ORIGINAL ARTICLE

# Trends in Problematic Infection of Lesions: Etiology and Multidrug Resistance

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**ABSTRACT**

**Introduction:** Infection of wound and pus lead to delayed healing, prolonged hospital stay, increased healthcare costs and rising mortality and morbidity. Their clinical impact is increased by emerging multidrug resistance, particularly among common pathogens in hospital settings. Understanding local bacteriological trends and antimicrobial susceptibility is crucial for guiding effective treatment. **Aims:** To determine the trends in bacteriological pathogens of infected lesions, assess antimicrobial susceptibility patterns, and evaluate the prevalence and distribution of Multidrug Resistant organisms among patients presenting with wound or pus infections. **Methods:** A retrospective descriptive study was conducted at Dhulikhel Hospital from September 2022 to September 2025. All wound and pus samples submitted for culture and sensitivity testing were included. Standard microbiological methods were used for bacterial isolation, identification, and antimicrobial susceptibility testing following Clinical and Laboratory Standard Institute guidelines. Data were analyzed to determine species distribution, sensitivity patterns, and Multidrug Resistance prevalence across age groups. **Results:** Of 8,199 samples processed, 2,678 (32.7%) showed bacterial growth. Gram-positive organisms were slightly predominant (55.5%) . *Staphylococcus aureus* (33.79%) was the most common pathogen showing high susceptibility to cloxacillin (97.2%) and amoxicillin-clavulanic acid (85.5%), while Methicillin Resistant *Staphylococcus aureus* isolates remained sensitive to linezolid (90.7%) and vancomycin (79.2%). Among gram-negative bacteria, *Escherichia coli* displayed high sensitivity to gentamicin (84.8%) but low susceptibility to β-lactams and carbapenems. *Acinetobacter spp*. demonstrated extensive Multidrug Resistance with poor response to most antibiotic classes. Overall Multidrug resistance prevalence was 51.6%, highest among elderly patients (83.3%), followed by adults (54.2%) and children (36.7%). **Conclusion:** The study highlights *Staphylococcus aureus* and *Enterobacterales* as major pathogens in wound infections and reveals a concerning rise in Multidrug Resistance, especially among gram-negative bacilli. These findings emphasize the need for strengthened antimicrobial stewardship, continuous surveillance, and evidence-based empirical therapy.

***Keywords:*** Drug resistance, *Enterobacterales*, Microbial sensitivity tests, *Staphylococcus aureus*, Wound infection

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## INTRODUCTION

Infective lesion develops from disruption of skin's defense barrier which favors growth and colonization of pathogens.[1,2] The infection in lesion delay the healing, leading to long hospital stays, complications, financial burden and higher rate of morbidity and mortality in patients.[3] The incidence of infected lesions may be due to factors like environmental factors, host immune response and virulence factor of the microbes. Etiology of infections also play an important role in treatment outcomes of a patient.[4,5] The cause of infection of the lesions are microorganisms like bacteria, virus, fungus and the bacterial microorganisms may also co-exist as polymicrobial organisms in chronic infections.[6] Bacterial pathogens mostly found causing these infections are *Escherichia coli (E. coli), Staphylococcus aureus (S. aureus)*, different strains of *Klebsiella, Proteus, Pseudomonas* and *Acinatobacter.*[7] The alarming rise in multidrug-resistance (MDR) is a disturbing trend that has emerged in recent years which has sparked concerns in appropriate use of antibiotics to combat with the infection.[5,8,9] Different studies carried out in Nepal have shown increased rate of resistance towards different antibiotics, specially, increasing rate

of Methicillin Resistant *Staphylococcus aureus* (MRSA) and Extended Spectrum Beta-Lactamase (ESBL) producing bacteria has been reported.[6,10] Recognizing the changing patterns of microorganisms and their resistance to antimicrobials is essential for effective treatment of infection. This study intends to explore current trends in bacterial etiology of infections of lesions, prevalence of MDR stains among the causative agents and its implications on treatment of the infected patients.

## METHODS

The study is a retrospective descriptive study that was conducted in outpatients and inpatients of Dhulikhel Hospital who had provided wound/pus swab sample for microbiological investigation from the September 2022 to September 2025. The analysis of the report was done at department of Microbiology, Dhulikhel Hospital. All the culture sensitivity reports of wound/pus swab has been included in the study. All age groups of patients were selected. For the microbiological investigation, sterile cotton swabs or sterile syringes were used to collect pus samples from infected wound and were labeled properly with patient's details along with date and time of sample collection. The collection and labeling of samples were done by trained nurses of respective departments. Collected samples were delivered to microbiology laboratory within an hour for microbiological tests. Microscopic examination was done after gram stain for presumptive identification of gram positive and gram-negative bacteria.[11,12]

