

Appropriate Preventive Measures for Potential Risks against Microbiota in Physical Therapists' Working Environment

Ujala Tariq¹, Minaal Jamil¹, Mahnoor Umar², Sadia Bibi³, Aimen Khalid⁴ and Maham Habib^{5,*}

¹Department of Physical Therapy, Faculty of Medical Sciences, Government College University Faisalabad, 38000, Punjab, Pakistan

²Nassau University Medical Center, East Meadow, New York

³Department of Clinical and Experimental Medicine, University of Modena and Reggio Emilia (Unimore), Italy

⁴Institute of Microbiology, Faculty of Life Sciences, Government College University Faisalabad, 38000, Punjab, Pakistan

⁵Department of Physical Therapy, Faculty of Allied Health Sciences, Riphah International University Faisalabad, 38000, Punjab, Pakistan

*Corresponding author: mahamhabib307@gmail.com

Abstract

Physical therapists exhibit a broad understanding of hospital infections, but this understanding also correlates with their educational background and other professional credentials. Sterile surgical instruments and equipment are equally crucial, and their sterility is directly dependent on proper handling of materials before sterilization, a suitable sterilization procedure, and adherence to storage and transportation regulations. Inadequate decontamination might result in legal problems in addition to financial, organizational, and medical repercussions. By taking these steps, pharmacists control the environment for patient safety and reduce the risk of infection. Hospital staff must be knowledgeable about, comprehend, and follow protocols for hygiene, disinfection, asepsis, and work organization. It is important to monitor the potential source of contamination and checking the cross contamination. Establishing and implementing of rules and regulations for prevention and control can minimize risk in future prospects. HCW infections were shown to be lower when gloves, gowns, masks, and goggles were used more frequently. Theoretically, transmission can also be avoided by shielding the skin and the mucous membranes of the mouth, nose, and eyes.

Keywords: Microbiota, Physical Therapist, Contamination, Donning and Doffing, Preventive Measure

Cite this Article as: Tariq U, Jamil M, Umar M, Bibi S, Khalid A and Habib M, 2025. Appropriate preventive measures for potential risks against Microbiota in physical therapists' working environment. In: García-Rubio VG, Alvi MA, Saeed Z and Ahmad M (eds), Foundations of Holistic Healing: Complementary and Alternative Medicine. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 225-229. <https://doi.org/10.47278/book.HH/2025.330>



A Publication of
Unique Scientific
Publishers

Chapter No:
25-031

Received: 25-Feb-2025
Revised: 12-Apr-2025
Accepted: 23-May-2025

Introduction

Enterococcus faecium, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, or *Enterobacter spp.* (ESKAPE) are accountable for most healthcare-associated infections, either directly or indirectly. High rates of cross-transmission between patients and healthcare workers (HCW) are caused by these hazardous microorganisms (HMO), which can persist on hospital surfaces and human skin for extended periods of time. The properties of the bacterium, the patient, and the actions of healthcare workers (HCW) determine how easily the infection might spread, while the subsequent infection can cause anything from no harm to death (Cheng, Kuo, & Zhou, 2018).

Healthcare facilities are a high-risk setting for the spread of HMO because of the mix of colonization and colonized HCWs or patients, who may be immunocompromised, and the restricted space. A person who has a disproportionately high propensity to spread HMO is referred to as a super-spreader. In the past, a number of catastrophic super-spreading events (SSE) were caused by super-spreaders. In closed healthcare settings, highly connected healthcare workers may be more susceptible to SSE (Hornbeck et al., 2012).

Globally, the healthcare industry engages more than 59 million people. Because they come into contact with patients' blood or bodily fluids like mucus, vomit, or inhaled droplets, some of these healthcare workers (HCW) are susceptible to life-threatening infectious infections. Although there are differences in the risk of infection and its effects, it is well acknowledged that there is an occupational risk. These dangers are particularly apparent during epidemics, when the infection rate among healthcare workers is complex than that of the general population. The possibility that infected healthcare workers will spread the disease to other patients or serve as a vector for disease transmission is another concern associated with HCW infection. Furthermore, infected healthcare workers will further reduce the capability of an already overworked healthcare system during epidemics.

