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INDOOR AIR QUALITY AND SICK BUILDING SYNDROME IN HEALTH CARE FACILITIES AND COMMERCIAL BUILDINGS

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INDOOR AIR QUALITY AND SICK BUILDING SYNDROME IN HEALTH CARE FACILITIES AND COMMERCIAL BUILDINGS

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ABSTRACT

The purpose of this research was to identify how Healthcare Acquired Infections (HAIs) spread in hospitals, as well as research practical ways to prevent the spread of these infections. The transmission of infections in hospitals costs the economy billions of dollars annually, and it also causes thousands of deaths each year. There are methods that can be used to prevent the spread of infection in hospitals, which include revised protocols, sealing construction sites and more frequent cleanings. This paper will analyze the methods that can be used as well as the costs associated.

Additionally, Sick Building Syndrome (SBS) and the primary causes were also explored, along with possible solutions to this phenomenon. SBS is often the result of inadequate ventilation in the workplace, although there are several other possible sources. SBS can lead to discomfort and loss of productivity, but it is often hard to diagnose. There are several ways to prevent SBS which include regular air quality tests as well as routine cleanings. This research will also present the primary chemical causes of SBS.

1.0 Critical Issue

The purpose of this white paper is to provide information and guidance on disease prevention methods both in hospitals and in the workplace. The white paper will also to investigate the economics behind infection control in the workplace as well as in hospitals.

An important issue that falls under communicable diseases is the spread of diseases in hospitals. There are a variety of antibiotic-resistant strains of bacteria that cause tens of thousands of deaths in United States hospitals annually including diseases such as tuberculosis and MRSA. A lack of infection control which exasperates Sick Building Syndrome (SBS) as well as the spread of communicable diseases cost the American healthcare system billions annually, and although their rate of transmission is decreasing, one in every 25 hospital patients acquires an infection while hospitalized. Hospitals can take preventative measures that can be taken to help reduce the spread of disease. These methods will be discussed in this white paper.

Another important component of this issue is SBS, which impacts up to 30% of new buildings according to the World Health Organization. SBS causes a decrease of productivity, increased absenteeism, as well as the costs to fix it to companies. There are suggested guidelines as well as standards that help to reduce the impacts and occurrence of SBS, which will be discussed in this whitepaper.

2.0 Definition of Sick Building Syndrome and Its Significance

SBS is a growing problem in the United States and around the world. SBS is defined by the USEPA as, “situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified.” SBS is more common in new buildings because newer buildings which are typically designed with less air flow than newer buildings and newly installed office furnishings, such as

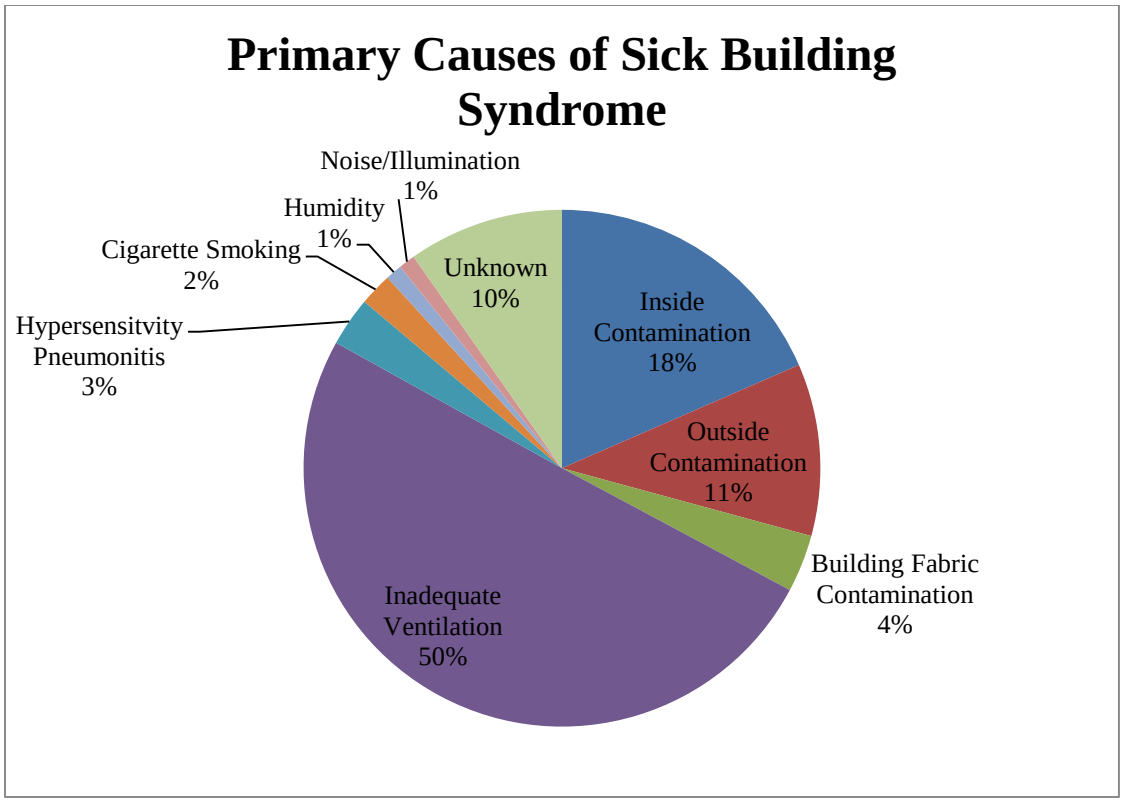
newly painted walls, building materials and furnishings, can be primary causes of SBS. In fact, in 1984 the World Health Organization (WHO) estimated that up to 30% of new buildings and recently renovated buildings are subject to excessive complaints about poor indoor air quality.

