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Epidemiology and Risk Factors of Nosocomial Infection in Hospitalized Children and Adults: A Review

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Abstract
Nosocomial infections (NI) or healthcare-associated infections (HAI) are infections not present at the time of admission to a hospital and manifest 48 hours after hospital admission. The specific factors contributing to the risk of infection during hospitalization remain unclear. Nosocomial infections are a growing public health threat that increases patient morbidity and mortality. Nosocomial infections (NIs) could lead to considerably longer length of the hospital stays and higher costs. Besides, the unreasonable use of antibiotics could lead to development resistance to different antibiotics and create limited therapeutic options, increased risks of treatment failure and poor patient management. These infections are a serious public health problem affecting both developed and developing countries. This study aimed to investigate the current status and changing trend of NI in various parts of the world, to provide a reference for the prevention and control of healthcare-associated infections.

Keywords: Healthcare-Associated Infections, Nosocomial Infection, Prevention, Children, Adult

1. Introduction
Nosocomial infections are a major concern for the global health safety of both patients and healthcare workers. Nosocomial infections also referred to as healthcare-associated infections (HAI), are infection(s) acquired during the process of receiving health care that was not present during the time of admission. These infections are not present or incubating at the time of admission to a hospital but are acquired after hospitalization and manifest 48 hours after admission. They may occur in different areas of healthcare delivery, such as in hospitals, long-term care facilities, and outpatient's settings. These infections are not related to the main cause of hospital admission and may occur even after the patient has been discharged from the hospital. HAIs also include occupational infections that may affect staff [1].
Although some of these infections can be treated easily, others may more seriously affect a patient's health, increasing length of their hospital stay and hospital costs, and causing considerable distress to these patients. Nosocomial infections are a potential risk to the patients, staff, and community as well.
Due to poor surveillance systems, there is minimal information on the burden of healthcare-associated infections. This is significant because when patients are undergoing treatment for other medical conditions, there is a high likelihood of them contracting respiratory infections, which can complicate the accurate assessment of the prevalence of any HAI within a medical facility.
The most frequently reported types of healthcare-associated infections are respiratory tract infections, surgical site infections, urinary tract infections, bloodstream infections and gastro-intestinal infections, with *Clostridioides difficile* infections representing almost half of the gastro-intestinal infections.
The five most common hospital-acquired infections in the United States, which include urinary tract infection, pneumonia, catheter sepsis, surgical wound infection, and infection caused by the bacterium Clostridium difficile, are estimated to cost the healthcare system in the United States $10 billion annually. The cost of a single medical treatment of a patient with catheter sepsis is approximately $45,000, and the cost of medical treatment of pneumonia in a patient on mechanical ventilation is approximately $40,000. *Clostridium difficile* infection is estimated to be the second most common nosocomial infection in the United States, and the cost of treating a patient with this type of infection is approximately $11,000 [2].

According to European Centre for Disease Prevention and Control more than 3.5 million cases of HAI are estimated to occur in the European Union and European Economic Area (EU/EEA) each year, leading to more than 90 thousand deaths and corresponding to approximately 2.5 million disability adjusted life years (DALYs), a burden estimated to exceed the cumulative burden of other infections including influenza and tuberculosis in the EU/EEA. Furthermore, HAIs constitute 71% of cases of infections with antibiotic-resistant bacteria, including bacteria resistant to last-resort antibiotics, such as carbapenem-resistant *Enterobacterales* [3].

Infection occurs when pathogen spread to a susceptible patient host. In modern healthcare, invasive procedures and surgery, indwelling medical devices, and prosthetic devices are associated with these infections. The etiology of HAI is based on the source or type of infection and the responsible pathogen, which may be bacterial, viral, or fungal.

HAI is the most common adverse event in health care that affects patient safety. They contribute to significant morbidity, mortality, and financial burden on patients, families, and healthcare systems. The emergence of multi-drug resistant organisms is another complication seen with HAI [4].

