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Do We Need an Evaluation Method On Microbial Contamination of the Contact Surface and Air Quality Inside the Ambulance for Improvement of the Control and Prevention Measure?

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Abstract: ***Background:*** *Ambulances carry the risk of contamination from any medical first aid treatment in confined spaces, as well as the internal air circulation system. Many countries have implemented measures to manage and ensure the safety against microbial contamination within ambulances, including regular cleaning and disinfection to eliminate pathogens from the air and contact surfaces. However, the efficiency of the current sanitization measures has not been evaluated.*

Aim: *Investigating microbial contamination in the air and on the contact surfaces after the disinfection process according to the standard procedures prescribed in Thailand for ambulance areas.*

Methods: *A surface swab sample test and air sampling test using the impaction method were performed in Basic Life Support Type (BLS) ambulances at the Ruamkatanyu Foundation Headquarters in Samutprakarn province, Thailand.*

Results: *70 surface samples and 20 air samples were collected. The frequent contact areas included: patient bed, patient bed handles, healthcare staff seats, and ambulance floor had been contaminated by bacteria with the concentration higher than 2.5 CFU/cm^2. The seats of the medical staff were found to have the highest level of bacterial contamination at a high concentration of 64 CFU/cm^2. Moreover, the total bacterial count in the air was 617 CFU/m^3, which exceeded the World Health Organization (WHO) standard of the maximum level at 100 CFU/m^3 for healthcare facilities. Additionally, the highest count of total fungal amount in the inside air reached 641 CFU/m^3.*

Conclusion: *The cleaning and disinfection processes in the ambulances according to the standards set by the government had limitations in the real practice. Considering the effectiveness of both processes in practice, it still cannot comply with the standard criteria, and this can pose health risks to both patients and healthcare workers. The improvement of standard procedures and guidelines for evaluating the effectiveness in the cleaning and disinfection of the ambulances to enhance effectiveness is an urgent issue to be discussed and carried out.*

Keywords: *microbial, contamination, contact surface, air quality, ambulance*

1. Introduction

Ambulances are considered crucial in providing emergency healthcare services and are often the first point of direct contact with patients. However, ambulances carry the risk of contamination from various body fluids and any medical first aid treatment in confined spaces, as well as the internal air circulation system [1]. This poses a risk of microbial contamination, which is dangerous for both patients and medical staffs [2]. To prevent the risk of healthcare-associated infections (HAIs), World Health Organization (WHO) and healthcare authorities in different countries have implemented measures to manage and ensure the safety against microbial contamination within the ambulances. These measures include regular cleaning and disinfection to eliminate pathogens from the air and surfaces inside the ambulance after each patient transfer [3]. Due to its ease of use and availability, chemical disinfection has traditionally been used for surface decontamination of furniture and medical equipment after patient discharge. However, a number of air decontamination products for ambulances have been developed [4, 5]. Among these developments are HEPA filtering systems, UV irradiation devices, and ozone fumigation, all of which have proven effective at reducing environmental contamination.

Previously, some studies on the contamination of bacteria and fungi in ambulances, as well as the presentation of the effectiveness of cleaning and disinfection methods were reported [6, 7]. The research approach typically involves surface sampling using swab tests to measure the contamination of bioburden on surfaces and air sampling using impaction methods [8]. However, most studies conducted so far have focused on sampling before the main cleaning procedures [9] or they examined the effectiveness in terms of percentage reduction in microbial contamination before and after cleaning methods [1]. There is still a lack of research on the actual quantity of pathogenic bacteria found after cleaning, following the procedures established by healthcare organizations. Such research would provide insights into the effectiveness of the prescribed cleaning methods. The recent guidelines provided by the Ministry of Public Health of Thailand highlight the current infection control and prevention measures in ambulance procedures, which include: Cleaning surfaces with detergents or cleaning solutions; Decontaminating surfaces by using disinfectants and spraying 70% alcohol for air decontamination; and Ventilating the ambulance for 30 minutes.

This research aimed to investigate the microbial contamination in the air and on the contact surfaces after disinfecting ambulances in accordance with Thai Ministry of Public Health-produced criteria. Surface swab tests and the impaction method of air sapling were used to conduct the assessment. Enhancing disinfection techniques requires evaluating the efficacy of cleaning and disinfection procedures for Thai ambulances. The study aimed to assess the levels of surface and air contamination following the disinfection process according to the standard procedures prescribed in Thailand for ambulance areas.

2. Material and Methods

The study was carried out from May to July 2020 in 10 ambulances at the Ruamkatanyu Foundation Headquarters in Samutprakarn province, Thailand. The ambulances used in the study were of the Basic Life Support Type (BLS) and were primarily responsible for providing first aid and urgent pre-hospital treatment in Bangkok and the Metropolitan region, covering a total of 6 provinces (Bangkok, Pathum Thani, Nonthaburi, Nakhon Pathom, Samut Sakhon, and Samut Prakan). The dimensions of the ambulances used in the study were 1.7 m x 3.35 m x 1.58 m (W x D x H).

