt, Christian; Hott, Uwe; Sohr, Dorit; Daschner, Franz; Gastmeier, Petra; Ruden	Operating Room Ventilation With Laminar Airflow Shows No Protective Effect on the Surgical Site Infection Rate in Orthopedic and Abdominal Surgery	Annals of Surgery	248	5	November	695--700	2008
103	Brandt, Steve; Taylor, Stephanie	Humidity , Human Health and Implications in improving Health Care					1--57	2015
104	Breathnach, A. S.; De Ruiter, A.; Holdsworth, G. M. C.; Bateman, N. T.; O'Sullivan, D. G. M.; Rees, P. J.; Snashall, D.; Milburn, H. J.; Peters, B. S.; Watson, J.; Drobniewski, F. A.; French, G. L.	An outbreak of multi-drug-resistant tuberculosis in a London teaching hospital	Journal of Hospital Infection	39	2		111--117	1998
105	Breier, Ann-Christin; Brandt, Christian; Sohr, Dorit; Geffers, Christine; Gastmeier, Petra	Laminar Airflow Ceiling Size: No Impact on Infection Rates Following Hip and Knee Prosthesis	Infection Control and Hospital Epidemiology	32	11		1097--1102	2011
106	Brogmus, George; Leone, William; Butler, Lorraine; Hernandez, Edward	Best Practices in OR Suite Layout and Equipment Choices to Reduce Slips, Trips, and Falls	AORN Journal	86	3		384--398	2007
107	Brohus, H.; Hyldig, M.; Kamper, S.; Vachek, U. M.	Influence of disturbances on bacteria level in an operating room.	Proceedings of Indoor Air 2008				3106--3111	2008
108	Brunner, Clemens; Delorme, Arnaud; Makeig, Scott	Thermomanagement in Neonatology and Paediatrics: Clinical Problems and Challenges.	Biomed Tech	58	1		24--25	2013
109	Bruschweiler, Evin D.; Danuser, Brigitta; Huynh, Cong Khanh; Wild, Pascal; Schupfer, Patrick; Vernez, David; Boiteux, Philippe; Hopf, Nancy B.	Generation of polycyclic aromatic hydrocarbons (PAHs) during woodworking operations.	Frontiers in oncology	2		October	148	2012
110	Budaiwi, Ismail M.; Al-Homoud, Mohammad S.	Effect of ventilation strategies on air contaminant concentrations and energy consumption in buildings	International Journal of Energy Research	25	12		1073--1089	2001
111	Burgess, J. L., Blackmon, G. M., Brodkin, C. A., Robertson, W.	Hospital preparedness for Hazardous Materials Incidents and Treatment of ContaminatedArticles Hospital Preparedness Patients	Occupational and Environmental Medicine Program,				387--391	1997
112	Burlingame, Byron	Operating Room Requirements for 2014 and Beyond					1--6	2014
113	Burroughs, H. E.	Filtration: An investment in IAQ	HPAC August.				55--65	1997
114	Burton, Mike	Lower Humidity Requirements in Surgery and Other Spaces : Why and What It Means Objectives	Florida healthcare engineering association					2010
115	Caglar, Omur; Atilla, Bulent; Tokgozoglu, Mazhar; Alpaslan, Mumtaz	The effect of collar on aSeptembertic loosening and proximal femoral bone resorption in hybrid total hip arthroplasty.	Orthopedics	31	3		227	2008
116	Campbell, Darrell A.; Henderson, William G.; Englesbe, Michael J.; Hall, Bruce L.; O'Reilly, Michael; Bratzler, Dale; Dellinger, E. Patchen; Neumayer, Leigh; Bass, Barbara L.; Hutter, Matthew M.; Schwartz, James; Ko, Clifford; Itani, Kamal; Steinberg, Steven M.; Siperstein, Allan; Sawyer, Robert G.; Turner, Douglas J.; Khuri, Shukri F.	Surgical Site Infection Prevention: The Importance of Operative Duration and Blood Transfusionâ€"Results of the First American College of Surgeonsâ€"National Surgical Quality Improvement Program Best Practices Initiative	Journal of the American College of Surgeons	207	6	December	810--820	2008
117	Canha, N.; Mandin, C.; Ramalho, O.; Wyart, G.; Riberon, J.; Dassonville, C.; Hanninen	Assessment of ventilation and indoor air pollutants in nursery and elementary schools in France	Indoor Air	26	3			Canha2016
118	Cao, Guoqing	Effect of ventilation on indoor airborne microbial pollution control		1			390--394	2008
119	Cao, Guangyu; Awbi, Hazim; Yao, Runming; Fan, Yunqing; Siren, Kai; Kosonen, Risto; Zhang, Jianshun (Jensen)	A review of the performance of different ventilation and airflow distribution systems in buildings	Building and Environment	73			171--186	2014
120	Cao, Guangyu; Liu, Shichao; Boor, Brandon E.; Novemberoselac, Atila	Dynamic interaction of a downward plane jet and a cough jet with respect to particle transmission: An analytical and experimental study	Journal of Occupational and Environmental Hygiene	14	8		618--631	2017
121	Cao, G.; Nielsen, P. V.; Jensen, R. L.; Heiselberg, P.; Liu, L.; Heikkinen, J.	Protected zone ventilation and reduced personal exposure to airborne cross-infection	Indoor Air	25	3		307--319	2015
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123	Carrilho da Gracca, G.; Daish, N. C.; Linden, P. F.	A two-zone model for natural cross-ventilation	Building and Environment	89			72--85	2015
124	Cavique, Miguel; Gonccalves-Coelho, A. M.	Axiomatic design and HVAC systems: An efficient design Decemberision-making criterion	Energy and Buildings	41	2		146--153	2009
125	CDC	Update: management of patients with suspected viral hemorrhagic fever	MMWR	44			475--9	1995
126	Cecchini, C.; Verdenelli, M. C.; Orpianesi, C.; Dadea, G. M.; Cresci, A.	Effects of antimicrobial treatment on fiberglassâ€acrylic filters	Journal of applied microbiology	97	2		371--377	2004

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128	Chang, Le; Tu, Shuyang; Ye, Wei; Zhang, Xu	Dynamic simulation of contaminant inleakage produced by human walking into control room	International Journal of Heat and Mass Transfer	113			1179--1188	2017
129	Chang, Le; Zhang, Xu; Wang, Shengji; Gao, June	Control room contaminant inleakage produced by door opening and closing: Dynamic simulation and experiments	Building and Environment	98			11--20	2016
130	Chang, T. J.; Hsieh, Y. F.; Kao, H. M.	Numerical investigation of airflow pattern and particulate matter transport in naturally ventilated multi-room buildings	Indoor Air	16	2		136--152	2006
131	Chao, C. Y.; Wan, M. P.	Experimental study of ventilation performance and contaminant distribution of underfloor ventilation systems vs. traditional ceiling-based ventilation system	Indoor Air	14	5		306--316	2004
132	Chao, C. Y. H.; Wan, M. P.	A study of the dispersion of expiratory aerosols in unidirectional downward and ceiling-return type airflows using a multiphase approach	Indoor Air	16	4	August	296--312	2006
133	Chao, C. Y. H.; Wan, M. P.; To, G. N. S.	Transport and removal of expiratory droplets in hospital ward environment	Aerosol Science and Technology	42	5		377--394	2008
134	Charnley, J.	Postoperative infection after total hip replacement with special reference to air contamination in the operating room						1972
135	Charnley, J.	Clean air in the operating room.	Cleveland Clinic quarterly	40	3		99--114	1973
136	Chau, O. K. Y.	CFD Analysis of the Performance of a Local Exhaust Ventilation System in a Hospital Ward	Indoor and Built Environment	15	3		257--271	2006
137	Chen, C.; Zhao, B.	Some questions on dispersion of human exhaled droplets in ventilation room: Answers from numerical investigation	Indoor Air	20	2		95--111	2010
138	Chen, Chun; Zhao, Bin; Cui, Weilin; Dong, Lei; An, Na; Ouyang, Xiangying	The effectiveness of an air cleaner in controlling droplet/aerosol particle dispersion emitted from a patient's mouth in the indoor environment of dental clinics.	Journal of the Royal Society, Interface / the Royal Society	7	48		1105--18	2010
139	Chen, Chun; Zhao, Bin; Yang, Xudong; Li, Yuguo	Role of two-way airflow owing to temperature difference in severe acute respiratory syndrome transmission: revisiting the largest nosocomial severe acute respiratory syndrome outbreak in Hong Kong.	Journal of the Royal Society, Interface / the Royal Society	8	58		699--710	2011
140	Chen, Huijuan; Januarybakhsh, Setareh; Larsson, Ulf; Moshfegh, Bahram	Numerical investigation of ventilation performance of different air supply devices in an office environment	Building and Environment	90			37--50	2015
141	Chen, S. C.; Chang, C. F.; Liao, C. M.	Predictive models of control strategies involved in containing indoor airborne infections	Indoor Air	16	6		469--481	2006
142	Siu Mee Cheng; Streifel, A. J.	Infection control considerations during construction activities: Land excavation and demolition	American Journal of Infection Control	29	5		321--328	2001
143	Cheng, Y.; Lin, Z.	Experimental study of airflow characteristics of stratum ventilation in a multi-occupant room with comparison to mixing ventilation and displacement ventilation	Indoor Air	25	6		662--671	2015
144	Cheong, K. W. D.; Phua, S. Y.	Development of ventilation design strategy for effective removal of pollutant in the isolation room of a hospital	Building and Environment	41	9		1161--1170	2006
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146	Chow, T. T.; Yang, X. Y.	Ventilation performance in operating theatres against airborne infection: review of research activities and practical guidance.	The Journal of hospital infection	56	2	February	85--92	2004
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149	Chung, Kee Chiang; Hsu, Shou Ping	Effect of ventilation pattern on room air and contaminant distribution	Building and Environment	36	9		989--998	2001
150	Clair, Jeffrey D.; Colatrella, Sandie	Opening Pandora's (Tool) Box : Health Care Construction and Associated Risk for Nosocomial Infection	Infectious Disorders-Drug Targets	13	3		177--183	2013
151	Clark, Burton; Clark, Justin	Decemberision Support for Early Intervention through Gas Exchange Ventilation- Perfusion Analysis	International Conference on Healthcare Informatics, Imaging and Systems Biology Decemberision					2011
152	Clark, Raymond P.; de Calcina-Goff, Mervyn L.	Some aspects of the airborne transmission of infection.	Journal of the Royal Society, Interface / the Royal Society	6 Suppl 6		October	S767--82	2009
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155	Clemente, Fabrizio; Romano, Marchchchia; Bifulco, Paolo; Cesarelli, Marchchchio	FMECA and HFMEA of indoor air quality management in home mechanical ventilation	IEEE Engineering in Medicine and Biology Magazine					2014
156	Cohen, Regev; Shimoni, Zvi; Ghara, Riad; Ram, Ron; Ben-Ami, Ronen	Effect of a ventilator-focused intervention on the rate of Acinetobacter baumannii infection among ventilated patients	American Journal of Infection Control	42	9		996--1001	2014
157	Cole, Eugene C.; Cook, Carl E.	Characterization of infectious aerosols in health care facilities: An aid to effective engineering controls and preventive strategies	American Journal of Infection Control	26	4		453--464	1998
158	Collier, Marchchchk; Evans, David; Farrington, Marchchchk; Gibbs, Elizabeth; Gould, Kate; Jenkinson, Helen; Kitson, Kathryn; Leaper, David; Thompson, Matt; Wilson, Jennie	Surgical site infection prevention and treatment of surgical site infection	Clinical Guidline			October	168	2008
159	Collinge, William H.	Infection Control in Design and Construction Work.	Health Environments Research & Design Journal (HERD) (Sage Publications, Ltd.)	8	3		68--79	2015
160	Conceicc~ao, Sandro Tavares; Pereira, Marchchchcelo Luiz; Tribess, Arlindo	A review of methods applied to study airborne biocontaminants inside aircraft cabins	International Journal of Aerospace Engineering	2011				2011
161	Cooper, E. E.; O'Reilly, M. A.; Guest, D. I.; Dharmage, S. C.	Influence of building construction work on Aspergillus infection in a hospital setting.	Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America	24	7		472--6	2003
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163	Cosgrove, Sara E.; Sakoulas, George; Perencevich, Eli N.; Schwaber, Mitchell J.; Karchmer, Adolf W.; Carmeli, Yehuda	Comparison of mortality associated with methicillin-resistant and methicillin-susceptible Staphylococcus aureus bacteremia: a meta-analysis.	Clinical infectious diseases	36	1		53--59	2003
164	Cressie, Noel	Statistics for Spatial Data	Terra Novembera	4	5		613--617	1992
165	Curry, Francis	Isolation Rooms : Design, Assessment and Upgrade	Institutional consulation services					
