The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 8, 2025

PREVALENCE OF PSEUDOMONAS AERUGINOSA IN HOSPITALIZED PATIENTS IN PAKISTAN: A REVIEW ARTICLE

Wali Ullah[1], Asmat Ullah[2], Amjad Ullah[3], Muhammad Imran[*4], Naveed Khan[5], Farid Gul[6], Muhammad Mustaqeem[7]

[1]*MS(MLS) Student at Riphah International University, Islamabad*
[2,3, *4,6,7]*BS (MLT) from Sarhad University of Science and Information Technology, Peshawar kpk, Pakistan*
[5]*M.Phil MLSc from The University of Haripur, Kpk Pakistan*

[1]walidawar009@gmail.com,[2]asmat8256@gmail.com,[3]amjaddawar523@gmail.com,
[*4]imranafd812@gmail.com,[5]naveedkhan012017@gmail.com,[6]faridgul.su1701154061@gmail.com,
[7]muhammadmustaqeem72@gmail.com

DOI: https://doi.org/10.5281/zenodo.16892081

Keywords
P. aeruginosa, Acquired infection, Prevalence.

Article History
Received on 20 May 2025
Accepted on 04 July 2025
Published on 18 August 2025

Corresponding Author: *
Muhammad Imran

Abstract

Pseudomonas aeruginosa is rod-shaped gram-negative bacterium. They are aerobic in nature and commonly cause hospital acquired infections. The current review article focuses on the prevalence of P. aeruginosa among hospitalized patients in Pakistan. P. aeruginosa is considered one of the most common pathogens acquired in hospitals and cause infections ranging from urinary tract to bacteremia. P. aeruginosa is one of the main causes in hospital Acquired infections (HAIs), especially in those patients who are admitted in ICU (Intensive Care Unit). The aim of this study was to find out the prevalence of P. aeruginosa in hospitalized patients throughout Pakistan. The prevalence of P. aeruginosa was found high in Faisalabad in hospitalized patient and low in Peshawar city Pakistan. Prevalence of P. aeruginosa is found more in males as compared to females.

INTRODUCTION

Pseudomonas aeruginosa was first isolated by Gessard in 1882 and was first identified as a pathogen by Charrin in 1890. In 1896 and 1899, the first cases in which the bacterium was cultured from blood samples of infected patients were reported (Abidi et al., 2013). P. aeruginosa is Gram-negative bacilli, bacteria. They are aerobic and have rod shaped. Its size range from 0.5 to 3.0 µm (Al-Zaidi et al., 2016). They contain more than 140 species and mostly of these are saprophytic in nature. More than 25 species of pseudomonas are related to humans (Ryan & Ray, 2004). P. aeruginosa has a single flagellum while some have two or three flagella (Nadeem et al., 2009). P. aeruginosa is a ubiquitous free-living bacterium that exists mostly in humid environments. It has also the ability to adapt and survive in various types of environments such as water, sewage, soils and other inanimate surfaces etc. (Hare et al., 2012). There are many possible sources for the spread of Pseudomonas infections in between the hospitalized patients due to the contaminated solutions, body lotions, sinks, and inhalation and resuscitation devices have all been shown to be short-lived carriers for individuals susceptible to slarge area of hospital environment, which includes critical care devices such as ventilators, nebulizers and antiseptic solutions etc. So environmental sources play main role in transmission of P. aeruginosa in hospitalized patients (Tanvir et al.,

2015).Majority of infections caused by Pseudomonas are opportunistic diseases. Pseudomonas aeruginosa is considered one of the most important bacteria because of its close pathogenic association with humans.

Although it rarely causes diseases in healthy individuals, it is a major threat to hospitalized and immunocompromised patients, especially those with serious underlying diseases such as cancer and burns (Nadeem et al., 2009). The high mortality related to these infections is due to a combination of weak host immune defense system, bacterial resistance to antibiotics, bacterial exoenzymes and toxins (Anzai, Kim, Park, Wakabayashi, & Oyaizu, 2000). P. aeruginosa infections among hospitalized patients are now one of the most serious global problems, leading to high mortality and increasing hospital costs.

P. aeruginosa is widely spread in nature and in hospital environment, so it is a common prevalent cause of nosocomial infections in patients especially in those who are using ventilators in intensive care unit (ICU) and high-dependency unit (HDU) (Mansoor et al., 2015). There are different pathogens such as Enterococcus, S. aureus, Klebsiella, Acinetobacter etc. which are acquired in hospital but P. aeruginosa is the most common and important pathogen found in hospitalized patient (Boucher et al., 2009).

