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Comparative Assessment of Microbial Air Contamination in Labor and Postnatal Ward at Mzuzu Central Hospital

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Abstract

Nosocomial infections are rapidly becoming a burden especially in developing countries. Neonates are part of the individuals who are at a high risk and mostly affected. Environmental contamination is one of the key agents of these infections. This study aimed to comparatively assess the microbial air contamination before and after cleaning in the labor and postnatal ward at Mzuzu Central Hospital. A comparative study design was employed, with a sample size of 60 paired culture plates (60 MacConkey agar plates and 60 Blood agar plates). Passive technique of air sampling was used to sample air there after 24 hours of culturing and isolation on blood agar and MacConkey agar for identification and quantification of bacterial colonies. Room observations were also done. There was a significant difference between contaminations before and after cleaning, only when MacConkey agar was used. The microorganisms that were identified include; Staphylococci aureus, Klebsiella, coagulase negative staphylococci and non-hemolytic streptococcus. Factors found to contribute to air contamination were, the size of the rooms, traffic of people in a room and number of people present in a room. This study has identified the hazard that these two wards are containing and suggests interventions to avoid nosocomial infections in the neonates.

Keywords: hospital infections; microbiology; air contamination; comparison.

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1. Introduction

Neonatal sepsis and other bacterial infections of newborns are among the leading cause of neonatal morbidity and mortality worldwide especially in developing countries [1]. In some settings these infections are also known as hospital acquired infections [2]. Such infections if occurred in neonates they are defined as infections that occur 48 hours after birth and are not maternally derived [3].

There are a lot of ways in which nosocomial infections can be transmitted. Direct contact and inhalation of contaminated air are some of the most common ways. Air is one of the reservoirs that contains different kinds of microorganisms in form of tiny droplets that can be suspended in it for a long period of time and might be highly infectious to an immune compromised individual [4]. The hospital environment is usually cleaned but the air is most of the times left unregulated or neglected [5]. Regular daily cleaning if done correctly is one of the good ways to improve air contamination [6]. Managing other factors that contributes to contamination in a hospitals like overcrowdings, traffic of people, size of the room, number of windows and the kind of disinfectants used can reduce the levels of indoor air contaminations significantly [7,8].

Despite a reported high-level neonatal sepsis cases, a study to assess the microbial air contamination in the labor and postnatal ward at Mzuzu central hospital, Malawi, has never been conducted before. This study therefore was designed to identify and quantify microbial air contamination in the labor and postnatal wards before and after cleaning the rooms and further to identify possible contributing factors to the air contamination. This study has the potential to help determining if daily routine cleaning has a significant impact to reduce air contamination in these wards and hypothetically direct ways that could be used to put in much effort on how maximum sterility can be achieved to avoid nosocomial infections, reducing neonatal morbidity and mortality and also reducing hospital stays which may lead to lessening financial burdens

2. Methodology

This research used comparative study design where variables of before and after room cleaning were compared. This research was conducted at Mzuzu Central Hospital in labor and postnatal ward. This hospital is the only tertiary referral hospital in the northern region of Malawi and so it serves as a referral of all the six district hospitals including private and mission healthy facilities in northern region of Malawi. The labor ward at this hospital has six rooms. The Delivery room 1 which is the largest room, Delivery room 2 is smaller, waiting room which is the passage way to the delivery rooms from the reception, the reception and the staff room. The postnatal ward has ten rooms, the reception, private room, stores, sluice room, bathroom, bay 1, bay 2, examination room and stuff room. Samples were taken from five rooms.

Two rooms from the labor ward (delivery room 1 and delivery room 2). Three rooms from the postnatal ward (bay 1, bay 2 and private room). These rooms were selected because they are the rooms where the neonates are found for a longer time. This study used the non-probability purposive method of sampling. The passive technique of air sampling (settle plates) was used. A total sample size of 60 paired culture plates (60 MacConkey agar plates and 60 Blood agar plates), was taken purposively in line with a study by Luksamijarulkul & Panya (9). four plates

per each room, five rooms had 20 plates hence 20 plates every 3 times a day, for two days coming up to 120 altogether.

