META ANALYSIS OF PATHOGENIC AIRBORNE BACTERIA AT NURSERIES AND DAY CARE CENTRES

Zakaria Hamid[1] , Ahmad Umar Qayyum Bin Abdul Aziz [2], Dr.Pang Jyh Chyang[3]
Institute of Medical Science Technology[1]
Email: zakariah@unikl.edu.my

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ABSTRACT

There are currently no specific rules and regulation on what the limit for the bacterial concentration at nurseries and day care centres. Being exposed to bioaerosols have become a health concern to the public especially children. This is because they spend most of their childhood in nurseries, day care centres and schools. Statistical analysis is done by Cochrane Software Review Manager 5.4. Based on the statistical analysis, the result of the included studies shows that the concentration of bacteria at nurseries and day care centres are significant. In recent studies, the values for indoor concentration ranged from the 510 CFU/m-3 until 52560 CFU/m-3. The most common types of bacteria that were found in the studies are Staphylococcus, Micrococcus, Bacillus, and Pseudomonas. In general, the studies noted that the bacteria were mostly non-pathogenic and do not pose an immediate danger to the children's health. However, children who are immunodeficient are at a risk of infection and catching a disease and possibly serious health effects.

KEYWORDS
Day-care centres, Nurseries, Pathogenic bacteria, airborne bacteria

INTRODUCTION

Indoor air quality (IAQ) is becoming an increasingly critical public health concern as the number of people living in densely packed buildings increases, and this is particularly true in schools due to the prevalence of a young population. Indoor air is polluted by a variety of contaminants, the most common of which are airborne microorganisms (bacteria and fungi). Allergies, respiratory and immunotoxic diseases can result from exposure to these pollutants.

Most microorganisms and/or their reproductive systems can be found in the outdoors, (Sivri N,2020). The types and population will vary according to the outdoor conditions. The inside of buildings may readily be entered by micro-organisms through doors, windows, hallways, public spaces and fresh air. There are some and insignificant amounts of micro-organisms in indoors under typical circumstances. Estimating culturable microbial pollutants in the form of bacteria from the indoor environment is still a major concern.

Fungal spores and bacterial organisms are frequently observed in aerosol samples collected in both outdoor and indoor environments. They are assumed to be related to air pollution and have been proposed as a cause of human health issues. Airborne bacteria are important biological components of aerosols, and they have a strong influence on the human health since they may induce illness and harm. Higher amounts can cause a number of microbiological illnesses. Several research on the negative health effects of bacteria and fungi penetration concluded that indoor airborne bacteria can cause meningitis, tuberculosis, severe skin infection, cardiovascular disease and even skin cancer (Aliabadi AA,2011). Indoor air pollution and children's respiratory health have been linked in studies conducted in school settings.

Exposure to bioaerosol particles contaminated with natural fungus and, to a lesser extent, bacteria in the indoor habitats of homes, business buildings, and schools has become a global public health concern. Schools, as public facilities, are the second most impressive indoor spaces for assessing indoor air quality, after clinics, and health components of students typically carry a bigger quantity of airborne bacteria than existing under normal conditions due to student activities. The concentrations of culturable airborne bacteria (CAB) and culturable airborne fungi (CAF) in school indoor air are main aspects of IAQ studies since they have direct effects on student' mental health, physical growth, and productivity of students, (Sivri N,2020). Regular monitoring of indoor CAB/CAF concentrations in school buildings is necessary to ensure students' wellbeing.

RESEARCH METHOD

Search strategy

Google Scholar and PubMed database is used to search for data. Data was searched and collected from July 2021 to October 2021 to find the relevant studies according to the following keywords: day care centres OR nurseries AND pathogenic airborne bacteria OR airborne bacteria OR bacterial aerosols. Journal articles that are available in full text is chosen and only the English language is picked

Inclusion Criteria

The whole journal articles was read thoroughly for it to include in the meta-analysis. The inclusion criteria are as follows.

1. Journal articles must be date from 2010 until 2021
2. Units of the concentration of the bacteria must be in colony forming units,CFU.m^{-3}
3. Journal articles includes the species of the airborne bacteria

Exclusion criteria

Certain journal articles are excluded from this meta-analysis as the data are unable to extracted quantitively and they are not in line with the objectives of this study

1. Non research paper or systematic reviews
2. Older journal articles date 2009 and below
3. Journal articles does not measure the concentration of airborne bacteria
4. Units of concentration of airborne bacteria is different than colony forming units CFU.m^{-3}
5. Journal articles does not study the species of bacteria.