Physical therapy is a recognized profession globally, and cardiorespiratory physical therapy has a well-established function in the treatment of acute and/or chronic respiratory problems. The microbiota is a dynamic population of bacteria that live in various parts of the body, including the stomach, skin, respiratory system, and mucous membranes. These microbes are essential for many bodily functions, including immune regulation, digestion, and pathogen protection. Physical therapists often treat patients whose microbiota may have altered due to medical conditions, medications, or surgical procedures. Thus, therapists can either enhance or lessen the risks

connected with these changes based on their practice and environment. The healthcare environment is a major breeding ground for microbial transmission since common infections such as respiratory viruses, *Clostridium difficile*, and MRSA (*methicillin-resistant Staphylococcus aureus*) are present in clinics. During physical therapy, direct touch with patients, contaminated surfaces, or medical equipment can all lead to exposure (Kinney et al., 2020).

Two to forty percent of all nosocomial infections are caused by hand-transmitted cross-infections. Antibiotics and immunosuppressive medications can save patients' lives and health, but they also frequently lead to hospital microorganisms becoming more resistant. It is crucial for medical personnel, especially nurses, to maintain high standards of hygiene in order to prevent infections. It is also necessary to be familiar with, comprehend, and follow the established hospital protocols for cleanliness, disinfection, aseptic techniques, and work organization in accordance with the knowledge gained (Lemiech-Mirowska, Kiersnowska, Michalkiewicz, Depta, & Marczak, 2021). Hospital infections may arise via contaminated surgical instruments, syringes, catheters, dressings, endoscopes, respirators, etc. (Suksatan et al., 2022).

Source of Microbial Contamination in PTs Clinics

There are many sources of microbial contamination in PTs Clinics such as:

- **Patients:** Patients with current illnesses or weakened immune systems are the main carriers of infection.
- **Staff and Therapists:** Staff and therapists provide source of contamination unintentionally from one patient to other.
- **Equipment and Surfaces:** If the tools, exercise equipment and surfaces are not properly disinfected then it harbors microorganisms.

Normal Pathogens in Physical Therapists' working Environment

- **Bacterial pathogens:** MRSA, VRSA, *E. coli*, *P. aeruginosa*, *S. aureus*
- **Fungal pathogens:** *Candida albicans*, *Aspergillus spp*
- **Viral pathogens:** COVID-19, Influenza virus, Norovirus
- **Opportunistic pathogens:** *Candida spp.*, *Enterococcus* and *S. epidermitis*

Pseudomonas aeruginosa

Numerous potentially fatal illnesses, including septicemia, endocarditis, pneumonia, cystitis, urinary tract infections, and surgical wound infections, have been linked to *Pseudomonas aeruginosa*. The persistence of *P. aeruginosa* in both hospital and community settings has been made possible by its capacity to endure in surroundings with little nutrients and a range of physical conditions, as well as its resistance to several medical disinfection techniques (Enciso-Martínez et al., 2022).

Staphylococcus aureus

MRSA and newly discovered strains of vancomycin-resistant *S. aureus* (VRSA) in particular are regarded as agents of utmost relevance since they have the potential to cause catastrophic health consequences if proper treatment and containment measures are not taken. This is troubling because vancomycin is frequently used as a last resort to treat MRSA infections.

Escherichia coli

Additionally, *E. coli* has been found to be a major contributor to CA and HA infections. Sepsis, bloodstream infections, and/or urinary tract infections are a few examples. Like the official ESKAPE members, *Escherichia coli*, a common gut commensal of humans and animals, can pick up resistance genes from other bacteria, especially those in the Enterobacteriales order. As a result, substantial rates of AMR have been seen in this species. Additionally, certain *E. coli* strains are extremely harmful and may have many virulence characteristics. These harmful strains of *E. coli* have since been separated into many pathotypes, including diffusely adherent, enteroinvasive, enterohemorrhagic, enteropathogenic, enterotoxigenic, and enteroaggregative (De Oliveira et al., 2020).

