Establishment of human and environmentally friendly hospital with consideration for human and environmental microbiome

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***Abstract* — In recent years, studies on the human and environmental microbiome have increased rapidly. These studies showed that microorganisms are highly abundant, diverse and play very important roles both in human health and in ecological systems.**

Although a hospital is a place where sick or injured people are treated and taken care of by doctors and medical staffs, hospital acquired infection (HAI) by viral, bacterial or fungal pathogens such as Methicillin-resistant *Staphylococcus aureus* (MRSA) presents a serious problem. This suggests that conventional cleaning and disinfection are not sufficient to prevent HAI.

In order to minimize HAI, it is important to prevent the growth and spreading of pathogens in the hospital indoor environment without recourse to antibiotics. It is also important to provide a quality food to hospitalized patients to promote the immune status and the strength for recovery.

We report here our activities on cleaning of hospital environment, experiment on MRSA prevention, kitchen garbage recycling, vegetable production and gardening by utilizing effective microorganisms (EM). These efforts are currently in progress at two hospitals in Japan with a goal of creating human and environmentally friendly hospital.

Keywords—Effective microorganisms, HAI, Health, Hospital, Microbiome, MRSA

1. INTRODUCTION

The microbiome in human is composed of trillions of microorganisms that live inside and outside of the human body. These microorganisms play important roles in human health. Recent studies suggested that the immune system depends on human-microbiome interactions and that microbiome disarray is associated with a number of chronic health conditions including gastrointestinal diseases, obesity, autoimmune diseases, diabetes, cancer, arthritis, asthma and cardiovascular diseases [1].

Microbes are also the most diverse and abundant entities on Earth inhabiting deep sea, rock, water, air and soil, constituting the microbial community called environmental microbiome. Microbes are living in the hospital as well and called hospital microbiome [2].

The Centers for Disease Control and Prevention, USA, estimated that 5% of patients admitted to hospitals are subjected to hospital acquired infection (HAI) by pathogens such as Methicillin-resistant *Staphylococcus aureus* (MRSA) infection during their stay, potentially leading to 99,000 deaths and costing $10 billion per year [3]. Today, antibiotic-resistant infections show no signs of stopping, nor do HAI. Since the hospital is a gathering spot of sick people, it has an inevitable potential for spreading infectious disease. With the advent of penicillin and other antibiotics, concerns about disease transmission diminished because of their superb ability to exterminate pathogenic bacteria. The appearance of antibiotic-resistant bacteria, however has changed the story. Lines of research on human microbiome have shown that the continuous use of antibiotics can disrupt the normal array of microbes that live in and on our bodies [4]. The conventional protocol for sterilization now in use in most hospitals might be effective at a certain level. They usually include the use of broad-spectrum antibiotics, bleach, and hand sanitizer. Those procedures are useful in eliminating harmful pathogens to a certain extent, but they also cut a swath through the hordes of nonpathogenic microorganisms, which compete with harmful microorganisms. Therefore, it is important to prevent the growth of these pathogenic bacteria without killing nonpathogenic and beneficial microorganisms in the hospital environment [5]. Also important is to provide a quality diet to hospitalized patients, to promote immunnopotency and the strength for recovery.

The concept and technology of effective microorganisms (EM) was originally developed by one of the authors, Teruo Higa (then, at University of the Ryukyus, Okinawa, Japan) in 1980s [6]. It was almost 25 years before the advent of the concept of microbiome that Higa advocated the possibility of active utilization of beneficial microorganisms. EM technology shed light on this tradition and thereby evolved into the production of human and environmentally friendly microbiome. EM consists of mixed cultures of beneficial microorganisms such as lactic acid bacteria, photosynthetic bacteria and yeast. At its initial stage, EM technology was effective as microbial inoculants to increase the microbial diversity and to improve the quality of the soil in agriculture [7]. Since then, the application of EM expanded immensely to other fields because of its safety, low cost and easy handling in addition to its effect. Nowadays, EM is widely applied to such fields as animal husbandry, fishery, environmental conservation (including kitchen garbage management and wastewater treatment), cleaning, construction and healthcare [8]. Furthermore, EM technology has been utilized at two hospitals, Noda Hospital and Asaka Kosei Hospital, in Japan, to make them human and environmentally friendly.

In this paper, we report the utilization of EM on cleaning, kitchen garbage recycling, vegetable production, wastewater treatment and gardening. We also evaluated the cleaning effect of EM against E. coli & coliform group, MRSA, and general viable bacteria in hospital environment.

2. MATERIALS AND METHODS

Noda Hospital, with 197 beds, is located in Noda city and in charge of direct healthcare of approximately 150,000 people in Chiba Prefecture. Use of EM started in 2008. Asaka Kosei Hospital is an 84-bed hospital in Asaka city, Saitama Prefecture, and provides direct healthcare to approximately 130,000 people. Active use of EM started in 2013. EM for hospitals use was produced with sugar cane molasses or apple molasses in a cultivation machine positioned at each hospital.