Two petri dishes containing Blood agar media and two containing MacConkey agar media were left open for settling of microorganisms from each of the five rooms of Labor and postnatal wards at three different time intervals (7:00am-8:00am, 10:00am-11:00am and 2:00pm-3:00pm) that is before cleaning, after cleaning (using 5% Chlorine) and after lunch respectively on Monday and Friday. Immediately after sample collection, the samples were taken to Mzuzu central hospital microbiology laboratory where they were incubated aerobically for 24 hours at 37^0C, then observations were done.

Colonies of bacteria present in each plate, were quantified using Omeliansky formula and converted to colony forming unit per cubic meter of air which was also used by Diaconu [10] and Hameed & Habeeballah [11] which is $N=5a \times 10^4 (b.t)^{-1}$. Where N=colony forming unit per cubic meter of air (CFU/m3), a= number of colonies per Petri dish, b=dish square centimeter and t= exposure time (minutes). After macroscopic examination of culture, colonies were isolated for identification on Blood agar and MacConkey agar media. Sample colonies were smeared on slides for gram staining to identify morphology.

Thereafter confirmatory tests were done on the following biochemical test; Catalase test to differentiate staphylococci and streptococci, coagulase test to distinguish staphylococci aureus from other staphylococci and Sulfur Indole Motility (SIM), Triple Sugar Iron (TSI) test to identify microorganisms from enterobacteriaceae family. This study went through the Mzuzu university faculty of health sciences research ethics committee and Mzuzu central hospital research committee for ethical approval and clearance

3. Results

The mean and variance of the number of colonies forming units (CFU) on blood agar and MacConkey agar were compared. At P. Value of alpha less than 0.05, on MacConkey agar the difference in contamination before and after cleaning the rooms is statistically significant while on blood agar the difference is not statistically significant (table 1)

Table 1: Means and Variance of CFU before and after cleaning

Variable	Before cleaning	After cleaning	P .value
Number colony forming units on MacConkey agar; mean (variance)	1183.1 (2337320.3)	89.5 (19469.1)	0.003
Number of colony forming units on blood agar; mean (variance)	3750.8 (6886335.5)	666.75(221623.6)	2.2

The four predominant microorganisms isolated from the rooms were; klebsiella, *Staphylococci aureus*, Coagulase Negative Staphylococci and Non hemolytic Streptococcus. n showing the count in Number and percentage in brackets. (Table 2)

Table 2: Microorganisms isolated from the rooms

Rooms	klebsiella n (%)	staphylococci aureus n (%)	coagulase negative staphylococci n (%)	non hemolytic streptococcus n (%)
Labor 1	9(27)	10(30)	8(24)	6(19)
Labor 2	8(29)	10(36)	6(21)	21(4)
Bay 1	12(32)	10(26)	10(26)	6(16)
Bay 2	11(31)	10(29)	9(23)	6(17)
Private	4(25)	12(75)	0	0

Bacterial counts of CFU per cubic meter of air on MacConkey agar media at 7:00hrs in the morning before the rooms were cleaned was high and highest in bay1 and 2, at 10:00hrs after the rooms were cleaned the CFU reduced and 14:00hrs after the rooms were cleaned CFU was the highest in Labor rooms. (Figure 1)