166	Da Costa, Alex Rodrigues; Kothari, Ami; Bannister, Gordon C.; Blom, Ashley W.	Investigating bacterial growth in surgical theatres: Establishing the effect of laminar airflow on bacterial growth on plastic, metal and wood surfaces	Annals of the Royal College of Surgeons of England	90	5		417--419	2008
167	Da Cunha, Jos'e Ant^onio; Moura, Elionai; Analide, Cesar	New Advances in Information Systems and Technologies	Data Mining in Academic Databases	2			189--198	2013
168	Dai, Chunyang; Zhang, Yan; Ma, Xiaoling; Yin, Meiling; Zheng, Haiyang; Gu, XueJune; Xie, Shaoqing; Jia, Hengmin; Zhang, Liang; Zhang, WeiJune	Real-time measurements of airborne biologic particles using fluorescent particle counter to evaluate microbial contamination: Results of a comparative study in an operating theater	American Journal of Infection Control	43	1		78--81	2015
169	Dai, Yunchuang; Jiang, Ziyan; Shen, Qi; Chen, Peizhang; Wang, Shiqiang; Jiang, Yi	A Decemberentralized algorithm for optimal distribution in HVAC systems	Building and Environment	95			21--31	2016
170	Dalewski, Marchchchiusz; Melikov, Arsen K.; Vesely, Michal	Performance of ductless personalized ventilation in conJunection with displacement ventilation: Physical environment and human response	Building and Environment	81			354--364	2014

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172	Dalstrom, David J.; Venkatarayappa, Indresh; Manternach, Alison L.; Palcic, Marchchchilyn S.; Heyse, Beth A.; Prayson, Michael J.	Time-Dependent Contamination of Opened Sterile Operating-Room Trays	The Journal of Bone and Joint Surgery-American Volume	90	5		1022--1025	2008
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174	Dascalaki, Elena G.; Lagoudi, Argyro; Balaras, Constantinos A.; Gaglia, Athina G.	Air quality in hospital operating rooms	Building and Environment	43	11		1945--1952	2008
175	Dascoli, Justin	Airflow Control Methods To Improve Infection Control for Patients and Medical Staff While Improving Energy Conservation	IAQ Conference					2011
176	Davis, G. W.; Griesemer, R. A.; Shadduck, J. A.; Farrell, R. L.	Effect of relative humidity on dynamic aerosols of adeNovemberirus 12	Appl Microbiol	21	4		676--679	1971
177	Dedesko, Sandra; Stephens, Brent; Gilbert, Jack A.; Siegel, Jeffrey A.	Methods to assess human occupancy and occupant activity in hospital patient rooms	Building and Environment	90			136--145	2015
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181	Dettenkofer, Marchchchkus; Scherrer, M.; Hoch, V.; Glaser, H.; Zentner, J.; Daschner, F. D.	Shutting Down Operating Theater Ventilation When The Theater Is Not In Use : Infection	Infection Control and Hospital Epidemiology	24	8		596--600	2003
182	Dharan, S.; Pittet, D.	Environmental controls in operating theatres	Journal of Hospital Infection	51	2	June	79--84	2002
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184	DIN 1946	Ventilation and Air-Conditioning. Part 4. Ventilation in Hospitals	Deutsches Institut fur Normung e.V., Beuth-Verlag, Berlin,	4				2008
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186	Centers for Disease Control; Prevention	Guidelines for preventing the transmission of Mycobacterium tuberculosis in health- care facilities	MMWR	43			1--132	1994
187	Centers for Disease Control; Prevention	Guidelines for environmental infection control in health-care facilities: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)					1--48	2003
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192	Dlugosz, L.	Ambient Airborne Particle Concentrations in Hospital Inpatient Rooms	ASHRAE Transactions	120			1--5	2014
193	Dobrovolsky, L.	Air quality in operating theatres: The effect of waste anaesthetics on personnel and exposure prevention measures	Indoor and Built Environment	12			113--120	2003
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212	Etheridge, David	A perspective on fifty years of natural ventilation research	Building and Environment	91			51--60	2014
213	Faeghi, Shiva; Lennerts, Kunibert	Flow analysis of airborne particles in a hospital operating room	AIP Conference Proceedings				17--22	2016
214	Fakih, Mohamad G.; Heavens, Michelle; Ratcliffe, Carol J.; Hendrich, Ann	First step to reducing infection risk as a system: Evaluation of infection prevention processes for 71 hospitals	American Journal of Infection Control	41	11		950--954	2013
215	Fan, Yunqing; Ito, Kazuhide	Integrated building energy computational fluid dynamics simulation for estimating the energy-saving effect of energy recovery ventilator with CO2 demand-controlled ventilation system in office space	Indoor and Built Environment	23	6		785--803	2014
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217	Faulkner, W. Brock; MeMarchchchzadeh, Farhad; Riskowski, Gerald; Kalbasi, Ahmad; Ching-Zu Chang, Audrey	Effects of air exchange rate, particle size and injection place on particle concentrations within a reduced-scale room	Building and Environment	92			246--255	2015
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257	Graves, Nicholas	Economics and Preventing Hospital-acquired Infection	Emerging Infectious Diseases	10	4		561--566	2004
258	Greeley, Damon G.; Platt, Marchchchk	Reverse Heating and Cooling systems	ASHRAE Journal	47	10			2005
259	Griffiths, W. D.; Bennett, A.; Speight, S.; Parks, S.	Determining the performance of a commercial air purification system for reducing airborne contamination using model micro-organisms: A new test methodology	Journal of Hospital Infection	61	3		242--247	2005
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281	Harper, G. J.	Airborne Micro-Organisms: Survival Tests with Four Viruses	Source: The Journal of Hygiene J. Hyg., Camb	59	59		479--486	1961
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329	Johnson, David L.; Lynch, Robert A.; Mead, Kenneth R.	Containment effectiveness of expedient patient isolation units	American Journal of Infection Control	37	2		94--100	2009
330	Jordan, Ante; Badovinac, Ana; vSpalj, Stjepan; Par, Matej; vSlaj, Marchchchtina; Planvcak, Darije	Factors influencing intensive care nurses' knowledge and attitudes regarding ventilator-associated pneumonia and oral care practice in intubated patients in Croatia	American Journal of Infection Control	42	10		1115--1117	2014
331	JoSeptemberh, Anjali	Patient safety learning lab (PSLL) on Realizing improved Patient Care through Human Centered Design in the OR	Grant number: P30HS0O24380					2015
332	JoSeptemberh, Anjali	Less infectious by design	Cleanroom Techology				1--6	2016
333	JoSeptemberh, Anjali; Bayramzadeh, Sara; Zamani, Zahra; Rostenberg, Bill	Safety, Performance, and Satisfaction Outcomes in the Operating Room: A Literature Review						
334	JoSeptemberhson, Adele; Gombert, Myles E.	Airborne Transmission of Nosocomial Varicella from Localized Zoster	The Journal of Infectious Diseases	158	1		238--241	1988
335	Juneg, Chien Cheng; Wu, Pei Chih; Tseng, Chao Heng; Su, Huey Jen	Indoor air quality varies with ventilation types and working areas in hospitals	Building and Environment	85			190--195	2015
336	Junejing, Yang; Sekhar, Chandra; Cheong, David; Raphael, Benny	Performance evaluation of an integrated Personalized Ventilation-Personalized Exhaust system in conJunection with two background ventilation systems	Building and Environment	78			103--110	2014
337	Jurelionis, Andrius; Gagyte, Laura; Seduikyte, Lina; Prasauskas, Tadas; Ciuzas, Darius; Marchchchtuzevicius, Dainius	Combined air heating and ventilation increases risk of personal exposure to airborne pollutants released at the floor level	Energy and Buildings	116			263--273	2016
338	Kakwani, R. G.; Yohannan, D.; Wahab, K. H. A.	The effect of laminar air-flow on the results of Austin-Moore hemiarthroplasty	Injury	38	7		820--823	2007
339	Kalliomaki	Airflow patterns through single hinged and sliding doors in hospital isolation rooms -Effect of ventilation, flow differential and passage	Building and Environment	107			154--168	2016
340	Kalm'ar, F.	InNovemberative method and equipment for personalized ventilation	Indoor Air	25	3		297--306	2015
341	Kameel, R.	Energy efficient and hygienic operating theatres' HVAC airside design architectural and engineering consideration						2003
342	Kameel, R.; Khalil, E.	The prediction of airflow regimes in surgical operating theatres: a comparison of different turbulence models	1st AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV; UNITED STATES; 6-9 January. 2003			January	1--10	2003
343	Kameel, Ramiz; Khalil, Essam E.	SIMULATION OF FLOW, HEAT TRANSFER & RELATIVE HUMIDITY CHARACTERISTICS IN AIR-CONDITIONED SURGICAL OPERATING THEATRES	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
344	Kameel, Ramiz; Khalil, Essam E.	Energy efficient air conditioning systems in hospitals operating theatres					814	2002
345	Kang, Yanming; Wang, YouJune; Zhong, Ke	Effects of supply air temperature and inlet location on particle dispersion in displacement ventilation rooms	Particuology	9	6		619--625	2011
346	Kang, Zhiqiang; Zhang, Yubo; Dong, Jiannan; Cheng, Xiaocong; Feng, Guohui	The Status of Research on Clean Air Conditioning System in Hospital Operation Room	Procedia Engineering	205			4129--4134	2017
347	Kao, P. H. H.; Yang, R. J. J.	Virus diffusion in isolation rooms	Journal of Hospital Infection	62	3		338--345	2006
348	Karakus, Zeynep; Taseli, Aysun; Benneyan, James C.	Relative Performance of Shewhart , EWMA p and g Statistical Control Charts for Monitoring Adverse Healthcare Event Rates	Proceedings of the 2012 Industrial and Systems Engineering Research Conference G.					2012
349	Karim, Kelvin	Tuberculosis and infection control.	British journal of nursing (Marchchchk Allen Publishing)	20	17		1128, 1130--3	2011
350	Karkalis, G.; Sakka, E.; Konnis, G.; Koutsouris, D.	Virtual Patient Record Architecture	Proceedings of the Second Joint EMBS/BMES Conference				1936--1937	2002
351	Kellerman, S. E.; Simonds, D.; Banerjee, S.; Towsley, J.; Stover, B.; Jarvis, W.	APIC and CDC survey of Mycobacterium tuberculosis isolation and control practices in hospitals caring for children. Part II: patient and family isolation policies and procedures	American Journal of Infection Control	26			478--82	1998

Row	Author	Title	Journal	Volume	Number	Month	Pages	Year
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353	Kerns, R. D.	Clinical research as a foundation for Veterans Health Administration Pain Management Strategy	J Rehabil Res Dev	40	5		ix--xi	2003
354	Khalil, Essam E.	Computer Simulation of Indoor Air Quality and Air Flow Regimes in Surgical Operating Theatres	Proceedings IAQVEC2007					2007
355	Khalil, Essam E.	Thermal Management in Healthcare Facilities : Computational Approach				January	1--8	2009
356	Khalil, Essam E.	Numerical Computations of Air Flow Regimes in Healthcare Facilities and their experimental verifications	International Energy Conversion Engineering Conference			August	1--11	2009
357	Khalil, Essam E.	Thermal Comfort and Air Quality in Sustainable Climate				January	1--10	2010
358	Khalil, Essam E.	Energy efficiency, air flow regime and relative humidity in air- conditioned surgical operating theatres	ASHRAE Transactions	118	PART 1		436--441	2012
359	Khalil, Essam E.; Kameel, R.	Requirements of air-conditioning systems' developments in hospitals and critical healthcare facilities	ASME					2004
360	Khankari, Kishor	Airflow Path Matters: Patient Room HVAC	ASHRAE Journal	58	6		16--26	2016
361	Khankari, Kishor	Analysis of Airflow Distribution and Contaminant Flow Path in the Hospital Operating Room						2017
362	Khankari, Kishor	Analysis of HVAC Configurations for a Hospital Operating Room						2017
363	Khodakarami, Jamal; Nasrollahi, Nazanin	Thermal comfort in hospitals - A literature review	Renewable and Sustainable Energy Reviews	16	6		4071--4077	2012
364	Kiel, D. E.; Wilson, D. L.	Combining door swing pumping with density driven flow					590--599	1989
365	Kierat, Wojciech; Bolashikov, Zhecho D.; Melikov, Arsen K.; Popiolek, Zbigniew; Brand, Marchchchek	Exposure to coughed airborne pathogens in a double bed hospital patient room with overhead mixing ventilation: Impact of posture of coughing patient and location of dOctoberor	IAQ Conference	1				2011