Risk Factors

Patients with weakened immune systems, such as those undergoing chemotherapy or immunosuppressive treatments, are more susceptible to infections. Elderly and post-operative individuals may also have reduced resistance to microbial threats due to age-related immune decline and recent surgery. Therapists are more vulnerable when they have direct patient touch, particularly when it comes to wound care or respiratory conditions. Individuals who work in environments Temperature, humidity, and ventilation are some of the environmental factors that affect how microbes multiply and spread. High-moisture environments (like gyms or hydrotherapy pools) or poorly ventilated places might promote microbial proliferation. Rehab centers and hospitals with a high patient turnover rate are more vulnerable (Abdel-Shafy & Mansour, 2018).

PTs can get infected by a variety of different methods, depending on the pathogen. Infections can happen through needle stick injuries through intact skin or splatters and droplets of infected bodily fluids on non- unbroken skin. Another way that infection can happen is if contaminated bodily fluids splash or drop on the lubricated membranes in the mouth, nose, or eyes, or if the same mucous membranes come into contact with unclean skin, like when you rub your eyes with a pathogen-carrying hand or touch a patient or contaminated surface. Although "high consequence pathogen" is also used, different countries have different lists of what a high significance pathogen is. According to the European Network for Infectious Diseases, a highly contagious disease is one that is easily spread from person to person, poses a major risk to public health and healthcare facilities, and necessitates particular control measures (Lee, Salahuddin, Gibson-Young, & Oliver, 2021).

Preventive Measures

The usage of appropriate personal protective equipment (PPE) is highly recommended by experts for the safety of both patients and healthcare workers. The "hierarchy of controls" is a best practice in the realm of occupational health. This implies that more broad control methods, like exposure control, ought to take precedence over more specialized ones, like personal protective equipment. Organizational strategies that reduce exposure to contaminated bodily fluids or infected patients are the most effective way to control HCW exposure. The hospital or healthcare facility should be properly organized to reduce needless interaction. This is the most significant preventive step. PPE is the primary method of lowering physical exposure to highly contagious diseases when this has been put into practice (Arora, Sardana, & Sinha, 2020).

Respirators are used to stop inhalation, while coveralls, gowns, hoods, masks, goggles, and face shields are used to keep skin and mucous membranes clean among other things. Different kinds of personal protective equipment (PPE) are advised depending on the infection's characteristics and the method of transmission. In the medical field, PPE is typically regarded as a component of transmission-based measures. The foundation of standard precautions, also known as universal precautions, is the idea that all bodily fluids, including blood, secretions, and excretions—aside from sweat, non-intact skin, and mucous membranes—may contain infectious organisms that can spread. Hand hygiene and the usage of personal protective equipment (PPE) like gloves, gowns, masks, and eye protection (such as goggles or face shields) should be used based on the expected exposure. Three categories describe the precautions that should be implemented when the transmission route or routes are not entirely disrupted by ordinary safeguards alone: precautions against touch, droplets, and airborne particle (Kapoor et al., 2020).

Among the many procedures included in these precautions is the use of suitable personal protective equipment (PPE) to stop the particular modes of transmission. The effectiveness of PPE depends on its ability to provide a barrier between the contaminated bodily fluids and the healthcare worker. As a result, guidelines have been established that, when followed, guarantee PPE is of a high enough caliber to guard against biohazards. These guidelines for biohazards are based on laboratory tests that assess how leak-tight protective clothing's fabric and seams are—that is, whether they are impermeable to liquids, viruses, or both at specific pressure levels. The United States and the European Union have different standards. The standards that PPE has been tested against should be clearly indicated (Dos Santos et al., 2021).

Technical Standards for PPE

PPE has complex technical standards, and the classification is unclear. There are garment standards in the EU, particularly for coveralls that shield employees from biological risks posed by microorganisms. According to ISO 2004a and ISO 2004b test methods, clothing that complies with the standard is further categorized based on the routes of contamination and the conditions that may lead to contamination (pressurized contaminated liquid, mechanical contact with substances containing contaminated liquid, contaminated liquid aerosols, contaminated solid particles). Surgical gowns are subject to a different standard, but this one is especially made to keep patients safe (Ağalar & Engin, 2020).