2.1 Surface Swab Sample Test

A surface swab sample test was conducted on the ambulance after the completion of cleaning and disinfection procedures. Moistened cotton wool swabs were used to swab seven surfaces within the ambulance cabin. The sampling areas were marked with numbered locations, including the patient bed, patient bed handles, two operation seats, equipment shelf, floor, and rear door (Figure 1). Following sampling, the swabs were promptly transferred into buffered peptone water (BPW) and inoculated onto Plate Count Agar. The agar plates were then incubated for 24 hours at a temperature of 35-37°C.

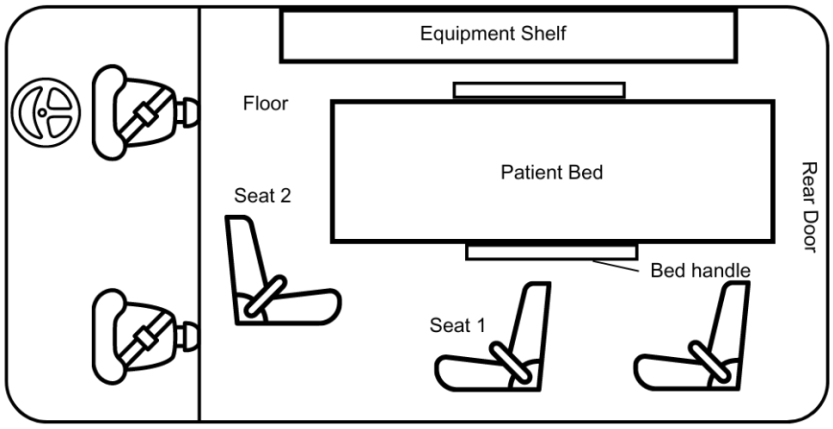

Fig. 1: The sampling areas for swab seven surfaces within the ambulance cabin

2.2 Air Sampling Test

Air sampling was performed in each ambulance using the impaction method. The Anderson six-stage air sampler from Thermo-Andersen (USA) was utilized to collect air samples from inside the ambulance cabin. The average air flow rate was set at 28.3 L/min for a duration of 3 minutes. Two types of media were employed to promote selective growth of fungi and bacteria: malt extract agar (MEA) for fungal characterization and tryptic soy agar (TSA) for assessing total bacterial counts. The interior of the ambulances was sampled using the two different media, and the plates were then transported to the laboratory for incubation. The MEA plates were incubated at 25°C for 3-7 days to allow for fungal growth, while the TSA plates were incubated at 35-37°C for 24 hours to facilitate bacterial growth. The resulting colony-forming units (CFUs) were recorded and used for further analysis.

3. Results

Over the period of 90 days, 10 ambulances were used to collect a total of 70 surface samples from diverse surfaces. Additionally, 20 air samples from the same ambulances were collected to evaluate the bioburden air contamination. These samples were collected after cleaning and disinfection according to the cleaning standard procedure established by the Thai Ministry of Public Health.

Surface samples were analyzed, and the results showed the bacterial contamination ranging from 0 to 64 CFU/cm^2. The bacterial contamination levels in the air samples were higher than 100 CFU/m^3 in 6 samples (60%), and the fungal contamination levels in the air samples were higher than 50 CFU/m^3 in the nine samples (90% of the total samples). The overall results are shown in Table 1.

TABLE 1: The result of bacterial contamination levels on surfaces and the total bacterial and fungal contamination level in air of the Basic Life Support ambulances type (BLS).

Ambulance No.	Surface Swab Sampling Test (CFU/cm^2)							Air Sampling Test (CFU/m^3)	
	Bed	Bed handle	Seat 1	Seat 2	Equipment Shelf	Floor	Rear door	bacterial	Fungi
1	0	0	1.7	1.5	0	1	0	135	188
2	0	0	1.2	0	0	0	0	82	106
3	0	0	0	0	0	6	0	77	253
4	0	0	0	1	0	0	0	65	118
5	1	21	2.6	1.4	0	5	0	71	135
6	0	1	0	1.3	0	7	0	617	370
7	3.8	0	0	1.4	0	1	0	159	35
8	3.6	0	64	0	0	24	0	153	429
9	0	1.3	1.2	1	0	3.5	0	593	641
10	1.9	54	0	5	0	23	0	223	141

4. Discussion

This study is the first to attempt to illustrate the risks associated with pathogenic microbiological contamination discovered in ambulances following cleaning and disinfection procedures that according to the established guidelines published by the Ministry of Public Health of Thailand. These results point to the limitations of the cleaning techniques that are currently used, which are thought to be sufficient in getting control of the hazardous microbiological contamination found in ambulances. It is well recognized that pathogenic microbial contamination greatly raises the danger for patients as well as medical staff, and ambulances play a critical role as the frontline of healthcare services [10]. According to several studies [11, 12], patients' excretions and secretions, which contaminate surfaces and spread through the air conditioning system of the vehicle, are the primary causes of pathogenic microbial contamination in ambulances. These contaminants also come from direct contact between patients and medical staffs. It is widely recognized that traditional cleaning methods, such as wiping, rarely completely disinfect all areas that require for sanitation [13]. Moreover, persistent pathogenic microorganisms could persist for long periods of time as well as spread continually throughout the environment [14-16].