2.1. Investigation

Investigation was conducted regarding the method of EM uptake and its resulting effects at Noda Hospital and Asaka Kosei Hospital.

2.2. Effect of EM cleaning with EM on *E. coli* & coliform group, Methicillin-resistant *Staphylococcus aureus* (MRSA) and general viable bacteria

To evaluate the effect of cleaning with EM on *E. coli* & coliform group, MRSA and general viable bacteria, samples were taken from 10 points at Asaka Kosei Hospital before and after EM application. Detection tests were performed with 3 types of easy detection kits (Petan-Check) produced by Eiken Chemical, Tokyo, Japan. This test was performed from Nov. 15, 2014 to April 26, 2016. Digitalized method was used to determine the contamination level [9].

3. RESULTS AND DISCUSSION

3.1. Investigation

3.1.1. Kitchen garbage recycling

Garbage from hospital kitchen and staff cafeteria was converted into organic fertilizer with EM at both hospitals. At Noda Hospital, almost all kitchen garbage was successfully recycled as quality organic fertilizer by a compost making machine placed on hospital property. Waste oil from the kitchens was recycled as handmade soap utilizing EM. At Asaka Kosei Hospital, no more than 10% of kitchen garbage was recycled due to lack of compost making machine.

3.1.2. Vegetable production

Vegetables were raised in the field attached to each hospital with recycled organic fertilizer and EM (Fig.1a, 1b). The use of agrochemicals was restricted as little as possible. Harvested vegetables were used for hospital diet.

Fig.1a. Dr. Kanemoto (middle) works in the field attached to Noda Hospital

Fig.1b. Broccoli harvested from the filed attached to Asaka Kosei Hospital

3.1.3. Improvement of hospital diet

Efforts were made to improve hospital diet using fresh vegetables from the field. These hospital diets earned a positive reputation from hospitalized patients.

3.1.4. Gardening

Flowers and ornamental plants were grown with EM and the organic fertilizer but without agricultural chemicals. Patients enjoyed seeing at them.

3.1.5. Wastewater treatment

At Noda Hospital, foul odor from the septic tank was minimized by periodical application of EM.

3.1.5. Cleaning of toilets, floors and rooms in hospital

Efforts were made to reduce the use of bleaching and bactericidal agents to the extent possible. EM was used for cleaning of toilets, floors and rooms. Sanitation workers sprayed EM on floor surfaces before mopping them (Fig.2a, 2b).

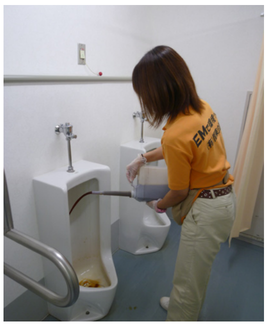

Fig.2a. EM is poured down the drain of urinal in Noda Hospital

Fig.2b. EM is sprayed on the floor surface before mopping them at Asaka Kousei Hospital

Based on the interview with patients and hospital staff, it was found that foul odor in toilets and particular smell of hospital disinfectant were remarkably reduced after introduction of EM for cleaning. Sanitation workers reported that their rough hands were improved after stopping the use of bleaching agents and bactericidal agents.

3.2. Effect of cleaning with EM on *E. coli* & coliform group, MRSA and general viable bacteria

Results at Asaka Kosei Hospital are shown in Tables 1, 2 and 3. Before cleaning with EM, less than 10 colonies per 10 cm^2 of *E. coli* & coliform group were detected in the garbage bin in the sanitary room and sink faucet. After the introduction of cleaning with EM, no colonies were detected except in the garbage bin in the sanitary room (Table 1). Colonies of MRSA were detected before cleaning with EM, at 5 out of 10 sampling points. Especially, 30 colonies of MRSA were detected on the floor of room 305. After introducing EM, colonies were still detected at 1 to 2 sampling points until Oct. 2015. No colonies were detected from Dec 2015 to Feb 2016 (Table 2).

Our data suggest that growth of *E. coli* & coliform group and MRSA is efficiently suppressed by cleaning with EM. Growth of other general viable bacteria, however, was not suppressed by cleaning with EM (Table 3).