**Culture and identification of isolates**: Samples were inoculated into MacConkey agar and Blood agar. They were then incubated at $37^0$C for 24 hours. After incubation, grown isolates were identified according to standard microbiological criteria such as colonies morphology, gram stain and biochemical properties.[11,13] Gram positive cocci were identified up to species level by Catalase test, Coagulase test and by using Optochin and Bacitracin disc whereas gram negative bacilli are identified by Catalase test, Oxidase test, Indole test, Motility, Hydrogen sulfide production, Triple sugar iron test, Urease test and Citrate test.[12,14]

**Antibiotic Susceptibility test (AST)**: Antibiotic susceptibility test were performed for all bacterial isolates by a modified Kirby – Bauer disk diffusion method according to the guidelines of Clinical and Laboratory Standard Institute (CLSI) on Mueller Hinton Agar.[15]

### Statistical Analysis:

Data were analyzed using SPSS version 16. Categorical variables were summarized as frequencies and percentages. The chi-square test was applied to assess the association between age groups and MDR status, with $p<0.05$ considered statistically significant.

## RESULTS

Among 8199 pus samples that were processed for bacterial culture and sensitivity, 2678 (32.7%) showed bacterial growth and 5521(67.3%) showed no growth. Slight male predominance in culture positivity was seen 1523 (56.9%) were from males and 1155 (43.1%) were from females.

Among 2678 bacterial isolates, 1487 (55.5%) were gram positive organisms and 1191 (44.5%) were gram negative. The most pre-dominant organism was found to be *Staphylococcus aureus* (33.8%) followed by *Escherichia coli* (19.6%), *Enterococcus* (9.5%), *Coagulase-negative staphylococci* (9.4%) and *Klebsiella pneumoniae* (9.0%). *Proteus spp., Pseudomonas spp. Streptococcus spp., Enterobacter spp., Acinetobacter spp., Klebsiella oxytoca, Citrobacter spp*. and Methicillin Resistant *Staphylococcus aureus* (MRSA) were among the less frequent isolates.

### Antibiotic sensitivity pattern:

Among gram positive organisms, *Staphylococcus aureus* has shown to be highly sensitive to Cloxacillin (97.2%) and Amoxycillin-clavulinic acid (85.5%) and sensitivity was low to Penicillin (17.3%). *Enterococcus spp*. showed high sensitivity to Linezolid (93.7%) and vancomycin (87.8%). For MRSA isolates, Vancomycin (79.2%) and Linezolid (90.7%) proved to be fairly effective.

Among gram negative organisms, *Escherichia coli* was highly sensitive to Gentamicin (84.8%), moderately sensitive to Ciprofloxacin (48.9%) and showed lowed low sensitivity to B-lactam antibiotics (Imipenem and meropenem both 25.6%). Proteus spp. showed high sensitivity to Ceftriaxone (73.8%) and Cefoperazone (66.2%), *Pseudomonas* showed high sensitivity to Cefepime (64.3%) and Ciprofloxacin (67.9%), *Acinetobacter spp.* has shown distinct multidrug-resistance with low sensitivity to most of the antibiotics including carbapenems (Imepenem 39.3%).

### MDR

The overall prevalence of MDR was 51.6%, elderly population was highly burdened (83.3%) than adults (54.2%) and pediatric patients (36.7%) ($p<0.05$).

Trends in MDR has revealed significant rise in Gram-Negative Bacilli (GNB). The burden of MDR was heaviest in Acinetobacter, which showed resistance to almost all antibiotic classes like cephalosporins, fluoroquinolones, carbepenems and B-lactam inhibitors. *K. pneumoniae* and *E. coli* showed markedly decreased susceptibility towards cephalosporins, fluroquinolones and carbapenems indicating increasing multidrug resistance and expanding carbapenem-resistant enterobacterales (CRE). MRSA and enterococcus species were the main gram positive organisms where MDR was observed. Last resort drugs like Linezolid and Vancomycin has proven to be still effective.

| Organisms | Count | Percentage (%) |
|---|---|---|
| *Staphylococcus Aureus* | 905 | 33.79 |
| *Escherichia coli* | 526 | 19.64 |
| *Enterococcus spp.* | 254 | 9.48 |
| *Coagulase Negative Staphylococcus (CONS)* | 251 | 9.37 |
| *Klebsiella Pneumoniae* | 241 | 9.00 |
| *Proteus spp.* | 106 | 3.96 |
| *Pseudomonas spp.* | 100 | 3.73 |
| *Streptococcus spp.* | 75 | 2.80 |
| *Enterobacter spp.* | 74 | 2.76 |
| *Acinetobacter spp.* | 65 | 2.43 |
| *Klebsiella Oxytoca* | 43 | 1.61 |
| *Citrobacter spp.* | 36 | 1.34 |
| *Methicillin Resistant Staphylococcus (MRSA)* | 2 | 0.07 |