Microorganisms such as *Streptococcus* spp., *Acinetobacter* spp., *enterococci*, *Pseudomonas aeruginosa*, Coagulase negative *staphylococci*, *Staphylococcus aureus*, *Bacillus cereus*, *Legionella*, and members of the *Enterobacteria* family are among the organisms that are frequently involved in nosocomial infections. These microorganisms can be spread from person to person, via shared objects and surfaces, the environment, contaminated water and food, diseased people, and contaminated healthcare workers' skin. The infection may have come from the outside environment, another sick patient, or potentially infected employees. Sometimes the microorganism comes from the patient's own skin microbiota and becomes opportunistic as a result of surgery or other treatments that undermine the skin's barrier of defense [5].

Just recently International Nosocomial Infection Control Consortium (INICC) reported of health care associated infections, data summary of 45 countries for 2015 to 2020, adult and pediatric units. Authors gathered data from 204,770 patients, 1,480,620 patient days, 936,976 central line (CL)-days, 637,850 mechanical ventilators (MV)-days, and 1,005,589 urinary catheter (UC)-days. The results showed 4,270 CL-associated bloodstream infections, 7,635 ventilator-associated pneumonia, and 3,005 UC-associated urinary tract infections. The combined rates of DA-HAIs were 7.28%, and 10.07 DA-HAIs per 1,000 patient days. CL-associated bloodstream infections occurred at 4.55 per 1,000 CL-days, ventilator-associated pneumonias at 11.96 per 1,000 MV-days, and UC-associated urinary tract infections at 2.91 per 1,000 UC days. In terms of resistance, *Pseudomonas aeruginosa* showed 50.73% resistance to imipenem, 44.99% to ceftazidime, 37.95% to ciprofloxacin, and 34.05% to amikacin. Meanwhile, *Klebsiella spp* had resistance rates of 48.29% to imipenem, 72.03% to ceftazidime, 61.78% to ciprofloxacin, and 40.32% to amikacin. *Coagulase-negative Staphylococci* and *Staphylococcus aureus* displayed oxacillin resistance in 81.33% and 53.83% of cases, respectively [6].

In another study of the International Nosocomial Infection Control Consortium (INICC), prospective data from 532,483 ICU patients hospitalized in 242 hospitals, for an aggregate of 2,197,304 patient days, were collected through the INICC Surveillance Online System (ISOS) during the 6-year study period from 2012 to 2017. DA-HAI rates were higher in the INICC ICUs: In the medical-surgical ICUs, the pooled central line-associated bloodstream infection rate was higher (5.05 vs 0.8 per 1,000 central line-days); the ventilator-associated pneumonia rate was also higher (14.1 vs 0.9 per 1,000 ventilator-days,), as well as the rate of catheter-associated urinary tract infection (5.1 vs 1.7 per 1,000 catheter-days). From blood cultures samples, frequencies of resistance, such as of *Pseudomonas aeruginosa* to piperacillin-tazobactam (33.0% vs 18.3%), were also higher [7].

In a systematic review and meta-analysis about global prevalence of nosocomial infection was conducted a comprehensive search of electronic databases including EMBASE, Scopus, PubMed and Web of Science between 2000 and June 2021. 7031 articles were analyzed. The rate of universal HAIs was 0.14 percent. The rate of HAIs is increasing by 0.06 percent annually. The highest rate of HAIs was in the AFR, while the lowest prevalence were in AMR and WPR. Besides, AFR prevalence in central Africa is higher than in other parts of the world by 0.27. Besides, *E. coli* infected patients more than other micro-organisms such as *Coagulase-negative staphylococci*, *Staphylococcus spp*. and *Pseudomonas aeruginosa*. In hospital wards, Transplant, and Neonatal wards and ICU had the highest rates. The prevalence of HAIs was higher in men than in women [8].

