



# Infection Insights: Microbial Profiling and Safety Strategies in Dialysis Unit

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## Introduction

Microbes are found in various environments, including soil, water, and air. Our body harbours many microorganisms, including bacteria, viruses, fungi, algae, archaea, and protozoa. The prevalence of obesity and diabetes has translated into more patients suffering from chronic kidney disease (CKD). Chronic kidney disease affects more than 10% of the general population worldwide. End-stage renal disease (ESRD) is the last stage of chronic kidney disease where the estimated glomerular filtration rate (GFR) is less than 15 ml per minute and the person requires dialysis.

**Key Words:** Infection Insights, dialysis, End-stage renal disease, Metagenomics, safety strategies.

## Prevalence of Infections in Dialysis Patients:

Around 1.5 million people are developing ESRD per year worldwide and are kept on dialysis for survival. Water is used as dialysate during dialysis. Dialysis patients are exposed to 400 to 600 litres of water each week. Worldwide there are around 23,000 dialysis units with water systems in place. Almost all of these are designed for chemical disinfection that is done either on a scheduled or as-needed basis. Scheduled chemical disinfection is generally infrequent (once a month or once a quarter), as the disinfection is a relatively complex process (injecting chemicals, exposure to all areas, rinsing and residual testing). As needed can be as seldom as once every eight years. Many of the organisms present in the dialysis apparatus form biofilms over the apparatus and are the constant source of the release of microbes to the dialysate as well as the patient's bloodstream. Moreover, dialysis patients are more prone to infections through nosocomial infections due to frequent hospital visits. They are immunocompromised due to their uraemia and other comorbid conditions, need for repeated vascular access through central venous catheters, arteriovenous grafts, and frequent prescriptions of antimicrobials.

## Objectives of the Literature Review:

The main objectives are to reduce infection through dialysis units, improve patient's health issues, and decrease the cost of hospital bills, increase lifespan. The patients with ESRD have many problems. Their quality of life is affected by haemodialysis as a time-consuming treatment and subsequent social and physical activity limitations, increased disability, and impaired functioning, moreover, in addition to several stressors including dietary limitations, loss of mobility, hypotension, muscle cramps, and limited activity. Patients also suffer from the psychological burdens of haemodialysis, such as depression and anxiety. Haemodialysis patients are faced with challenges such as medical conditions, loss of previous routine daily living and body, mind, and spirit challenges. Life restrictions include limitations in travel, income, social contact, daily diet, and fluid restrictions and these challenges create the need to get support from family, friends, and support groups.

## Microbial Composition of Dialysis Facilities:

The fluids utilized in dialysis are all water-based, providing a favourable environment for microorganisms. This issue leads to an increased presence of microorganisms, endotoxins, and the formation of metabolites. During each dialysis session, the patient meets the dialysis fluid due to back filtration, whereby varying amounts of dialysis fluid are filtered through the dialyzer membrane into the blood, ranging from 100 ml to several Liters.

According to recent literature, there are descriptions of 1,194 genera of bacteria encompassing 6,466 species. Contemporaneous perspectives propose that there could be 3 to 4 million diverse microorganisms of all kinds. Besides bacteria, other groups of microorganisms include fungi (100,000), algae (50,000), protozoa (65,000), and viruses (50,000). Consequently, testimonial literature might contain about 300,000 microorganisms, of which only 6,466 are bacteria. A significant proportion of the known microorganisms are connected to humans, which explains why they have been discovered. On the other hand, the microflora in the environment is not well-documented.

The facility microbiome, encompassing the diverse microbial communities present in healthcare settings such as hospitals, clinics, and long-term care facilities, has a significant impact on patient infections. The facility microbiome can act as a reservoir for pathogenic microorganisms. For instance, surfaces, air, and even the hands of healthcare workers can harbour pathogens like *Clostridium difficile*, *Methicillin-resistant Staphylococcus aureus* (MRSA), and *Vancomycin-resistant Enterococcus* (VRE), which can then be transmitted to patients.