P. aeruginosa is considered one of the most common pathogens acquired in hospitals and causes different diseases in patients who are admitted in hospital. The infections caused by P. aeruginosa in hospitalized patients range from urinary tract to bacteremia (Streit, Jones, Sader, & Fritsche, 2004). P. aeruginosa can also be regarded as a sign of increased mortality in the hospital (Nathwani, Raman, Sulham, Gavaghan, & Menon, 2014). The mortality rate of patients infected with P. aeruginosa is high in hospital as compare to other pathogens (Weinstein, Gaynes, Edwards, & System, 2005). P. aeruginosa is a complex pathogen and also known the most causative agent of ventilator associated pneumonia (VAP) (Mansoor et al., 2015). Hussain et al reported in their study that the P. aeruginosa is the most common infectious agent in hospital admitted patients (A. Hussain et al., 2015). P. aeruginosa is also considered one of the most common causative agent of nosocomial pneumonia, nosocomial urinary tract infection and nosocomial bacteremia in hospitalized patients (Lister, Wolter, & Hanson, 2009).

Among all gram-negative bacteria, P. aeruginosa has been considered a predominant opportunistic pathogen in hospitalized patient (Ali, Mumtaz, Naz, Jabeen, & Shafique, 2015) which usually infects immunocompromised patient (Hayward et al., 2000). In hospital admitted patients, P. aeruginosa mainly attacks patients with burns and wounds which further complicate the primary condition and mostly lead to bacteremia. (Kalantar et al., 2012). Burns remove the protective skin layer and expose the body to many bacterial pathogens (F. Ullah, Malik, & Ahmed, 2009). P. aeruginosa known as opportunistic pathogen, it often causes infection in burn patients (Van Eldere, 2003). Mortality in burn patients is mostly due to P. aeruginosa infections (Bloemsma, Dokter, Boxma, & Oen, 2008). In different studies P. aeruginosa has been reported to be the main agent isolated via culturing from a burn patient's wounds (Bloemsma et al., 2008). It is also an important cause of death from sepsis in burn patients (Tredget, Shankowsky, Rennie, Burrell, & Logsetty, 2004). P. aeruginosa may also cause life-threatening condition in immunocompromised patients who were admitted in hospital.(Ikpeme, Enyi-idoh, Nfongeh, Etim, & Akubuenyi, 2013).

The colonization of P. aeruginosa is also one of the main problems in wound infections which increase the rate of mortality and morbidity in hospital. Wound is defined as discontinuity of body tissue and considered as a serious problem around the world especially when it becomes infectious. The curing of wound delayed due to presence of bacteria which increases the inflammation (Xu, Moore, Murphy, Millar, & Elborn, 2004). The most important bacteria present in different types of wounds are P. aeruginosa. The P. aeruginosa is mostly present in patients of burn, accidental, surgical and pus wounds along with urinary tract and ear infection (Khalid et al., 2017). There are many factors due to which P. aeruginosa cause mostly hospital acquired infection such as, overuse and misuse of antibiotics, patient linked issues, improper prescription by the doctors, self-medication, unnecessary use of broad spectrum and untrained staff etc. (Bhatia & Narain, 2010).

P. aeruginosa cause different types of infections such as pneumonia, urinary tract infection, eye, ear

infection and surgical site infections (Farooq, Memon, Ismail, & Sadiq, 2019). P. aeruginosa also play an important role in the enhancement of complications in chronic obstructive pulmonary disease (COPD) (Reinhart & Oglesby-Sherrouse, 2016). P. aeruginosa infection is also the main reason for morbidity in people with COPD (Murphy et al., 2009).

The pathogenicity of P. aeruginosa is the result of long-term adaptation in environment. P. aeruginosa has ability to adapt and release virulence factors such as enzymes etc. to escape host immune system (Naqvi, Hashmi, Rizwan, & Kharal, 2005). Once P. aeruginosa enters the airway, the bacterium will replicate and colonize the airway cavity and alveolar sacs (Rashid & Kornberg, 2000). Some of the bacteria will be engulfed and cleared by lung macrophages while some release inflammatory factors, cytokines, enzymes etc. and damage the respiratory system, resulting in immune cell infiltration (Bucior, Pielage, & Engel, 2012). The bacteria cross the protection barrier such as mucin or surfactant films through the damage area (Vallet, Olson, Lory, Lazdunski, & Filloux, 2001). Then, bacteria adhere to the epithelial cell membrane and cross the membrane to replicate and colonize in the cell (Chemani, 2009). The flagella and pili of Pseudomonas helps in adhesions with host cell (Hayashi et al., 2015).

β-lactam antibiotics have a broad host spectrum and low toxicity. They can penetrate gram-negative bacteria through outer membrane channel proteins called porins, and are considered a relatively safe treatment option (Saleem & Bokhari, 2020). Other studies have also recorded high resistance to penicillin, cephalosporins and aminoglycoside in Pseudomonas (Shahid & Malik, 2005). The carbapenems (imipenem and meropenem) were used as an effective treatment for P. aeruginosa since last decade but during the last few years' bacteria show resistance against these antibiotics (Perez & Endimiani, 2007) and recently colistin or polymyxin B antibiotics are used as a last choice of treatment for P. aeruginosa (Fernández, 2010), while resistance against colistin has also been reported.(Lescat, Poirel, Tinguely, & Nordmann, 2019).