In a study which was performed in Slovenia the impact of a nosocomial infection in the treatment process and the direct costs of patient hospitalization was analyzed. The results showed that the total direct cost of hospitalization of a non-colonised patient was 1,317.58 euro per day, and the direct cost of hospitalization of a patient with a nosocomial infection was 2,268.14 euro per day of hospitalization. It was concluded, that reducing nosocomial infections would have a significant impact on the savings or reduction in healthcare costs associated with a different work process for patients in isolation. It would save 950.56 euro per patient for each day of hospitalization for individual treatment of a patient hospitalized in an isolation room as consequence of a nosocomial infection [9].

Point prevalence surveys of healthcare-associated infections and antimicrobial use in the European Union and European Economic Area (EU/EEA) from 2016 to 2017 included 310,755 patients from 1,209 acute care hospitals (ACH) in 28 countries and 117,138 residents from 2,221 long-term care facilities (LTCF) in 23 countries. After adjustment for over-representation of countries contributing more than 20,000 patients to the point prevalence survey (PPS), 325,737 patients from 1,275 acute care hospitals (ACH) remained in the final sample. A total of 19,626 HAI were reported in 18,287 patients with HAI (1.07 HAI per infected patient). The prevalence of patients with at least one HAI in the EU/EEA sample was 5.9% (country range: 2.9–10.0%). The prevalence varied between 4.4% (2,177/49,381 patients) in primary care hospitals (n=333) to 7.1% (7,591/104,562 patients) in tertiary care hospitals (n=222) and was highest in patients admitted to intensive care units, where 19.2% (2,751/14,258) patients had at least one HAI compared with 5.2% (15,536/296,397) on average for all other specialties combined. The most frequently reported types of HAI were

respiratory tract infections (21.4% pneumonia and 4.3% other lower respiratory tract infections), urinary tract infections (18.9%), surgical site infections (18.4%), bloodstream infections (10.8%) and gastro-intestinal infections (8.9%), with *C. difficile* infections accounting for 44.6% of the latter or 4.9% of all HAI. Twenty-three per cent of HAI were present on admission. One third of HAI on admission were surgical site infections. After correction for non-participating countries and validation, a total of 4.5 million HAI were estimated to occur per year in the period 2016 to 2017 in ACH in the EU/EEA. A total of 13,085 microorganisms were reported in 10,340 (52.7%) HAI. The 10 most frequently isolated microorganisms were *E. coli* (16.1%), *S. aureus* (11.6%), *Klebsiella spp*. (10.4%), *Enterococcus spp*. (9.7%), *P. aeruginosa* (8.0%), *C. difficile* (7.3%), *coagulase negative staphylococci* (7.1%), *Candida spp*. (5.2%), *Enterobacter spp*. (4.4%) and *Proteus spp*. (3.8%).

After adjustment for over-representation, 117,138 residents from 2,221 LTCF were included for analysis. The main aggregated results were reported for 80.5% of participating LTCF, i.e. general nursing homes (n=1,025), residential homes (n=176) and mixed LTCF (n=587), corresponding to 102,301 residents and 1,788 LTCF in EU/EEA countries. A total of 3,858 HAI were reported in 3,780 residents with HAI (1.02 HAI per infected resident). The prevalence of residents with at least one HAI was 3.7% (country range: 0.9–8.5%). When extrapolated to the average number of occupied LTCF beds per country, the weighted HAI prevalence in LTCF was 3.6%. The most frequently reported types of HAI in LTCF were respiratory tract infections (33.2% overall, 3.7% pneumonia, 22.0% other lower respiratory tract infections, 7.2% common cold/pharyngitis, 0.3% influenza), urinary tract infections (32.0%) and skin infections (21.5%). The majority of the reported HAI (84.7%) were associated with the LTCF where the PPS was performed, while 7.5% and 1.4% were associated with a hospital or another LTCF, respectively. Microbiological data in LTCF were available for 742 (19.2%) HAI. The 10 most frequently isolated bacteria were *E. coli* (30.7%), *S. aureus* (12.3%), *Klebsiella spp*. (11.4%), *Proteus spp*. (10.6%), *P. aeruginosa* (7.1%), *Enterococcus spp*. (4.8%), *C. difficile* (4.4%), *Streptococcus spp*. (2.8%) *Enterobacter spp*. (2.1%) and *coagulase negative staphylococci* (1.9%) [10].