A diverse microbiome might dilute the presence of pathogenic species through competition. However, low microbial diversity can be a risk factor for infections, as it may be indicative of an environment conducive to the survival and proliferation of pathogens. This impact is multifaceted, affecting infection rates, outcomes, and the effectiveness of infection control measures. Studies show that MRSA and *C. difficile* can persist on hospital surfaces, and these pathogens can cause healthcare-associated infections (HAIs) if proper sanitation and hygiene are not maintained. Airborne transmission of pathogens, such as *Acinetobacter baumannii* or *Pseudomonas aeruginosa*, is also a concern. The facility microbiome's airborne components can contribute to the spread of infections, particularly in areas with inadequate ventilation. Outbreaks of airborne infections like tuberculosis can be influenced by the microbiome present in the facility's air.

Patient microbiomes can be altered by the healthcare facility microbiome, which can influence susceptibility to infections. For example, the introduction of resistant strains or pathogenic microorganisms can disrupt the normal microbiota of patients, making them more susceptible to infections. Some facilities use probiotics to help maintain a balanced microbiome and reduce the risk of infections, especially in patients on antibiotics. Probiotics are sometimes used to restore gut microbiota disrupted by antibiotic treatments, which may help prevent

opportunistic infections like those caused by *C. difficile*. Monitoring and analysing the facility microbiome can help identify sources and transmission pathways of infections, aiding in the development of targeted infection control measures. Ongoing surveillance of the facility microbiome can provide early warnings of potential infection outbreaks and help refine infection control strategies. Active surveillance of *MRSA* and *VRE* in healthcare facilities can help track infection rates and guide infection control interventions.

Metagenomics can help elucidate microbial interactions by analysing the genetic material from all community members. Researchers can identify patterns of co-occurrence, potential competitive or cooperative interactions, and community responses to environmental changes. Metagenomic analysis of the human oral microbiome has provided insights into how microbial communities interact with each other and how these interactions relate to oral health and disease. Metagenomics allows for high-resolution, high-throughput sampling and analysis, enabling researchers to track changes in microbial communities over time and in response to environmental changes or interventions. Longitudinal metagenomic studies have been used to track shifts in the gut microbiome associated with dietary changes, antibiotic treatments, or disease progression. The wide applications include,

### A. Infection Control and Prevention

- **Pathogen Identification:** Pathogens associated with dialysis-related infections can be identified such as *Corynebacterium jeikeium* or *Enterococcus faecalis*.
- **Antibiotic Resistance Monitoring:** To study resistance genes to develop efficacious infection control strategies.

### B. Environmental Monitoring

- **Surface and Air Microbiome Analysis:** Study microbial communities on surfaces and in the air of dialysis units to assess potential contamination sources.
- **Sanitation Effectiveness:** Evaluate the effectiveness of cleaning protocols and identify areas for improvement.

### C. Patient Health and Outcomes

- **Microbiome-Patient Interaction:** Investigate how the facility microbiome affects patient health, including the risk of infections and other complications.
- **Probiotic and Preventative Measures:** Assess the potential benefits of probiotics or other interventions to maintain a healthy microbiome for patients.

### *Correlation Between Facility Microbiome and Dialysis Patient Pathogens:*

Pathogen	Facility Source	Infection Risk	Control Measures
Staphylococcus aureus	High-touch surfaces, staff/patient interactions	Catheter infections, skin infections	Surface cleaning, hand hygiene, infection control practices.
Staphylococcus epidermidis	Skin flora, medical devices	Catheter-related infections	Proper sterile techniques, regular inspections.
Escherichia coli	Water sources, handling of equipment	Peritonitis, UTIs	Water quality monitoring, proper equipment handling.

