Avicenna J Environ Health Eng. 2019 Dec;6(2):119-123 http://ajehe.umsha.ac.ir

Review Article

doi 10.15171/ajehe.2019.16

The Potential Effectiveness of Probiotic-Based Sanitation Procedures in Nosocomial Infection Control: A Review Article

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Published online December 31, 2019

Abstract

The sanitation of the hospital environment for the purpose of preventing the transmission of nosocomial infections has a major role in reducing the infection of hospitalized patients with the bacteria living on hospital surfaces. The excessive use of chemical detergents in recent decades has led to microbial resistance in nosocomial infectious bacteria. Researchers' attention has therefore been drawn to the use of probiotics for disinfecting hospital surfaces. The present study was conducted to assess the potential effectiveness of probiotic products in controlling the contamination of inert surfaces in the environment and medical instruments in health centers and investigate the claim that the antagonistic property of probiotic microorganisms offers an effective method for controlling nosocomial infections and a suitable alternative to conventional disinfection methods. A search was carried out for relevant articles published from 2000 to 2018 in databases including ISI, PubMed, Scopus, EMBASE, and Google Scholar, using the keywords "nosocomial infections", "disinfection", "sanitation", "probiotics" and "infected surfaces". The articles published from 2000 to 2018 confirmed the greater effectiveness of probiotic disinfection (by up to 90%) compared to conventional chemical disinfection in controlling nosocomial infections. Nevertheless, more extensive studies are needed on probiotics to determine the possibility of replacing good bacteria with bad bacteria in future decades.

Keywords: Nosocomial infection, Disinfection, Probiotic, Infected surfaces, Pathogens

Received July 20, 2019; **Revised** December 1, 2019; **Accepted** December 11, 2019

1. Introduction

Contaminated surfaces in hospitals provide an important source for transmission of health care-associated pathogens (1). Therefore, the use of disinfectants has a major role in the management of nosocomial infections. As a huge challenge throughout the world, nosocomial infections threaten the health of 15% of hospitalized patients (2,3). Pathogens including vancomycin-resistant *Enterococcus*, methicillin-resistant *Staphylococcus aureus*, *Norovirus*, *Clostridium difficile*, and multidrug-resistant gram-negative bacteria (MDR) can survive in the hospital environment for days and months and act as a source of spreading infection (4-6). Conventional sanitation based on the use of chemicals not only is ineffective in preventing the re-infection of surfaces but also produces multidrug-resistant microbial strains. The theory of probiotic-based improvement was formed and probiotic microorganisms were first introduced by Kramer et al, who pointed out their antagonistic effect on the proliferation of pathogens on hospital surfaces (3). By producing the extracellular polysaccharide matrix, *Staphylococcus aureus* and *Escherichia coli* adhere to inert surfaces and produce biofilm (7). This biofilm formation enables microorganisms to benefit from survival against their planktonic (free-floating) rivals and provides an optimal environment for the growth, proliferation, gene transfer, and the microbial population development. The proximity of rival species can have an antagonistic effect on the formation of biofilm (8). *Lactobacillus* species can produce amphipathic molecules called bio-surfactant, which have anti-adhesion properties against pathogenic microbes (9,10). The extensive use of chemical disinfectants not only produces disinfectant-resistant microbial strains but also makes them resistant against antibiotics. According to a recent report, using chlorhexidine leads to the emergence of multidrug-resistant gram-negative bacteria (MDR-GNB) against colistin. This antibiotic was used until 2016 as the drug of last resort for the treatment of infections caused by MDR-GNB (11). The potential to cause microbial resistance is a highly undesirable side-effect of chemical detergents, and the spread of pathogens is responsible for a large part of nosocomial infections (12,13). Self-disinfecting method can be proposed as an alternative method in which hospital surfaces are smeared with a bactericidal agent using silver and copper. This method is expensive and not suitable for all surfaces (14). The issue of minimizing the risk of nosocomial infection and preventing the increase in drug resistance has turned the attention of researchers to the management of "hospital environment sanitation" instead of "patients' physical health" (15,16). The present article aims to review the potential effectiveness of bio-surfactants in controlling nosocomial infections in studies conducted from 2000 to 2018.

2. Materials and Methods

2.1. Study Objective

The present study aimed to review articles published from 2000 to 2018 to find evidence in favor of the claim that probiotics have the required effectiveness for controlling nosocomial infections.

2.2. Study Strategy

Published literature was retrieved through a search using the words (MeSH was applied to select appropriate keywords) "microbial infection", "infection control", "disinfectant", "probiotic organisms", "bio-surfactant", "nosocomial infections" and "sanitation" in databases including PubMed, EMBASE, ISI, and Google Scholar (2000-2018) (Fig. 1).