In 2022 PubMed, Scopus and Google Scholar databases were searched to find point-prevalence studies of HAIs in Africa. Of the 6094 articles identified from the databases, fifteen eligible articles were selected. The studies were conducted in the North, South, East and West African regions with Tunisia (n = 4) and South Africa (n = 2) having the highest number of studies. The pooled prevalence of HAIs was 12.76% with a high degree of heterogeneity. The prevalence of HAIs varied between wards with the highest rate found in the ICU (25.2%-100%), followed by neonatal ICU/ward (7.0%-53.6%) and paediatric medical ward (2.7%-33.0%). Surgical site infection was the most common HAIs and accounted for 41.6% of all HAIs, followed by bloodstream infection (17.07%) and respiratory tract infections/pneumonia (17.04%). Recent hospitalization, presence of peripheral vascular catheter and having diabetes mellitus were the strongest predictors of HAIs in Africa. Only 37.9% of HAIs had documented positive microbiological culture result with gram negative bacteria including *Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Acinetobacter baumannii* and *Citrobacter* been the most common microorganisms and accounted for 40%-100% of the pathogens. It was shown, that the pooled point-prevalence of HAIs in Africa is more than two times higher than the rate reported in developed countries. The prevalence varied between the countries and was highest in the ICU and neonatal ICU/ward. Surgical site infection and bloodstream infection were the most common HAIs reported in African studies [11].

In a very recent paper from Africa MEDLINE/PubMed, CINAHL, and Global Health databases (EBSCOhost interface) were searched for studies published in English and French describing HCAI in Africa from 2010 to 2022. Data on prevalence of HCAI, risk factors, etiologic agents, and associated antimicrobial resistance patterns were extracted. Of 2541 records screened, 92 were included, comprising data from 81,968 patients. Prevalence of HCAI varied between 1.6 and 90.2% with a median of 15% across studies. Contaminated wound, long hospital stays, urinary catheter, intubation and ventilation, vascular catheters were among risk factors associated with HCAI. Bacteria reported from included studies comprised 6463 isolates, with *E. coli* (18.3%), *S. aureus* (17.3%, *Klebsiella spp*. (17.2%), *Pseudomonas spp*. (10.3%), and *Acinetobacter spp*. (6.8%) being most common. Resistance to multiple antibiotics was common; 70.3% of *Enterobacterales* were 3rd -generation cephalosporin resistant, 70.5% of *S. aureus* were methicillin resistant and 55% *Pseudomonas spp*. were resistant to all agents tested. It was concluded, that HCAI is a greater problem in Africa than other regions, however, there remains a paucity of data to guide local action [12].

Isigi *et al* demonstrated that patients with previous colonization and underlying conditions are at increased risk of nosocomial infections due to frailty, extended hospital stay, and suppressed immunity. The use of indwelling devices, increased age, high BMI, and intrahospital transfers increase the susceptibility of patients to nosocomial infections. Intrahospital transfers expose patients to other infectious patients, staff, and hospital environments, thereby increasing their risk for infection. In addition, the number of staff per patient has been positively associated with an increased risk of infection. Readmissions, underlying conditions and/or active cancer, prior antibiotic intake associated with drug-resistant microorganisms, and colonization with opportunistic organisms contribute to nosocomial infections. Indwelling devices such as urinary catheters increase the risk of sepsis, while obesity and age are strongly associated with SSIs. The most common organisms associated with nosocomial infections included *C. difficile*, *E. coli*, *P. aeruginosa*, *Enterococcus spp, K. pneumoniae*, *S. aureus*, coliform species, anaerobic cocci, MRSA, *coagulase-negative Staphylococcus*, *Enterobacteriaceae*, and *streptococci.* Implemented interventions should consider the time frame before and after admission to control for organisms acquired during both periods. Further studies are needed to identify the risk factors of nosocomial infections and drug-resistant pathogens targeting a larger patient group for better infection prevention and control [1].

