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Review Article on the Most Common Bacteria in Hospital Pollution

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Annotation: Introduction to Hospital Pollution: The pollution of indoor hospital environments has become increasingly concerning since pollutants produced due to inadequate waste management and inappropriate chemical disposal have shown considerable negative influence on both the hospital staff and patients. Generally, large amounts of polyethylene, rubber, wood, cardboard, paper, cotton wool, food, carbon-based objects, ink-paper, X-ray solutions, and machine oil are extensively used in hospitals, and once these products become outdated, they are generally thrown away to landfills without considering the potential of soil and environmental pollution. Besides chemical wastes, other remarkable indoor hospital pollutants such as chemicals and biological materials, including tissue, bone, and biohazard materials from human infections and hospital surgeries, could potentially spread higher concentrations of several more

diverse bacterial hazards than similar outdoor environmental conditions. Hospital staff and day admissions are mostly at risk from surfaces that are highly exposed to various pollution materials, such as those on operation theater floors and table surfaces, and many departments, including the surgical department. Microbial pollution may lead to severe infections in humans, causing injuries from cutting instruments during surgery and affecting wound tissues.

Hospital pollution should be properly highlighted, and awareness campaigns should be run about its impact on human health. Presently, preventative measures and products adopted by local hospitals could also be submitted for publication. It should also be noted that hospitals not only treat patients but are also considered to be major potential pollutants. Despite cleaning and disinfecting treatments, multi-antibiotic resistant DNA has the potential to build up and survive long-term in the presence of disinfectants, for instance, in dust and on surfaces. Various important issues dwell on patient infections, surgical incisions, devices, and other items in use in the indoor hospital environment and their management efficacy, and these important issues are just a little apart from the main objectives.

1.1. Definition and Causes of Hospital Pollution

Pollution on its own is irreparable damage done to the environment and is directly responsible for threatening standards of living. Hospital pollution is not just the contamination of air, water, and land; it also includes biological pollution, chemical pollution, and socially toxic pollution. Biological pollution involves the spread of diseases and parasites. In this context, pollution refers mainly to bacteria and biological contaminants in the hospital environment and/or on surfaces and articles within hospital premises. Many activities can contribute to the pollution of places where humans are domiciled. Failures in human social and industrial activities lead to the production of various waste, which in turn contributes to the final waste pileup worldwide. [1][2]

The generation of hospital waste is characterized by the type of waste it produces rather than the total amount of waste. The presence of radioactive, toxic, and infectious biological waste in hospital areas contributes significantly to the volume of waste produced by hospitals. To better understand hospital pollution, it is important to understand the patient and hospital environment, hospital layout and design, past and present medical practice, the direction of waste disposal, staffing levels and attitudes, social and public education, hospital regulations, and investment. Medications and patient treatments that include airborne pollutants have increased levels of pollution in the hospital environment. Medications may include antibiotic-type drugs, antiseptics, germicides, fungicides, air fresheners, floor cleaning agents, etc. Medications and treatments often go hand in hand using biological and physical/electronic equipment that also contributes to increasing the level of pollution within hospital surgical standard areas. Environmental factors such as heat, high moisture, high relative humidity, trapped stagnant air, single or no flow of general background ambient air, low air filtration rates, and poorly located or contaminated hospital ventilation equipment also contribute to the overall increased levels of pollution in hospitals. [3][4]

2. Importance of Identifying Common Bacteria

Given the consequences of the presence of microorganisms in the hospital environment for the improvement of healthcare networks in patient safety, as well as the expected compromise in the quality of results in medical practice, the presence of these microorganisms, whether in the air, in immunological analyses, in meat, or in environments that aid in therapy, is an object of interest for the development of infection control measures. Common bacteria are associated with higher rates of healthcare-associated infections, which translate into high morbidity and mortality, as well as the need for continuous treatment, ranging from pharmacological agents to surgery. Thus, the development of strategic actions that can indicate probable emerging outbreaks of common bacteria in hospital pollution or the likelihood of cross-infection between patients is important in a continuous effort to find solutions to health problems. The substantial scientific output has also shown the tremendous potential of infection and disease associated with territories contaminated with drug-resistant bacteria in hospitals, with possible corresponding effects in the community. Hospital pollution monitoring, with the active search for viable microorganisms, is an important aspect of public health quality policy. Therefore, the identification of specific bacteria in higher pollution from hospital environments is used by health agencies for the implementation of surveillance policies. However, for public health, the common bacteria that live in high proportions of hospital pollution not only alert health officials but also monitor the success of health policies in the medium and long term, and for the population itself to adopt some prevention care. Thus, this review discusses the importance of these common types of bacteria in hospital environments and calls for further discussion of the issue. [5][6]