The results of this study show that the surfaces in the patient area of two ambulances were found to be contaminated with bacteria, with a total aerobic colony count (ACC) exceeding 2.5 CFU/cm^2, even after the ambulances had been disinfected according to with the Ministry of Public Health's standards. Two ambulances had the contaminated patient bed and patient bed handles, three had the contaminated healthcare professional seats, and six had the contaminated ambulance floor. The seats of the medical staff were found with the highest level of bacterial contamination, measuring 64 CFU/cm^2. There are currently no recognized regulations in Thailand or other nations that define the maximum degree of bacterial contamination that may be present on certain surfaces and equipment. Because of this, the total aerobic colony count (ACC) criterion was used in this investigation to assess the bioburden on surfaces [17-20]. The widely accepted ACC requirement is less than 2.5 CFU/cm^2.

The findings of the surface swab tests suggest that relying exclusively on wiping as the primary cleaning method for frequently touched surfaces may not be adequate to reduce the contamination of pathogenic bacteria. Additionally, due to direct touch with these surfaces, the residual high level of bacterial contamination might cause cross-infection of patients and healthcare professionals [12]. Although the medical equipment shelves and door handles inside the ambulances had a low level of contamination, the surface swab tests also showed this, demonstrating a significant correlation between frequent contact areas and the level of bacterial contamination [21].

Furthermore, based on examples of the bacterial contamination in the air inside the ambulances, which were collected using the Andersen six-stage sampler, a method used to represent the human respiratory system and assess the risk of respiratory tract infections [22, 23], it was found that six ambulances had a total bacterial count in the air exceeding the WHO standard of 100 CFU/m^3, with the highest count of 617 CFU/m^3. Additionally, nine ambulances had a total fungal count in the air exceeding the WHO standard of 50 CFU/m^3, with the highest count of 641 CFU/m^3. Currently, the acceptable level of bacterial and fungal contamination in ambulance air has not been subject to any established standards. Only criteria for bacterial contamination in the air inside healthcare facilities have been established, as per the standards set by the World Health Organization (WHO), which states that healthcare facilities should have bacterial contamination in the air not exceeding 100 CFU/m^3 and fungal contamination not exceeding 50 CFU/m^3. The presence of elevated levels of bacterial and fungal contamination in the air beyond the established standards indicates a risk for the spread of various infectious diseases [24], and prolonged exposure to airborne fungi or bacteria can directly impact the health [25]. In most Basic Life Support (BLS) ambulances, the air circulation system typically relies on the installed air conditioner, which does not have basic mechanisms to eliminate pathogenic bacteria, such as HEPA filters, thus lacking initial means of eliminating disease-causing microorganisms from the air.

Currently, according to the procedures set by the Ministry of Public Health in Thailand, using antimicrobial agents, various touchpoints within ambulances must be cleaned. Additionally, the use of foggy spraying with 70% alcohol has been implemented within the ambulances. These measures were

introduced as additional steps following the outbreak of COVID-19. However, based on the study results, it can be observed that these measures could not be sufficient to significantly lower the number of infectious agents that could possibly emerge from aerosols produced by patients or from the environment.

The importance of assessing the outcomes after performing cleaning and disinfection to eliminate pathogens in ambulances has been highlighted by the comprehensive study, as it demonstrates the effectiveness of the prescribed methods and the actual implementation by healthcare personnel in their work. It is necessary for ambulance staff, who have the responsibility of caring for the vehicles, to have an increased awareness of the importance of enhancing safety measures against pathogenic microorganisms [9]. Since it directly affects the health and safety of both the healthcare workers themselves and the patients who utilize ambulance services. Additionally, there should be continuous efforts in developing and improving suitable protocols for cleaning and disinfection in ambulances, in order to adequately address and mitigate the risks for both patients and staff members.

5. Conclusion

This study reveals the limitations of the cleaning and disinfection process in ambulances according to the standards set by the government. The effectiveness of the process, as indicated by the results, may pose health risks to both patients and healthcare workers. This can be observed from the following points: i) The total bacterial count on the surfaces inside the ambulances after undergoing the cleaning and disinfection process exceeded the standard criteria set for frequency contact areas. ii) The total bacterial count in the air and the total fungal count in the air through the ambulance's air conditioning system were higher than the safety standards set by the World Health Organization (WHO) for healthcare facilities.

Therefore, the improvement of the standards on cleaning and disinfection of ambulances to enhance effectiveness must be carried out by the government or relevant agencies, responsible for oversight. Consideration should be given to the utilization of appropriate methods, procedures, and tools that are convenient for healthcare workers. Additionally, guidelines for evaluating the effectiveness of the cleaning and disinfection process and the practices for the staff should be established, as there are currently no these specific guidelines in this regard. This is important to ensure that the monitoring and maintenance of safety standards are upheld, which will have a direct impact on the healthcare hygiene standards in ambulances and the confidence of future users.

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