In a retrospective observational study conducted in a 6-bed surgical intensive care unit (SICU) at An-Najah National University Hospital (NNUH) in Palestine the incidence of nosocomial infections from January 2020 until December

2021 was detected. The study group included 157 patients who received antibiotics during their stay in the SICU. It was concluded, that the incidence of suspected or confirmed nosocomial infections in all admitted patients to the SICU was 26.9%, and approximately 60.5% of the patients who received antibiotics during this period were confirmed or suspected to have nosocomial infections. Pneumonia, followed by skin and soft tissue infections and urinary tract infections, made up the great majority of infections. Gram-negative bacteria constituted the majority of reported cultures. Piperacillin/tazobactam and vancomycin were the most common antibiotics used to treat these nosocomial infections. It was recommended that all healthcare workers in ICU departments strive for better strategies to minimize the incidence of nosocomial infections. This can be achieved by practicing hand hygiene, environmental hygiene, surveillance cultures, antibiotic stewardship programs, and following guidelines and patient safety cultures [13].

In Turkey, a retrospective evaluation of 48 pediatric patients aged 1 month to 18 years who had been admitted between February 2022 and January 2023 at University of Health Sciences Türkiye, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital was performed. Children with NI were included. Demographic clinical and outcome data were analyzed. It was demonstrated, that respiratory diseases (50%) were the most common reasons for admission to the PICU, followed by sepsis (22.9%) and trauma (12.5%). The mortality rate was 18.8%. The requirement for renal replacement treatment was significantly higher in the non-survival group. Patients had similar prolonged PICU stay rates and requirements of mechanical ventilation, plasma exchange, and inotropic agents. Procalcitonin (PCT), and procalcitonin/albumin ratio (PAR) were also higher in the non-survival group than those in the survival group. Receiver operating characteristic (ROC) curves were used to predict mortality with PCT and PAR. It was concluded, that risk factors that cannot be changed, such as the underlying disease, should be considered in patients. Other modifiable risk factors for NIs will likely be the focus of efforts to enhance patient care [14].

A hospital based prospective study was carried out on 725 patients aged between 1 month and 12 years admitted in PICU of Al-Ameen medical college hospital, Bijapur, Karnataka, India and institute of child health and hospital for children, Madras medical college, Chennai, Tamil Nadu, India from 2020 to 2022. Out of 725 pediatric admissions, the incidence of nosocomial infection in the present was found to be 108 (14.8%). Concerning the type of infection, the commonest reported types were central-line associated bloodstream infection (CABI) 59 (54.6%) and ventilator-associated infection (VAI) 52 (48.1%), followed by bloodstream infection 45 (41.6%), catheter associated urinary tract infection (CA-UTI) 38 (35.1%) and urinary tract infection (UTI) 30 (27.7%) respectively. The commonest causative organism for CA-UTI and UTI was *E. coli* with 38 (35.1%) and 40 (37.03%) respectively. For bloodstream infection and central line associated blood stream infection, the commonest causative organism was *Klebsiella pneumoniae* (35.1% and 31.4%), respectively [15].