SBS has adverse, sometimes unseen impacts on the economy, worker productivity and absenteeism. Annually, $200 billion is lost in worker performance due to SBS, and there is at least a 2% loss in productivity annually due to poor indoor air quality. Additionally, according to the USEPA, indoor air pollution, which is often associated with SBS, costs businesses $60 billion a year. SBS costs companies in both worker productivity and efficiency, as well as in absenteeism. The cost in absenteeism for a company is eight times the possible energy savings from reduced ventilation in the building. The newer, "green" buildings, designed to environmental metrics such as Leadership in Energy and Environmental Design (LEED) guidelines, have an average of 5% less sick time than in traditional office buildings, as well as an average 15% increase in worker productivity.

3.0 Symptoms and General Causes of Sick Building Syndrome

There are a variety of symptoms of SBS. Most symptoms are ones that are associated with slight discomforts while working. The USEPA determined that the SBS symptoms include: headaches, irritation found in the eyes, noses and throat, a persistent dry cough, skin that is dry or unusually itchy, nausea and dizziness, difficulty concentrating while in the building, unusual fatigue and a heightened sensitivity to odors. In order for the building to be categorized as having SBS, at least 80% of the occupants must complain of these symptoms.

It can be difficult to identify the causes of SBS, so several studies have been done to try and identify the primary causes. The chart below summarizes the results of a study done by the National Institute for Occupational Safety and Hygiene on the primary causes of SBS.



It is clear that the primary cause of SBS is inadequate ventilation, as in the study of 194 buildings; half of them had inadequate ventilation as their primary cause of SBS. However, inside contamination accounted for almost 20% of SBS, which is an alarmingly high number. Inside contamination includes chemicals found in office furnishings and supplies, such as copy machines, carpets and building materials. This can be prevented through proper maintenance and choosing building materials that have low VOCs, irritating materials, etc. The third most common cause is outside contamination, which accounts for 11% of SBS. This is a problem when contaminants come from outside of the building, including exhaust, noise pollution and combustion products that can come from nearby garages, as vapor intrusion can become a problem in many buildings.

4.0 Contaminants and Factors of Concern

There are several contaminants that are primary causes of SBS. Chemical contaminants can be especially dangerous and include formaldehyde, radon, asbestos (in older buildings), radon, pesticides used in and around the building, scents from cleaning products, tobacco smoke as well as lead from paint. Carbon dioxide levels above 1,000 ppm can begin to cause eye and throat irritation, fatigue and headaches. When carbon dioxide levels are consistently at or above 1,000 ppm, the ventilation system should be evaluated and changes should be made. Carbon dioxide levels of above 30,000 ppm are rare but can cause asphyxiation and death can occur at that level. Dust and dust mites also create problems in offices, as dust can cause coughing and sneezing in workers, especially those who suffer from allergies. Additionally, dust being inhaled over an extended period of time can be damaging to the lungs as dust is small particles suspended in air. Ozone can be released by office appliances such as photo copiers, which can cause irritation in the throat, as well as excessive coughing, pain or burning when taking deep breaths as well as shortness of breath and wheezing.

5.0 Indoor Air Quality Testing

Indoor Air Quality (IAQ) is a concern and a factor that contributes to SBS. In order to properly sample the IAQ of a building, every reasonable measure should be taken to avoid opening the building up to outside air, and potentially outside contamination. When samples are collected, they should be collected from a variety of occupied spaces during the times that they are commonly occupied to get the most representative samples. The samples should also be taken over a one hour period and employees should try to avoid lingering unnecessarily in the area to avoid interfering with the sampling devices. If the goal is to collect a sample that is

representative of a longer period of time, the sampling should continue for more than sixty minutes to gain a more representative sample.