366	King, M. F.; Noakes, C. J.; Sleigh, P. A.	Modeling environmental contamination in hospital single- and four-bed rooms	Indoor Air	25	6		694--707	2015
367	Klevens, R. M.; Edwards, J. R.; Richards Jr., C. L.; Horan, T. C.; Gaynes, R. P.; Pollock, D. A.; Cardo, D. M.	Estimating health care-associated infections and deaths in U.S. hospitals, 2002	Public Health Rep	122	2		160--166	2007
368	Klontz, K. C.; Hynes, N. A.; Gunn, R. A.; Wilder, M. H.; Harmon, M. W.; Kendal, A. P.	An outbreak of influenza A/Taiwan/1/86 (H1N1) infections at a naval base and its association with airplane travel.	American journal of epidemiology	129	2	February	341--8	1989
369	Knibbs, Luke D.; Morawska, Lidia; Bell, Scott C.; Grzybowski, Piotr	Room ventilation and the risk of airborne infection transmission in 3 health care settings within a large teaching hospital	American Journal of Infection Control	39	10		866--872	2011
370	Kohani, Mehdi; Pecht, Michael	New minimum relative humidity requirements are expected to lead to more medical device failures	Journal of Medical Systems	40	3			2016
371	Kokkonen, Anna; Hyttinen, Marchchchko; Holopainen, Rauno; Salmi, Kari; Pasanen, Pertti	Performance testing of engineering controls of airborne infection isolation rooms by tracer gas techniques	Indoor and Built Environment	23	7		994--1001	2014
372	Kolarik, B.; Andersen, Z. JovaNovemberic; Ibfelt, T.; Engelund, E. Hoj; Moller, E.; Brauner	Ventilation in day care centers and sick leave among nursery children	Indoor Air	26	2		157--167	2016
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374	Kowalski, W. J.	Technologies for controlling respiratory disease transmission in indoor environments: Theoretical performance and economics					617	1998
375	Kowalski, Wladyslaw J.	Air-Treatment Systems for Controlling Hospital-Acquired Infections	HPAC Engineering	79	1		28--48	2007
376	Kowalski, W. J. J.; Bahnfleth, William; W. J. Kowalski; Bahnfleth, William	Airborne respiratory diseases and mechanical systems for control of microbes	HPAC Engineering	70	7		34--48	1998
377	Kowalski, W. J.; Bahnfleth, W. P.; Whittam, T. S.	Filtration of airborne microorganisms: modeling and prediction.	ASHRAE Transaction	105			4--17	1999
378	Krasinski, K.; Holzman, R. S.; Hanna, B.; Greco, M. a; Graff, M.; Bhogal, M.	Nosocomial fungal infection during hospital reNovemberation	Infection control : IC	6	7		278--282	1985
379	Kruppa, Ben; Ruden, Henning	The Influence of Various Air Exchange Rates on Airborne Particles and Microorganisms in Conventionally Ventilated Operating Rooms	Indoor Air	6	2		93--100	1996
380	Kuehn, Thomas H.	Airborne Infection Control in Health Care Facilities	Journal of Solar Energy Engineering	125	3		366	2003
381	Kuehn, T. H.; Gacek, B.; Yang, C. H.; Grimsrud, D. T.; Januaryni, K. A.; Streifel, A. J.; Pearce, M. R.	Identification of contaminants, exposures, effects, and control options for construction/reNovemberation activities					89--101	1996
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383	KuMarchchchi, D. N. P.; Haji, T. C.; Keer, V.; Hawkey, P. M.; Duncanson, V.; Flower, E.	Ventilation grilles as a potential source of methicillin-resistant Staphylococcus aureus causing an outbreak in an orthopaedic ward at a district general hospital	Journal of Hospital Infection	39	2		127--133	1998
384	Kundsin, Ruth B.	Documentation of Airborne Infection During Surgery	Annals of the New York Academy of Sciences	353	1		255--261	1980
385	Kusumah, Yaya S.	Graph Theoretic Based Heuristics For the Facility Layout Design Problems						2001
386	Laforce, E. Marchchchc	Airborne Infections and Modern Building Technology	Environment International	12	14		137--146	1986
387	Lai, a C. K.	Particle deposition indoors: a review.	Indoor air	12	4		211--214	2002
388	Lai, A. C. K.; Cheung, A. C. T.; Wong, M. M. L.; Li, W. S.	Evaluation of cold plasma inactivation efficacy against different airborne bacteria in ventilation duct flow	Building and Environment	98			39--46	2016
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390	Landrin, A.; Bissery, A.; Kac, Guillaume	Monitoring air sampling in operating theatres: Can particle counting replace microbiological sampling?	Journal of Hospital Infection	61	1		27--29	2005
391	Langmuir, A. D.	Epidemiology of airborne infection	Bacteriology Review	25			173--181	1961
392	Latenser, Barbara A.	Critical care of the burn patient: The first 48 hours	Critical Care Medicine	37	10		2819--2826	2009
393	Harold Laufman	Current status of special air-handling systems in operating rooms.	Medical Instrumentation	7	1		7--15	1973
394	Lax, Simon; Gilbert, Jack A.	Hospital-associated microbiota and implications for nosocomial infections	Trends in Molecular Medicine	21	7		427--432	2015
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396	Leclair, Jeanne M.; Zaia, John A.; Levin, Myron J.; Congdon, Richard G.; Goldmann, Donald A.	Airborne Transmission of Chickenpox in a Hospital	New England Journal of Medicine	302	8		450--453	1980
397	Lee, Chang Shing; Wang, Mei Hui	Ontology-based intelligent healthcare agent and its application to respiratory waveform recognition	Expert Systems with Applications	33	3		606--619	2007
398	Lee, Sihwan; Park, Beungyong; Kurabuchi, Takashi	Numerical evaluation of influence of door opening on interzonal air exchange	Building and Environment	102			230--242	2016
399	Letts, R. M.; Doermer, E.	Conversation in the operating theater as a cause of airborne bacterial contamination.	The Journal of Bone & Joint Surgery	65	3			1983
400	Michael K H Leung, Oliver K Y Chau, Liu Chun Ho	Hospitals Local Exhaust Ventilation for Infection Control	HKIE Transactions Hong Kong Institution of Engineers	3733		November		2016
401	Leung, W. T.; Sze-To, G. N.; Chao, C. Y. H.; Yu, S. C. T.; Kwan, J. K. C.	Study on the interzonal migration of airborne infectious particles in an isolation ward using benign bacteria	Indoor Air	23	2		148--161	2013
402	Levin, Hal	Natural ventilation: A sustainable solution to infection control in healthcare settings?	IAQ Conference					2008

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404	Li, Chih Shan; Hou, Po A.	Bioaerosol characteristics in hospital clean rooms	Science of the Total Environment	305	1-3		169--176	2003
405	Li, Chih-Shan; Hopke, Philip K.	Efficacy of air cleaning systems in controlling indoor radon Decemberay products	Health Physics	61	6		785--797	1991
406	Li, Y.; Huang, X.; Yu, I. T. S.; Wong, T. W.; Qian, H.	Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong	Indoor Air	15	2		83--95	2005
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408	Li, Yuguo; Nielsen, Peter V.; Sandberg, Mats	Displacement ventilation in hospital environments	ASHRAE Journal	53	6		86--88	2011
409	Licina, D.; Melikov, A.; Pantelic, J.; Sekhar, C.; Tham, K. W.	Human convection flow in spaces with and without ventilation: Personal exposure to floor-released particles and cough-released droplets	Indoor Air	25	6		672--682	2015
410	Licina, D.; Melikov, A.; Sekhar, C.; Tham, K. W.	Human convective boundary layer and its interaction with room ventilation flow	Indoor Air	25	1		21--35	2015
411	Lidwell, O. M.	Design and ventilation of operating room suites for control of infection and for comfort	Institution of Heating and Ventilating Engineers	30			320--328	1962
412	Lidwell, O. M.; Lowbury, E. J.; Whyte, W.; Blowers, R.; Stanley, S. J.; Lowe, D.	Effect of ultraclean air in operating rooms on deep Septembersis in the joint after total hip or knee replacement: a randomised study.	British medical journal (Clinical research ed.)	285	6334		10--4	1982
413	Lidwell, O. M.; Lowbury, E. J.; Whyte, W.; Blowers, R.; Stanley, S. J.; Lowe, D.	Infection and Septembersis after operations for total hip or knee-joint replacement: influence of ultraclean air, prophylactic antibiotics and other factors	J.Hyg.(Lond)	93	3		505--529	1984
414	Lidwell, O. M.; Lowbury, E. J. L.; Whyte, W.; Blowers, R.; Stanley, S. J.; Lowe, D.	Airborne contamination of wounds in joint replacement operations: the relationship to Septembersis rates	Journal of Hospital Infection	4	2		111--131	1983
415	Lilly, H. A.; Lowbury, E. J. L.; Cason, J. S.	Trial of a laminar air-flow enclosure for the control of infection in a burns operating theatre	Burns	10	5		309--312	1984
416	Lim, Eunsu; Ito, Kazuhide; Sandberg, Mats	Performance evaluation of contaminant removal and air quality control for local ventilation systems using the ventilation index Net Escape Velocity	Building and Environment	79			78--89	2014
417	Lim, Taesub; Cho, Jinkyun; Kim, Byungseon Sean	The predictions of infection risk of indoor airborne transmission of diseases in high-rise hospitals: Tracer gas simulation	Energy and Buildings	42	8		1172--1181	2010
418	Lim, Taesub; Cho, Jinkyun; Kim, Byungseon Sean	Predictions and measurements of the stack effect on indoor airborne virus transmission in a high-rise hospital building	Building and Environment	46	12		2413--2424	2011
419	Lin, George Guan-hua; Scott, Jeffrey G.	Quantitative analysis of hyperpolarized 129 Xe ventilation imaging in healthy volunteers and subjects with chronic obstructive pulmonary disease	NMR in Biomedicine	100	2		130--134	2012
420	Lin, Hsin-Lan; Lai, Chih-Cheng; Yang, Li-Yu	Critical care nurses' knowledge of measures to prevent ventilator-associated pneumonia.	American journal of infection control	42	8		923--5	2014
421	Lin, Hsin-Lan; Yang, Li-Yu; Lai, Chih-Cheng	Factors related to compliance among critical care nurses with performing oral care protocols for mechanically ventilated patients in the intensive care unit.	American Journal of Infection Control	42	5		533--5	2014
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423	Linden, P. F.	The fluid Mechanics of natural ventilation	Fuild Mechanics					1999
424	Lindsley, William G.; Reynolds, Jeffrey S.; Szalajda, Jonathan V.; Noti, John D.; Beezhold, Donald H.	A Cough Aerosol Simulator for the Study of Disease Transmission by Human Cough-Generated Aerosols	Aerosol Science and Technology	47	8		937--944	2013
425	Liu, C.; Zhang, Y.; Benning, J. L.; Little, J. C.	The effect of ventilation on indoor exposure to semivolatile organic compounds	Indoor Air	25	3		285--296	2015
426	Liu, De Ling	Particle Deposition onto Enclosure Surfaces	Developments in Surface Contamination and Cleaning: Particle Deposition, Control and Removal				1--56	2010
427	Liu, George; Maguire, Gerlad Jr.	A class of mobile motion prediction algorithms for wireless mobile computing and communications	Mobile Networks and Applications	1	2		113--121	1996
428	Liu, Junejie; Wang, Haidong; Wen, Wenyong	Numerical simulation on a horizontal airflow for airborne particles control in hospital operating room	Building and Environment	44	11		2284--2289	2009
429	LJunegqvist, B., Reinmüller, B., Gustén, J., Gustén, L., & Nordenad	Contamination risks due to door openings in operating rooms	41 st R 3-Nordic Symposium				148--160	2010
430	Lomas, K. J.; Giridharan, R.	Thermal comfort standards, measured internal temperatures and thermal resilience to climate change of free-running buildings: A case-study of hospital wards	Building and Environment	55			57--72	2012
431	Lomas, Kevin John; Ji, Yingchun	Resilience of naturally ventilated buildings to climate change: Advanced natural ventilation and hospital wards	Energy and Buildings	41	6		629--653	2009
432	Longo, D. R.; Brownson, R. C.; Kruse, R. L.	Smoking bans in US hospitals: Results of a national survey	Journal of the American Medical Association	274	6		488--491	1995
433	Loo, V. G.; Bertrand, C.; Dixon, C.; Vity'e, D.; DeSalis, B.; McLean, A. P. H.; Brox, A.; Robson, H. G.	Control of construction associated nosocomial aspergillosis in an antiquated hematology unit	Infection Control & Hospital Epidemiology	17	6		360--364.	1996
434	Loo, V. G.; Bertrand, C.; Dixon, C.; Vity'e, D.; DeSalis, B.; McLean, A. P. H.; Brox, A.; Robson, H. G.	Control of construction-associated nosocomial aspergillosis in an antiquated hematology unit.	Infection Control and Hospital Epidemiology	17	6		360--364	1996