DISCUSSION

A study was conducted by (Mansoor et al., 2015) from January 2013 to January 2015 in the Microbiology Department of Ziauddin Medical University Hospital Karachi, Pakistan. Blood, urine, body fluids, pus, tracheal aspirate and bronchial alveolar samples were collected from patients who were admitted in the ICU at the hospital. The prevalence of P. aeruginosa was reported 36%. A similar study was conducted by (Sabir, Alvi, & Fawwad, 2013) in Karachi, Pakistan. They were collected different samples such as urine, pus, blood and tracheal aspirates etc. The prevalence of P. aeruginosa was reported 36.2%

A research study was conducted by (Ijaz, Siddique, Rasool, & Shafique, 2019) in Department of Microbiology, Government College University, Faisalabad, Pakistan from January to December 2018. A total of 532 samples were collected from various types of wounds such as surgical wound, burn wound, accidental wound and pus wound out of which 203 samples were confirmed P. aeruginosa. The prevalence of P. aeruginosa was 38%.

In another study by (M. S. Hussain, Nasir, Shahid, Sarwar, & Ejaz, 2017) in the department of pathology (Microbiology section) Sheikh Zayed Medical College/Hospital, Rahim Yar Khan, from 1st October 2015 to 31st January 2016. A total of hundred specimens were collected such as blood, pus, urine and wound swab from patients admitted in different wards and units in the hospital. Total of hundred (100) samples were collected from burn unit (22%), ICU (16%), OPD (28%), surgical ward (16%) and medical ward (18%) patients. Clinical samples included blood (10%), wound swabs (36%), pus (28%) and urine (26%). P. aeruginosa was confirmed positive from urine 4 (17%), pus 6 (26%), blood 2 (9%) and wound swab 11 (48%). The prevalence of P. aeruginosa was reported 23% in total of 100 samples.

It was assessed in another study by (Khan, Khan, & Kazmi, 2014) from January 2012 to January 2013 in Microbiology Department, University of Karachi. Different clinical samples were collected such as blood, urine, pus etc. from different hospital of Karachi. The maximum number of P. aeruginosa was confirmed positive in pus samples 10 (33.3%) followed by wound swabs 8 (26.6%), bronchial fluid 7 (23.5%), urine 3 (10%) and blood samples 2 (6.6%). The prevalence of P. aeruginosa was reported 30%.

Study assessed by (Abbas et al., 2015) in microbiology section of Pathology laboratory Khyber Teaching Hospital and Lady Reading Hospital Peshawar. A total of 2058 different clinical samples were collected such as pus, urine, blood, ear swab, sputum etc. Out of total, 258 clinical samples were confirmed positive for P. aeruginosa which include pus samples 177 (68.6%), urine 17 (6.6%), blood 17 (6.6%), ear swab 25 (9.7%), pleural fluid 10 (3.8%), sputum 8 (3.1%) and miscellaneous 4 (1.8%). The prevalence of P. aeruginosa was reported 12.5%. Positive tested samples for P. aeruginosa consisted of 159 males and 99 females. The prevalence of P. aeruginosa for males and females were reported 61.6% and 38.4% respectively as represented in (Figure.1). Ages of patient was range from 5 years to 74 years. (Table1).

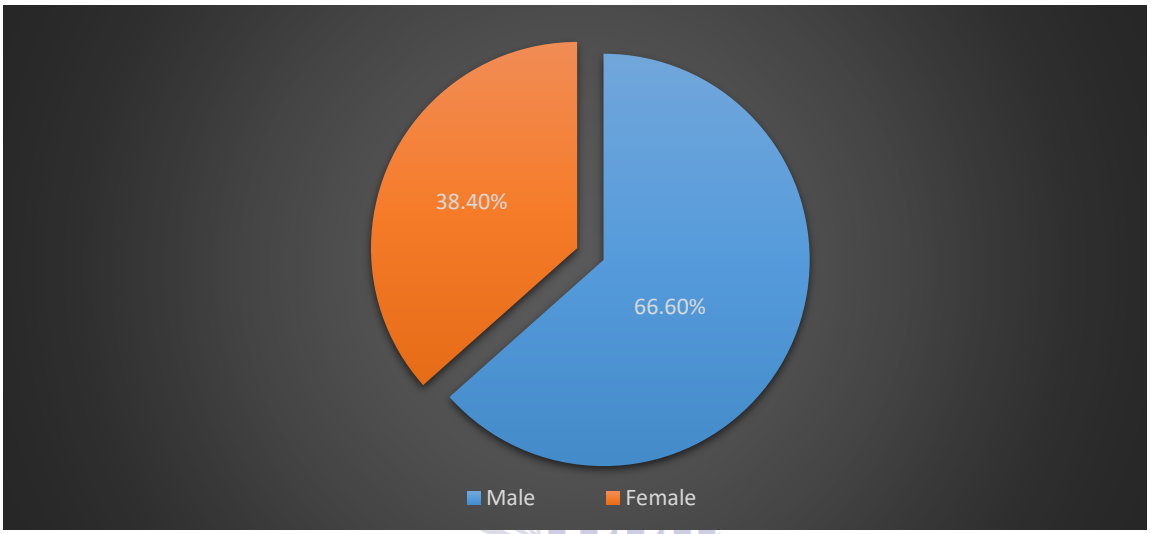

Figure 1. Gender wise Prevalence of P. aeruginosa. (Abbas et al., 2015)