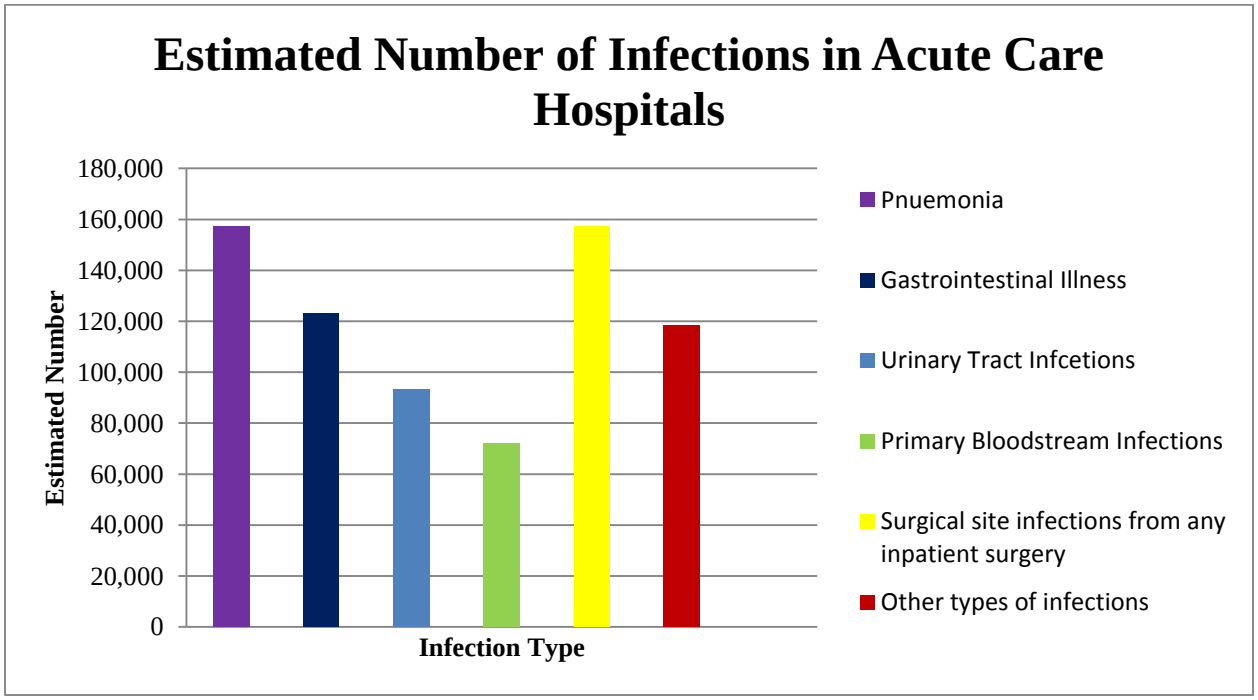
When delivering the samples to a laboratory, other information must be included to aid in the analysis of the air samples. Important information includes air flow diagrams, floor plans and observations such as odors are all important in the analysis of air samples. When testing the samples for chemicals that can cause irritation, the laboratory must test for the chemicals of concern as well as the potential breakdowns of those chemicals. Breakdown products that are of concern include: 1,1,1-trichloroethane analysis should also include 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, chloroethane and vinyl chloride. These chemical breakdowns are common in ground water, oil spills and soil vapor. There are several other chemical indicators that can be tested for which all indicate different chemical contaminants. When testing air quality, it is more common to test for indicator compounds rather than the chemical itself. When testing, the laboratories must have the Environmental Laboratory Approval Program (ELAP) certification for the combinations that they will be testing the air for. They must also be able to test for background levels of contaminants (such as VOCs) which are very low, often one microgram per cubic meter.

IAQ can be an important indicator for the SBS potential of a building. When testing the air quality for a building, if there are higher than recommended levels of a contaminant or of a chemical breakdown, SBS becomes a concern for the building. Often, when high concentrations of chemicals are found in a commercial building, it is an indicator of improper ventilation which is one of the primary causes of SBS. The higher the concentrations of chemical contaminants, it is more likely that the building will suffer from SBS.