2.1. Impact on Public Health

2.1. Impact on Public Health

Hospital-acquired infections (HAIs) pose a significant challenge in their management within the healthcare environment. The spectrum of infections may vary from minor infections to critical, life-threatening infections. The sequence of events in HAIs largely depends on the immune status of the patient, the nature of the organisms, and the environment in which the disease can be acquired. The mortality and morbidity rates can increase by 2 to 10 times with the onset of HAIs. These localized infections can be further propagated to different body sites, which could lead to systemic symptoms. It has been identified that hospital-acquired bacterial infections are not confined to the hospital environment and can further spread into the community. Furthermore, the identification of HAIs causes an increased rate of hospitalization, reporting 1 to 3% death rates from pneumonia cases at a cost of 30% of healthcare expenditure. Infections are often overlooked by society and healthcare professionals, and can be improved either through effective health education for the public or stringent practices to reduce the propensity for such infections by healthcare professionals. Recently, these groups have been assessing societal functionality concerning this scenario. Additionally, hospital-acquired infections that spread disease are significant sequelae, which have been on the public agenda for disease control and are more principle-oriented, aligning with resistance strategies that adopt a broad-spectrum approach. Overall, refining these mechanistic strategies would shape the perception of public health management and community engagement in an emerging non-health setting of intervention and prevention strategy, drawing a synchronization between health and societal norms.

State and federal governments, along with public health practitioners, should, from a functional perspective, initiate and measure preventive strategy mechanisms to control the spread of diseases derived from hospital pollution. Furthermore, it elucidates the importance of the public health system and raises the question of how the public health system plays a vital role in rediscovering an organized individual approach strategy. Thus, it is essential to integrate community-level sharing and consider different perspectives for healthcare infections that would aid in appropriate health interventions and preventive measures. Population health management has several definitions articulated by individual agencies and programs. It essentially includes diseases and their impacts on given pathological conditions, as well as beneficial serology adequate in health and medicine. In recent infectious disease epidemiology, five criteria integrated by academia and related communities highlight pandemics and their methods of combating diseases. The highly intellectualized descriptive community accepts and endorses policy frameworks for human health approaches that overlook many integrated aspects of the direct and delayed nature of healthcare-derived bacterial infections and their public health ramifications. [7][8]

3. Methodologies for Identifying Bacteria in Hospital Pollution

A variety of methodologies are available to identify bacteria in hospital settings, each with its advantages and disadvantages. Some traditional techniques, mostly of historic interest, include the use of color and appearance of the bacteria when visualized under dark-field or fluorescence microscopy, gram staining, and performing various biochemical tests to narrow down potential bacteria. More modern techniques are known to increase speed, are likely to be more specific and sensitive, and may even be less expensive once appropriately equipped facilities are available. Importantly, skilled personnel trained in the standards can work with these identification methods.

A variety of identification methods are available to aid in selecting additional or more aggressive prevention or detection strategies to eradicate bacteria from hospitals. The choice of method depends on the specific sample collected and where and what type of hospital it was collected from: operating room, intensive care unit, etc. All methodologies described below have some built-in uncertainty in terms of their sensitivity and specificity - some of the methods are more error-prone than others. The escalating antimicrobial resistance problem suggests that approaches to these methods must change over time as new or modified bacteria are identified. It should be noted that untrained or unskilled personnel and/or those working in unregulated laboratory conditions cannot perform these techniques accurately; strong statements must be made. Furthermore, it is essential that each approach is adopted with strict laboratory standards in mind. [9][10][11]

3.1. Culturing Techniques

3.1. Culturing Techniques. Culturing techniques have been widely used for a century as a means of isolating and identifying microorganisms derived from different samples, mainly microbiota. The most important aspect of the presumption of such methods is that they can be based on the isolation of specific bacterial strains using selective media and multiple incubation conditions. A traditional bacteriological method can use mixed, differential, and selective agar as a culture media method based on isolation. Therefore, it is presumed that the bacteria from the sample mimic the isolation principles. For the detection of microbiota associated with hospitals, the collection and measurement of bacteria in the environment are fundamental for evaluating the risk of HAIs.