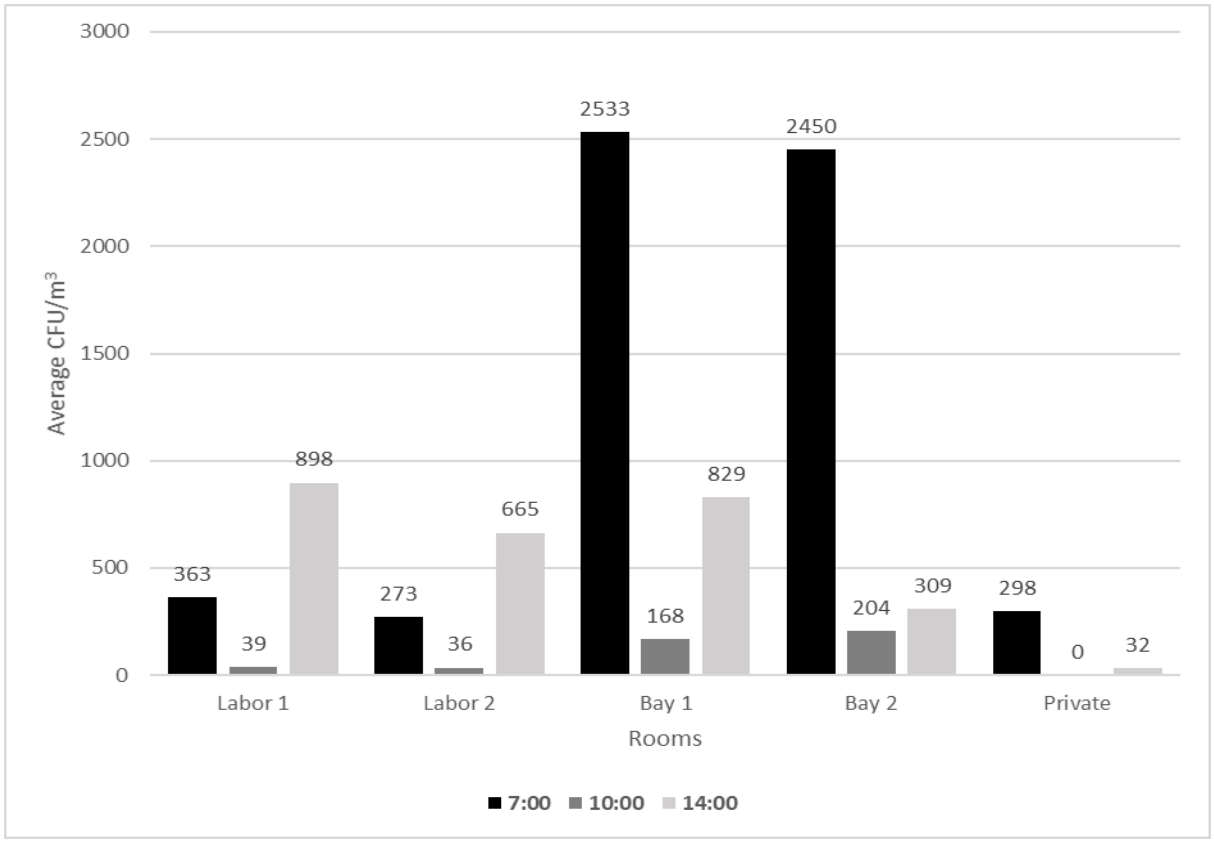

Figure 1: Bacterial counts of colony forming unit per cubic meter of air on MacConkey agar

Bacterial counts of colony forming unit per cubic meter of air on Blood agar media at 7:00hrs in the morning before the rooms are cleaned was the highest, 10:00hrs after the rooms were cleaned the CFU reduced and 14:00hrs after the rooms were cleaned CFU was high again (Figure 2)