Surgical and isolation gowns are categorized using a four-level liquid barrier performance system in the United States. Level 4 provides the highest amount of protection against liquid and viral penetration, while level 1 offers only a limited level of water resistance. Emergency medical personnel's protective gear must meet a number of performance standards, such as resistance to virus penetration, tensile strength, liquid integrity, and seam strength. In conclusion, the characteristics of protective apparel that have been approved by various standards are complicated and not entirely comparable. However, they all seek to guarantee that protective apparel is of a caliber that, when worn with a certain amount of pressure, prevents water and blood-like fluids containing virus particles from penetrating. Technically, clothing that is produced in accordance with the aforementioned requirements and at the proper level of protection will not contaminate the skin since it is impervious to bodily fluids and viruses (Howard & Lal, 2020).

Guidelines for choosing proper PPE

The World Health Organization created guidelines for the prevention and management of acute respiratory infections in healthcare settings that are susceptible to epidemics and pandemics. According to the technique and suspected pathogen, the recommendation highly advises using the PPE that is appropriate based on the risk assessment. A combination of medical masks (surgical or procedure masks), gloves, long-sleeved gowns, and eye protection (goggles or face shields) may be considered appropriate personal protective equipment (PPE) when caring for patients who are exhibiting symptoms of acute respiratory infection (ARI). This combination, along with a surgical or procedural mask or a particle respirator, is conditionally advised for aerosol-generating procedures (AGPs). A waterproof apron should be put over the gown if spilling blood or other bodily fluids is expected and the gown is not fluid-resistant (Ambigapathy et al., 2020).

Medical masks are defined as flat, pleated, or cup-shaped masks that are strapped to the head. Otherwise, no quality standards are given for the PPE components. The fact that isolation gowns can have a wide range of characteristics, most end users are unaware of, makes this particularly concerning. Additionally, the neck is left exposed in the majority of isolation gown styles, which may lead to contamination. When caring for patients with questioned or confirmed cases, healthcare workers should utilize non-sterile, disposable patient isolation gowns, which are used for normal patient care in healthcare settings, according to the Centers for Disease Control and Prevention (CDC).

Some suggest wearing gloves in three layers because, based on their experience, this is the ideal way to do it while being overly protective can be problematic. It might, however, make work more challenging and ultimately result in a higher risk of infection rather than a lower one, particularly while doffing (i.e., taking off the personal protective equipment). For instance, using multiple respirators at once likely does not result in increased protection but rather significantly increases the worker's workload (Russi, Heaton, & Demaerschalk, 2020).

Donning and Doffing of PPE

Even with good PPE, self-contamination via improper PPE removal by healthcare workers is likely the greatest risk of infection. Certain PPE makes it harder to put on and take off, which raises the possibility of contamination. There is proof that wearing two pairs of gloves

reduces the chance of contamination when donning personal protective equipment (PPE). A simulated research about cleaning up vomit has also provided a clear illustration of how PPE becomes contaminated. The outcomes of these simulation studies should boost HCW's confidence in carrying out the proper donning and doffing processes, which can also serve as a motivator for their adoption and adherence to the rules.

As a result, particular instructions for putting on and taking off PPE have been created. Guidance on proper PPE use in healthcare has typically had low compliance. Using PPE is difficult, and PTs occasionally mistrust infection control. Compliance with respiratory protection, such as masks and respirators, has frequently been reported to be about 50%. Real field circumstances rarely meet laboratory requirements because of improper fitment and misuse. There is still tremendous space for improvement in hand hygiene, according to research, and guidelines suggest combining education and training with other implementation strategies (Tang et al., 2020).

It is evident from HCW reports that the most suitable PPE is difficult to utilize in tropical environments. Since it is not composed of permeable material, it stops heat loss through perspiration. A common cause of a PPE barrier breach is when a worker perspires and then automatically wipes their face. Since we anticipated that PPE would have a distinct effect, we did not include other highly contagious but less dangerous viral infections, such as norovirus. Hand Washing or hygiene is crucial to prevent skin contamination. Since SARS was extremely contagious, occasionally lethal, and had comparable guidelines for PPE use and illness awareness training, we included it. The impact of therapies to enhance their intake as well as the preventive effect of various forms of respiratory protection are discussed (Prater et al., 2019).