Culturing samples under anaerobic conditions is also a common practice to determine the isolation of anaerobes. In the case of open health care environments, several culturing methods are available to isolate both aerobic and anaerobic hygiene-associated microbiota. Recently, to reduce the isolation time of microbiota, rapid culturing techniques have been adapted for human clinical samples, particularly those used for predicting blood culture and antimicrobial susceptibility testing. Although culturing procedures provide limitations, such as the recovery of only cultivable bacteria and the growth of fastidious microorganisms, they may still be available for environmental sample measurements. When performing culturing procedures, horizontal and operator-related contamination can be found in improved sampling techniques. Thus, culturing methods have been briefly described to provide detailed information regarding the presumed bacterial population in a contaminated area, particularly from personnel isolated samples. [12][13]

4. Common Bacteria Found in Hospital Pollution

As infectious diseases continue to be one of the world's greatest causes of morbidity and mortality, much work is being done to understand and eliminate threats present in the environment that surrounds us. The hospital environment is no exception, being a hotbed of often dangerous bacteria.

In this review, we aim to cover the most common bacteria found in hospital pollution, an environment littered with diverse bacterial life.

Staphylococcus, Bacillus, Streptococcus, and Pseudomonas are common genera found in healthcare, of which Staphylococcus and Bacillus are the most numerous. These genera are often found in healthcare dust and on hospital surfaces due to their sources in hospital waste. Bacteria like Staphylococcus are associated with skin, while Bacillus are soil saprophytes and enter via fine dust or via air handling systems. Such bacteria are most often found in close conjunction with hospital waste, with a strong negative correlation in air prevalence greater than 101 m from the nearest source. S. aureus is common on contaminated surfaces like fomites and medical equipment. While pathogenic in some settings with some strains, clinical infections of Streptococcus were more often transmitted in non-hospital settings like serotype A in childcare centers or B in the food industry. Bacilli can resist desiccation, survive for years on surfaces and dust, and can be transmitted via fomite/dust contacts; continually being a dominant environmental strain.

The surfaces of a clinical setting may contain clinically dangerous bacteria. A study found that at a medical center, 7.5% of examined surfaces were specifically polluted with Staphylococcus aureus. In terms of bacterial transmission, there were a total of 35 reports of vancomycin-resistant enterococci (VRE) across several hospitals, with transmission thought to have occurred through hand contact, skin scales, or fomites. Hand hygiene and awareness of hospital pollution would reduce not just patient infections but also staff rates of infection by common or uncommon hospital bacteria. In developing nations, the role of a clean hospital environment has shown to be important in maintaining patient safety. In a population of doctor inpatients, housecleaning reduced the hospital infection rate from 7.9 to 4.5 infections per 100 patient admissions. [14][15]

4.1. Staphylococcus aureus

Staphylococcus aureus is a common bacterium found in hospital environments. It primarily exists in the anterior nares and skin of humans and animals. It is also widely distributed in the environment, such as in water, soil, sewage, and air. Staphylococcus aureus is one of the most common infections in healthcare settings, causing a wide range of infections indicative of disease severity. It is transmitted from the patient's own endogenous infection source or by healthcare workers who do not comply with hand hygiene after contacting infectious patients. Staphylococcus aureus can remain viable for a long time on the surfaces of objects, such as bed units, lockers, bed handrails, medical equipment, and patient care equipment. Inadequate hand hygiene or failure to disinfect the environment can contaminate the hands of healthcare workers and cause cross-infection between patients by transferring pathogens from the environment to the hands. The most common Staphylococcus aureus infections involve nosocomial pneumonia, soft tissue infections, endovascular infections, and medical device-related infections. Because Staphylococcus aureus has a strong ability to adhere to the surfaces of biomaterials, it forms a film on the surfaces of medical devices such as cardiac valves and prosthetic joints, and most infections are difficult to cure. Severely immunosuppressed patients have an increased risk for Staphylococcus aureus bloodstream infections. The discovery of S. aureus in the patient's hospital environment is critical for infection control practices. Approximately 10% of healthy people and 20% of hospitalized patients are persistent carriers of Staphylococcus aureus. Infected or colonized patients can contaminate the environment during treatment or care. The main form of transmission is direct contact between the patient and the contaminated surfaces after contamination with Staphylococcus aureus during treatment or care. After multiple single-use or reuse, there is a large risk of equipment surfaces being contaminated, such as intravenous drip poles, bed units, bedside tables, and bed handrails.