Table.1 Effect of cleaning with EM on *E. coli* & coliform group

Sampling point	Contamination level								
	No EM	Clening with EM							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 Toilet doorknob, 2nd floor	▯	▯	▯	▯	▯	▯	▯	▯	▯
2 Toilet seat, 2nd floor	▯	▯	▯	▯	▯	▯	▯	▯	▯
3 Garbage bin in the sanitary room, 3rd floor	⌖	▯	▯	▯	⌖	▯	▯	⌖	▯
4 Staircase rail, 1st floor west side	▯	▯	▯	▯	▯	▯	▯	▯	▯
5 Rail in front of the endoscope room, 1st floor	▯	▯	▯	▯	▯	▯	▯	▯	▯
6 Floor of Room 305	▯	▯	▯	▯	▯	▯	▯	▯	▯
7 [illegible]	▯	▯	▯	▯	▯	▯	▯	▯	▯
8 [illegible]	⌖	▯	▯	▯	▯	▯	▯	▯	▯
9 [illegible]	▯	▯	▯	▯	▯	▯	▯	▯	▯
10 [illegible]	▯	▯	▯	▯	▯	▯	▯	▯	▯

Table.2 Effect of cleaning with EM on Methicillin-resistant *Staphylococcus aureus* (MRSA)

Sampling point	Contamination level								
	No EM	Clening with EM							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 Toilet doorknob, 2nd floor	▯	▯	▯	▯	▯	▯	▯	▯	▯
2 Toilet seat, 2nd floor	⌖	▯	▯	▯	▯	▯	▯	▯	▯
3 Garbage bin in the sanitary room, 3rd floor	⌖	▯	▯	▯	⌖	⌖	▯	▯	▯
4 Staircase rail, 1st floor west side	▯	▯	▯	▯	▯	▯	▯	▯	▯
5 Rail in front of the endoscope room, 1st floor	▯	▯	▯	▯	▯	▯	▯	▯	▯
6 Floor of Room 305	▯▯	⌖	▯	▯	▯	▯	▯	▯	▯
7 [illegible]	⌖	▯	▯	▯	▯	▯	▯	▯	▯
8 [illegible]	⌖	▯	▯	▯	▯	▯	▯	▯	▯
9 [illegible]	▯	▯	▯	▯	▯	▯	▯	▯	▯
10 [illegible]	▯	⌖	▯	▯	▯	▯	▯	▯	▯

Table.3 Effect of cleaning with EM on general viable bacteria

Sampling point	Contamination level								
	No EM	Clening with EM							
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1 Toilet doorknob, 2nd floor	⌖	⌖	▯	▯	⌖	⌖	▯	▯	⌖
2 Toilet seat, 2nd floor	⌖	▯	▯	⌖	⌖	⌖	⌖	▯	▯
3 Garbage bin in the sanitary room, 3rd floor	▯▯	▯▯	▯	▯▯	▯	▯	⌖	⌖	⌖
4 Staircase rail, 1st floor west side	▯▯	▯▯	▯	⌖	▯	▯	▯	▯	▯
5 Rail in front of the endoscope room, 1st floor	▯	▯▯	⌖	⌖	⌖	▯	▯	▯	▯
6 Floor of Room 305	▯▯	▯▯	▯	▯	▯	⌖	▯	▯	▯
7 [illegible]	⌖	▯▯	⌖	⌖	⌖	⌖	⌖	⌖	⌖
8 [illegible]	▯	▯	▯▯▯▯	▯▯▯	▯▯▯▯	▯▯	▯▯▯▯	⌖	⌖
9 [illegible]	⌖	▯▯	⌖	⌖	▯	▯	⌖	⌖	▯
10 [illegible]	▯	▯▯	▯▯▯▯	▯▯▯▯	⌖	⌖	⌖	▯	▯▯

Criteria method based on L. Ten Cate

Number of colonies/10cm^2	Rating
No colony was formed	▯
<10	⌖
10 ~ 30	▯
30 ~ 100	▯▯
> 100	▯▯▯
Too numerous to count	▯▯▯▯

This finding may suggest that growth of *E. coli* & coliform group and MRSA is suppressed by microbes such as lactic acid bacteria in EM. It was previously shown that the direct interaction of lactic acid bacteria and MRSA in such a mixture led to the elimination of 99% of the MRSA cells within 24 hours. [10]

A detection test for MRSA was also performed at Noda hospital, and no colonies were detected from all sampling points (n=10). Re-infection of MRSA was not reported after introducing EM at both Asaka Kosei Hospital and Noda Hospital.

Our observations and findings show that active use of beneficial microorganisms such as EM in hospital environment turns into reality the kitchen garbage recycling, improvement of hospital diet, improvement of gardening and greening, reduction of foul odor in wastewater and toilets, reduction of use bleaching agents and bactericidal agents, and suppression of pathogen such as coliform group and MRSA in hospital.

Intentional use of microorganisms in hospitals could conceptually be regarded as opposite to the conventional approach from the point of hospital hygiene. Therefore, studies are needed to further understand the effect of EM application on human and hospital microbiome.

4. CONCLUSION

Our studies in two hospitals in Japan suggest that improving the human and hospital microbiome utilizing effective microorganisms (EM) in a hospital environment represents an alternative approach to control hospital acquired infection (HAI) and to create a human and environmentally friendly hospital.

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