435	Loomans, M. G. L. C.; De Visser, I. M.; Loogman, J. G. H.; Kort, H. S. M.	Alternative ventilation system for operating theaters: Parameter study and full-scale assessment of the performance of a local ventilation system	Building and Environment	102			26--38	2016
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439	Lydon, Gearoid P.; Ingham, Derek B.; Mourshed, Monjur M.	Ultra clean ventilation system performance relating to airborne infections in operating theatres using CFD modelling	Building Simulation	7	3		277--287	2014
440	Macal, Charles M.; North, Michael J.	Tutorial on agent-based modelling and simulation	Journal of Simulation	4	3		151--162	2010
441	MacKay, David J. C.	Information Theory, Inference, and Learning Algorithms David J.C. MacKay		100			1--640	2005
442	Maddalena, R.; Mendell, M. J.; Eliseeva, K.; Chan, W. R.; Sullivan, D. P.; Russell, M.; Satish, U.; Fisk, W. J.	Effects of ventilation rate per person and per floor area on perceived air quality, sick building syndrome symptoms, and Decemberision-making	Indoor Air	25	4		362--370	2015
443	Magill, Shelley S.; Edwards, Jonathan R.; Bamberg, Wendy; Beldavs, Zintars G.; Dumyati, Ghinwa; Kainer, Marchchchion A.; Lynfield, Ruth; Maloney, Meghan; McAllister-Hollod, Laura; Nadle, Joelle; Ray, Susan M.; Thompson, Deborah L.; Wilson, Lucy E.; Fridkin, Scott K.	Multistate Point-Prevalence Survey of Health Careâ€"Associated Infections	New England Journal of Medicine	370	13		1198--1208	2014
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447	Mai, Vu M.; Tutton, Sean; Prasad, PottuMarchchchthi V.; Chen, Qun; Li, Wei; Chen, Chi; Liu, Benjamin; Polzin, Jason; Kurucay, Saban; Edelman, Robert R.	Computing oxygen-enhanced ventilation maps using correlation analysis	Magnetic Resonance in Medicine	49	3		591--594	2003
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449	Manzo, JoSeptemberh P.	RETROFITTING HOSPITAL AIR CONDITIONING SYSTEMS.	Specifying Engineer					1977
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451	Marchchchklund, Anthony; Lai, Pauline	Developing a Business Case for Improved Indoor Environment Quality in Green Healthcare Facilities	ASHRAE					
452	Marchchchley, F.; Denman, A. R.; Phillips, P. S.	Studies of radon and radon progeny in air conditioned rooms in hospitals	Radiation Protection Dosimetry	76	4		273--276	1998
453	Marchchchschall, Jonas; Agniel, Denis; Fraser, Victoria J.; Doherty, Joshua; Warren, David K.	Gram-negative bacteraemia in non-ICU patients: factors associated with inadequate antibiotic therapy and impact on outcomes	Journal of Antimicrobial Chemotherapy	61	6		1376--1383	2008
454	Marchchchshall, J. W.	Health care ventilation standard: air changes per hour or CFM/ patient	The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Journal,					1996
455	Marchchchshall, John W.; Vincent, James H.; Kuehn, Thomas H.; Brosseau, Lisa M.	Studies of ventilation efficiency in a protective isolation room by the use of a scale model	Infection Control and Hospital Epidemiology	17	1	January	5--10	1996
456	Marchchchtinez-Almansa, J. J.; Fernandez-Gutierrez, A.; Parras, L.; Del Pino, C.	Numerical and experimental study of a HVAC wall diffuser	Building and Environment	80			1--10	2014
457	Mateus, Nuno M.; Carrilho da Gracca, Guilherme	A validated three-node model for displacement ventilation	Building and Environment	84			50--59	2015
458	Maus, R.; Goppelsroder, A.; Umhauer, H.	Survival of bacterial and mold spores in air filter media	Atmospheric Environment	35			105--113	2001
459	Mazzacane, Sante; Giaconia, Carlo; Costanzo, Silvia; Cusumano, Alessia	A survey on the thermal conditions experienced by a surgical team	INDOOR AND BUILT ENVIRONMENT	16	2		99--109	2007
460	Mccrory, Bernadette; Ph, D.; Lowndes, Bethany R.; Thompson, Darcy L.; Emily, E.; Riggle, Jakeb D.; Wadman, Michael C.; Hallbeck, M. Susan	Workload Comparison of Intraoral Mask To Standard Mask Ventilation Using a Cadaver Model	PROCEEDINGS of the HUMAN FACTORS and ERGONOMICS SOCIETY 56th ANNUAL MEETING				1728--1732	2012
461	McDade, J. J.; Whitcomb, J. G.; Rypka, E. W.; Whitfield, W. J.; Franklin, C. M.	Microbiological studies conducted in a vertical laminar air flow surgery	Journal of the American Medical Association					1968
462	Mcdonald, L. C.; Walker, M.; Carson, L.; Arduino, M.; Aguero, S. M.; Gomez, P.; Mcneil, P.; Jarvis, W. R.	Outbreak of Acinetobacter spp. bloodstream infections in a nursery associated with contaminated aerosols and air conditioners	The Pediatric infectious disease journal	17	8		716--722	1998
463	McGregor, Carolyn; Kneale, Bruce; Tracy, Marchchchk	On-demand Virtual Neonatal Intensive Care units supporting rural, remote and urban healthcare with Bush Babies Broadband	Journal of Network and Computer Applications	30	4		1309--1323	2007
464	McHugh, S. M.; Hill, A. D. K.; Humphreys, H.	Laminar airflow and the prevention of surgical site infection. More harm than good?	The Surgeon	13	1		52--58	2015
465	McManus, A. T.; Mason, A. D.; McManus, W. F.; Pruitt, B. A.	A Decemberade of reduced gram-negative infections and mortality associated with improved isolation of burned patients.	Archives of surgery (Chicago, Ill. : 1960)	129	12		1306--9	1994
466	McNeill, James; Hertzberg, Jean; Zhai, Zhiqiang(John)	Experimental Investigation of Operating Room Air Distribution in a Full-Scale Laboratory Chamber Using Particle Image Velocimetry and Flow Visualization	Journal of Flow Control, Measurement & Visualization	1	1		24--32	2013
467	Mears, Simon C.; Blanding, Renee; Belkoff, Stephen M.	Door Opening Affects Operating Room Pressure During Joint Arthroplasty	Orthopedics	38	11	November	e991--e994	2015
468	Melikov, A. K.	Personalized ventilation	Indoor Air, Supplement	14	SUPPL. 7		157--167	2004
469	Melikov, A. K.	Advanced air distribution: Improving health and comfort while reducing energy use	Indoor Air	26	1		112--124	2016
470	Melikov, Arsen K.; Bolashikov, Zhecho; Georgiev, Emanuil	Novemberel ventilation strategy for reducing the risk of airborne cross infection in hospital rooms					1--6	2011
471	Melikov, Arsen Krikor; Bolashikov, Zhecho Dimitrov; KostadiNovember, Kamen ; Kierat, Wojciech; Popiolek, Zbigniew	Exposure of health care workers and occupants to coughed airborne pathogens in a double-bed hospital patient room with overhead mixing ventilation						2012
472	MeMarchchchzadeh, Farhad	Ventilation Strategy for Laboratories	HPAC Engineering			July	1--8	2007
473	MeMarchchchzadeh, Farhad	Effect of reducing ventilation rate on indoor air quality and energy cost in laboratories	Journal of Chemical Health and Safety	16	5		20--26	2009
474	MeMarchchchzadeh, Farhad	Improved Strategy to Control Aerosol- Transmitted Infections in a Hospital Suite	IAQ Conference					2010
475	MeMarchchchzadeh, Farhad	The Environment of Care and Health Care-Associated Infections	American Society of Healthcare Engineers (ASHE)					2011
476	MeMarchchchzadeh, Farhad	The Environment of Care and Health Care-Associated Infections: an engineering perspective						2011
477	MeMarchchchzadeh, Farhad	Literature review of the effect of temperature and humidity on viruses	ASHRAE Transactions	118	PART 1		1049--1060	2012
478	MeMarchchchzadeh, Farhad	Literature Review: Room Ventilation and Airborne Disease Transmission	The American Society for Healthcare Engineering (ASHE)			October	1--54	2013
479	MeMarchchchzadeh, Farhad; Jiang, Januarye	Methodology for minimizing risk from airborne organisms in hospital isolation rooms	TRANSACTIONS-AMERICAN SOCIETY OF HEATING REFRIGERATING AND AIR CONDITIONING ENGINEERS	106	2		731--747	2000
480	MeMarchchchzadeh, Farhad; Jiang, Zheng	Effect of operation room geometry and ventilation system parameter variations on the protection of the surgical site	IAQ Conference					2004
481	MeMarchchchzadeh, Farhad; Jiang, Zheng; Xu, Weiran	Analysis of efficacy of UVGI inactivation of airborne organisms using Eulerian and Lagrangian approaches					15--17	2004
482	MeMarchchchzadeh, Farhad; Manning, Andy	Thermal Comfort , Uniformity , and Ventilation Effectiveness in Patient Rooms : Performance Assessment Using Ventilation Indices	ASHRAE Transactions					2000
483	MeMarchchchzadeh, F.; Manning, A.	Comparison of Operating Room Ventilation Systems in the Protection of the Surgical Site	Ashrae				1--13	2002
484	MeMarchchchzadeh, Farhad; Manning, Andy; Jiang, Zheng	Numerical Investigation on Ventilation Strategy for Laboratories : A Novemberel Approach to Control Thermal Comfort Using Cooling Panels						2007
485	MeMarchchchzadeh, Farhad; Manning, Andy; Jiang, Zheng	Energy Efficient Laboratory Design: A Novemberel Approach to Improve Indoor Air Quality and Thermal Comfort	American Biological Safety Association Volume	12	3		145--158	2007
486	MeMarchchchzadeh, Farhad; Olmsted, Russell N.; Bartley, Judene M.	Applications of ultraviolet germicidal irradiation disinfection in health care facilities: Effective adJunect, but not stand-alone technology	American Journal of Infection Control	38	5 SUPPL.		S13--S24	2010
487	MeMarchchchzadeh, Farhad; Wilson, Deborah E.; Ramesh, Krishnan	Design of a Specialized Airborne-Infection- Isolation Suite	HPAC Engineering			February	24--34	2011
488	MeMarchchchzadeh, Farhad; Xu, Weiran	Role of air changes per hour (ACH) in possible transmission of airborne infections	Building Simulation	5	1		15--28	2012
489	Mendes, Ana; Bonassi, Stefano; Aguiar, L'ivia; Pereira, Cristiana; Neves, Paula; Silva, Susana; Mendes, Diana; GuiMarchchch~aes, Lu'is; Moroni, Rossana; Teixeira, Jo~ao Paulo	Indoor air quality and thermal comfort in elderly care centers	Urban Climate					2015
490	M'endez, C.; San Jos'e, J. F.; Villafruela, J. M.; Castro, F.	Optimization of a hospital room by means of CFD for more efficient ventilation	Energy and Buildings	40	5	January	849--854	2008
491	Menzies, D.; Fanning, A.; Yuan, L.; FitzGerald, J. M.	Hospital ventilation and risk for tuberculosis infection in Canadian health care workers	Ann.Intern.Med.	133			779--789	2000
492	Mermel, L. A.; Dempsey, J.; Parenteau, S.; JoSeptemberhson, S.	Association of Legionnaires Disease With Construction: Contamination of Potable Water?	Infection Control & Hospital Epidemiology	16	2		76--81	1995
493	Messerges, J.	Modeling systolic pressure variation due to positive pressure ventilation	Conf Proc IEEE Eng Med Biol Soc	1			1806--1809	2006

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495	Miller, W. S.; Artenstein, M. S.	Aerosol Stability of Three Acute Respiratory Disease Viruses	Experimental Biology and Medicine	125	1	May	222--227	1967
496	Miller-Leiden, S.; Lohascio, C.; Nazaroff, W. W.; Macher, J. M.	Effectiveness of In-Room Air Filtration and Dilution Ventilation for Tuberculosis Infection Control	Journal of the Air & Waste Management Association	46	9		869--882	1996
497	Miner, Andrew L.; Losina, Elena; Katz, Jeffrey N.; Fossel, Anne H.; Platt, Richard	Deep infection after total knee replacement: impact of laminar airflow systems and body exhaust suits in the modern operating room.	Infection control and hospital epidemiology : the official journal of the Society of Hospital Epidemiologists of America	28	2		222--226	2007
498	Minns, R. J.; Flynn, M.; Ljuneggren, A. H.; Agnew, J. C.	Design and evaluation of a low cost columnar flow ventilation scheme in an operating theatre	Engineering in Medicin	8	1		27--32	1979
499	Monn, C. H., Fuchs, A., Högger, D., Juneker, M., Kogelschatz, D., R	Particulate matter less than 10 µm (PM10) and fine particles less than 2.5 µm (PM2. 5): relationships between indoor, outdoor and personal concentrations	*Science of the Total Environment*	208	1--2		15--21	1997
500	Mora, R.; English, M. J. M.; Athienitis, A. K.	Assessment of Thermal Comfort During Surgical Operations	ASHRAE Winter Meeting CD, Technical and Symposium Papers	107			65--74	2001
501	Morawska, L.	Droplet fate in indoor environments, or can we prevent the spread of infection?	Indoor Air	16	5		335--347	2006
502	Morawska, L.; Jamriska, M.; Francis, P.	Particulate Matter in the Hospital Environment	Indoor Air	8	4		285--294	1998