Table -1: Number of isolates collected from different age groups (Abbas et al., 2015)

Age (years)	Number of isolates (Total= 258)	Prevalence (%)	Reference
5-15	33	12.79	(Abbas & Naeem, 2015)
15-30	39	15.11	
30-40	52	20.15	
40-50	61	23.63	
50+	33	12.79	
60+	40	15.50	

Similar study was conducted by (Samad, Ahmed, Rahim, Khalil, & Ali, 2017) from January to December 2014 in Northwest General Hospital and Research Centre, Peshawar. A total of 354 sputum samples were collected out of which 71 samples were confirmed positive for P. aeruginosa. The prevalence of P. aeruginosa was reported 71 (20.05%) out of which 39 (54.93%) were males and 32 (45.07%) were females as shown in Figure.2.

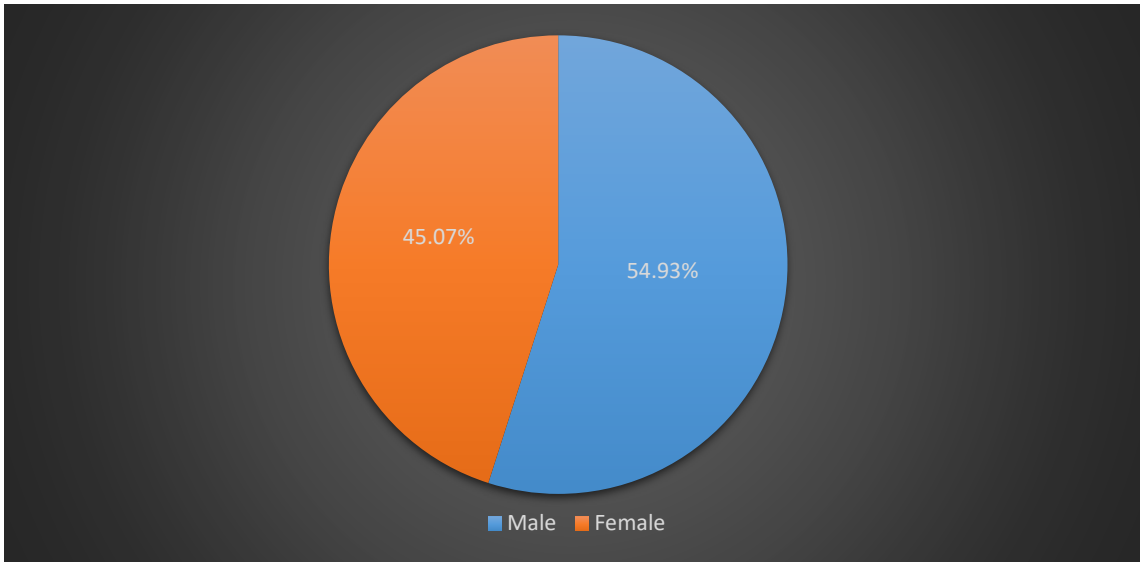

Figure 2. Gender wise Prevalence of P. aeruginosa. (Samad et al., 2017)

(W. Ullah et al., 2016) at tertiary care hospital, Peshawar, Pakistan from September 2013 to January 2014. Different clinical samples such as urine, sputum, pus and wound swab were collected from hospitalized patients. Total of 3700 samples were collected out of which 102 (2.7%) were confirmed positive for P. aeruginosa. Prevalence of P. aeruginosa was found more in male 54 (52%) as compared to female 48 (47.05%). Prevalence of P. aeruginosa was also reported in different wards of the hospital. The prevalence of P. aeruginosa was found in burn ward 26 (25.4%) followed by surgical ward 16 (15.8%), medical ward 14 (13.8%), orthopedic and ICU ward 6 (5.8% each), skin and cardiovascular wards 4(3.9% each). Lowest prevalence was reported in ENT and plastic 4 (3.9% each) as represented in (table 2).

Table 2. Prevalence of P. aeruginosa in different wards

Ward wise	No of isolates	Prevalence %	Reference
Surgical ward	16	15.68	(Ullah & Qasim, 2016)
Burn ward	26	25.48	
Cardiovascular ward	4	3.92	
Orthopedics ward	6	5.88	
Skin ward	4	3.92	
ICU ward	6	5.88	
Plastic surgery ward	1	0.98	
ENT ward	1	0.98	
Medical ward	14	13.76	
OPD	24	23.52	
Total	102	100	

CONCLUSION

This study concluded that P. aeruginosa is one of the most commonly isolated bacteria from hospitalized patients in Pakistan. P. aeruginosa is considered one of the most common pathogens acquired in hospitals and cause infections ranging from urinary tract to bacteremia. The prevalence of P. aeruginosa was found high in Faisalabad in hospitalized patient and low in Peshawar city Pakistan. Prevalence of P. aeruginosa is found more in males as compared to females. P. aeruginosa mostly cause diseases in hospitalized patients, so it rarely causes disease in

healthy individuals. P aeruginosa is a major threat to hospitalized and immunocompromised patients, especially those with serious underlying diseases such as cancer and burns etc. The prevalence of P. aeruginosa was reported high in burn ward and low in ENT ward. The average prevalence of P. aeruginosa was reported 24.80% in Pakistan.