6.0 Disease Spread in Hospitals

The spread of diseases in hospitals is an environmental and healthcare issue, and it has gained publicity recently. There are several reasons for this, including the introduction of Obamacare and rising healthcare costs. It is very easy for diseases to spread in hospitals, there are hundreds of sick people in close proximity, and in 2007, only three states (Illinois, New Jersey and Pennsylvania) had passed legislation requiring hospitals to routinely test high-risk patients for MRSA. In the same year, only New Jersey and Illinois required all intensive care patients to be screened for MRSA. Additionally, approximately 25% of hospitals screen patients for bacterial colonies upon entry through nasal swabbing. The CDC is working vigilantly with hospitals to reduce infection rates and tighten protocols so that both the patients as well as the healthcare workers are protected.

The graph below shows the most common infections and their estimated occurrence in acute care hospitals in the United States.



According to the CDC, every year one in 25 hospital patients in the United States will acquire an infection during their stay, and between 78,000 and 90,000 people die annually in the United States from hospital acquired illnesses. From an economic standpoint, hospital acquired diseases cost up to $1.77 million a year for a 200 bed hospital. In 2007 the estimated cost for treating hospital acquired infections in the United States was between $20 and $30 billion, or 2-3% of the nation's spending on healthcare.

7.0 Lessons Learned from the Spread of Disease in Hospitals

Although the spread of disease in hospitals is a chronic problem that has adversely impacted millions in the United States, there are important lessons to be learned from the spread of disease. The CDC has successfully in reduced the MRSA rate by 54% between 2005 and 2011. As a result of the high rates of infection, the CDC has developed three elements to be used when trying to prevent communicable disease; strong public health fundamentals, high-impact interventions and sound health policies. Through using this three-tiered approach, the CDC has been able to reduce the occurrence of communicable diseases in hospitals.

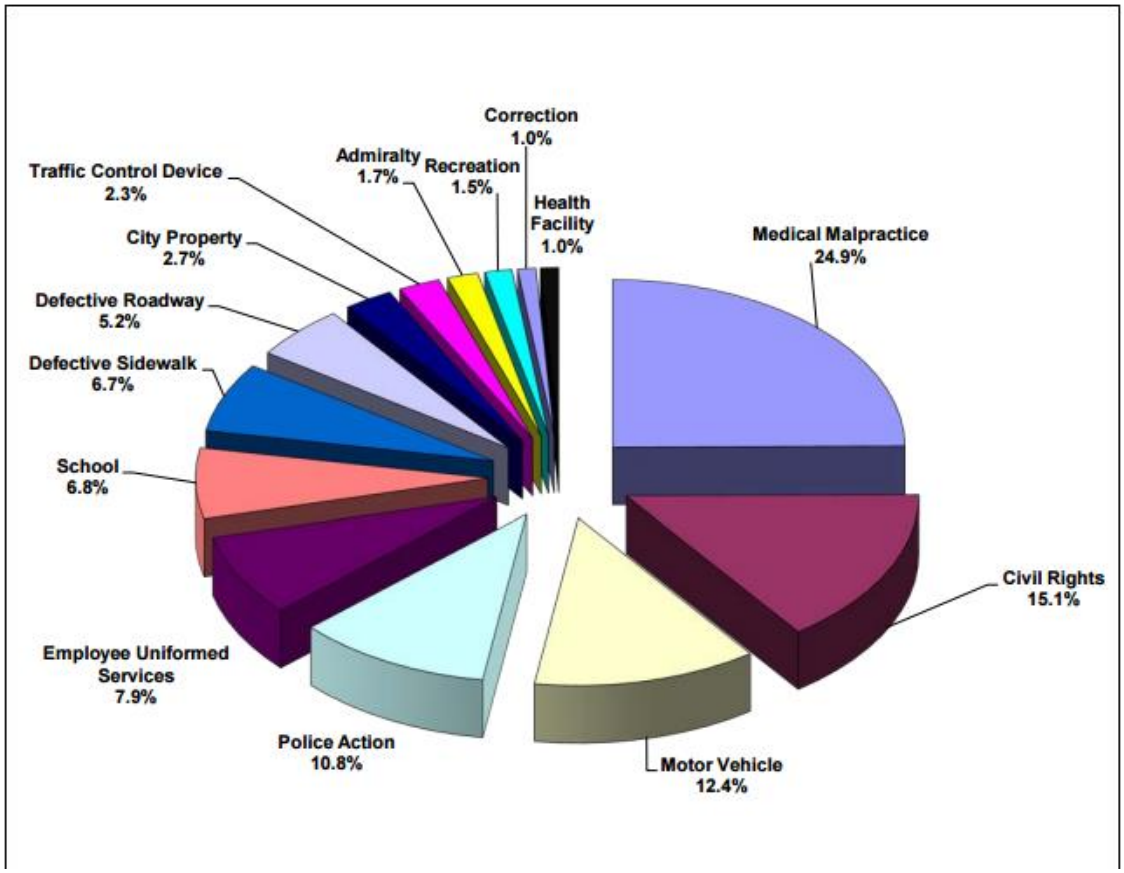
The CDC has also learned that when the protocols are followed closely, the occurrence of Healthcare Associated Infections (HAI) is significantly reduced. It has become clear from the experience that with routine cleanings that it is possible to drastically reduce, or even eradicate problematic diseases from the American healthcare system. Overall, through analyzing the patterns of HAIs in hospitals, it has been found that it is possible to reduce and eliminate communicable diseases. Maintaining strict protocols is essential to reducing the spread of disease and infections in healthcare facilities.