2.3. Article Inclusion Criteria and Data Extraction

First, the abstracts of all the retrieved papers were reviewed to select the relevant articles. Then, data were extracted by reviewing the full text of the selected articles. The data extraction criteria consisted of the type of experiment, results, type of probiotic and type of hospital organism.

3. Results and Discussion

Of the 65 articles retrieved, 15 were identified as relevant (Fig. 1). After printing out the full text of all these articles, the careful assessment of the data and results was carried out personally. Half of the experiments were in vitro experiments and the other half were field evidence. The *Bacillus* species made up a greater proportion of the probiotic bacteria. According to Table 1, the probiotic-based sanitation methods used in the experiments had been able to reduce pathogens on hospital surfaces about 50% to 100% more than conventional chemical methods. It is a generally-accepted fact that some good bacteria are crucial and valuable for human health and can be effectively used in the prevention and treatment of infectious diseases (32). Fig. 2 shows the schematic plan of replacing pathogens with probiotic bacteria.

Health care-associated infections are one of the serious problems concerning the safety of public health worldwide. As a challenge throughout the world, nosocomial infections threaten the health of 15% of hospitalized patients (33). It is well known that contaminated surfaces in hospitals act as reservoirs for the pathogenic bacteria, increasing the risk of infection (34). The extensive use of the traditional chemical disinfectants

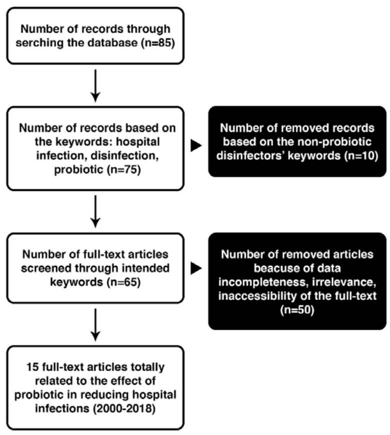

Fig.1. Flow Chart of Literature Review (2000-2018) of Included and Excluded Studies for Nosocomial Disinfection by Probiotics.

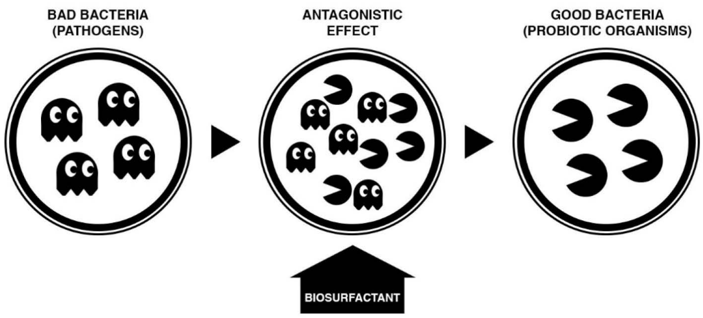

Fig. 2. The Schematic Plan of the Antagonistic Effect of Probiotic Bacteria on Pathogens Living on Hospital Surfaces and Medical Instruments.