A yearlong hospital-based cross-sectional study was conducted from April 2020 to April 2021 at two large tertiary-level hospitals in Zambia. Eight hundred and forty-one clinical specimens (skin swabs, urine or sputum) were collected and analyzed. The majority (69.9%) of clinical specimens had positive bacterial cultures. More pathogens were isolated from surgical (55.6%) compared to medical wards; returning OPD patients had more pathogens isolated (56.2%) compared to admitted patients. Of the 588 pathogens isolated, 199 (17.8%) were *Escherichia coli*, 116 (13.7%) *Pseudomonas aeruginosa*, 87 (5.6%) *Proteus vulgaris*, 79 (5.5%) *Klebsiella pneumonia* and 107 (11.4%) other bacteria. Medical devices-related nosocomial infection was a common presentation. Among surgical patients, a urinary catheter was frequently inserted in patients being managed for BPH. Catheter-associated UTI was the most common nosocomial infection (57%). The other common diagnosis was infected pressure sores (38.7%). The factors associated with nosocomial infection in univariate analysis were medical device insertion, age ≥65 years, male gender, prior admission and prolonged hospital admission. Co-morbidities included hypertension (8%) and diabetes mellitus (4%). Nine participants were psychiatric patients presenting with infected wounds. More than half (62%) of participants reported a history of previous hospital exposure within the past 30 days, which were prior medical visits or being ex-bedsiders taking care of patients [16].

A retrospective investigation of the clinical data of HAI patients in Dongying People's Hospital in China from January 1, 2018, to December 31, 2021, was carried out. The incidence of HAI was 0.93%. It was on the rise from 2018 to 2020 but declined in 2021. The departments with the highest rate of HAI were the Intensive Care Unit (ICU), neurosurgery department, cardiothoracic surgery department, and hematology department. HAI often occurred in the lower respiratory tract, urinary tract, and in blood. The most common pathogenic microorganisms in cases of HAI were *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and *Staphylococcus aureus*. The rate of bacterial culture delivery for therapeutic drugs has increased from year to year. This study shows that the incidence of HAI in the hospital is generally low. Gram-negative bacteria are still the main source of HAI. The rate of bacterial culture delivery for therapeutic use improved over the years and has gradually been standardized. It is necessary to focus on the management of HAI in the ICU, neurosurgery, cardiothoracic surgery, and hematology departments [17].

The retrospective, cross-sectional study was conducted in the pediatric population aged from one month to 14 years old who acquired infections after 48 hours of admission to the PICU at East Jeddah General Hospital, Saudi Arabia from 2021 to 2022. A total of 51 patients developed 145 HAIs with an incidence rate of 35 per 1,000-person days. Patients' ages ranged from one month to 13 years with a mean age of 3.5 ± 4.2 years. In total, 32 (62.7%) patients had comorbidities. The most reported types of HAI were central line-associated bloodstream infections (CLABSIs) (28.3%; 41), followed by BSIs (19.3%; 28), skin and soft-tissue infections (12.4%; 18), VAP (11%; 16), catheter-associated urinary tract infections (CAUTIs) (9%; 13), UTIs (8.3%; 12), and pneumonia (6.2%; 9). The most commonly isolated organisms were gram-negative organisms (58.7%; 85) mainly *Klebsiella pneumoniae* (35.2%), *Escherichia coli* (9%), and *Pseudomonas aeruginosa* (6.9%). A total of 51 (35.1%) organisms were yeasts mainly *Candida parapsilosis* (12.4%; 18), *Candida tropicalis* (11.7%; 17), and *Candida albicans* (4.1%; 6). Only nine (6.2%) organisms were gram-positive mainly *Staphylococcus aureus* (5.5%; 8), and 1 case

had *Streptococcus pyogenes* (group A). The highest in-hospital mortality rate was reported among patients who had CLABSIs (48.8%), BSIs (46.4%), and UTIs (41.7%) compared to none who had ear infections and SSIs. Likewise, 56.9% of infants infected with fungi died compared to 25.9% of others infected with gram-negative bacteria and none infected with gram-positive bacteria [18].