Control of Staphylococcus aureus infection is complicated by the many types of infections it can cause, the pathogenic nature of the bacterium, and the ease of antibiotic resistance. Infection and infectivity, together with its ease of transfer, led to its global priority status in the health sector. The development of an appropriate infrastructure in laboratories is also very important in studying this bacterium. In addition to the need for an aseptic working environment, it is also necessary for the facilities to have the ability to genetically and bacteriologically analyze Staphylococcus aureus. In conclusion, practices that can be applied specifically for Staphylococcus aureus can help to prevent infections and can increase patient safety as well as standard prevention measures. [16][17]

5. Health Risks Associated with Common Bacteria

Contrary to environmental pollution in general, patients in hospitals are often affected by poor indoor microbial air quality, particularly in ventilation systems. Infection of healthcare workers, inhabitants, newborns, and the elderly who require longer hospital stays are some of the risks associated with bacterial air pollution. The most frequent bacteria present in environmental and, in particular, hospital pollution are described, along with risk-related problems of infection and the inadequate diagnostic and therapeutic approach. Efficient decontamination systems associated with the evidence of bacterial endotoxins are able to reduce these pollution-related problems.

Common bacteria in the ventilation systems of hospital environments are able to become healthcare workers and, in some cases, the inpatients' carriers and, consequently, to increase the problem of healthcare-associated infections. Among the most frequently isolated bacteria, the following can be listed: Enterococcus spp., Staphylococcus spp., Micrococcus spp., Citrobacter spp., Aeromonas spp., Acinetobacter spp., Pseudomonas spp., Flavobacterium spp., Ochrobactrum spp., Erwinia spp., Gluconobacter spp., Enterobacter spp., Bacillus spp., Streptococcus spp., Microbacterium spp., Actinomyces spp., and Propionibacterium spp. The very elderly, immunosuppressed patients, and newborns are at risk for both double aetiology and a combined exerted action for infection development, extended length hospital stay consequences, and prolonged pharmacological therapy for the same infectious trigger. Usually, the currently known diagnostic tools and/or pharmacological therapy systems are not always sufficient to eradicate colonization and/or infection in hospitals. Moreover, the most indicated treatment therapy shows a minimum preventive recovery percentage. For all these reasons, it is mandatory to strengthen the monitoring activities and to implement scrubber systems as well. [5][18][19]

5.1. Antibiotic Resistance

The prevalence of emerging antibiotic resistance rates among the most common bacteria in hospital pollution causes great concern. Antibiotics are often misused and inappropriately used in healthcare settings. This overuse and inappropriate use enable the bacteria to change and make the antibiotic ineffective over time. Resistant bacteria are more commonly found in the hospital setting. There are surveillance data that show the percentage of antibiotic-resistant bacteria in a certain country. This data is different for each strain of bacteria. In the United States, the top three species with confirmed resistant rates are Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter baumannii. The spread of resistant bacteria causes patient health problems and provokes the public because people are worried that they can be contracted in hospitals. The most challenging bacteria spreading in healthcare facilities are methicillin-resistant Staphylococcus aureus, vancomycin-resistant Enterococcus, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter baumannii. The main acquired mechanism for antibiotic resistance in hospitals is the production of beta-lactamase, including extended-spectrum beta-lactamase, AmpC beta-lactamase, and carbapenemase. Cephalosporins are one of the most frequently consumed antibiotics, and Enterobacteriaceae are the most common bacteria to produce beta-lactamase, especially ESBL. These enzymes are also called 'antibiotic breakers' because the drugs available in the hospital are ineffective. For the clinical impact, the antibiotic-resistant issue that has been identified is related to the infection rate and patient safety, and also has an influence on the length of hospitalization, complications, healthcare costs, and mortality. [20][21]

6. Preventive Measures and Control Strategies

The most effective preventive measures and control strategies to reduce the impact of air pollution on human health are based on primary prevention and reduction of the emission of dangerous smog components, in adequate compliance with the principles of public health. Pollution, particularly the air pollution caused by vehicles, is highest in urban environments, and as a consequence, urban hospitals could be affected by these problems. The multifactorial approach requires a general enhancement and optimization of prevention and infection control measures, as well as a detailed plan for the prevention of and solution to air pollution phenomena and continuous control of infections, as well as health surveillance. On this basis, a culture of preventing is a culture of safety, including air pollution and CNS case prevention, is mandatory to be shared. Some other measures, such as more effective environmental cleaning and waste management, are directly the task of healthcare organizations and their employees. A great emphasis ought to be devoted to the education and training of healthcare workers and medical practitioners. Close collaboration is needed among hospital staff, public health institutions, local, regional, and national regulatory authorities, and health and hospital management authorities. Regulatory authorities and healthcare organizations should at least regularly make an official profile of the resistance of bacteria, according to validated methodology, and share the information. In conclusion, studies about antibiotic resistance, in particular concerning CNS, are deficient in the literature and deserve attention. Innovative solutions and environmental technology are necessary for protecting patient safety, also from air pollution and infections caused by bacteria. Innovative and intelligent technologies can find the best way, different for every single healthcare or clinical setting and person, to help in tracking infections and limit the diffusion, giving an increased life expectancy in a healthy environment. Best practices for reducing the incidence of antibiotic-resistant pathogens in the NICU are aimed at preventing contact with bodily fluids of colonized or infected infants. Measures for preventing cross-contamination and subsequent colonization of an outbreak isolate include hand hygiene, cohorting of infants and staff, use of localized ventilation, addition of trained infectious disease personnel to the NICU, compliance with evidence-based guidelines for outbreak management, and communication with the hospital infection control service. [22][23]