8.0 The Cost of Medical Lawsuits

Medical malpractice is defined as, “improper, unskilled or negligent treatment of a patient by a physician, dentist, nurse, pharmacist, or other health care professional.” Medical malpractice can include not following protocols, not following procedure or behaving in a way that causes preventable injury in the patient. There has been a significant rise in medical malpractice cases in the United States since the 1970’s, and as a result, the legal costs as well as the payments for each case have risen significantly.

In New York City, medical malpractice claims account for almost 25% of the total personal injury expenditures, except the number of claims is one of the lowest of any category. As a result, medical malpractice suits are proportionally the most expensive law suits that face the city. Additionally, New York State does not have a limit on the amount that can be paid out in medical malpractice suits, so one suit can cost upwards of one million dollars.

Percentage of Total Personal Injury Expenditures Recorded by Claim Type
FY 2012



9.0 Differences in Disease Spread in Hospitals and Office Buildings

Although the spread of illnesses in office buildings and in hospitals are both concerns, there are several differences in how infections spread in the two environments. The spread of infections within hospitals is driven primarily by the close proximity of multiple sick patients, breathing in the same air and being treated by the same doctors. Many of the infections that are acquired by patients can be fatal, as close to 90,000 people a year die from HAIs. In office buildings, the illnesses are often due to SBS, and can result in discomfort, and in extreme cases long-term hypersensitivity to indoor pollutants such as fresh paint and dust. However, there are no known cases of SBS that have resulted in death. SBS impacts people exposed to the same

environment in different ways, some workers are more prone to certain symptoms than others. However, in hospitals, once the disease is transmitted to the patient, it infects them, unlike SBS where some workers will not have any symptoms and others may need to take numerous sick days. Finally, the spread of disease in hospitals can often be prevented on the level of the individual, with proper hand hygiene and adhering closely to protocols set forth by the CDC. However, in buildings, SBS is often a result of materials used to construct and furnish the building, so proper ventilation must be used and indoor and outdoor contaminants must be monitored and eliminated, which must be done on the level of the company or building.

10.0 Prevention Methods for Hospitals

There have been several prevention methods that have been created for hospitals. Methods that have been implemented for patient rooms include increased air ventilation, the usage of reverse pressure ventilation, filtration of air, increased air circulation, Ultraviolet Germicidal Irradiation (UVGI), HEPA filters and the proper sealing of work areas when there is construction in the hospital. It is essential that HEPA filters are maintained and kept in working condition as the removing of the physical particles from the air is the first step in maintaining indoor air quality. Moreover, the use of disposable blood pressure cuffs, putting hand sanitizer dispensers in hallways and common areas as well as nasal swabbing to test for bacterial infections have helped to significantly reduce the rate of infection in hospitals. Regular, industrial cleanings are also important as diseases can be spread through touching shared surfaces such as stethoscopes, over-the-bed tables and other furniture. Additionally, it has been found that tuberculosis can be carried in the doctor's ties and in the curtains of the room, so it is important that both are cleaned well. Scrubs should never be worn outside of sterile

environments, as they can pick up outside contamination and bring it into sterile environments such as the Intensive Care Unit.

Mechanisms for maintaining and improving indoor air quality are using HEPA filters both in patient rooms and in construction areas. High-efficiency air filters are the next step in maintaining air quality, in a hospital environment 90% efficiency is the minimum needed for successful infection control. Patient windows must also be sealed when there is construction in the hospital, especially if the rooms are near the construction area. Also, negative air flow should be used in the patient areas as well the construction areas to remove all contaminated area before it can become damaging. Moisture control in the environment is also essential for infection control, bacteria grows at a more rapid pace in moist environments. To prevent the spread of water-borne infection, the water temperature should be kept cool or cold, and water fountains should be cleaned regularly according to the instructions of the manufacturer as well. Water fountains should also not be placed in areas that have high-risk infections, as the likelihood of infections residing in water fountains in those areas is much greater.