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504	Moser, M. R.; Bender, T. R.; Marchchchgolis, H. S.; Noble, G. R.; Kendal, A. P.; Ritter, D. G.	An outbreak of influenza aboard a commercial airliner.	American journal of epidemiology	110	1	July	1--6	1979
505	Mousavi, Ehsan	Airborne Infection in Healthcare Environments : Implications to hospital corridor design						2015
506	Mousavi, Ehsan S.; Grosskopf, Kevin R.	Transport of respiratory aerosols in patient corridors subject to a directional and non-directional airflow-a case study	ASHRAE Transactions	120	2			2014
507	Mu, Yi; Edwards, Jonathan R.; Horan, Teresa C.; Berr'ios-Torres, Sandra I.; Fridkin, Scott K.	Improving risk-adjusted measures of surgical site infection for the National Healthcare Safety Network.	Infection control and hospital epidemiology	32	10		970--86	2011
508	Mui, K. W.; Wong, L. T.; Wu, C. L.; Lai, Alvin C. K.	Numerical modeling of exhaled droplet nuclei dispersion and mixing in indoor environments	Journal of Hazardous Materials	167	1-3		736--744	2009
509	Murakami, Masahiro; Hyakusoku, Hiko; Ogawa, Rei	The use of Japanese kenzan" flower holders to create scar-less drainage holes in skin grafts"	Burns	36	5		732--733	2010
510	Murphy, John	Temperature & humidity control in surgery rooms	ASHRAE Journal	48	6			2006
511	Murphy, John	Temperature & humidity control in surgery rooms	ASHRAE Journal	48	6			2006
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513	Narayan, Shruti; Lavendrine, Isabelle; McClintock, Maurya	A Humanistic approach to Building Design to achieve comfort and optimize building energy use	ASES Annual Conference					2016
514	Nardell, Edward A.; Keegan, Joann; Cheney, Sally A.; Etkind, Sue C.	Airborne Infection: Theoretical Limits of Protection Achievable by Building Ventilation		144	2		302--306	1991
515	Nastase, Ilinca; Croitoru, Cristiana; Vartires, Andreea; Tataranu, Ligia	Indoor Environmental Quality in Operating Rooms: An European Standards Review with Regard to Romanian Guidelines	Energy Procedia	85			375--382	2016
516	Naumov, Alexander L.; Kapko, Dmitry V.; Brodach, Marchchchianna M.	Ventilation systems with local recirculation diffusers	Energy and Buildings	85			560--563	2014
517	Nazaroff, William W.	Indoor Particle Dynamics	Indoor Air	14	7		175--183	2004
518	Nazaroff, William W.	Indoor bioaerosol dynamics	Indoor Air	26	1		61--78	2016
519	Nazaroff, William W.; Nicas, Marchchchk; Miller, Shelly L.	Framework for Evaluating Measures to Control Nosocomial Tuberculosis Transmission	Indoor Air	8	4		205--218	1998
520	Neumayer, Leigh; Hosokawa, Patrick; Itani, Kamal; El-Tamer, Mahmoud; Henderson, William G.; Khuri, Shukri F.	Multivariable Predictors of Postoperative Surgical Site Infection after General and Vascular Surgery: Results from the Patient Safety in Surgery Study	Journal of the American College of Surgeons	204	6	June	1178--1187	2007
521	Nicas, Marchchchk; Nazaroff, William W.; Hubbard, Alan	Toward understanding the risk of secondary airborne infection: emission of respirable pathogens.	Journal of occupational and environmental hygiene	2	3	March	143--54	2005
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523	Nielsen, Peter V.	Control of airborne infectious diseases in ventilated spaces.	Journal of the Royal Society Interface the Royal Society	6	Suppl_6		S747--S755	2009
524	Nielsen, Peter V.; Li, Yuguo; Buus, Morten; Winther, Frederik V.	Risk of cross-infection in a hospital ward with downward ventilation	Building and Environment	45	9		2008--2014	2010
525	Nilsson, K. G.; Lundholm, R.; Friberg, S.	Assessment of horizontal laminar air flow instrument table for additional ultraclean space during surgery	Journal of Hospital Infection	76	3		243--246	2010
526	Ninomura, Paul; Hermans, Richard	Ventilation standard for health care facilities		50	10			2008
527	Ninomura, Paul; Rousseau, Chris; Ninomura, Tyler	Current Trends for Health-Care Ventilation	ASHRAE			April		2014
528	Ninomura, Paul T.; Sheerin, Michael Patrick; Rousseau, Chris P.; Cohen, Theodore; Dombrowski, John M.; Erickson, Douglas S.; Gregory, James Skip; Hardin, Jeffery M.; Keen, Michael R.; Kloostra, Marchchchvin L.; Langowski, Peter Hogan; Mamayek, Michael F.; Seth, Anand K.; Bushby, Steven T.; Newman, H. Michael; Baker, Robert G.; Beda, Michael F.; Cooper, Kenneth W.; Dean, K. William; Fraser, Allan B.; Hammack, Katherine G.; Myers, Frank; Peterson, Januaryice C.	ASHRAE / ASHE STANDARD Ventilation of Health Care Facilities	ASHRAE	4723				2009
529	Noakes, Catherine; CaMarchchchgo-valero, Miller Alonso	Simulating pathogen transport within a naturally ventilated hospital ward	World Academy of Science, Engineering and Technology International	55		July	303--309	2011
530	Noakes, C. J.; Beggs, C. B.; Sleigh, P. A.; Kerr, K. G.	Modelling the transmission of airborne infections in enclosed spaces	Epidemiology and Infection	134	2006		1082--1091	2006
531	Noakes, Catherine J.; Sleigh, P. Andrew	Mathematical models for assessing the role of airflow on the risk of airborne infection in hospital wards	Journal of the Royal Society, Interface / the Royal Society	6 Suppl 6		October	S791--S800	2009
532	Noakes, Catherine J.; Sleigh, P. Andrew; Khan, Amirul	Appraising healthcare ventilation design from combined infection control and energy perspectives	IAQ Conference	18	4		658--670	2011
533	Noie-Baghban, S. H.; Majideian, G. R.	Waste heat recovery using heat pipe heat exchanger (HPHE) for surgery rooms in hospitals	Applied Thermal Engineering	20	14		1271--1282	2000
534	Nolley, Eric P.; Trevino, Sergio E.; Babcock, Hilary M.; Kollef, Marchchchin H.	A targeted educational intervention to reduce ventilator-associated complications	American Journal of Infection Control	44	11		1406--1407	2016
535	Novemberoselac, Atila; Srebric, Jelena	A critical review on the performance and design of combined cooled ceiling and displacement ventilation systems	Energy and Buildings	34	5	June	497--509	2002
536	Novemberoselac, Atila; Srebric, Jelena	Comparison of air exchange efficiency and contaminant removal effectiveness as IAQ indices		109 PART 2	2		339--349	2003
537	Nuckchady, Dooshanveer; Heckman, Michael G.; Diehl, Nancy N.; Creech, Tara; Carey, Darlene; Domnick, Robert; Hellinger, Walter C.	Assessment of an automated surveillance system for detection of initial ventilator-associated events	American Journal of Infection Control	43	10		1119--1121	2015

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539	Octoberober, Revised; Technologists, Surgical	AST CONTINUING EDUCATION POLICIES FOR THE CST textregistered AND CSFA textregistered	Association of surgical technologist			October	1--23	2016
540	Offermann, Francis J.; Eagan, Aaron; Offermann, Aidan C.; Lewis, J.	Infectious Disease Aerosol Exposures With and Without Surge Control Ventilation System Modifications	International Conference on Indoor Air Quality and Climate				98	2014
541	Offermann, Francis J.; Eagan, Aaron; Offermann, Aidan C.; Subhash, Shobha S.; Miller, Shelly L.; RadoNovemberich, Lewis J.	Potential airborne pathogen transmission in a hospital with and without surge control ventilation system modifications	Building and Environment	106			175--180	2016
542	Ojima, June	Generation rate and particle size distribution of wood dust by handheld sanding operation.	Journal of occupational health	58	6	November	640--643	2016
543	Olmedo, I.; Nielsen, P. V.; de Adana, M. Ruiz; Jensen, R. L.	The risk of airborne cross-infection in a room with vertical low-velocity ventilation	Indoor Air	23	1		62--73	2013
544	Olmedo, I.; Nielsen, P. V.; Ruiz de Adana, M.; Jensen, R. L.; Grzelecki, P.	Distribution of exhaled contaminants and personal exposure in a room using three different air distribution strategies	Indoor Air	22	1		64--76	2012
545	Olmsted, Russell N.	Pilot study of directional airflow and containment of airborne particles in the size of Mycobacterium tuberculosis in an operating room	American Journal of Infection Control	36	4		260--267	2008
546	Olmsted, Russell N.	Prevention by Design Construction and ReNovemberation of Health Care Facilities for Patient Safety and Infection Prevention	Infectious Disease Clinics of North America	30	3		713--728	2016
547	Olsen, Marchchchgaret A.; Mayfield, Jennie; Lauryssen, Carl; Polish, Louis B.; Jones, Marchchchilyn; Vest, Joshua; Fraser, Victoria J.	Risk factors for surgical site infection in spinal surgery	Journal of neurosurgery	98	2 Suppl	March	149--55	2003
548	Oren, I.; Haddad, N.; Finkelstein, R.; Rowe, J. M.	Invasive pulmonary aspergillosis in neutropenic patients during hospital construction: Before and after chemoprophylaxis and institution of HEPA filters.	American Journal of Hematology	66	4		257--262	2001
549	Orini, M.; Giraldo, B. F.; Bailon, R.; Vallverdu, M.; Mainardi, L.; Benito, S.; Diaz, I.; Caminal, P.	Time-frequency analysis of cardiac and respiratory parameters for the prediction of ventilator weaning	Conf Proc IEEE Eng Med Biol Soc	2008			2793--2796	2008
550	Owers, K. L.; James, E.; Bannister, G. C.	Source of bacterial shedding in laminar flow theatres	Journal of Hospital Infection	58	3		230--232	2004
551	Özgür, Eylem Sercan, Elif Sahin Horasan, Kerem Karaca, Gülden E	Ventilator-associated pneumonia due to extensive drug-resistant Acinetobacter baumannii: Risk factors, clinical features, and outcomes	American Journal of Infection Control	42	2		206--208	2014
552	Pada, Surinder; Perl, Trish M.	Operating room myths: what is the evidence for common practices	Current Opinion in Infectious Diseases	28	4		369--374	2015
553	Palmer Gary, I. I.; Abernathy James H, I. I. I.; Swinton, Greg; Allison, David; Greenstein, Joel; Shappell, Scott; Juang, Kevin; Reeves, Scott T.; Palmer, Gary; Abernathy, James H.; Swinton, Greg; Allison, David; Greenstein, Joel; Shappell, Scott; Juang, Kevin; Reeves, Scott T.; Palmer Gary, I. I.; Abernathy James H, I. I. I.; Swinton, Greg; Allison, David; Greenstein, Joel; Shappell, Scott; Juang, Kevin; Reeves, Scott T.	Realizing Improved Patient Care through Human-centered Operating Room Design	Anesthesiology	119	5		1--1077	2013
554	Panahi, Pedram; Stroh, Mitchell; Casper, David S.; Parvizi, Javad; Austin, Matthew S.	Operating room Traffic is a major concern during total joint arthroplasty hip	Clinical Orthopaedics and Related Research	470	10		2690--2694	2012
555	Pantelic, Jovan; Tham, Kwok Wai	Adequacy of air change rate as the sole indicator of an air distribution system's effectiveness to mitigate airborne infectious disease transmission caused by a cough release in the room with overhead mixing ventilation: A case study	HVAC & R Research	19	8	November	947--961	2013
556	Parikh, Shital N.; Grice, Salih S.; Schnell, Beverly M.; Salisbury, Shelia R.	Operating Room Traffic: Is There Any Role of Monitoring it?	Journal of Pediatric Orthopaedics	30	6	September	617--623	2010
557	Park, J. S.; Jee, N. Y.; Jeong, J. W.	Effects of types of ventilation system on indoor particle concentrations in residential buildings	Indoor Air	24	6		629--638	2014
558	Parker, Sarah E. Henrickson; Laviana, Aaron A.; Wadhera, Rishi K.; Wiegmann, Douglas A.; Sundt, Thoralf M.	Development and evaluation of an observational tool for assessing surgical flow disruptions and their impact on surgical performance	World Journal of Surgery	34	2		353--361	2010
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562	Patankar, S. V.; Spalding, D. B.	A calculation procedure for heat, mass and momentum transfer in three-dimensional parabolic flows	Numerical Prediction of Flow, Heat Transfer, Turbulence and Combustion			October	54--73	1983
563	Patel, Hiren; Ge, Gaoming; Abdel-Salam, Mohamed R. H.; Abdel-Salam, Ahmed H.; Besant, Robert W.; Simonson, Carey J.	Contaminant transfer in run-around membrane energy exchangers	Energy and Buildings	70		February	94--105	2014
564	Patkin, M.	What surgeons want in operating rooms.	Minimally invasive therapy & allied technologies : MITAT : official journal of the Society for Minimally Invasive Therapy	12	6		256--62	2003