The unreasonable use of antibiotics, unsanitary environment and practices of health-related personnel are considered to be factors that may increase the prevalence of P. aeruginosa in hospitalized patients.

The frequency of P. aeruginosa is raised. More attention is required to disinfect the hospital environment and limit the transfers of P. aeruginosa among hospitalized patients.

So, this study is limited to only few cities in Pakistan therefore we recommended to conduct a large-scale study to find out the exacted prevalence of P. aeruginosa in hospitalized patient in the Pakistan.

REFERENCES

Abbas, S. H., et al. (2015). "Sensitivity patterns of Pseudomonas aeruginosa isolates obtained from clinical specimens in Peshawar." Journal of Ayub Medical College Abbottabad 27(2): 329-332.

Anzai, Y., et al. (2000). "Phylogenetic affiliation of the pseudomonads based on 16S rRNA sequence." International journal of systematic and evolutionary microbiology 50(4): 1563-1589.

Abidi, S. H., Sherwani, S. K., Siddiqui, T. R., Bashir, A., & Kazmi, S. U. (2013). Drug resistance profile and biofilm forming potential of Pseudomonas aeruginosa isolated from contact lenses in Karachi-Pakistan. BMC ophthalmology, 13(1), 1-6.

Bhatia, R. and J. P. Narain (2010). "The growing challenge of antimicrobial resistance in the South-East Asia Region-Are we losing the battle?" The Indian journal of medical research 132(5): 482.

Boucher, H. W., et al. (2009). "Bad bugs, no drugs: no ESKAPE! An update from the Infectious Diseases Society of America." Clinical infectious diseases 48(1): 1-12.

Fernández, L., et al. (2010). "Adaptive resistance to the “last hope” antibiotics polymyxin B and colistin in Pseudomonas aeruginosa is mediated by the novel two-component regulatory system ParR-ParS." Antimicrobial agents and chemotherapy 54(8): 3372-3382.

Hare, N. J., et al. (2012). "Proteomic profiling of Pseudomonas aeruginosa AES-1R, PAO1 and PA14 reveals potential virulence determinants associated with a transmissible cystic fibrosis-associated strain." BMC microbiology 12(1): 1-14.

Hussain, A. (2015). "Frequency and susceptibility pattern of Multidrug Resistant Pseudomonas aeruginosa in isolates of patients from."

Hussain, M. S., et al. (2017). "Prevalence and Antibiogram of pseudomonas aeruginosa isolated from clinical samples at a tertiary care hospital." Blood 2: 9.

Ijaz, M., et al. (2019). "Frequency of multi drug resistant Pseudomonas aeruginosa in different wound types of hospitalized patients." Pakistan journal of pharmaceutical sciences 32.

Khalid, F., et al. (2017). "Efficacy of bacteriophage against multidrug resistant Pseudomonas aeruginosa isolates." Southeast Asian J Trop Med Public Health 48: 1056-1062.

Khan, F., et al. (2014). "Prevalence and susceptibility pattern of multi drug resistant clinical isolates of Pseudomonas aeruginosa in Karachi." Pakistan journal of medical sciences 30(5): 951.

Lescat, M., et al. (2019). "A resazurin reduction-based assay for rapid detection of polymyxin resistance in Acinetobacter baumannii and Pseudomonas aeruginosa." Journal of clinical microbiology 57(3): e01563-01518.

Lister, P. D., et al. (2009). "Antibacterial-resistant Pseudomonas aeruginosa: clinical impact and complex regulation of chromosomally encoded resistance mechanisms." Clinical microbiology reviews 22(4): 582-610.

Mansoor, K., et al. (2015). "Frequency and susceptibility pattern of Multidrug Resistant Pseudomonas aeruginosa in isolates of patients from a tertiary care hospital of Karachi, Pakistan." Eur J Biotechnol Bio Sci 2(5): 33-36.

Nadeem, S., et al. (2009). "Comparison of the in vitro susceptibility of Clinical isolates of Pseudomonas aeruginosa in a local hospital setting in Karachi, Pakistan a in a local hospital setting in Karachi, Pakistan a in a local hospital setting in Karachi, Pakistan." British Journal of Medical Practitioners 2(4).

Nathwani, D., et al. (2014). "Clinical and economic consequences of hospital-acquired resistant and multidrug-resistant Pseudomonas aeruginosa infections: a systematic review and meta-analysis." Antimicrobial resistance and infection control 3(1): 1-16.

Perez, F. and A. Endimiani (2007). "hujer, MK, Bonomo, AR." The continuing challenge of esBLs. curr opin pharmacol 7: 459-469.

Ryan, K. J. and C. G. Ray (2004). "Medical microbiology." McGraw Hill 4: 370.

Sabir, R., et al. (2013). "Antimicrobial susceptibility pattern of aerobic microbial isolates in a clinical laboratory in Karachi-Pakistan." Pakistan journal of medical sciences 29(3): 851.

