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Introductory Chapter: Understanding Infections Caused by Opportunistic Bacterial Pathogens

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1. Introduction

Infectious diseases caused by virus, bacteria and fungi represent a major apprehension globally in terms of detrimental public health and economy. Some of the infectious agents such as virus (e.g., Coronavirus, influenza, Ebola, chicken-pox), bacteria (e.g., tuberculosis, cholera, whooping cough) are highly contagious and are responsible for communicable diseases. Communicable diseases spread from person to person through close contact including touching and kissing, also via coughing and sneezing, contamination of food and water. Many bacteria are also opportunistic pathogens and are commonly cause mild–moderate infections including sore throat, acne, tooth decay, urinary tract infections, cellulitis/skin infection, sexually transmitted infection, bacterial vaginosis, peptic/stomach ulcer, keratitis/eye infection, to severe/life-threatening infections such as pneumoniae, septicaemia/sepsis, meningitides in humans, animals, and birds. Most opportunistic bacteria exist as a commensal flora within the host body (gastrointestinal tract, skin, mucosal, oral, and nasal cavity, urogenital tract) and commonly found in abiotic surfaces (water, food, soil) in the environment [1, 2]. Under normal conditions i.e., in healthy people these bacterial pathogens do not cause infections. Infections caused by opportunistic bacteria are primarily triggered by either invasion of host commensal bacteria or bacteria from environmental sources gets into host bodily tissue [1, 2]. However, these opportunistic bacteria primarily target and cause fatal infections in immunocompromised people including acquired immunodeficiency syndrome (AIDS/HIV positive) patients, cancer patients (treated with immunosuppressive drugs, corticosteroids), hospital admitted patients for surgery, patients with underlying diseases such as cystic fibrosis, diabetes [2]. Most common examples of opportunistic bacteria found in mammals, birds and environment are *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Neisseria meningitides*, *Acinetobacter baumannii*, *Helicobacter pylori*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, *Streptococcus mutans*, *Clostridioides difficile*, *Legionella pneumophila*, *Propionibacterium acnes*, etc. On the other hand, mammalian and bird's body also host different species of good bacterial species (probiotics) which are essential for general wellbeing [3]. Lactobacillus and Bifidobacteria species are the common example of probiotics bacteria that are present in the mammalian digestive tract, they aid in maintaining daily healthy lifestyle includes food digestion, balancing pH of the body, alleviate symptoms of Gastroesophageal reflux diseases (GERD) such as heartburn, acid-reflux [4, 5].

2. Biofilms associated infection and its impact on human health and economy

Infection is predominantly triggered by biofilm formation. It is projected that more than 60% of all bacterial infections are associated with biofilms [6]. In simple words, biofilms mean colonization of bacteria on biotic and abiotic surfaces. Biofilm is the most supreme stage of bacterial lifestyle. Biofilm formation involves various stages to instigate with initial adhesion (reversible adhesion) of individual bacteria (planktonic stage) through their cell appendages (flagella, fimbriae, pili, that are anchored to bacterial cell surface) to host bodily surfaces such as skin, mucosa, and teeth also on medical devices such as implants, catheters, contact lenses and on water pipes, sinks, bathtub. The second steps are microcolony formation and biosynthesis of numerous exogenous biopolymers by bacteria such as nucleic acids (extracellular DNA, RNA), proteins, polysaccharides, virulence factors and metabolites that aids them in irreversible/strong adhesion to the surfaces, cell-to-cell adhesion, and foundation for initial architecture for biofilm. Later stages include further maturation and growth of bacteria within the microcolony and production of biomolecules and formation of robust three-dimensional biofilm and finally dispersion of individual bacteria from the mature biofilms to initiate colonization at new site [7, 8]. This close vicinity of the bacterial cells within the biofilm empowers exchange and distribution of various essential products includes nutrients, genetic materials, proteins, metabolites and other small molecules for the fitness, growth, and survival of bacterial cells and exclusion of toxic end products [9]. The complex biofilm architecture defends the bacterial cells within them from antibiotics, antiseptics, soaps and detergents, physical shear forces and the host immune system [10].