Data extraction and analysis

Data from journal articles was extracted as mentioned in the inclusion criteria and tabled for statistical analysis. The data that was extracted is the concentration of airborne

bacteria from the chosen studies. The data is table in Microsoft excel in the form of table and histogram

Data analysis software that is used is Review Manager 5.4 (RevMan 5.4) by Cochrane Software. The main objectives of the analysis is to find out whether the data from the experiments have a common effect on the forest plot. The statistical method chosen is inverse variance, for the effect measure is standard mean difference while the analysis model is random effects. Confidence interval is set at 95%.

RESULT AND DISCUSSION

Based on the analysis done by the RevMan 5.4 software on the bacteria concentrations, the results for the heterogenicity are as follows; Tau^2=0.39, Chi^2=2599.96, the I^2 test shows 100% and the overall p-value is 0.003 which is less that 0.05.This means that the results are significant. Based on the forest plot, it can be seen that the study by (Bragoszewska et al., 2016), (Mendes et al., 2014) and (Bragoszewska et al., 2015) are statistically significant while the study by (Madureira et al., 2015) is not statistically significant as the result has touched the line of no effect.

Study done by Mendes et al., 2014, found that the lowest concentration was 1950 $CFU.m^{-3}$ while the highest was 10835 $CFU.m^{-3}$. In the same study, a kindergarten lowest was 510 $CFU.m^{-3}$ while its highest was 52560 $CFU.m^{-3}$.A study done by (Madureira et al., 2015) found that bacterial concentration was in the range of 1498-5705 $CFU.m^{-3}$, In a study by (Bragoszewska E. et al., 2016), the lowest bacterial concentration in a rural nursery in Poland was 670 $CFU.m^{-3}$ and the highest was 2588 $CFU.m^{-3}$. In a study by (Bragoszewska et al., 2015), the level of bacterial aerosol concentration in the indoor air ranged from 2545 to 3098 $CFU.m^{-3}$ and the concentration exceeded 6–8.7 times the level recorded in the outdoor air. The numbers reported at Gliwice nursery school are similarly close to the data obtained in experiments done in one of the schools in Lublin, Poland, where the concentration of airborne bacteria was 3500 and 2000 $CFU.m^{-3}$, respectively (Dumała and Dudzinska 2013). Significantly, the increased quantity of culturable bacteria indoors might be attributable to the entry of outdoor dust particles and their subsequent resuspension from various interior surfaces (Bragoszewska et al., 2015). Small particles with a diameter of less than 4.7µm are more common in indoor air. These respirable particles are more likely to settle in the tracheal, bronchial, or alveolar regions of the lungs. At the three kindergartens, the amount of bacteria in the indoor air samples was higher than that in the corresponding outside air samples, although the differences were minor (Deng et al., 2016)

Indoor concentrations of airborne cultivable bacteria and fungus were found to be greater in children day-care centres (Madureira J. et al., 2015). Being exposed to bioaerosols have become a health concern to the public especially children. This is because they spend most of their childhood in nurseries, day care centres and schools. There is currently no international standards on how much is the acceptable level of bioaerosols level in the indoor environment. World Health Organization (WHO) standards suggest that indoor bioaerosols should be less than 500 $CFU.m^{-3}$. Factors that may include the level of indoor airborne bacteria are human activity, population density and also the efficiency of ventilation. Previous study have shown that gram positive bacteria is the most commonly found airborne bacteria in indoor environment. *Staphylococcus, Micrococcus, Bacillus, and Kocuria* are the most common bacteria found in indoor environments. Bacteria species such as *Staphylococcus* and *Micrococcus* are from human origins (Mandal and Brandl, 2011). *Bacillus sp., Arthrobacter globiformis*, and *Staphylococcus warneri* have been linked to allergies and immunological toxicity in humans (Mandal and Brandl, 2011). Gram-positive bacteria in the air were the most prevalent, accounting for 90% of the