Table 1: The Effectiveness of Probiotic Bacteria in Reducing Hospital Pathogens

Method	Reference	Probiotics	Surfaces	Hospital Bacteria	Outcome
In situ	Caselli et al (2018) (17)	PCHS (probiotic cleaning hygiene system)	Floor, Sink, Footboard	*Staphylococcus spp., Enterobacteriaceae spp., Acinetobacter spp., Mycetes, Pseudomonas spp., Clostridium difficile*	Over 83% reduction of surfaces pathogens
Commercial hatchery	Graham et al (2018) (18)	*Bacillus subtilis*		*Staphylococcus, Pseudomonas, Escherichia coli*	
In situ	Caselli (2017) (19)	*Bacillus subtilis, Bacillus pumilus, Bacillus megaterium*	Floor, Sink	Common bacteria	Over 90% reduction compared to the routine methods
In situ	Caselli et al (2016) (20)	Controlled pre-post interventional study		Hospital bacteria	Over 90% reduction compared to the routine methods
In vitro, in situ (opinion)	Caselli et al (2016) (21)	*Bacillus subtilis, Bacillus pumilus, Bacillus megaterium*			Over 90% reduction compared to the routine methods
In vitro	Fanci et al (2015) (22)		Floor, Washbasin, Desk	*Enterococcus faecalis, Candida albicans, Pseudomonas, Acinetobacter, Klebsiella pneumoniae*	92.2%-99.9% bacterial reduction, 100% reduction of *Pseudomonas, Acinetobacter*
In vitro	Vandini et al (2014) (23)	*Bacillus subtilis spp*. spores	Floor, Sink, Toilet	*Staphylococcus aureus Coliforms Pseudomonas spp. Candida spp.*	Over 80% reduction of microbial load
In situ	Vandini et al (2014) (24)	Genus of *bacillus*	Floor, Doors,Showers toilet, Windows sill, Sink (all made of stone, plastic, wood, glass, and metal)	*Coliforms, Staphylococcus aureus, Clostridium difficile, Candida albicans*	50%-89% reduction in microbial load on the surfaces
In situ and in vitro	Mazzacane et al (2014) (25)	Genus of *Bacillus*, vegetative form and spore	Toilet, Floor, Corridor floor	*Coliforms, Staphylococcus aureus, Candida albicans, Acinetobacter spp., Pseudomonas spp.*	About 90% reduction in microbial cell
In vitro	Walencke et al (2008) (26)	*Lactobacillus acidophilus*	Floor	*Staphylococcus aureus, Staphylococcus epidermidis* biofilm	About 5%-56% reduction
In vitro	Rodrigues et al (2006) (27)	*Streptococcus thermophilus*	Silicon, Rubber	*Coliforms, Staphylococcus aureus, Candida albicans, Acinetobacter spp., Pseudomonas spp.*	97% reduction in adhesion of bacterial cell
In vitro	Rodrigues et al (2004) (28)	*Lactococcus lactis*	Silicon, Rubber	*Staphylococcus aureus, Candida albicans, Staphylococcus epidermidis, Streptococcus salivarius*	Adhesion of pathogenic bacteria
In vitro	Rodrigues et al (2004) (29)	*Streptococcus thermophilus, Lactococcus lactis*	Silicon, Rubber	*Staphylococcus aureus, Candida albicans, Staphylococcus epidermidis, Streptococcus salivarius*	Significant decrease in the number of bacteria on the surface
In vitro	Hoogmoed et al (30)	*Streptococcus mitis*	Glass	*Streptococcus mutans*	Release of biosurfactant by *Streptococcus mitis* and decrease in the number of *s. mutans* cells
In vitro	Vander Mei et al (2000) (31)	*Lactobacillus spp., Streptococcus thermophilus*	Silicon, Rubber	*Candida spp., Streptococcus spp., Staphylococcus spp.*	Decrease in the number of pathogens on the surface

not only produces disinfectant-resistant microbial strains but also makes them resistant against antibiotics (11). The issue of minimizing the risk of nosocomial infection and the safety of public health has turned the attention of the researchers to the use of probiotic bacteria (17-31).

The results of the present review study show that despite the significant results reported, which generally confirm the effect of the probiotic-based sanitation method, a definitive answer cannot yet be given to the following questions: 1) How do probiotic microorganisms survive on inert surfaces and how long can they keep up and continue their dominance in competition with hospital pathogens? 2) To what extent are probiotics able to fight and act as antagonists against pathogenic microorganism growth? 3) How can we ensure the safety of probiotics and probiotic-containing detergents for consistent use in hospitals? 4) How can hospitalized patients' health be promoted as a result of shifting from pathogens to probiotics? In other words, to what extent does replacing nosocomial pathogens with probiotics have a share in preventing dangerous pulmonary, gastric and urinary infections in patients? 5) Are probiotics and their products enough for inhibiting all microbial species? and 6) Is it possible for the epidemiology of nosocomial infections to be shifted toward microorganisms on which probiotics have no effect?

The in vitro experiments conducted on hydrophobic materials (such as glass) and hydrophilic materials (such as silicon) somewhat support the first question (35). The safety of using the probiotic-based sanitation method has been confirmed by the European Union Workshop (36), although several species of lactobacillus used in humans as probiotics have reportedly caused *lactobacillus* bacteremia (a very rare disease) in patients with serious underlying diseases (37). There has been a reduction in the frequency of nosocomial infections, diarrhea, colon infections (38), upper respiratory tract infections (39), and surgical site infections (40). The environmental parameters, such as humidity, temperature, and microbial flora, of different hospital units are regarded as factors affecting the disinfection of hospital surfaces and should therefore be considered in all antimicrobial processes.
This review study shows that a probiotic-based cleaning strategy is more effective (up to 90%) in reducing microbe, compared to a traditional chemical disinfectant. However, to develop a better understanding of the mechanism of the effectiveness of probiotics, further studies are needed.

4. Conclusion

The literature review (2000-2018) confirmed the greater effectiveness of probiotic disinfection (by up to 90%) compared to traditional chemical disinfection in controlling nosocomial infections. Since it is not possible to fully disinfect pathogens from all surfaces, nosocomial infections and drug-resistant pathogens can perhaps be controlled by relying on greater knowledge about the defects and shortcomings of the idea of using probiotics and by replacing "bad bacteria" with "good bacteria". There is no easy way to remove microbes from surfaces. As a "green" alternative to chemical disinfectants, probiotics are biodegradable and environment-friendly. Using them is an innovative way to disinfect hospital environments effectively.

5. Acknowledgment

The review was performed by the sole author.

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