Saleem, S. and H. Bokhari (2020). "Resistance profile of genetically distinct clinical Pseudomonas aeruginosa isolates from public hospitals in central Pakistan." Journal of infection and public health 13(4): 598-605.

Samad, A., et al. (2017). "Antimicrobial susceptibility patterns of clinical isolates of Pseudomonas aeruginosa isolated from patients of respiratory tract infections in a Tertiary Care Hospital, Peshawar." Pakistan journal of medical sciences 33(3): 670.

Streit, J. M., et al. (2004). "Assessment of pathogen occurrences and resistance profiles among infected patients in the intensive care unit: report from the SENTRY Antimicrobial Surveillance Program (North America, 2001)." International journal of antimicrobial agents 24(2): 111-118.

Tanvir, S. B., et al. (2015). "Emerging resistance to meropenem in Pseudomonas aeruginosa Isolates among patients of a tertiary care hospital of Pakistan." European Journal of Biotechnology and Bioscience 3(4): 22-24.

Ullah, W., et al. (2016). "Multi drug resistant Pseudomonas aeruginosa: Pathogen burden and associated antibiogram in a tertiary care hospital of Pakistan." Microbial pathogenesis 97: 209-212.

Weinstein, R. A., et al. (2005). "Overview of nosocomial infections caused by gram-negative bacilli." Clinical infectious diseases 41(6): 848-854.

Xu, J., et al. (2004). "Early detection of Pseudomonas aeruginosa–comparison of conventional versus molecular (PCR) detection directly from adult patients with cystic fibrosis (CF)." Annals of Clinical Microbiology and Antimicrobials 3(1): 1-5.

Abbas, Syed Hussain, Naeem, Mohammad, Adil, Muhammad, Naz, Syeda Maria, Khan, Ayasha, & Khan, Muhammad Usman. (2015). Sensitivity patterns of Pseudomonas aeruginosa isolates obtained from clinical specimens in Peshawar. Journal of Ayub Medical College Abbottabad, 27(2), 329-332.

Al-Zaidi, Jawad R. (2016). Antibiotic susceptibility patterns of Pseudomonas aeruginosa isolated from clinical and hospital environmental samples in Nasiriyah, Iraq. African journal of microbiology research, 10(23), 844-849.

Ali, Zaheer, Mumtaz, Nusrat, Naz, Sehar Afshan, Jabeen, Nusrat, & Shafique, Maryam. (2015). Multi-drug resistant Pseudomonas aeruginosa: a threat of nosocomial infections in tertiary care hospitals. JPMA, 65(12), 12-16.

Anzai, Yojiro, Kim, Hongik, Park, Ju-Young, Wakabayashi, Hisatsugu, & Oyaizu, Hiroshi. (2000). Phylogenetic affiliation of the pseudomonads based on 16S rRNA sequence. International journal of systematic and evolutionary microbiology, 50(4), 1563-1589.

Bhatia, Rajesh, & Narain, Jai P. (2010). The growing challenge of antimicrobial resistance in the South-East Asia Region-Are we losing the battle? The Indian journal of medical research, 132(5), 482.

Bloemsma, GC, Dokter, J, Boxma, H, & Oen, IMMH. (2008). Mortality and causes of death in a burn centre. Burns, 34(8), 1103-1107.

Bodey, Gerald P, Bolivar, Ricardo, Fainstein, Victor, & Jadeja, Leena. (1983). Infections caused by Pseudomonas aeruginosa. Reviews of infectious diseases, 5(2), 279-313.

Boucher, Helen W, Talbot, George H, Bradley, John S, Edwards, John E, Gilbert, David, Rice, Louis B, . . . Bartlett, John. (2009). Bad bugs, no drugs: no ESKAPE! An update from the Infectious Diseases Society of America. Clinical infectious diseases, 48(1), 1-12.

Bucior, Iwona, Pielage, Julia F, & Engel, Joanne N. (2012). Pseudomonas aeruginosa pili and flagella mediate distinct binding and signaling events at the apical and basolateral surface of airway epithelium. PLoS pathogens, 8(4), e1002616.

Chemani, Chanez, Imberty, Anne, de Bentzmann, Sophie, Pierre, Maud, Wimmerová, Michaela, Guery, Benoît P, & Faure, Karine. (2009). Role of LecA and LecB lectins in Pseudomonas aeruginosa-induced lung injury and effect of carbohydrate ligands. Infection and immunity, 77(5), 2065-2075.

Farooq, Lubna, Memon, Zahida, Ismail, Muhammad Owais, & Sadiq, Sara. (2019). Frequency and antibiogram of multi-drug resistant pseudomonas aeruginosa in a Tertiary Care Hospital of Pakistan. Pakistan journal of medical sciences, 35(6), 1622.

Fernández, Lucía, Gooderham, W James, Bains, Manjeet, McPhee, Joseph B, Wiegand, Irith, & Hancock, Robert EW. (2010). Adaptive resistance to the "last hope" antibiotics polymyxin B and colistin in Pseudomonas aeruginosa is mediated by the novel two-component regulatory system ParR-ParS. Antimicrobial agents and chemotherapy, 54(8), 3372-3382.