Following protocols set forth by the CDC is also essential to disease prevention in hospitals. When hospitals closely complied CDC protocols for hand washing and infection control, the rate of disease transmission drops significantly. This can be seen from the CDC's *Vital Signs* newsletter, where results from a study are shared; when hospitals followed protocol closely, they were able to significantly reduce the number of bloodstream infections in patients with central lines, reducing the diseases caused by the staph germ by 73% over a few years.

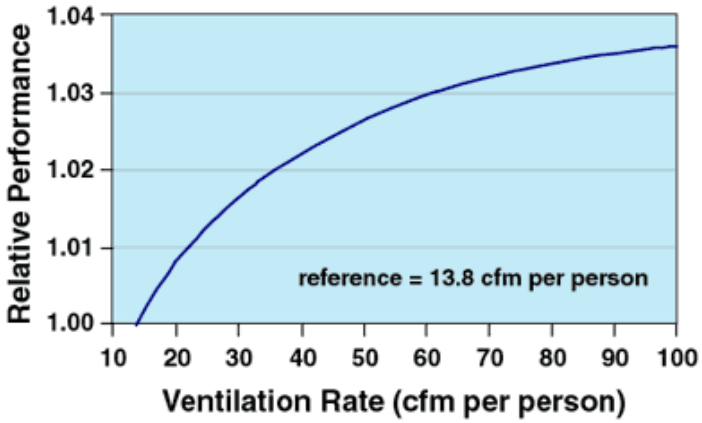
Another essential part of preventing the spread of diseases in hospitals is the proper treatment of construction areas in hospitals. If not properly sealed off, construction dust can become vectors for dangerous infections such as Legionella and Aspergillus. Aspergillus is

especially dangerous because it is a mold, and routine cleanings using Clorox will not eradicate it. Construction areas must follow an Infection Control Risk Assessment (ICRA), which categorizes the destructiveness of the construction project, as well as the sensitivity of the patients to determine the level of protection that is needed. In all cases, the construction area must be sealed off; duct tape is suitable in some scenarios, but a more protective sealant may also be required if a higher level of protection is needed. Also, all materials that leave the work area must be sealed in all cases and it is very important that the minimal amount of dust is raised by the work. The site must also be reviewed at the beginning and end of each day by the supervisor to make sure that the cleanup took place to prevent the spread of germs during nonworking hours.

11.0 Prevention Methods for Buildings

There are several ways to prevent SBS in office buildings. An essential step in preventing SBS is the use of proper ventilation. According to the USEPA, workers can experience SBS symptoms when the ventilation rate is between 10 and 35 cfm per person. However, most building codes require a ventilation rate of 15-20 cfm per person. When the ventilation rate is at or above 53 cfm per person, the symptoms of SBS are typically eradicated. The suggested number of air changes per hour in private offices is four. Increasing ventilation also increases productivity, as can be seen in the graph from the Indoor Air Quality Scientific Findings Resource Bank.

Relative Performance of Individual Workers Compared with the Ventilation Rate



Another way to help prevent SBS is to install proper filters to help eliminate outdoor contaminants and remove indoor contaminants from the airflow. This allows cleaner air to flow through the office space, with fewer contaminants in the air, workers are much less likely to have SBS symptoms.

An additional SBS prevention method is to have regular, industrial, cleanings of the office spaces because when a space looks cleaner, employees tend to feel more satisfied with their workplace and they are less likely to suffer from and report SBS symptoms. Lighting is also an important part of SBS; improper lighting can result in headaches along with other symptoms. Improper lighting can also aggravate other symptoms of SBS as well; it may not be the primary cause of the symptoms, but changing the lighting and adding more natural light can help relieve many symptoms. Additionally, when more natural light is in a workplace, employees feel more satisfied with their workplace, reducing their symptoms as well as complaints.

12.0 Compliance Costs

The Occupational Safety and Health Administration (OSHA) conducted a study on the average costs of complying with the standards on Indoor Air Quality (IAQ) annually. The

standards are the ones that the OSHA is proposing, and the study was done to evaluate how much it would cost. Some applicable standards are 29 CFR 1904, Recording and Reporting Occupational Injuries and Illnesses, 29 CFR 1910.94, Ventilation, 29 CFR 1910.1000, Air Contaminants, 29 CFR 1910.1048, Formaldehyde, 29 CFR 1910.1450, Occupational exposure to hazardous chemicals in laboratories. Although the costs are high ($8 billion annually nationwide), they are significantly less than the costs of SBS ($60 billion annually nationwide).