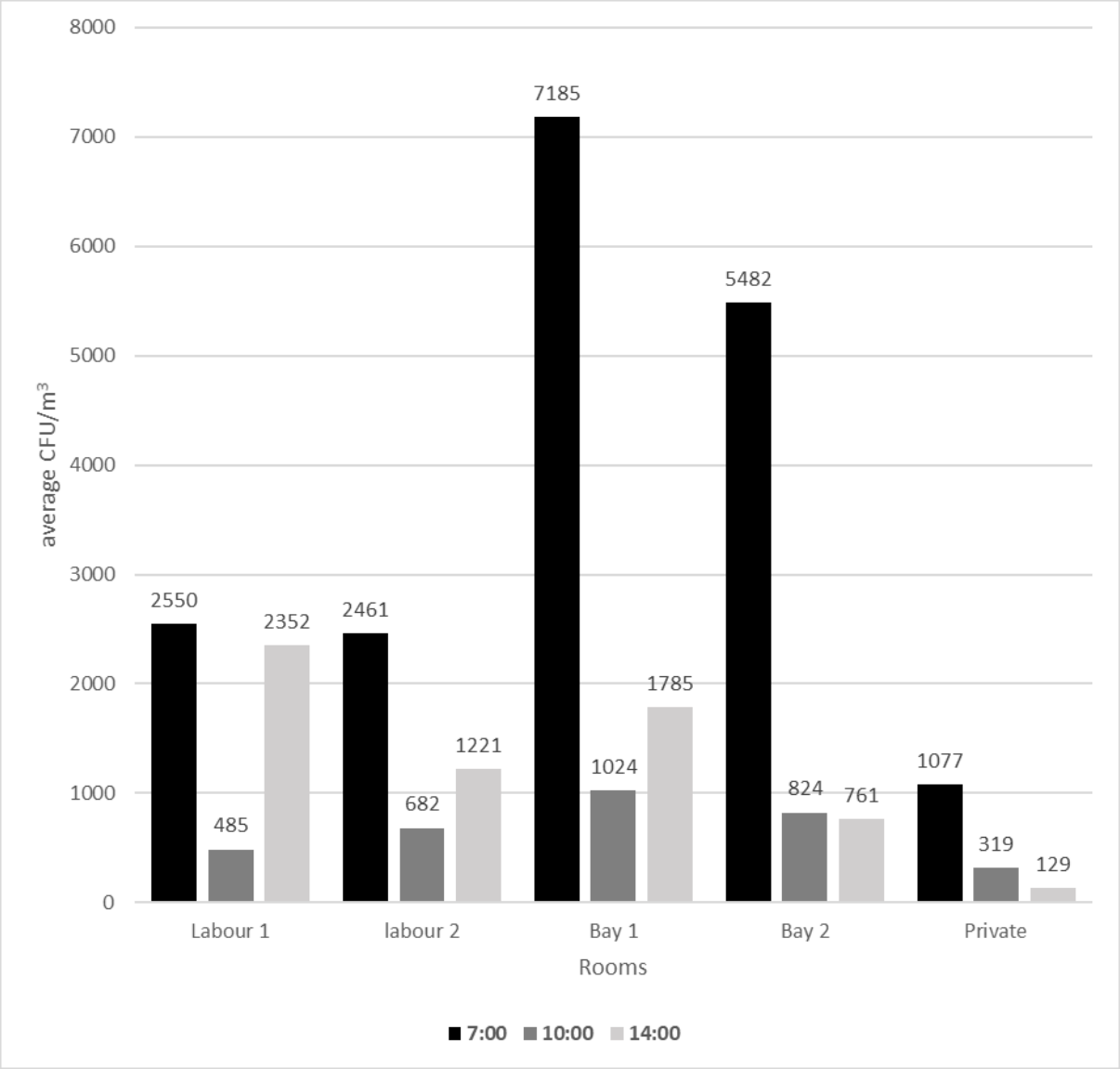

Figure 2: Bacterial counts of colony forming unit per cubic meter of air on Blood agar media at given time

Room size, traffic of people and number of windows is directly proportional to CFU but the rooms with most windows had reduced CFU.

Number of beds represented the presence of people in a room. The room with most people had the highest CFU (Table 3)

Table 2: Possible contributing factors to air contamination

Variables	**Average of blood agar CFU**	**Average of MacConkey agar CFU**
Room size	Frequency (%)	Frequency (%)
Small	981(17)	217(13)
Medium	1796(32)	433(25)
Large	2843(52)	1082(62)
Number of windows		
1	981(12)	217(8)
2	1796(21)	433(15)
3	3331(39)	1177(42)
4	2356(28)	988(35)
Number of beds		
1	1625(33)	379(24)
2	508(10)	110(7)
12	2843(57)	1082(69)
Traffic		
Very low (0-2)	508(10)	110(7)
Low (3-5)	1625(33)	379(24)
High (≥6)	2843(57)	1082(69)

4. Discussion

Contamination of the hospital environment by different sorts of microorganisms is the major source of nosocomial infections worldwide [12]. In this study, a total of 60 paired air samples (60 MacConkey agar plates and 60 Blood agar plates) were collected from both the postnatal wards (Bay 1, Bay 2 and Private rooms) and Labor wards (Labor 1 and Labor 2). Results of this study has shown that the air of these wards contained potential pathogenic bacterial contaminations both before and after cleaning but significantly higher before cleaning. This study finding is very similar to other studies [7,13,14]. It is more like that the higher level of bacterial isolation before cleaning could be due to several factors like mechanical movements of people, increase in the number of people visiting their relatives in the evening as well as morning hours which all have cumulative effect on the morning bacterial population. As stipulated by Obakpororo [7] these factors plus many more could be the determinants of the quality of indoor air and be a contributing factor to the increase of indoor airborne disease. Bacteria that were mostly isolated from the wards in this study were *Staphylococci Aureus, Klebsiella species*, Coagulase Negative *Staphylococci* and non-hemolytic *Streptococcus.* Non-hemolytic streptococcus and coagulase negative staphylococci were completely absent in the private ward however, more *Staphylococci aureus* were isolated.