Hare, Nathan J, Solis, Nestor, Harmer, Christopher, Marzook, N Bishara, Rose, Barbara, Harbour, Colin, . . . Cordwell, Stuart J. (2012). Proteomic profiling of Pseudomonas aeruginosa AES-1R, PAO1 and PA14 reveals potential virulence determinants associated with a transmissible cystic fibrosis-associated strain. BMC microbiology, 12(1), 1-14.

Hayashi, Naoki, Nishizawa, Hideyuki, Kitao, Seiya, Deguchi, Sakurako, Nakamura, Takano, Fujimoto, Akiyo, . . . Gotoh, Naomasa. (2015). Pseudomonas aeruginosa injects type III effector ExoS into epithelial cells through the function of type IV pili. FEBS letters, 589(8), 890-896.

Hayward, AC. (2000). Encyclopedia of microbiology. San Diego: Academic, 32-42.

Hussain, Arif. (2015). Frequency and susceptibility pattern of Multidrug Resistant Pseudomonas aeruginosa in isolates of patients from.

Hussain, Muhammad Shahbaz, Nasir, Bushra, Shahid, Hina, Sarwar, Faiza, & Ejaz, Asma. (2017). Prevalence and Antibiogram of pseudomonas aeruginosa isolated from clinical samples at a tertiary care hospital. Blood, 2, 9.

Ijaz, Muhammad, Siddique, Abu Baker, Rasool, Muhammad Hidayat, & Shafique, Muhammad. (2019). Frequency of multi drug resistant Pseudomonas aeruginosa in different wound types of hospitalized patients. Pakistan journal of pharmaceutical sciences, 32.

Ikpeme, Emmanuel Maundy, Enyi-idoh, Kingsley Hovana, Nfongeh, Joseph Fuh, Etim, Lawrence Bassey, & Akubuenyi, Felix Chinedu. (2013). Prevalence, antibiogram profile and cross transmission of Pseudomonas aeruginosa in a tertiary burn unit. Malaysian Journal of Microbiology, 9(1), 116-119.

Kalantar, Enayat, Taherzadeh, Shadi, Ghadimi, Tayeb, Soheili, Fariborz, Salimizand, Heiman, & Hedayatnejad, Alireza. (2012). Pseudomonas aeruginosa, an emerging pathogen among burn patients in Kurdistan Province, Iran. Southeast Asian Journal of Tropical Medicineand Public Health, 43(3), 712.

Khalid, Faseeha, Siddique, Abu Baker, Nawaz, Zeeshan, Shafique, Muhammad, Zahoor, Muhammad Asif, Nisar, Muhammad Atif, & Rasool, Muhammad Hidayat. (2017). Efficacy of bacteriophage against multidrug resistant Pseudomonas aeruginosa isolates. Southeast Asian J Trop Med Public Health, 48, 1056-1062.

Khan, Fouzia, Khan, Adnan, & Kazmi, Shahana Urooj. (2014). Prevalence and susceptibility pattern of multi drug resistant clinical isolates of Pseudomonas aeruginosa in Karachi. Pakistan journal of medical sciences, 30(5), 951.

Lescat, Mathilde, Poirel, Laurent, Tinguely, Camille, & Nordmann, Patrice. (2019). A resazurin reduction-based assay for rapid detection of polymyxin resistance in Acinetobacter baumannii and Pseudomonas aeruginosa. Journal of clinical microbiology, 57(3), e01563-01518.

Lister, Philip D, Wolter, Daniel J, & Hanson, Nancy D. (2009). Antibacterial-resistant Pseudomonas aeruginosa: clinical impact and complex regulation of chromosomally encoded resistance mechanisms. Clinical microbiology reviews, 22(4), 582-610.

Mansoor, Kanaan, Tanvir, Syed Bilal, Shariq, Ali, Hussain, Arif, Farooqi, Badar Jahan, Ahmed, Sumera, & Tanvir, Roofia. (2015). Frequency and susceptibility pattern of Multidrug Resistant Pseudomonas aeruginosa in isolates of patients from a tertiary care hospital of Karachi, Pakistan. Eur J Biotechnol Bio Sci, 2(5), 33-36.

Murphy, Timothy F. (2009). Pseudomonas aeruginosa in adults with chronic obstructive pulmonary disease. Current opinion in pulmonary medicine, 15(2), 138-142.

Nadeem, SG, Qasmi, SA, Afaque, F, Saleem, M, Nadeem, ST Hakim SG, & Hakim, ST. (2009). Comparison of the in vitro susceptibility of Clinical isolates of Pseudomonas aeruginos in a local hospital setting in Karachi, Pakistan a in a local hospital setting in Karachi, Pakistan a in a local hospital setting in Karachi, Pakistan. British Journal of Medical Practitioners, 2(4).

Naqvi, ZULFIQAR A, Hashmi, KHURSHEED, Rizwan, QAZI M, & Kharal, SALEEM A. (2005). Multidrug resistant Pseudomonas aeruginosa: a nosocomial infection threat in burn patients. Pakistan Journal of Pharmacology, 22(2), 9-15.