population analysed (Bragoszewska et al., 2015). Only *Pseudomonas spp.* was detected among the Gram-negative bacteria in the study by (Bragoszewska et al., 2015). 58 sites were positive for nasopharyngeal bacteria (16.8 percent). Nonhemolytic *streptococci* (40 sites, 12 percent) and *Aerococcus sp.* (15 locations, 4 percent) dominated the species list, whereas *S. pneumoniae* and *Moraxella sp.* were detected in one location and two locations, respectively (Ibfelt et al, 2015). *Bacillus spp., Staphylococcus sp., and Pseudomonas sp.* were shown to be the most common bacteria on culture plates, whereas *Pseudomonas spp.* and *Oxalobacteria spp.* dominated the study (Ibfelt et al, 2015). Gram-positive cocci, non-sporing Gram-positive rods, sporing Gram-positive rods (family: *Bacillaceae*), and Gram-negative rods were discovered as viable bacteria. Gram-positive cocci were the most common (66–94 percent): *Micrococcus spp.* and *Staphylococcus spp.* (Bragoszewska E. et al., 2016). The main bacteria flora in the DCC environment consisted of coagulase negative staphylococci (CoNS), *Bacillus spp.*, and Pseudomonas-like bacteria, all of which very rarely be a cause of disease in humans (Ibfelt et al, 2015).

In one study. for the spring season, overall bacteria counts were 57 and 52-fold greater in the nursery and kindergarten, respectively, than outside (Mendes et al, 2014). The concentration of bacterial aerosol collected at 6:30 without the presence of children was in the range of 390 to 440 $CFU.m^{-3}$, which was five times lower than the values obtained during children's activities (Bragoszewska E. et al., 2016). According to research conducted in Ankara, Turkey, the greatest concentrations of total bacteria aerosols were recorded in kindergartens, with 649 and 1462 $CFU.m^{-3}$ in the winter and summer seasons, respectively (Mentese et al., 2011). Since acceptable standards and recommendations do not yet exist, authorities must be consulted, and study must be done to identify acceptable contamination concentrations and exposures. According to the Occupational Health and Safety Research Institute Robert Sauvé (IRSST), when total airborne bacteria counts exceed 1000 $CFU.m^{-3}$, probable microbial contamination requires further evaluation of the problem and an action necessity. Increase in humidity and temperature are both related with considerably increased quantities of culturable bacteria and fungus in indoor air. If the indoor respirable ratio is greater than the outdoor ratio, the quantity of airborne bacteria contamination in the nursery cannot be considered safe. The statistical analysis to relate the temperature and humidity are not able to be done as there were lack of data in current studies.

Gram-positive cocci predominate the indoor air, whereas Gram-positive rods dominated the outdoor air (Bragoszewska E. et al., 2016). Gram-positive *bacilli* have a wide range of pathogenicity. Many have the potential to be opportunistic pathogens, capable of causing disease only in people with impaired host resistance, which is particularly common in small children. Because children's activity levels are often high, Gram-positive cocci can be transported to the air via their bodies and respiratory tracts. *Micrococcus* is not generally considered a pathogen, but in people with weakened immune systems, such as newborn, it can cause skin infections with intense itching, and it has the ability to colonise the human mouth and upper respiratory tract (Shahidah N. et al., 2017).Staphylococci are indicators of air pollution severity, and their presence may suggest the presence of harmful bacteria. (Kubera et al., 2015).

In general, exposure to bacterial aerosol in the air of the researched studies does not pose an immediate danger of any acute health impacts; nevertheless, long-term inhalation of such large quantities of airborne bacteria can induce certain detrimental health effects, particularly among vulnerable people. Such people may be more prone to upper respiratory tract illnesses and allergy symptoms such as headaches, watery eyes, itchy skin, coughing, and so on. It is reasonable to predict that if some sick children are present in the kindergarten, the amount of pathogenic bacteria in this facility will swiftly rise, particularly

in the rooms with younger children. As a result, a rise in the air exchange rate is strongly advised. There is no evidence of a correlation between culturable microbial concentrations in the air and infection. One reason for this might be that infection should be linked to dosage rather than concentration. The amount of time the children spent at the DCC every week had no effect on the likelihood of bacteria colonisation. A previous study revealed a non-significant increase in risk among children who attended a DCC full-time versus children who attended part-time. There was no indication of a decrease in bacterial transmission associated with less time spent at the DCC.