Summary of Projected Compliance Costs for Proposed OSHA IAQ Standards

	Annualized Cost ($ millions)	**Recurring Cost ($ millions)**	**Annual Cost ($ millions)**
IAQ Written Compliance Program	21.1	-	21.2
IAQ Maintenance and Operation Program	1,2814.1	6,697.4	7,978.5
Information and Training: Maintenance Workers	0.5	0.8	1.3
All Employees	-	-	-
Controls for Tobacco Smoke*	68.1	-	68.1
Total	1,371.0	6,698.2	8,069.1

*The cost depends on the current damage due to tobacco smoke as well as the previous laws and standards regarding tobacco smoke in the area.

From the chart, it is clear that the first year adopting the new standards will be the most expensive, but once the standards have been adopted, the costs will be reduced by over one billion dollars. The cost is also much less than the annual cost in loss of productivity due to SBS (this estimate varies between $5 and $40 billion).

OSHA has the following calculation for individual companies to calculate the cost of developing the written IAQ compliance program that is required as a part of the OSHA standards:

$$C(o) = E(n) \times P(c) \times ((W(t) \times T(1)) + (W(m) \times T(2)))$$

Where:

C(o) = the cost of developing operation and maintenance information

E(n) = the number of establishments

P(c) = the percentage of establishments to develop operation and maintenance information (95%)

W(t) = the technician wage rate ($15.51 hourly compensation rate)

T(1) = the technician time required to compile and develop building system operation and maintenance information (1 hour)

W(m) = the managerial wage rate ($30.48 hourly compensation rate)

T(2) = the managerial time required to develop some requirements of the written plan (15 minutes)

The cost of implementing the air quality compliance program at an individual company can be calculated as:

$$C(p) = M(s) (N(h) \times C(a) + N(p) \times C(a) + N(p) \times C(i) \times A(20))$$

Where:

C(p) = cost for providing regular HVAC maintenance

M(s) = mean square footage per building (14,000)

N(h) = number of buildings without HVAC maintenance

C(a) = cost per square foot for providing HVAC maintenance ($0.21)

N(p) = number of problem buildings without HVAC maintenance

C(i) = cost per square foot for providing HVAC maintenance and IAQ improvement actions ($1.14)

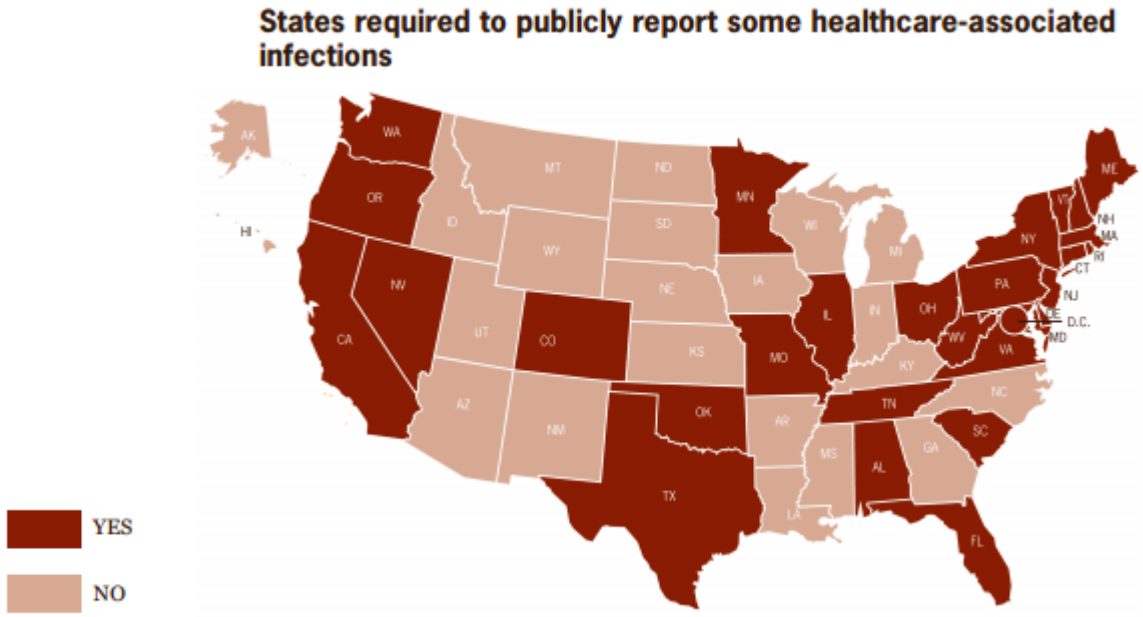
A(20) = Annualization factor at 10% over 20 years (0.117)