565	Patwardhan, Narendra; Kelkar, Uday	Disinfection, sterilization and operation theater guidelines for dermatosurgical practitioners in India	Indian Journal of Dermatology, Venereology, and Leprology	77	1		83	2011
566	Pavelchak, Nicholas; Depersis, Ronald P.; London, Matthew; Oxtoby, Marchchchgaret; Diferdinando, George; Marchchchshall, Elizabeth	Identification of Factors that Disrupt Negative Air Pressurization of Respiratory Isolation Rooms	Infection Control and Hospital Epidemiology	21	3		191--195	2000
567	Pearson, Michele L.; Jereb, John A.; Frieden, Thomas R.; Crawford, Jack T.; Davis, Barry J.; Dooley, Samuel W.; Jarvis, William R.	Nosocomial transmission of multidrug-resistant Mycobacterium tuberculosis	American Journal of Infection Control	23	2		146--151	1995
568	Peng, Lei; Nielsen, Peter V.; Wang, Xiaoxue; Sadrizadeh, Sasan; Liu, Li; Li, Yuguo	Possible user-dependent CFD predictions of transitional flow in building ventilation	Building and Environment	99			130--141	2016
569	Pereira, Marchchchcelo Luiz	Modeling and Measurement of Air Contaminant Distribution in an Operating Room Ventilated with Split System , Part II : The Impact on Airborne Particles	ASHRAE					2011
570	Persily, A. K.	Field measurement of ventilation rates	Indoor Air	26	1		97--111	2016

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572	Pidaparti, Ramana M.; Koombua, Kittisak; Ward, Kevin R.	Assessment of mechanical ventilation parameters on respiratory mechanics.	Journal of medical engineering & technology	36	1		34--41	2012
573	Pidaparti, Ramana M.; Swanson, John	Effect of mechanical ventilation waveforms on airway wall shear	Journal of Medical Engineering & Technology	1902	1		1--8	2014
574	Pimentel-aguilar, Ana B.; Ortiz-posadas, Marchchchtha R.	Hospital Risk Management using Healthcare Failure Mode and Effects Analysis A Case Study on Ventilators Whithin an Intensive Care Unit	IAQ Conference				328--335	2013
575	Pittet, Didier; Ducel, Georg	Infectious Risk Factors Related to Operating Rooms		17	3		227--235	1994
576	Post, Auke a; de Groot, Gert; Daffertshofer, Andreas; Beek, Peter J.	Pumping a playground swing.	Motor control	11	2		136--50	2007
577	Poulakos, A. R. Turk; E.M.	Practical approaches for healthcare : Indoor air quality management	Energy Engineering					1996
578	Prasauskas, Tadas; vZemaitytÄ—, Aida; Krugly, Edvinas; Ciuvzas, Darius; Marchchchtuzevivcius, Dainius	Characterization of Particle Size Distributions of Powdery Building Material Aerosol Generated by Fluidization and Gravitation	Environmental Research, Engineering and Management	61	3		50--57	2012
579	Price, D. L.; Simmons, R. B.; Crow, S. A.; Ahearn, D. G.	Mold colonization during use of preservative-treated and untreated air filters, including HEPA filters from hospitals and commercial locations over an 8-year period (1996–2003)	Journal of Industrial Microbiology and Biotechnology	32	7		319--321	2005
580	Pryor, F.; Messmer, P. R.	The effect of traffic patterns in the OR on surgical site infections.	AORN journal	68	4	October	649--60	1998
581	Qian, H.; Li, Y.	Removal of exhaled particles by ventilation and deposition in a multibed airborne infection isolation room	Indoor Air	20	4		284--297	2010
582	Qian, Hua; Li, Yuguo; Huang, Xinhua; Sun, Hequan; Seto, W. H.; Yuen, P. L.	Use of a Portable Hepa Air Cleaner in a Hospital Ward for Reducing Disease Infection	IAQ Conference					2007
583	Qian, Hua; Li, Yuguo; Nielsen, Peter V.; Hyldgaard, Carl E.	Dispersion of exhalation pollutants in a two-bed hospital ward with a downward ventilation system	Building and Environment	43	3		344--354	2008
584	Qian, H.; Li, Y.; Nielsen, P. V.; Hyldgaard, C. E.; Wong, T. W.; Chwang, A. T. Y.	Dispersion of exhaled droplet nuclei in a two-bed hospital ward with three different ventilation systems	Indoor Air	16	2		111--128	2006
585	Qian, Hua; Li, Yuguo; Seto, W. H.; Ching, Patricia; Ching, W. H.; Sun, H. Q.	Natural ventilation for reducing airborne infection in hospitals	Building and Environment	45	3		559--565	2010
586	Rahimi, Mostafa; Tajbakhsh, Kaveh	Reducing temperature stratification using heated air recirculation for thermal energy saving	Energy and Buildings	43	10		2656--2661	2011
587	Rahnama, Samira; Afshari, Alireza; Bergsoe, Niels Christian; Sadrizadeh, Sasan	Experimental study of the pressure reset control strategy for energy-efficient fan operation: Part 1: Variable air volume ventilation system with dampers	Energy and Buildings	139			72--77	2017
588	Railsback, Steven F.; Lytinen, Steven L.; Jackson, Stephen K.	Agent-based Simulation Platforms: Review and Development Recommendations	SIMULATION	82	9		609--623	2006
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594	Reeths, Anne	A Journey to Reduce Possible Ventilator Associated Pneumonia (PVAP) Infections in One Intensive Care Unit	American Journal of Infection Control	44	6		S31--S32	2016
595	Reichman, David E.; Greenberg, James A.	Reducing surgical site infections: a review.	Reviews in obstetrics & gynecology	2	4		212--21	2009
596	ReiJulya, J., Holopainen, R., Kähkönen, E., ReiJulya, K., & Tommel	Intelligent HVAC systems in hospitals	*Intelligent Buildings International*	5	2		101--119	2013
597	Reisman, R. E.; Mauriello, P. M.; Davis, G. B.; Georgitis, J. W.; DeMasi, J. M.; High-efficiency	A double-blind study of the effectiveness of a high efficiency particulate air (HEPA) filter in the treatment of patients with perennial allergic rhinitis and asthmaStates	Allergy Clin. Immunol	85			1050--1057	1990
598	Richardson, M. D.; Rennie, S.; Marchchchshall, I.; Morgan, M. G.; Murphy, J. A.; Shankland, G. S.; Watson, W. H.; Soutar, R. L.	Fungal surveliance of an open haematology ward	Journal of Hospital Infection	45	4		288--292	2000
599	Richmond-Bryant, Jennifer	Transport of exhaled particulate matter in airborne infection isolation rooms	Building and Environment	44	1		44--55	2009
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602	Riley, E. C.; Murphy, G.; Riley, R. L.	Airborne spread of measles in a suburban elementary school	American journal of epidemiology	107			421--432	1978
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604	Riley, W. W.; McKone, T. E.; Lai, A. C. K.; Nazaroff, W. W.	Indoor particulate matter of outdoor origin: Importance of size-dependent removal mechanisms					LBNL--47437	2001
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607	Ritter, M. A.	Surgical wound environment.	Clinical orthopaedics and related research		190	November	11--3	1984
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609	Rivers, R. D.	Discussion following Pate article	ASHRAE Transactions	83			651	1977
610	Rocasermeno, By Pablo	Pressurizing with dust collectors : Making the right Decemberision	Plant Engineering				3--5	2013
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619	Christopher Rousseau; Bare, Adam R.	Designing Hospital Pharmacy HVAC Systems	ASHRAE Journal	49	2			2007

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622	Ruesch, Cecilee; Mossakowski, Jackie; Forrest, Januaryine; Hayes, Marchchchy; Jahrsdoerfer, Marchchchy; Comeau, Elaine; Singleton, Marchchchy	Using nursing expertise and telemedicine to increase nursing collaboration and improve patient outcomes	Telemedicine and e-Health	18	8		591--595	2012
623	Rui, Zhang; Guangbei, Tu; Jihong, Ling	Study on biological contaminant control strategies under different ventilation models in hospital operating room	Building and Environment	43	5		793--803	2008
624	Russell, J. A.; Poon, M.-C.; Jones, A. R.; Woodman, R. C.; Ruether, B. A.	Allogeneic bone-Marchchchrow transplantation without protective isolation in adults with malignant disease	The Lancet	339	8784		38--40	1992
625	Russenberger, H. J.; Wanner, H. U.	Keimgehalt der Raumluft in Abhangigkeit des Luftwechsels	Zentralblatt fur Bakferiologie und Hygiene,	227			564--567	1980
626	Rutala, W. A.; Jones, S. M. N.; Worthington, J. M.; Reist, P. C.; Weber, D. J. J.	Efficacy of portable filtration units in reducing aerosolized particles in the size range of Mycobacterium tuberculosis	Infect Control Hosp Epidemiol	16			391--8	1995
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628	Rydock, J. P.; Eian, P. K.	Containment testing of isolation rooms	Journal of Hospital Infection	57	3		228--232	2004
629	Sadrizadeh, Sasan	Design of Hospital Operating Room Ventilation using Computational Fluid Dynamics (PhD thesis)				February	146	2016
630	Sadrizadeh, Sasan; Holmberg, Sture	Surgical clothing systems in laminar airflow operating room: a numerical assessment	Journal of Infection and Public Health	7	6		508--516	2014
631	Sadrizadeh, Sasan; Holmberg, Sture	Effect of a portable ultra-clean exponential airflow unit on the particle distribution in an operating room	Particuology	18			170--178	2015
632	Sadrizadeh, Sasan; Holmberg, Sture	How safe is it to neglect thermal radiation in indoor environment modeling with high ventilation rates ?	In Proceedings of 36th AIVC, 5th TightVent & 3rdventicool Conference	2015			1--5	2015
633	Sadrizadeh, Sasan; Holmberg, Sture	Impact of staff posture on airborne particle distribution in an operating theatre equipped with ultraclean-zoned ventilation	In Proceedings of 36th AIVC, 5th TightVent & 3rdventicool Conference				1--6	2015
634	Sadrizadeh, Sasan; Holmberg, Sture	Evaluation of various turbulence models for indoor airflow prediction: a comparison with experimental data					1--7	2016
635	Sadrizadeh, Sasan; Holmberg, Sture; Nielsen, Peter V.	Three distinct surgical clothing systems in a turbulent mixing operating room equipped with mobile ultraclean laminar airflow screen: A numerical evaluation	Science and Technology for the Built Environment	22	3		337--345	2016
636	Sadrizadeh, Sasan; Holmberg, Sture; Tammelin, Ann	A numerical investigation of vertical and horizontal laminar air flow ventilation in an operating room	Building and Environment	82			517--525	2014
637	Sadrizadeh, Sasan; Loomans, Marchchchcel G. L. C.	Thermal comfort in Hospital and healthcare facilities â€“ a literature review	In Proceedings of 9th International Conference on Indoor Air Quality Ventilation & Energy Conservation In Buildings				1--12	2016
638	Sadrizadeh, Sasan; Tammelin, Ann; Ekolind, Peter; Holmberg, Sture	Particuology Influence of staff number and internal constellation on surgical site infection in an operating room	Particuology	13			42--51	2014
639	Sadrizadeh, Sasan; Tammelin, Ann; Nielsen, Peter V.; Holmberg, Sture	Does a mobile laminar airflow screen reduce bacterial contamination in the operating room? A numerical study using computational fluid dynamics technique.	Patient safety in surgery	8	1		27	2014
640	Sajadi; , Behrang; Ahmadi, Goodarz; Saidi, Mohammad Hassan	On the operating rooms ventilation system		1				2011
641	Salamon, Peter; Fern`andez-Garcia, Daniel; G'omez-Hern'andez, J. Jaime	A review and numerical assessment of the random walk particle tracking method	Journal of Contaminant Hydrology	87	3-4		277--305	2006
642	Salonen, Heidi; Lahtinen, Marchchchjaana; Lappalainen, Sanna; Nevala, Nina; Knibbs, Luke D.; Morawska, Lidia; ReiJulya, Kari	Design approaches for promoting beneficial indoor environments in healthcare facilities: a review	Intelligent Buildings International	5	1		26--50	2013
643	Salonen, Heidi; Lahtinen, Marchchchjaana; Lappalainen, Sanna; Nevala, Nina; Knibbs, Luke D.; Morawska, Lidia; ReiJulya, Kari	Physical characteristics of the indoor environment that affect health and wellbeing in healthcare facilities: a review	Intelligent Buildings International	5	1		3--25	2013
644	Sandberg, Mats; Kabanshi, Alan	Experimental evaluation of an intermittent air supply system e Part 1 : Thermal comfort and ventilation efficiency measurements	Building and Environment	95			240--250	2016
645	Sanden, N. P. M. Van Der	Personal ventilation to control airborne infectious diseases in hospital patient rooms				July		2012
646	Santos, L.; Santos, J.; Rebelo, A.; Vieira Da Silva, M.	Indoor air quality in community health centers: A preliminary study	Occupational Safety and Hygiene - Proceedings of the International Symposium on Occupational Safety and Hygiene, SHO 2013				443--447	2013