<i>Pseudomonas aeruginosa</i>	Water sources, moist environments	Peritonitis, catheter infections	Regular maintenance of water systems and equipment.
<i>Klebsiella pneumoniae</i>	Surfaces, water sources	Peritonitis, pneumonia	Routine surface cleaning, equipment maintenance.
<i>Enterococcus faecalis</i>	Patient contamination	Peritonitis, endocarditis	Adherence to infection control practices, patient isolation.
<i>Candida albicans</i>	Surfaces, equipment	Peritonitis, catheter-related infections	Proper sterilization of equipment and surfaces.
Hepatitis B Virus (HBV)	Bloodborne pathogens, contaminated surfaces	HBV infections	HBV vaccination, strict infection control practices.
Hepatitis C Virus (HCV)	Bloodborne pathogens, contaminated surfaces	HCV infections	HCV screening, infection control procedures.
Human Immunodeficiency Virus (HIV)	Bloodborne pathogens, contaminated surfaces	Opportunistic infections	Antiretroviral therapy, infection control practices.

### Novel Pathogens and Emerging Risks

In the evolving landscape of infectious diseases, novel pathogens and emerging risks pose significant challenges for dialysis facilities. Understanding these threats and developing effective strategies for their management is crucial for ensuring patient safety. Bacteria like *Mycobacterium chimaera*, *Elizabethkingia anopheles*, and *Acinetobacter baumannii* cause endocarditis, disseminated disease, bloodstream infections, and pneumonia. Viruses like SARS-CoV-2 and human bocavirus cause Hepatitis B, C, and HIV, respiratory infections, bloodstream infections, HCV, and opportunistic infections. The management strategies include a combination of antibiotics, vaccination, screening, and antimicrobial stewardship programs.

### Assessment of Potential Risks Associated with the Pathogens

Risks include infection risks, transmission risks, antimicrobial resistance and environmental contamination and mitigating the risks posed by lesser-known or emerging pathogens in dialysis facilities is crucial for maintaining patient safety. Pathogens may cause infection risk in patients particularly those who are immuno-compromised. Transmission risk is potential as the pathogens spread in the dialysis facility environment. Pathogens may exhibit resistance to standard treatments complicating infection management. Risks of pathogens, contaminating surfaces, water, or air leading to potential outbreaks. Emerging pathogens may pose broader risks beyond the immediate facility affecting public health.

#### 1. Cleaning Protocols:

Cleaning protocols are designed to manage microbial populations on surfaces and equipment in facilities. The effectiveness of these protocols can significantly impact the facility's microbiome. Using chemical agents like hydrogen peroxide, and quaternary ammonium compounds to kill or inhibit microorganisms. Removal of dirt and organic matter through mechanical means like scrubbing and wiping. Sterilization using autoclave, and dry-heat

sterilization will eliminate all microorganisms including spores. Routine and deep cleaning like daily or weekly cleaning schedules will reduce microorganisms.

## **2. Water Quality:**

Water quality affects microbial growth and survival in facilities, particularly in systems like plumbing and cooling. The pH levels like acidity and alkalinity of water influence microbial growth, extreme pH can kill or inhibit microbes. The chlorine levels used for chemical disinfection kill the pathogens but also affect microbial diversity. Water temperature affects microbial metabolism. High temperatures can kill microbes; low temperatures can inhibit growth. The cloudiness of water caused by suspended particles can harbor microorganisms and affect disinfection efficiency.

## **3. Types of Air Circulation and its Impact on Microorganisms:**

Air circulation affects the distribution and movement of microorganisms in the air and on surfaces within a facility. Air circulation systems like HVAC systems used for heating, ventilation, and air conditioning systems for climate control Can disperse microbes throughout the facility; effectiveness depends on filter types and maintenance. Air purifiers like HEPA filters and UV-C air purifiers that remove contaminants from the air reduce airborne microbial load and improve air quality. Natural ventilation like Open windows, and vents use natural forces like wind and buoyancy for air exchange can dilute and remove airborne contaminants but may be less effective in extreme weather conditions. Mechanical ventilation like exhaust fans, and air handling units use fans and ducts to control airflow, and quality provides controlled air quality and can be optimized for specific needs.