6.1. Hand Hygiene Protocols

Hand hygiene is the basis for preventing the transmission of pathogenic agents in the hospital environment and acts directly in the reduction of bacteria, having a number of hospital-acquired infections. The use of alcoholic solutions to sanitize hands in health facilities is a convenient method due to practicality, efficiency, and low growth of the bacterial flora on a physician’s hands in contact with the patient. The use of this solution also allows for a quicker recovery of hand flora than washing hands with water and soap, against which resistance is very common. The importance of this tool is highlighted, as a report cites a number of hospitals and points out the inadequacy of this practice, with a decrease in sanitary compliance from 58% to 100%, according to the hospital cited. Among the strategies to facilitate the adoption of adequate practices of sanitation of hands, one cites the creation of leadership models that guarantee the implementation and adherence to this practice among professionals in the hospital.

Several interventions have been proposed to improve healthcare worker compliance with hand hygiene practices. Many have relied on education as the primary tool for creating awareness of the importance of hand hygiene in hospital settings and included the training of infection control specialists or hospital-based personnel. Educational programs have been used to highlight the impact of hand hygiene compliance on the quality of patient care. These interventions also attempt to emphasize that improving the environmental cleanliness of the hospital alone is bound to fail as long as infections can be directly transmitted through the hands of healthcare workers. The importance of healthcare worker hand hygiene is indisputable to protect patients from harmful bacteria that the patient is not already carrying. [24][25]

7. Conclusion and Future Research Directions

Airborne and dust-borne bacteria are ubiquitous in hospital air, which has direct implications for patient safety and public health. Pathogens are commonly present in hospital air, corroborating the importance of better control measures and the need for efforts that address air as a vehicle for hospital bacteria, referred to as hospital "pollution." Currently, our understanding of the hospital environments consists of a limited number of fractionated investigations. The role of building spaces in microbial movement and the transfer of antimicrobial resistant bacteria, especially carbapenemases, is under-researched, as are bioaerosols that carry these and other bacteria and their subsequent deposit of settled matter in the hospital environment. "Pathogens" and their movement are never static, and so ongoing investigation and management of threats are required.

As hypothesized above, airborne and dust-borne bacteria are an ongoing, more diffused, dynamic threat in the healthcare environment and require control measures as thoroughly pursued as those controlling the movement of index cases of infections. More research regarding new threats and fresh mitigation strategies is needed. The future direction of this research is to conduct large-spectrum biodiversity and quantitative studies on a variety of dust samples taken from different urban and rural environments to assess how these urban surfaces contribute to urban contamination. Continuation of the trend of focusing multidisciplinary research on threats is also encouraged. The predominance of ants, cockroaches, and flies, essential in organic matter degradation and nutrient cycling, and pathogens found among hospital air and dust samples, reflects nitrate, phosphate, and sulfate levels often exceeding the levels. Coupled with high levels of coal and wood dust, urban particulate matter, bacteria, yeasts, and fungi attach to these abiotic carriers, which initiate the strong, biodiverse attraction of this hazard. Research has also concluded that surfaces have higher potential for dissemination than the better-studied issue of air movement. The strength of the hazard's attractors combines to augment the knowledge supporting policies for financial investment in the field of hospital sanitation practices. Conventional techniques, new implementations, and the value of international collaborations between physics, veterinary science, public health, engineering, and the social sciences emerge.

Overall, the conclusion of this review is that while bacteria (including large numbers of antimicrobial resistant isolates) are frequently detected in hospital air and suspended or settled dust, and as such are an element of the dynamic threat that bacteria and emerging threats pose in the healthcare environment, they require newer and more effective measures for ongoing control. Increasing future research in the study of urban microbiomes as they link with human virulence factors on urban surfaces for spreading disease is crucial to our holistic, multidisciplinary understanding of the danger, while broader interdisciplinary oversights for hazards such as the one discussed may commence. Providing resources to a skilled workforce in the field of hospital sanitation, as "the eyes and ears for information on the placement of hazards" may thus be strategically incentivized. Let us, collectively working for the global good of the software and the hardware of international healthcare standards, synergize.

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