The prevalence and persistence of biofilm associated infections has direct adverse impact on human health and World's economy including costing billions of dollars annually for treatment across several different sectors such as wound and burns treatment, dentistry, endocarditis, bronchitis's, cystic fibrosis and surgical (hip, knee joints, pacemakers, cardiac valves) and non-surgical (contact lenses, urinary catheters, artificial teeth) implants [11, 12]. For instance, United States of America spends approximately 94 billion USD a year with more than half a million deaths related to biofilms [13]. Biofilm related Hospital-acquired infections/nosocomial infection includes pneumoniae, surgical site infections, Urinary tract infections (UTIs), blood stream infections alone cost USA health care 11 billion USD with approximately 2 million cases per year and is responsible for fourth leading cause of deaths in USA [6, 14, 15]. In general, it is speculated that nosocomial infection in patients becomes apparent within 48 hrs of early patient care [14]. Australia's health system already expended \$909 million annually for treatment associated with Urinary tract infections (UTIs). To note: the ratio of patients affected with UTIs in Australia is estimated to be 1 out of 2 women and 1 out of 20 men in their lifetime. UTIs associated implications in Australia also resulted in over 2.5 million visits to clinics and 75,000 hospital stay yearly [16]. As per statistics, report by European centre for disease prevention and control, nosocomial infection rate in European Union countries is soar, estimated to be around 3 million people get infected and around 50,000 death associated with it per year [17]. Primary factors that trigger the increase in infection rate, morbidity and mortality and associated treatment cost are due to poor hygiene, malnutrition, and lack of sanitation especially in the low-income countries, also misuse of antibiotic in food industry (agriculture, livestock, dairy) and unwarranted prescription (e.g., antibiotics prescribed to patients for common cold). Development of multidrug resistance bacteria or superbugs further escalates infection rate and associated

treatment cost and death rate. News article published by leading newspaper “Times of India” reported mortality rate in India due to superbugs is 13% in comparison to 2–7% in developed countries [18]. Biofilms also poses’ serious threat to food sector including agriculture, dairy, and livestock. It is estimated that infections in plants by microbial biofilms add to 10% of global food supply loss and directly contribute to foodborne infections [11]. Bovine mastitis, potentially fatal mammary gland infection/inflammation of the udder in cow, caused by bacteria attribute to loss of two billion dollars to the US dairy industry [11].

3. *Pseudomonas aeruginosa* a critical opportunistic bacterium

Pseudomonas aeruginosa, is one such opportunistic Gram-negative rod-shaped bacterial pathogen known for its ubiquity. World health organization (WHO) have placed *P. aeruginosa* in top priority (critical) organism list considering its intrinsic antibiotic resistance profile and remarkable ability to acquire tolerance to antibacterial agents [19]. In addition, *P. aeruginosa* forms robust biofilm and triggers severe infections especially in immunocompromised and hospital admitted patients. *P. aeruginosa* commonly found in human gastrointestinal tract, skin, soil, water, meat, plants, and vegetables and one of the leading causes for blood stream infection, UTI, microbial keratitis, wound and burn infection, HIV/AIDS patients, in ICU patients (ventilator associated pneumoniae) and a leading death cause in cystic fibrosis patients. *P. aeruginosa* associated hospital-acquired infections ranges between 10 and 15% globally [20]. Global epidemiology survey on *P. aeruginosa*, recorded numerous antibiotic resistance strains isolated from infected patients. These isolates are resistance to many antibiotics (carbapenem, gentamicin, ciprofloxacin, tobramycin, meropenem, and others) which are commonly used to treat infected patients [21–24]. This bacterium secretes numerous biomolecules such as DNA, proteins, polysaccharides, pyocyanin, rhamnolipids, siderophores which supports them in colonization at infection site and spread virulence in host and shield them from antibacterial agents [25]. In this book, we elaborated on general bacterial biofilm and in specifically focused on mechanism of *P. aeruginosa* biofilm formation, pathogenicity, antibiotic resistance, and treatment. The collections of chapters in this book will enlighten different end users including infectious diseases scientist, medical professional, medical and microbiology students and public.