Ventilator-associated pneumonia (VAP) is a common healthcare-associated disease in intensive care units, leading to significant morbidity and mortality. The systematic review, performing by Mohamed H *et al* aimed to investigate the prevalence, risk factors, and prevention strategies for VAP in the Middle East. Ten studies, involving a total of 6295 patients diagnosed with VAP, were included in this review. Among these patients, 336 (5.3%) developed VAP. All reviewed studies emphasized the importance of infection control measures in reducing the risk of VAP. The primary risk factors for developing VAP include prematurity, low birth weight, prolonged artificial breathing, enteral feeding, invasive devices such as umbilical catheters, and cardiac operations. One study found that *Candida albicans* infection was common in VAP patients. Omeprazole and pre- and post-bundles were ineffective in preventing VAP. All of the included studies revealed that infection control techniques are critical for preventing the spread of VAP [19].

In a study, performing in Iran, all electronic medical records of nosocomial infection episodes in hospitalized pediatric patients were retrospectively reviewed during the 3-year period. The bacterial and fungal profile and antimicrobial susceptibility profiles of isolates recovered from different samples of patients with NIs were determined. A total of 718 patients were included. Among the patients, 27.2% had underlying heart disease and 16.3% had seizures. Intrinsic and acquired immunodeficiency was also reported in a number of patients (4.9% and 8.2%, respectively). Three hundred and eighty-four patients (53.5%) utilized catheters, and 101 of them (14.1%) had endotracheal tube during their hospitalization.

Klebsiella pneumonia and *Candida* spp. were the most prevalent isolates (17.4% and 16.9%, respectively), followed by *P. aeruginosa* (10%) and CoNS (9.6%). Also, most of the samples were isolated from blood (69%), followed by sterile fluids (23%) and finally wounds (8%). *Klebsiella pneumonia* was the most frequent organism isolated from blood and wounds, and *Candida* spp. was the most frequent organism isolated from sterile fluids. Most of the isolates were collected from hospitalized patients at neonatal intensive care unit (NICU) and pediatric intensive care unit (PICU) (15.2% and 13.9%, respectively) and the most isolated microorganisms from them were *K. pneumonia* (26.6%) and *Candida* spp. (25%), respectively. Antibiotic susceptibility frequencies of evaluated microorganisms: *Escherichia coli*, *Acinetobacter baumannii*, *S.marcescens*, *K.pneumonia* and *Pseudomonas* spp. strains showed 100% sensitivity to colistin. *Pseudomonas aeroginusa* strains as a whole showed significant sensitivity to the studied and the most sensitive antibiotics were imipenem (80.4%) and ceftazidime (80.8%). Subsequently, the highest sensitivity to ceftazidime was observed in *Pseudomonas* spp. (79.2%), while *A. baumannii* strains showed 94.8% resistance to this antibiotic [20].

In Ethiopia 223 patients were selected by systematic random sampling from a two-year retrospective chart review admitted from 2019 to 2020 to the PICU. Forty-five (20.2%) patients developed nosocomial infection. The median age was 4 years. About invasive procedures done, the most common was nasogastric tube (57%), followed by mechanical ventilation (17.9%) and urinary catheter (13.9%). The main focus of the infection was chest (53.3%), followed by bloodstream infection (22%) and gastrointestinal infection (9%). The odds of HAI were 3.3 times higher among under-five compared to those aged between 5 and 18 years. The odds of HAI were also 4.1 times higher in those who stayed for more than two weeks compared to those who stayed in the pediatric ICU 2 to 14 days. The mean duration of mechanical ventilation in those patients with and without NI was 1.65 days and 13.96 days, respectively. Patients who started antibiotics at admission and patients who were on nasogastric tube feeding were also statistically significant risk factors for developing NI [21].

As a conclusion, the review identified a number of essential details about the rate of HAIs in different parts of the world. It revealed that the rate of HAIs and the number of publications in this regard has risen in recent years. The HAIs rate and the most common micro-organism were different in various regions. However, several important gaps were identified such as lack of data in different regions and territories and different domains like the cause of HAIs. This information can help decision makers establish preventive strategies and implement effective and reliable plans. More focus needs to be dedicated to the prevention of HAI and AMR, through the application of available recommendations and guidelines. The high rates of HAI and bacterial resistance emphasize the ongoing need for continued efforts to control them.

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