Depending on the area, studies utilising culture samples have indicated that 10%–60% of the samples are positive for coliform bacteria. Non-pathogenic bacteria, including Coagulase-negative staphylococci (CoNS) (333 positive sites, 97 percent), and other water bacteria, such as *Pseudomonas*-like bacteria (159 positive spots, 46 percent) and *Acinetobacter spp.*, were the most common results (61 positive spots, 18 percent) (Ibfelt et al, 2015). Only a few nasopharyngeal pathogenic bacteria was discovered in the day care centre environment, which were mostly non-pathogenic (Ibfelt et al, 2015). *Acinetobacter spp., Moraxellaosloensis ,Pseudomonasstutzeri spp.* and *Roseomonas spp* were some of the gram negative bacteria that were found and Gram-positive bacteria that have been identified include *Staphylococcus haemolyticus, Micrococcus luteus, Rothia,* and *Bacillus subtilis* (Shahidah N. et al., 2017). Haemolyticus was discovered, and its antibiotic resistance phenotype, as well as its propensity to build biofilms, making it a challenging pathogen to treat (Shahidah N. et al., 2017). Despite its low virulence, *Rothia spp.*, which also includes Gram-positive cocci, has been linked to tooth plaque and periodontal disease in children. *P. stutzeri* is an opportunistic pathogen that has been linked to a few infections. *A.baumannii* is a Gram-negative coccobacillus that can cause nosocomial infection outbreaks due to its multidrug resistance and resistance to desiccation Nevertheless, the findings concluded that the bacteria that were found in these study are mostly non-pathogenic and can rarely cause disease in a healthy child. The ones that are at risk are children with immunodeficiency.

Environments in children day care centres are important as their immune system has not yet matured. Thus, they are more prone to infections and allergic reactions. High bacterial concentrations might possibly be attributable to inadequate ventilation, as most schools are naturally ventilated, and greater levels of CO2 were obtained in association with higher occupant densities (Madureira J. et al., 2015). Ventilation has a substantial impact on indoor pollutant levels, and hence on indoor exposure. Several authors have documented the relationship between indoor pollutant levels and child day care facility ventilation types (e.g., naturally ventilated, hybrid ventilated, air conditioning with or without mechanical ventilation). Levels were found to be lower in hybrid ventilation systems than in other systems, indicating that pollutants were diluted more effectively. The relationship between indoor air pollutant levels and ventilation system types such as natural, hybrid, and mechanical ventilation indicated that hybrid ventilation generated a lower level of indoor air pollutants (Shahidah N et al, 2017). If the nursery and DCC is located close to major roadways, the nursery and DCC will be exposed to a greater number of pollutants emitted by automobiles. Because of the emission of carbon monoxide, this will have an effect on the IAQ in certain conditions. There are studies that show that bacteria levels are related to high occupancy, poor sanitary conditions of the inhabitants, and insufficient ventilation. A greater overall bacterial count might be linked to a lower temperature and a higher percentage of relative humidity (Shahidah N. et al., 2017). These two parameters are a ideal condition for the growth of bacteria. These high total bacteria concentrations may impair indoor air quality. The total bacteria parameter was the major focus of this investigation, with concentrations reaching 50-fold greater than outside in the

nursery and kindergarten in the spring and 30-fold higher in the winter. However, despite these high overall bacteria levels, low levels of gram-negative bacteria detection may be owing to high occupation rates and low ventilation rates, as seen by a significant correlation between CO2, total bacteria, and gram-negative bacteria (Qian et al., 2012). It is worth noting that there is an increase in respiratory morbidity, which shows a link between airway alterations and overall exposure to air pollution in wheezing children (Martins et al., 2012). Natural variables around the structures, such as plants and soil outside, as well as the impact of the season could also be an attributable factor. These differences might potentially be attributed to changes in research design (sampling period, length, and sample size). However, statistical analysis could not be done as there were no raw data provided in recent studies.

The limitation of this meta-analysis is that we were not able to directly correlate the significance of the concentration of the airborne bacteria directly with the condition of the children's health and the condition of the nurseries and day care centres as no raw data were provided by the authors. There were also no recent studies that directly shows the significance of the concentrations of bacteria and health of children and the condition of the nurseries and day care centres.

CONCLUSION

The meta-analysis of bacterial concentration was completed, and it shows a significant result in the studies that were chosen. The bacterial concentration in the chosen studies were nearly identical as of other studies and some shows even a higher-than-expected value. Although most of the airborne bacteria were non-pathogenic. Measures must be taken to provide a safer and healthier conditions for children to stay in as immunocompromised children have a chance to get sick and infected with diseases. The bacteria that dominated in these studies were mostly Staphylococcus, Bacillus, Micrococcus and Pseudomonas. Although the air may be high in concentrations of these types of bacteria, in general they do not immediately pose a threat the children's health at the nurseries and day care centres. Hopefully more research in the future will provide more statistical data in order to provide a safer condition for children in nurseries and day care centres.

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