Nathwani, Dilip, Raman, Gowri, Sulham, Katherine, Gavaghan, Meghan, & Menon, Vandana. (2014). Clinical and economic consequences of hospital-acquired resistant and multidrug-resistant Pseudomonas aeruginosa infections: a systematic review and meta-analysis. Antimicrobial resistance and infection control, 3(1), 1-16.

Perez, F, & Endimiani, A. (2007). hujer, MK, Bonomo, AR. The continuing challenge of esBLs. curr opin pharmacol, 7, 459-469.

Rashid, M Harunur, & Kornberg, Arthur. (2000). Inorganic polyphosphate is needed for swimming, swarming, and twitching motilities of Pseudomonas aeruginosa. Proceedings of the National Academy of Sciences, 97(9), 4885-4890.

Reinhart, Alexandria A, & Oglesby-Sherrouse, Amanda G. (2016). Regulation of Pseudomonas aeruginosa virulence by distinct iron sources. Genes, 7(12), 126.

Ryan, Kenneth J, & Ray, C George. (2004). Medical microbiology. McGraw Hill, 4, 370.

Sabir, Rubina, Alvi, S Faraz Danish, & Fawwad, Asher. (2013). Antimicrobial susceptibility pattern of aerobic microbial isolates in a clinical laboratory in Karachi-Pakistan. Pakistan journal of medical sciences, 29(3), 851.

Saleem, Sidra, & Bokhari, Habib. (2020). Resistance profile of genetically distinct clinical Pseudomonas aeruginosa isolates from public hospitals in central Pakistan. Journal of infection and public health, 13(4), 598-605.

Samad, Abdul, Ahmed, Tanveer, Rahim, Afaq, Khalil, Abdul, & Ali, Iftikhar. (2017). Antimicrobial susceptibility patterns of clinical isolates of Pseudomonas aeruginosa isolated from patients of respiratory tract infections in a Tertiary Care Hospital, Peshawar. Pakistan journal of medical sciences, 33(3), 670.

Shahid, M, & Malik, Abida. (2005). Resistance due to aminoglycoside modifying enzymes in Pseudomonas aeruginosa isolates from burns patients. Indian Journal of Medical Research, 122(4), 324.

Streit, Jennifer M, Jones, Ronald N, Sader, Helio S, & Fritsche, Thomas R. (2004). Assessment of pathogen occurrences and resistance profiles among infected patients in the intensive care unit: report from the SENTRY Antimicrobial Surveillance Program (North America, 2001). International journal of antimicrobial agents, 24(2), 111-118.

Tanvir, Syed Bilal, Mansoor, K, Shariq, A, Shariq, H, Hussain, A, Farooqi, BJ, & Tanvir, R. (2015). Emerging resistance to meropenem in Pseudomonas aerugonisa Isolates among patients of a tertiary care hospital of Pakistan. European Journal of Biotechnology and Bioscience, 3(4), 22-24.

Tredget, Edward E, Shankowsky, Heather A, Rennie, Robert, Burrell, Robert E, & Logsetty, Sarvesh. (2004). Pseudomonas infections in the thermally injured patient. Burns, 30(1), 3-26.

Ullah, Farhat, Malik, Salman Akbar, & Ahmed, Jawad. (2009). Antimicrobial susceptibility and ESBL prevalence in Pseudomonas aeruginosa isolated from burn patients in the North West of Pakistan. Burns, 35(7), 1020-1025.

Ullah, Waheed, Qasim, Muhammad, Rahman, Hazir, Bari, Fazli, Khan, Saadullah, Rehman, Zia Ur, . . . Muhammad, Noor. (2016). Multi drug resistant Pseudomonas aeruginosa: Pathogen burden and associated antibiogram in a tertiary care hospital of Pakistan. Microbial pathogenesis, 97, 209-212.

Vallet, Isabelle, Olson, John W, Lory, Stephen, Lazdunski, Andrée, & Filloux, Alain. (2001). The chaperone/usher pathways of Pseudomonas aeruginosa: identification of fimbrial gene clusters (cup) and their involvement in biofilm formation. Proceedings of the National Academy of Sciences, 98(12), 6911-6916.

Van Eldere, Johan. (2003). Multicentre surveillance of Pseudomonas aeruginosa susceptibility patterns in nosocomial infections. Journal of Antimicrobial Chemotherapy, 51(2), 347-352.

Weinstein, Robert A, Gaynes, Robert, Edwards, Jonathan R, & System, National Nosocomial Infections Surveillance. (2005). Overview of nosocomial infections caused by gram-negative bacilli. Clinical infectious diseases, 41(6), 848-854.

Xu, Jiru, Moore, John E, Murphy, Philip G, Millar, B Cherie, & Elborn, J Stuart. (2004). Early detection of Pseudomonas aeruginosa–comparison of conventional versus molecular (PCR) detection directly from adult patients with cystic fibrosis (CF). Annals of Clinical Microbiology and Antimicrobials, 3(1), 1-5.