647	Saravia, Stefan A.; Raynor, Peter C.; Streifel, Andrew J.	A performance assessment of airborne infection isolation rooms	American Journal of Infection Control	35	5		324--331	2007
648	Scaltriti, S.; Cencetti, S.; Rovesti, S.; Marchchchchesi, I.; Bargellini, A.; Borella, P.	Risk factors for particulate and microbial contamination of air in operating theatres	Journal of Hospital Infection	66	4		320--326	2007
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651	Schiavon, Stefano	Adventitious ventilation: A new definition for an old mode?	Indoor Air	24	6		557--558	2014
652	Schonholtz, G. J.	Maintenance of aSeptembertic barriers in the conventional operating room: general principles	Journal of Bone and Joint Surgery	58-A	4		139--115	1976
653	Schultz, Carl C.	Infection isolation for surgical cases	IAQ Conference					2004
654	Schultz, Carl C.	TB SARS and the Surgical Suite	Engineered Systems				36--44	2004
655	Scott, R. Douglas	The direct medical costs of healthcare-associated infections in U.S. hospitals and the benefits of prevention	CDC			March	13	2009
656	Sehulster, L.; Chinn, R. Y.; Arduino, M. J.; Carpenter, J.; Donlan, R.; Ashford, D.; Besser, R.; Fields, B.; McNeil, M. M.; Whitney, C.; Wong, S.	Guidelines for environmental infection control in health- care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC).						2004
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660	Services, Medicaid	RH of â‰¥20 Percent Permitted in Anesthetizing Locations:						2013
661	Shalaby, Alaa; Atwood, Charles; Hansen, Claudius; Konermann, Marchchchtin; Jamnadas, Pradip; Lee, Kent; Willems, Roger; Hartley, Jesse; Stahmann, Jeffrey; Kwok, Jonathan; Ni, Quan; Neuzner, Joerg	Feasibility of automated detection of advanced sleep disordered breathing utilizing an implantable pacemaker ventilation sensor	PACE - Pacing and Clinical Electrophysiology	29	10		1036--1043	2006
662	Sharan Thatiparti, Deepthi; Ghia, Urmila; Mead, Kenneth R.	Computational fluid dynamics study on the influence of an alternate ventilation configuration on the possible flow path of infectious cough aerosols in a mock airborne infection isolation room	Science and Technology for the Built Environment	4731		November	0--0	2016
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665	Shih, Yang Cheng; Chiu, Cheng C.; Wang, Oscar	Dynamic airflow simulation within an isolation room	Building and Environment	42	9		3194--3209	2007
666	Shirani, K. Z.; McManus, A. T.; VAugusthan, G. M.; McManus, W. F.; Pruitt, B. A.; Mason, A. D.	Effects of environment on infection in burn patients.	Archives of Surgery	121	1		31--36	1986
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668	Shuyun, Dong; Guangbei, Tu; Rongguang, Cao; Zhenfeng, Yu	Numerical Study on Effects of Door-Opening on Airflow Patterns and Dynamic Cross-Contamination in an ISO Class 5 Operating Room	Transactions of Tianjin University	15	1		70--74	2009
669	Siddiqui, Zishan K.; Zuccarelli, Rebecca; Durkin, Nowella; Wu, Albert W.; Brotman, Daniel J.	Changes in patient satisfaction related to hospital reNovemberation: Experience with a new clinical building	Journal of Hospital Medicine	10	3		165--171	2015
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671	Simsek Yavuz, Serap; Bicer, Yesim; Yapici, Nihan; Kalaca, Sibel; Aydin, Osman Ozcan; Camur, Gercek; Kocak, Funda; Aykac, Zuhal	Analysis of risk factors for sternal surgical site infection: emphasizing the appropriate ventilation of the operating theaters.	Infection control and hospital epidemiology	27	9		958--63	2006
672	Sirbu, D.; Curseu, D.; Popa, M.	Monitoring the air microbiologic quality in health care units		20	1		239--240	2009
673	Siskin, M.	Klimaanlagen im Krankenhaus	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
674	Siskin, M.	Microbiological Contamination of Air in Hospital Clean Room""	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
675	Siskin, M.	Potential of building automation system towards efficient energy management of healthcare buildings	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
676	Siskin, M.	Development and Testing of a real-time sterilization unit using in Ventilation Duct	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
677	Siskin, M.	Numerical Investigations of Indoor air quality infection isolation rooms	Journal of Analytical and Applied Pyrolysis	287			173--196	1983
678	Skaria, Shaji; Smaldone, Gerald	Mechanisms of Airborne Particle Protection with Masks and Respirators	American Journal of Infection Control	41	6		S8--S9	2013
679	Skoog, Jennie; Fransson, Niklas; JageMarchchch, Lennart	Thermal environment in Swedish hospitals: Summer and winter measurements	Energy and Buildings	37	8		872--877	2005
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681	Smedbold, H. T.; Ahlen, C.; Norback	Sign of eye irritation in female hospital workers and the indoor environment.	Indoor air	11	4		223--231	2001
682	Smith, Eric B.; Raphael, Ibrahim J.; Maltenfort, Mitchell G.; Honsawek, Sittisak; Dolan, Kyle; Younkins, Elizabeth A.	The effect of laminar air flow and door openings on operating room contamination	Journal of Arthroplasty	28	9		1482--1485	2013
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685	Spagnolo, A. M.; Ottria, G.; Amicizia, D.; Perdelli, F.; Cristina, Marchchchia Luisa	Operating theatre quality and prevention of surgical site infections	Journal of Preventive Medicine and Hygiene	54	3		131--137	2013
686	Speck, Kathleen; Rawat, Nishi; Weiner, Noah C.; Tujuba, Haddis G.; Farley, Donna; Berenholtz, Sean	A systematic approach for developing a ventilator-associated pneumonia prevention bundle	American Journal of Infection Control	44	6		652--656	2016
687	Spiess, Jeffrey; Joens, Yves T.; Dragnea, Raluca; Spencer, Peter	Monitoring High Performance Data Streams in Vertical Marchchchkets: Theory and Applications in Public Safety and Healthcare	Bell Labs Technical Journal	18	4		3--17	2014
688	Srebric, Jelena; Chen, Qingyan	An example of verification, validation, and reporting of indoor environment CFD analyses (RP-1133)	ASHRAE Transactions	108 PART 2	2		185--194	2002
689	Srebric, Jelena; Chen, Qingyan	Simplified numerical models for complex air supply diffusers	ASHRAE Transactions	109 PART 1	3		90	2003
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691	Canadian Tuberculosis Standards	Prevention and Control of Tuberculosis Transmission in Health Care and Other Settings		76	6		386--394	2014
692	Stanke, By Dennis A.; Chandra, Niraj	Explaining Science Behind Standard 62.1-2004	ASHRAE Journal	7				2006
693	Stein, Michael L.	Interpolation of Spatial Data		61			180--183	1999
694	Stenvik, Marchchchyann; Tjomsland, Ole; Lien, Steinar; Gunnes, Sigurd; Kirkeby-Garstad, Idar; Astudillo, Rafael	Effect of subcutaneous suture line and surgical technique on wound infection after saphenectomy in coronary artery bypass grafting: a prospective randomised study	Scandinavian Cardiovascular Journal	40	4	January	234--237	2006
695	Stephens, Brent	HVAC filtration and the Wells-Riley approach to assessing risks of infectious airborne diseases	NAFA foundation report				44	2013
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703	Streifel, Andrew; Rhamme; , Frank	Hospital Building Design for Particle Management					72--75	1995
704	Streifel, A. J.	Design and maintenance of hospital ventilation systems and prevention of airborne nosocomial infections					1211--21	1999
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711	Sundell, January; Levin, Hal	Ventilation Rates and Health : Report of an Interdisciplinary Review of the Scientific Literature Final Report	National Center For Energy Management					2006
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Row	Author	Title	Journal	Volume	Number	Month	Pages	Year
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715	Sze-To, Gin Nam; Yang, Yang; Kwan, JoSeptemberh K. C.; Yu, Samuel C. T.; Chao, Christopher Y. H.	Effects of surface material, ventilation, and human behavior on indirect contact transmission risk of respiratory infection	Risk Analysis	34	5		818--830	2014
716	Taaffe, K.; Lee, B.; Ferrand, Y.; Fredendal, L.; D. San, C. Salgado; Shvorin, D.; Khoshkenar, A.; Reeves., S.	The influence of traffic, area location, and other factors on operating room microbial load						2017
717	Tan, Bin; Xian, Xian Yang; Zhang, Xian; Xi, Peng Zhou; Wang, Peng; Jian, Xue; Ya, Ling Huang; Ying, Li Li; Jing, Fu Qiu	Epidemiology of pathogens and drug resistance of ventilator-associated pneumonia in Chinese neonatal intensive care units: A meta-analysis	American Journal of Infection Control	42	8		902--910	2014
718	Tang, Chin Sheng; Wan, Gwo Hwa	Air Quality Monitoring of the Post-Operative Recovery Room and Locations Surrounding Operating Theaters in a Medical Center in Taiwan	PLoS ONE	8	4			2013
719	Tang, Julyian W.; Eames, I.; Li, Y.; Taha, Y. A.; Wilson, P.; Bellingan, G.; Ward, K. N.; Breuer, J.	Door-opening motion can potentially lead to a transient breakdown in negative-pressure isolation conditions: The importance of vorticity and buoyancy airflows	Journal of Hospital Infection	61	4		283--286	2005
720	Tang, J. W. W.; Li, Y.; Eames, I.; Chan, P. K. S. K. S.; Ridgway, G. L. L.	Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises	Journal of Hospital Infection	64	2		100--114	2006
721	Tang, J. W.; Liebner, T. J.; Craven, B. A.; Settles, G. S.	A schlieren optical study of the human cough with and without wearing masks for aerosol infection control	J R Soc Interface	6 Suppl 6		October	S727--36	2009
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723	Tanner, Judith; Norrie, Peter; Melen, Kate	Preoperative hair removal to reduce surgical site infection				November		2011
724	Taylor, Christopher N.; Noronha, Luke; Wichman, Christopher S.; Varman, Meera	Evaluation of 2 sets of screening criteria for ventilator-associated pneumonia in a children's hospital	American Journal of Infection Control	42	9		1011--1013	2014
725	Taylor, Stephanie	Managing your hospital building can save patient lives	Engineered Systems					2014
726	Tedja, Rudy; Nowacki, Amy; Fraser, Thomas; Fatica, Cynthia; Griffiths, Lori; Gordon, Steven; Isada, Carlos; Van Duin, David	The impact of multidrug resistance on outcomes in ventilator-associated pneumonia	American Journal of Infection Control	42	5		542--545	2014
727	Tehrani, Fleur T.	Automatic control of mechanical ventilation. Part 2: The existing techniques and future trends	Journal of Clinical Monitoring and Computing	22	6		417--424	2008
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729	Tellier, Raymond	Review of aerosol transmission of influenza A virus		12	11		1657--1662	2006
730	Tellier, Raymond	Review of Aerosol Transmission of Influenza A Virus Aerosol Transmission of Influenza A Virus | CDC EID	Emerging Infectious Diseases	12	11		1657--1662	2006
731	Tellier, Raymond	Aerosol transmission of influenza A virus: a review of new studies.	Journal of the Royal Society, Interface / the Royal Society	6 Suppl 6	Suppl 6		S783--90	2009
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733	Teter, Jonathan; Guajardo, Isabella; Al-Rammah, Tamrah; Rosson, Gedge; Perl, Trish M.; Manahan, Michele	Assessment of operating room airflow using air particle counts and direct observation of door openings	American Journal of Infection Control	45	5		477--482	2017
734	Thatcher, T. L.; McKone, Thomas E.; Fisk, W. J.; Sohn, M. D.; Delp, W. W.; Riley, William J.; Sextro, R. G.	Factors Affecting the Concentration of Outdoor Particles Indoors (COPI): Identification of Data Needs and Existing Data	Lawrence Berekly Lab			December	1--6	2001
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737	Tjade, O. H.; Gabor, I.	Evaluation of airborne operating room bacteria with a Biap slit sampler.	The Journal of hygiene	84	1	February	37--40	1980
738	Tong, Shanshan; Li, Hua	An efficient model development and experimental study for the heat transfer in naturally ventilated inclined roofs	Building and Environment	81			296--308	2014