### **Adaptability of Microbes in Dialysis Facilities has Significant Implications for Infection Control:**

In the realm of infection control in dialysis facilities, continuous surveillance and monitoring are imperative to safeguard patients' safety. It is significant that regular microbial testing and surveillance to promptly identify and address potential sources of infection. Review monitoring technologies, such as biosensors and rapid microbial detection systems that present promising avenues for bolstering infection control measures in dialysis settings.

Enhanced disinfection protocols are pivotal in curbing microbial proliferation. The effectiveness of novel disinfectants and cleaning methods tailored to combat biofilms and resilient pathogens, underscoring the importance of refining disinfection practices as a cornerstone of infection control. Educating and training healthcare professionals in meticulous infection control measures is critical. The indispensability of continuous staff education on infection control measures. Thereby underscoring the pivotal role of knowledge dissemination in maintaining a safe dialysis environment.

The prudent use of antibiotics and the pursuit of alternative therapies is crucial in infection control. Efficacious antibiotic stewardship programs are imperative in healthcare settings to curtail antibiotic resistance. Exploring alternative treatments such as phage therapy and antimicrobial peptides shows promise in addressing challenges posed by antibiotic-resistant infections.

**Summary of Recommendations:**

Area	Recommendation	Action Steps
Facility Design and Maintenance	Antimicrobial surfaces, HVAC improvements, advanced cleaning	Install antimicrobial materials, upgrade HVAC systems, adopt advanced cleaning protocols
Infection Control Protocols	Modality-specific guidelines, staff training, compliance audits	Develop and implement specific protocols, provide training, conduct regular audits
Monitoring Techniques	Microbiome monitoring, real-time data analytics	Establish routine sampling schedules, use real-time analytics for decision-making
Ethical Considerations	Ethical research guidelines, data management practices	Develop ethical guidelines, ensure secure data handling and patient consent
Broader Implications	Policy advocacy, public health initiatives	Advocate for policy changes, promote best practices through public health campaigns

**Policy Recommendations Based on Microbiome Research:**

Microbiome balance affects infection risks, hence develop guidelines that address microbial diversity and infection control based on the latest research. Developing clear ethical guidelines for conducting microbiome research including consent and privacy considerations. Implementing evidence-based policies to ensure infection control policies based on the latest scientific evidence and research findings. Formulating modality-specific regulations for infection control tailored to specific risks of haemodialysis and peritoneal dialysis. Funding and encouraging collaborative research across multiple centres to establish best practices for infection control.

**Conclusion:**

Dialysis centres are special places that prioritize keeping patients safe while maintaining effective infection control. The varied communities of microorganisms found in these environments, whether in in-centre haemodialysis, home haemodialysis, or peritoneal dialysis, provide us with valuable insights to help us better protect patients. Understanding these microbiomes and the factors that affect them allows us to customize our infection control practices to address the specific challenges in each environment effectively. We have witnessed how environmental elements such as air quality, water purity, and surface cleanliness significantly impact the spread of infections. Microbes' adaptability, particularly their capacity to develop biofilms and withstand standard cleaning methods, underscores the fact that infection control is an ongoing challenge, making continuous monitoring, innovative disinfection techniques, and thorough staff training more important than ever.

In addition to technical considerations, it is evident that enhancing infection control in dialysis centres demands a collective endeavour. By uniting healthcare professionals, researchers, and policymakers, we can ensure that our practices are informed by the latest scientific research while also remaining practical and adaptable to real-world conditions. Furthermore, integrating ethical considerations into this undertaking ensures that patient care remains the central focus of our initiatives. Ultimately, by embracing a more comprehensive approach that integrates state-of-the-art science with empathetic care, we can make dialysis facilities safer for everyone. The

goal is not only to reduce infection rates but to also enhance the quality of care and guarantee that every patient feels safe and well-supported in these settings.

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