13.0 Recent Actions Taken to Prevent the Spread of Diseases in Hospitals

Due to the importance of the transmission of infection in hospitals, there have been several different courses of action taken by federal and state governments as well as individual hospitals. Starting in the 2015 fiscal year, hospitals saw a 1% funding cut if they had a high rate of "hospital-acquired conditions". This score is heavily influenced by the occurrence of HAIs. Each hospital was ranked on three categories; Serious Complications, Central Line Associated Bloodstream Infections (CLABSIs) and Catheter-Associated Urinary Tract Infections (CAUTIs). In the ranking, ten is the worst score and one is the best. The scores are averaged together, and hospitals with a score above seven are penalized. This program will cut funding from 724 hospitals, and will cause payments to drop about $330 million. The hospitals in New York City that had their funding cut are Lenox Hill Hospital, Mount Sinai St. Luke's Roosevelt Hospital, New York University Langone Medical Center, New York Methodist Hospital, Montefiore Medical Center, Lutheran Medical Center, Brookdale Hospital Medical Center, Brooklyn Hospital Center, Downtown Campus, Coney Island Hospital, Kings County Hospital Center, Kingsbrook, Jewish Medical Center, SUNY/Downstate University Hospital of Brooklyn, Wycoff Heights, Medical Center, Jamaica Hospital Medical Center, St. John's Episcopal Hospital at South Shore, Jacobi Medical Center, and St. Barnabas Hospital (located in the Bronx). The two types of hospitals that are most impacted by this program are hospitals which serve lower-income populations and teaching hospitals. This program has received heavy criticism, but the Centers for Medicare and Medicaid Services have had several successful initiatives over the last few years and believe this is the next step in battling HAIs.

State governments have also begun to take steps to help prevent HAIs. A few states have begun to mandate nasal swabbing to test for bacteria counts when patients enter the emergency rooms, and many others require the routine swabbing of critical or high risk patients. Additionally, most states have laws that require that all HAIs are reported to the state government, and that information is publically available. This helps patients choose which hospitals they want to go to for their care and also helps the government monitor the infection rates in hospitals.

Image from the CDC



There have also been actions taken by individual hospitals that have successfully in the reduction of hospital acquired diseases. One example of disease control and prevention can be found in the Veteran's Administration hospital system. The system implimented four anti-MRSA measures in the hospitals, and as a result, MRSA rates fell by 68.6% over five years. This has helped to prevent thousands of infections as well as deaths, and data is suggesting a further drop in the MRSA rates. Another hospital system that has successfully driven down infection rates is

the Hospital Corporation of America (HCA), which has implemented universal decolonization, which disinfects the nasal passages and skin of everybody who enters the intensive care unit. This method reduced the infection rate by 30%, and a new handwashing iniative, ABC, has reduced infection rates another 30%. Through new, stricter protocol, several hospitals have been able to drasticallly reduce their infection and MRSA transmission rates.

14.0 Recent Actions Taken to Prevent Sick Building Syndrome

SBS is difficult to treat, and once a building has a reputation for being “sick”, it is difficult to get rid of the reputation and it could have a negative impact on marketing and leasing. However, there have been several recent actions that have been useful in preventing SBS. The first is new legislation that has banned smoking indoors and in workplaces, which has helped improve Indoor Air Quality significantly. This has had a positive widespread impact on air quality across the United States, both in and around buildings. There have also been new guidelines for air quality and ventilation set by organizations like OSHA, which help insure that there is proper light and ventilation to create a safe and comfortable environment for office workers. When these guidelines are implemented in offices, it has a positive impact. Another recent trend in building construction that has had a positive impact on the reduction of SBS is using frosted glass. This allows for natural light to enter but with less intensity, reducing SBS symptoms. Community and terrace gardens, as well as indoor plants, have helped to filter some chemicals that are responsible for SBS as well. Finally, education and research have been very beneficial in the treatment of SBS. About thirty years ago, SBS was not considered a real problem but due to education and research to find the causes, as well as research into prevention methods, there has been significant progress in treating and eliminating SBS.

15.0 Conclusion

Healthcare Acquired Infections are an important issue in the United States as they cause thousands of deaths annually and cost billions of dollars to treat. These infections that are spread are transmitted from one patient to the other, and this transmission can often be the result of carelessness in healthcare workers. However, there are cost-effective prevention methods that can be implemented to help hospitals save money and lives.

SBS is a growing problem in the United States as it gains recognition as a health condition. It causes discomfort in workers, but can have long-term health impacts if the causes are not addressed. Like HAIs, SBS is costly to the economy and the companies that have space in the buildings that suffer from SBS as worker productivity is lost, absenteeism is increased and there is a higher turnover rate amongst staff.

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