739	Traversari, Roberto; Goedhart, Rien; Schraagen, January Maarten	Process simulation during the design process makes the difference: Process simulations applied to a traditional design	Health Environments Research and Design Journal	6	2	January	58--76	2013
740	Tung, Yun Chun; Hu, Shih Cheng; Tsai, Tung I.; Chang, I. Lang	An experimental study on ventilation efficiency of isolation room	Building and Environment	44	2		271--279	2009
741	Tung, Yun Chun; Shih, Yang Cheng; Hu, Shih Cheng	Numerical study on the dispersion of airborne contaminants from an isolation room in the case of door opening	Applied Thermal Engineering	29	8-9		1544--1551	2009
742	Tung, Yun-Chun; Hu, Shih-Cheng	Infection Risk of Indoor Airborne Transmission of Diseases in Multiple Spaces	Architectural Science Review	51	1		14--20	2008
743	Uduman, S. A.; Farrukh, A. S.; Nath, K. N. R.; Zuhair, M. Y. H.; Ifrah, A.; Khawla, A. D.; Sunita, P.	An outbreak of Serratia Marchchchcescens infection in a special-care baby unit of a community hospital in United Arab Emirates: the importance of the air conditioner duct as a nosocomial reservoir	Journal of Hospital Infection	52	3		175--180	2002
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745	Ulrich, Roger S.; Zimring, Craig; Zhu, Xuemei; DuBose, Jennifer; Seo, Hyun-Bo; Choi, Young-Seon; Quan, Xiaobo; JoSeptemberh, Anjali	A Review of the Research Literature on Evidence-Based Healthcare Design (Part I)	HERD: Health Environments Research & Design Journal	1	3		61--125	2008
746	U'scinowicz, Piotr; Chludzi'nska, Marchchchta; Bogdan, Anna	Thermal environment conditions in Polish operating rooms	Building and Environment	94	P1		296--304	2015
747	Verdenelli, M. C.; Cecchini, C.; Orpianesi, C.; Dadea, G. M.; Cresci, A.	Efficacy of antimicrobial filter treatments on microbial colonization of air panel filters	Journal of Applied Microbiology	94	1		9--15	2003
748	Verheyen, January; Theys, Nele; Allonsius, Luk; Descamps, Filip	Thermal comfort of patients: Objective and subjective measurements in patient rooms of a Belgian healthcare facility	Building and Environment	46	5		1195--1204	2011
749	Verkkala, Kalervo, Anne Eklund, Juhani Ojajärvi, Leena Tiittanen, Ja	The conventionally ventilated operating theatre and air contamination control during cardiac surgery - Bacteriological and particulate matter control garment options for low level contamination	European Journal of Cardio-thoracic Surgery	14	2		206--210	1998
750	Verma, T. N.; Sinha, S. L.	Contaminant Control in Intensive Care Unit of Hospital	Applied Mechanics and Materials	592			2486--2490	2014
751	Viessman, W.	Environmental control in hospital facilities	heating piping and air conditioning	36	5			1964
752	Viessman, W.	Why, when, how to recirculate hospital air	Heating, piping and air conditioning	37	6			1965
753	Warren Viessman	Providing the Best Environment For the Hospital Surgical Suite	HPAC Engineering			August	61--65	1968
754	Villafruela, J. M.; San Jos'e, J. F.; Castro, F.; Zarzuelo, A.	Airflow patterns through a sliding door during opening and foot traffic in operating rooms	Building and Environment	109			190--198	2016
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757	R-P. Vonberg; Gastmeier, P.	Nosocomial aspergillosis in outbreak settings		63	3		246--254	2006
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761	Wahr, Joyce A.; Prager, Richard L.; Abernathy, J. H.; Marchchchtinez, Elizabeth A.; Salas, Eduardo; Seifert, Patricia C.; Groom, Robert C.; Spiess, Bruce D.; Searles, Bruce E.; Sundt, Thoralf M.; Sanchez, Juan A.; Shappell, Scott A.; Culig, Michael H.; Lazzara, Elizabeth H.; Fitzgerald, David C.; Thourani, Vinod H.; Eghtesady, Pirooz; Ikonomidis, John S.; England, Michael R.; Sellke, Frank W.; Nussmeier, Nancy A.	Patient Safety in the Cardiac Operating Room: Human Factors and Teamwork	Circulation					2013
762	Walker, J. T.; Hoffman, P.; Bennett, A. M.; Vos, M. C.; Thomas, M.; Tomlinson, N.	Hospital and community acquired infection and the built environment â€" design and testing of infection control rooms	Journal of Hospital Infection	65			43--49	2007
763	Wan, Gwo-Hwa; Chung, Feng-Fang; Tang, Chin-Sheng	Long-term surveillance of air quality in medical center operating rooms.	American journal of infection control	39	4		302--308	2011
764	Wan, M. P.; Chao, C. Y. H.	Transport characteristics of expiratory droplets and droplet nuclei in indoor environments with different ventilation airflow patterns.	Journal of biomechanical engineering	129	3		341--53	2007
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766	Wan, M. P.; Sze To, G. N.; Chao, C. Y. H.; Fang, L.; Melikov, A.	Modeling the Fate of Expiratory Aerosols and the Associated Infection Risk in an Aircraft Cabin Environment	Aerosol Science and Technology	43	4		322--343	2009
767	Wang, Fujen; Chi-Ming, Lai; Cheng, Tsung-Juneg; Zhuan-Yu, Liu	Performance evaluation of indoor environment parameters for an unoccupied operating room.	ASHRAE Transaction	117	1		557	2011
768	Wang, Fujen; Lee, Mengchieh; Cheng, TsungJuneg; Law, Yuquan	Field evaluation of thermal comfort and indoor environment quality for a hospital in a hot and humid climate	HVAC and R Research	18	4		671--680	2012
769	Wang, Haidong; Zhai, Zhiqiang John; Li, Yuguo; Liu, Xiang	Identifying index (source) patient location of SARS transmission in a hospital ward	HVAC & R Research	18	4		616--625	2012
770	Wang, Miao; Lin, Chao Hsin; Chen, Qingyan	Advanced turbulence models for predicting particle transport in enclosed environments	Building and Environment	47	1		40--49	2012
771	Wang, Yu Chun; Lin, Yu Kai	Association between temperature and emergency room visits for cardiorespiratory diseases, metabolic syndrome-related diseases, and accidents in metropolitan Taipei	PLoS ONE	9	6			2014
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784	Williams, R. E. O.; Harding, Lynn	Studies of the effectiveness of an isolation ward	Journal of Hygiene	67	4		649	2009
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786	Woloszyn, M.; Virgone, J.; Melen, S.	Experimental study of an air distribution system for operating room applications	International Journal of Ventilation	4	1			2005
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793	Xuan, Xiaodong	A Review on Relationship Between Airborne Infection and Two Different Ventilation Systems in Hospitals					173--196	2011
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797	Yang, Jinho; Nam, Insick; Sohn, Jong Ryeul	The influence of seasonal characteristics in elderly thermal comfort in Korea	Energy and Buildings	128			583--591	2016
798	Yang, Junejing; Sekhar, Chandra; Wai, David Cheong Kok; Raphael, Benny	Computational fluid dynamics study and evaluation of different personalized exhaust devices	Hvac & R Research	19	8		934--946	2013
799	Yang, J.; Sekhar, S. C.; Cheong, K. W. D.; Raphael, B.	Performance evaluation of a Novemberel personalized ventilation-personalized exhaust system for airborne infection control	Indoor Air	25	2		176--187	2015
800	Yang, Xiufeng; Zhong, Ke; Zhu, Hui; Kang, Yanming	Experimental investigation on transient natural ventilation driven by thermal buoyancy	Building and Environment	77			29--39	2014
801	Yau, Y. H.; Chandrasegaran, D.; Badarudin, A.	The ventilation of multiple-bed hospital wards in the tropics: A review	Building and Environment	46	5		1125--1132	2011
802	Yau, Y. H.; Ding, L. C.	A comprehensive computational fluid dynamics simulation on the air distribution in an operating room at University of Malaya Medical Centre Malaysia	Indoor and Built Environment	24	3		355--369	2015
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804	Ye, Jiancheng; Huang, Guoliang	Real time monitoring to the odour of excrement for health of infants and elderly completely bedridden						
805	Yin, Yonggao; Xu, Weiran; Gupta, J. K.; Guity, Arash; Marchchchmion, Paul; Manning, Andy; Gulick, Bob; Zhang, Xiaosong; Chen, Q.	Experimental Study on Displacement and Mixing Ventilation Systems for a Patient Ward	HVAC & R Research	15	6		1175--1191	2009

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807	Young, R. S.; O'Regan, D. J.	Cardiac surgical theatre traffic: time for traffic calming measures?	Interactive CardioVascular and Thoracic Surgery	10	4	April	526--529	2010
808	Younger, Matthew	Natural Ventilation In Nursing Facility	ASHRAE Journal	49		April		2007
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810	Yu, Conson K. H.; Li, Min; Chan, Vincent; Lai, Alvin C. K.	Influence of mechanical ventilation system on indoor carbon dioxide and particulate matter concentration	Building and Environment	76			73--80	2014
811	Yu, H. C.; Mui, K. W.; Wong, L. T.; Chu, H. S.	Ventilation of general hospital wards for mitigating infection risks of three kinds of viruses including Middle East respiratory syndrome coronavirus	Indoor and Built Environment	26	4	April	514--527	2017
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813	Zhang, Hualing; Hong, Shiyao; Feng, Hehua	The characteristics of the patient's requirement for the ward thermal environment	Procedia Engineering	205			288--295	2017
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816	Zhao, Bin; Yang, Caiqing; Chen, C.; Feng, Chao; Yang, Xudong; Sun, Luchun; Gong, Wei; Yu, Li	How Many Airborne Particles Emitted from a Nurse will Reach the Breathing Zone/Body Surface of the Patient in ISO Class-5 Single-Bed Hospital Protective Environments?â€"A Numerical Analysis	Aerosol Science and Technology	43	10		990--1005	2009
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818	Zhao, Bin; Zhang, Zhao; Li, Xianting; Huang, Dongtao	Comparison of diffusion characteristics of aerosol particles in different ventilated rooms by numerical method	ASHRAE Transactions	110 PART 1			88--95	2004
819	Zhou, Qi; Lee, Shoo K.; Jiang, Si-yuan; Chen, Chao; Kamaluddeen, Majeeda; Hu, Xiao-jing; Wang, Chuan-qing; Cao, Yun	Efficacy of an infection control program in reducing ventilator-associated pneumonia in a Chinese neonatal intensive care unit.	American journal of infection control	41	11		1059--64	2013
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821	Zoon, W. A. C.; van der Heijden, M. G. M.; Loomans, M. G. L. C.; Hensen, J. L. M.	On the applicability of the laminar flow index when selecting surgical lighting	Building and Environment	45	9		1976--1983	2010
822	Curry Internation Tuberculosis Center,	Tuberculosis Infection Control A Practical Manual for Preventing TB					87-111	2011
823	International Conference of Building Officials	Uniform building code	*Int Conf Build Off*				42-54	2006
824	Mousavi, Ehsan S. and Grosskopf, Kevin R.	Directional airflow and ventilation in hospitals: A case study of secondary airborne infection	Energy Procedia	78			1201-1206	2015
825	Overberger, Pamela A. Wadowsky, Robert M. Schaper, Michelle M.	Evaluation of Airborne Particulates and Fungi During Hospital ReNovemberation	American Industrial Hygiene Association Journal	56	7		706-712	1995
826	Wiseman, Brian	Room pressure for critical environments	ASHRAE Journal	45	2		34-39	2003
827	US Department of Health and Human Services	Minimum Requirements of Construction & Equipment for Hospital and medical facilities	He.(HRA)				81-14500	1982
828	Jensen, Paul A., Lauren A. Lambert, Michael F. IadeMarchchchco, Renee Ridzon	Centers for disease control: guidelines for prevention of tuberculosis transmission in hospitals	Biomed Instrum Technol	46			478-487	2012
829	Centers for Disease Control	Centers for Disease Control: Use of BCG vaccines in the control of tuberculosis: A joint statement byt he ACIP and the advisory committee for the elimination of tuberculosis	MMWR-Morbidity and mortality weekly report	37	43		663--675	1988
830	Konkani A, Oakley B, Bauld TJ	Reducing hospital noise: A review of medical device alarm management	World Health Organization					2009
831	Rupp, M.E., Iwen, P.C., Tyner, L.K., Marchchchion, N., Reed, E. and	Routine sampling of air for fungi does not predict risk of invasive aspergillosis in immunocompromised patients	Journal of Hospital Infection	68	3		270--271	2008