Occupational and Professionals Awareness

PTs, their supervisors, or occupational health specialists should first select the appropriate kind of personal protective equipment (PPE) as stated in the preceding recommendations. The PTs must thereafter be able to put on and take off clothing, PPE in accordance with the given rules. The PTs must then use, put on, and take off PPE in accordance with specified protocols. To improve compliance, education and training are employed. In order to reduce the chance of making a mistake, the focus while teaching the proper use of personal protective equipment (PPE) is on moving slowly and carefully. PPE is typically put on with the help of a friend or helper, maybe accompanied by a mirror, and doffing is supervised by a hygienist. Personal supervision and instruction, checklists, performance audits, feedback, and enough time for donning and doffing can all improve compliance (Nathwani & Rahman, 2021).

Immediate and long-term effects should result from education and training on PPE adoption and compliance. One way to improve compliance is through education and training. Having enough PPE that is comfortable, fits well, and is easier for patients to use can also increase compliance with PPE. Hand hygiene standards have been studied for compliance. Although there is some evidence supporting the importance of multiple treatments and stakeholder involvement, there is not enough data to draw clear conclusions.

Therefore, we are confident that PPE will be helpful in a technical sense and that the WHO and CDC propose that the bare minimum of PPE include gloves, a gown, and protection for the mouth, nose, and eyes. However, the guidelines do not specify the most protective PPE kind or quality level. The best kind, number, composition, and application techniques for full-body personal protective equipment (PPE) to avoid contaminating healthcare workers' skin and mucous membranes while treating patients with highly contagious diseases remain unknown (Russi et al., 2020).

The recognition of the need for a safer, more convenient, and culturally suitable secure system in accordance with the risk, WHO has released standards for industry, health workers, engineers, designers, medical and scientific scientists, and others to reexamine, energize, and create for a better PPE system for the HCW adjusting to pandemics in tropical climates (WHO 2018).

A terms of the gear, it's unclear if face shields offer the same level of protection as goggles, particularly when goggles are worn with a hood. When and if double or triple gloves would be more protective than single gloves is unknown. Regarding suits, it's unknown how breathable and virus- or liquid-impermeable gowns should be, as well as whether they're as protective as coveralls. The impact of integrity tests on gloves and other equipment, as well as whether gloves should be replaced when heavily contaminated, are unknown when it comes to donning and doffing processes (Mishra et al., 2021).

Conclusion

One strategy to guarantee their safety and defense against infectious diseases is to create a new PPE design that takes a comprehensive approach to the entire PPE ensemble. Particularly, it's uncertain if doffing may be done alone or if it should be done in pairs with a helpful buddy taking off a portion of the PPE. The question of whether applying a disinfectant spray, like chlorine spray, is more protective than not utilizing spray is another aspect of the donning process that is unclear. Which disinfectant—alcohol gel or chlorine solution—is the most effective antiviral, and at what dose, is unclear. The study's main findings would be an excellent place to start when creating new PPE to protect healthcare workers' health and safety from infectious environments. Analysis and research in a wide range of fields, such as advanced materials testing and evaluation, product design and evaluation, novel functional textile and materials science, and policy-making (e.g., standards/regulations), are necessary for the development and distribution of effective PPE.

References

- Abdel-Shafy, H. I., & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, 27(4), 1275-1290.
- Ağalar, C., & Engin, D. Ö. (2020). Protective measures for COVID-19 for healthcare providers and laboratory personnel. *Turkish Journal of Medical Sciences*, 50(9), 578-584.
- Ambigapathy, S., Rajahram, G., Shamsudin, U., Khoo, E., Cheah, W., Peariasamy, K., Khor, S. (2020). How should front-line general practitioners use personal protective equipment (PPE)? *Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia*, 15(1), 2.
- Arora, P., Sardana, K., & Sinha, S. (2020). Real-world assessment, relevance, and problems in use of personal protective equipment in clinical