These microorganisms are similar as those that were identified in a study conducted elsewhere [7,15]. It is very interesting to observe that, much all these studies have almost similar profile of the isolates, our study used passive method (air settling) just like the study by Obakpororo et. al.[7], but Kunwar et. al. [15] used an active method where they performed an active impactor sampling method by using "Hi-Air" air sampler. Therefore, this entail that much as diversity of organisms captured use different approach may differ but the main culprits remain the same. For instance, most of the studies disregarding of methods they find staphylococcus aureus as the leading isolated organisms Basically, it is a known fact that most of the microorganisms identified in this study are potentially harmful to human health because they are known causes of a lot of infections among neonates [3,16–19]. For instance, *Staphylococci aureus* as studied in the southern part of Malawi was found to cause around 15.3% of neonatal bacterial septicemia in the study [18]. Furthermore, in Israel [20] a survey conducted reported an outbreak of *Staphylococcus aureus* in the neonatal samples of which 60% were Multidrug resistance, some of these neonates presented with sepsis and others pneumonia and it was noted that these were mostly nosocomial contracted and caused severe morbidities and deaths. Furthermore, a study in Iran [19], showed that of all the neonatal sepsis cases, tests identified coagulase negative to be responsible for 35%. In the same study, *Klebsiella* was found as one of the main causative agents of central nervous system infections, responsible for 66% of the cases. Likewise, a study conducted in some of developing countries [21], found that in the first week of life, neonates of these countries acquire nosocomial infections. In their study, *Klebsiella* and *Staphylococcus aureus* were the major causes of infections rating as high as 25% and 18% respectively. The findings of this study show significant difference in the bacterial colony counts before and after cleaning on MacConkey agar while the difference on blood agar was not statistically significant. This significance on MacConkey agar might be because MacConkey agar is a selective media which inhibits growth of other contaminants meaning that some microorganism that grew on blood agar may not have grown on MacConkey agar. Most of studies do not report this effect of the media on the results [22, 10]. However, although this may need a follow up study to validate this finding but it is an important finding as it displays that the use of different media may help to capture diverse organisms which can best help understand the nosocomial threats of a particular environment. Studies have shown that among many other factors, hospital air contamination comes from mechanical movement of people within a place, level of hygiene, number of beds and size of rooms [6, 7]. Basically, the larger the size of the room the more the contaminations similarly the more the beds and the people the higher the contaminations rate. Our study findings indicated that two large rooms, Bay 1 and 2, which had 12 beds each, 3 and 4 windows respectively contained the most contaminations. These rooms were the ones that also registered with more traffic and containing a lot of people at one time as compared to the rest of the rooms. A combination of these factors can be seen to contribute to the microbial contamination because in the case of private room, which was the smallest room, had only two beds, very little traffic and presence of people had very little contaminants. As such it is very important for the hospital authorities to put in place and reinforce regulations which may help to control the traffic and number of people who may be contained per room so as to reduce the level of air contaminations

5. Limitations

This study is the first of its kind to be conducted at Mzuzu central hospital and likely in Malawi and it carries its strength in having used the settle plate technique of air sampling which is directly proportional to the settling of

microorganisms on an individual. Despite that, it cannot be concluded that these rooms only contained the identified microorganisms because this study used only two types of media (Blood agar and MacConkey agar). Our study also has a limitation of linking the type of isolates to the current infections in the wards as that could directly demonstrate the link. Our sample size and duration of study was also not large enough for general and wholistic conclusion at a national level

6. Conclusion and Recommendations

The microorganisms that were identified are very dangerous especially to neonates due to their suppressed immunity. The colony counts were found to be very high than recommended. The most encouraging observation is that the cleaning of these rooms seems to be effective. Factors that could have contributed to contamination not declining to optimal levels are traffic, presence of people in a room and the size of the room. This study has shown that there might be the risk of increasing cases of nosocomial infections and prolonged stay in the hospitals can follow leading to financial loss. This calls for early interventions to secure the safety of the neonates. Furthermore, there might be a need for other studies including; investigating better ways of reducing air contamination and also to check if these contaminations contribute to neonatal infections by correlating air contamination in neonatal wards to neonatal samples.

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