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References

- [1] Ribet D, Cossart P. How bacterial pathogens colonize their hosts and invade deeper tissues. *Microbes & Infect.* 2015;17(3):173-183. Doi: <https://doi.org/10.1016/j.micinf.2015.01.004>
- [2] Jose JR, Brown SJ. Opportunistic bacterial, viral and fungal infections of the lung. *Medicine (Abingdon).* 2016;44(6):378-383. doi: 10.1016/j.mpmed.2016.03.015
- [3] [Internet]. Available from: <http://www.melbournebirdvet.com/use-of-probiotics/>.
- [4] Aiba Y, Nakano Y, Koga Y, Takahashi K, Komatsu Y. A highly acid-resistant novel strain of *Lactobacillus johnsonii* No. 1088 has antibacterial activity, including that against *Helicobacter pylori*, and inhibits gastrin-mediated acid production in mice. *Microbiologyopen.* 2015;4: 465-474. doi: 10.1002/mbo3.252.
- [5] Urita Y, Goto M, Watanabe T, Matsuzaki M, Gomi A, Kano M, Miyazaki K, Kaneko H. Continuous consumption of fermented milk containing *Bifidobacterium bifidum* YIT 10347 improves gastrointestinal and psychological symptoms in patients with functional gastrointestinal disorders. *Biosci. Microb. Food H.* 2015;34:37-44. doi: 10.12938/bmfh.2014-017.
- [6] [Internet]. Available from: <https://lbtinnovations.com/projects/biofilm/>
- [7] Berne C, Ellison CK, Ducret A, Brun YV. Bacterial adhesion at the single-cell level. *Nat. Rev. Microbiol.* 2018;16, 616-527. doi: <https://doi.org/10.1038/s41579-018-0057-5>
- [8] Hollmann B, Perkins M, Walsh D. Biofilms and their role in pathogenesis. [Internet]. Available from: [https://www.immunology.org/public-information/](https://www.immunology.org/public-information/bitesized-immunology/pathogens-and-disease/biofilms-and-their-role-in)
- [9] Nazzaro F, Fratianni F, D'Acerno A, Coppola R, Jesus F, Gomez da Cruz AA, Feo VD. *Essential Oils and Microbial Communication.* IntechOpen, 2019.
- [10] Saxena P, Joshi Y, Rawat K, Bisht R. Biofilms: Architecture, Resistance, Quorum Sensing and Control Mechanisms. *Indian J Microbiol.* 2019; 59(1):3-12.doi: 10.1007/s12088-018-0757-6.
- [11] [Internet]. Available from: <https://www.paconsulting.com/insights/rise-to-the-biofilm-challenge/>
- [12] Rao AN, Avula MN, Grainger DW. Aging and the Host Response to Implanted Biomaterials. Book: Host response to Biomaterials. Academic Press. 2015.
- [13] Wolcott RD, Rhoads DD, Bennett ME, Wolcott BM, Gogokhia L, Costerton JW, Dowd SE. Chronic wounds and the medical biofilm paradigm. *J Wound Care.* 2010;19(2): 45-46, 48-50, 52-43.
- [14] Wenzel RP. Health Care–Associated Infections: Major Issues in the Early Years of the 21st Century. *Clin Infect Dis.* 2007; 15;45. doi: 10.1086/518136.
- [15] [Internet]. Available from: <https://cleanhands-safehands.com/hais-4th-leading-cause-of-death/>
- [16] [Internet]. Available from: <https://outbreakproject.com.au/2020/11/17/australias-multi-billion-dollar-superbug-crisis/>
- [17] The First European Communicable Disease Epidemiological Report. 2007. European Centre for Disease Prevention and Control <https://www.ecdc.europa.eu/sites/portal/files/media/en/>

publications/Publications/0706_SUR_First_%20Annual_Epidemiological_Report_2007.pdf

[18] [Internet]. Available from: <https://timesofindia.indiatimes.com/india/superbugs-kill-more-in-india-than-globally-mortality-rate-is-13/articleshow/66674259.cms>

[19] [Internet]. Available from: <https://www.who.int/news/item/27-02-2017-who-publishes-list-of-bacteria-for-which-new-antibiotics-are-urgently-needed>

[20] Blanc DS, Petignat C, Janin B, Bille J, Francioli P. Frequency and molecular diversity of *Pseudomonas aeruginosa* upon admission and during hospitalization: a prospective epidemiologic study. Clin Microbiol Infect. 1998;4:242-7. doi.org/10.1111/j.1469-0691.1998.tb00051.x.

[21] Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, Kallen A, Brandi Limbago B, Fridkin S, Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. Infect Control Hosp Epidemiol. 2013. 34(1):1-14. Doi: 10.1086/668770.

[22] Kumari M, Khurana S, Bhardwaj N, Malhotra R, Mathur P. Pathogen burden & associated antibiogram of *Pseudomonas* spp. in a tertiary care hospital of India. Indian J Med Res. 2019 Feb;149(2):295-298. Doi: 10.4103/ijmr.IJMR_14_18.

[23] Khan MA, Faiz A. Antimicrobial resistance patterns of *Pseudomonas aeruginosa* in tertiary care hospitals of Makkah and Jeddah. Ann Saudi Med. 2016;36(1):23-28. Doi: 10.5144/0256-4947.2016.23.

[24] Rashid A, Chowdhury A, Rahman SHZ, Begum SA, Muazzam N.

Infections by *Pseudomonas aeruginosa* and antibiotic resistance pattern of the isolates from Dhaka Medical College hospital. Bangladesh J Med Microbiol. 2007;1:48-51.

[25] Das T, Manoharan A, Glasbey T, Whiteley G, Jim Manos. *Pseudomonas aeruginosa* biofilms and infections: Roles of extracellular molecules. Book Name: New and Future Developments in Microbial Biotechnology and Bioengineering: Microbial Biofilms. Elsevier; 2019.