- dermatology practice in a COVID referral tertiary hospital. *Journal of Cosmetic Dermatology*, 19(12), 3189-3198.
- Cheng, C.-H., Kuo, Y.-H., & Zhou, Z. (2018). Tracking nosocomial diseases at individual level with a real-time indoor positioning system. *Journal of Medical Systems*, 42(11), 222.
- De Oliveira, D. M., Forde, B. M., Kidd, T. J., Harris, P. N., Schembri, M. A., Beatson, S. A., Walker, M. J. (2020). Antimicrobial resistance in ESKAPE pathogens. *Clinical Microbiology Reviews*, 33(3), 10.1128/cmr.00181-00119.
- Dos Santos, L., Furlan, J. P. R., Gallo, I. F. L., Ramos, M. S., Savazzi, E. A., & Stehling, E. G. (2021). Occurrence of multidrug-resistant *Enterococcus faecium* isolated from environmental samples. *Letters in Applied Microbiology*, 73(2), 237-246.
- Enciso-Martínez, Y., González-Aguilar, G. A., Martínez-Téllez, M. A., González-Pérez, C. J., Valencia-Rivera, D. E., Barrios-Villa, E., & Ayala-Zavala, J. F. (2022). Relevance of tracking the diversity of *Escherichia coli* pathotypes to reinforce food safety. *International Journal of Food Microbiology*, 374, 109736.
- Hornbeck, T., Naylor, D., Segre, A. M., Thomas, G., Herman, T., & Polgreen, P. M. (2012). Using sensor networks to study the effect of peripartetic healthcare workers on the spread of hospital-associated infections. *The Journal of Infectious Diseases*, 206(10), 1549-1557.
- Howard, B. E., & Lal, D. (2020). Rhinologic practice special considerations during COVID-19: visit planning, personal protective equipment, testing, and environmental controls. *Otolaryngology-Head and Neck Surgery*, 163(4), 676-681.
- Kapoor, K. M., Chatrath, V., Boxley, S. G., Nurlin, I., Snozzi, P., Demosthenous, N., Kapoor, P. (2020). COVID-19 pandemic: consensus guidelines for preferred practices in an aesthetic clinic. *Dermatologic Therapy*, 33(4), e13597.
- Kinney, M., Seider, J., Beaty, A. F., Coughlin, K., Dyal, M., & Clewley, D. (2020). The impact of therapeutic alliance in physical therapy for chronic musculoskeletal pain: a systematic review of the literature. *Physiotherapy Theory and Practice*, 36(8), 886-898.
- Lee, Y. A., Salahuddin, M., Gibson-Young, L., & Oliver, G. D. (2021). Assessing personal protective equipment needs for healthcare workers. *Health Science Reports*, 4(3), e370.
- Lemiech-Mirowska, E., Kiersnowska, Z. M., Michalkiewicz, M., Depta, A., & Marczak, M. (2021). Nosocomial infections as one of the most important problems of healthcare system. *Annals of Agricultural and Environmental Medicine*, 28(3).
- Mishra, A., Shukla, V., Saha, R., Ray, K., Misra, R., & Basu, M. (2021). Awareness about donning and doffing of personal protective equipment among doctors working in a fever clinic of West Bengal. *Indian Journal of Health Sciences and Biomedical Research Kleu*, 14(1), 53-59.
- Nathwani, S., & Rahman, N. (2021). The 3 P's model enhancing patient safety during the COVID-19 pandemic. *Oral Surgery*, 14(3), 246-254.
- Prater, A. G., Mehta, H. H., Kosgei, A. J., Miller, W. R., Tran, T. T., Arias, C. A., & Shamoo, Y. (2019). Environment shapes the accessible daptomycin resistance mechanisms in *Enterococcus faecium*. *Antimicrobial Agents and Chemotherapy*, 63(10), 10.1128/aac.00790-00719.
- Russi, C. S., Heaton, H. A., & Demaerschalk, B. M. (2020). *Emergency medicine telehealth for COVID-19: minimize front-line provider exposure and conserve personal protective equipment*. Paper presented at the Mayo Clinic Proceedings.
- Suksatan, W., Jasim, S. A., Widjaja, G., Jalil, A. T., Chupradit, S., Ansari, M. J., Mohammadi, M. J. (2022). Assessment effects and risk of nosocomial infection and needle sticks injuries among patients and health care worker. *Toxicology Reports*, 9, 284-292.
- Tang, S. W., Romano, M. R., Wong, D. H., Montericcio, A., Yip, N. K., Montalbano, C., Li, K. K. (2020). The use of personal protective equipment in clinical ophthalmology during corona virus disease-2019: a review of international guidelines and literature. *Current Opinion in Ophthalmology*, 31(5), 435-446