***Table I: Distribution of different organisms isolated from infected lesions***

| Antibiotic | *Staphylococcus aureus* n (%) | *CoNS* n (%) | *Enterococcus spp.* n (%) | *Streptococcus spp.* n(%) |
|---|---|---|---|---|
| **Penicillin** | 157 (17) | 0 (0) | 148 (58.2) | 39 (52.6) |
| **Amoxicillin-clavulinic acid** | 774 (85.5) | 6 (2.3) | 52 (20.6) | 39 (52.6) |
| **Erythromycin** | 548 (60.6) | 6 (2.3) | 0 (0.0) | 20 (26.3) |
| **Cloxacillin** | 880 (97.2 ) | 6 (2.3) | 0 (0.0) | 0 (0.0) |
| **Gentamicin** | 154 (17.0) | 12 (4.7) | 227 (89.4) | 24 (31.6) |
| **Ciprofloxacin** | 429 (47.4) | 18 (7.0) | 129 (50.8) | 16 (21.1) |
| **Tetracycline** | 41 (4.5) | 0 (0.0) | 110 (43.4) | 24 (31.6) |
| **Cotrimoxazole** | 658 (72.7) | 6 (2.3) | 0 (0.0) | 8 (10.5) |
| **Amikacin** | 57 (7.3) | 12 (4.7) | 103 (40.7) | 8 (10.5) |
| **Vancomycin** | 60 (6.6) | 0 (0.0) | 223 (87.8) | 47 (63.2) |
| **Linezolid** | 72 ( 8.0) | 0 (0.0) | 238 (93.7) | 43 (57.9) |

***Table II: Gram positive organisms and its sensitivity to different antibiotics***

| Antibiotic | *E. coli* n (%) | *Acinetobacter spp.* n (%) | *Proteus spp.* n (%) | *K. pneumoniae* n (%) | *K. oxytoca* n (%) | *Citrobacter spp.* n (%) | *Pseudomonas spp.* n (%) | *Enterobacter spp.* n (%) |
|---|---|---|---|---|---|---|---|---|
| **Cefuroxime** | 136 (25.9) | 0 (0.0) | 41 (38.5) | 69 (28.6) | 30 (70.8) | 6 (15.8) | 0 (0.0) | 27 (36.2) |
| **Gentamicin** | 446 (84.8) | 37 (57.1) | 78 (73.8) | 174 (72.2) | 43 (100) | 32 (89.5) | 61 (60.7) | 55 (74.5) |
| **Amikacin** | 292 (55.6) | 33 (50.0) | 34 (32.3) | 78 (32.3) | 14 (33.3) | 15 (42.1) | 75 (75.0) | 39 (53.2) |
| **Ciprofloxacin** | 257 (48.9) | 23 (35.7) | 65 (61.5) | 121 (50.4) | 23 (54.2) | 21 (57.9) | 68 (67.9) | 47 (63.8) |
| **Cotrimoxazole** | 29 (5.6) | 0 (0.0) | 13 (12.3) | 20 (8.3) | 5 (12.5) | 8 (21.1) | 0 (0.0) | 8 (10.6) |
| **Cefepime** | 28 (5.3) | 12 (17.9) | 15 (13.8) | 38 (15.8) | 7 (16.7) | 0 (0.0) | 64 (64.3) | 0 (0.0) |
| **Colistin** | 79 (15.0) | 23 (35.7) | 11 (10.8) | 80 (33.1) | 5 (12.5) | 0 (0.0) | 20 (19.6) | 13 (17.0) |
| **Imipenem** | 253 (48.1) | 26 (39.3) | 11 (10.8) | 62 (25.6) | 9 (20.8) | 4 (10.5) | 23 (23.2) | 30 (40.4) |
| **Meropenem** | 259 (49.2) | 21 (32.1) | 24 (23.1) | 62 (25.6) | 16 (37.5) | 8 (21.1) | 20 (19.6) | 33 (44.7) |
| **Cefoperazone** | 190 (36.1) | 7 (10.7) | 70 (66.2) | 112 (46.6) | 22 (50.0) | 28 (78.9) | 7 (7.1) | 38 (51.1) |
| **Ceftriaxone** | 221 (42.0) | 5 (7.1) | 78 (73.8) | 98 (40.6) | 5 (12.5) | 21 (57.9) | 0 (0.0) | 35 (46.8) |

***Table III: Gram-negative organisms and its sensitivity to different antibiotics***

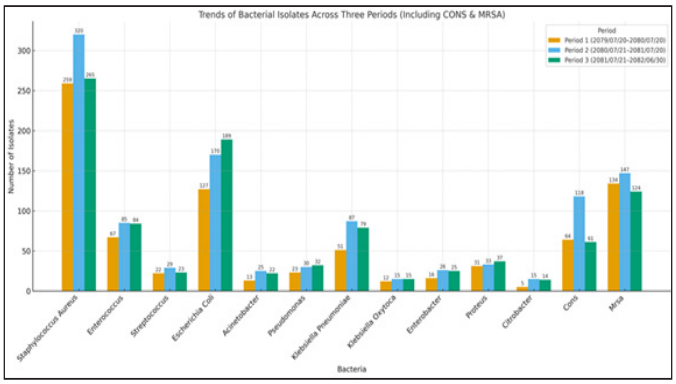


***Figure 1: Bacterial Trend analysis across period of three years***

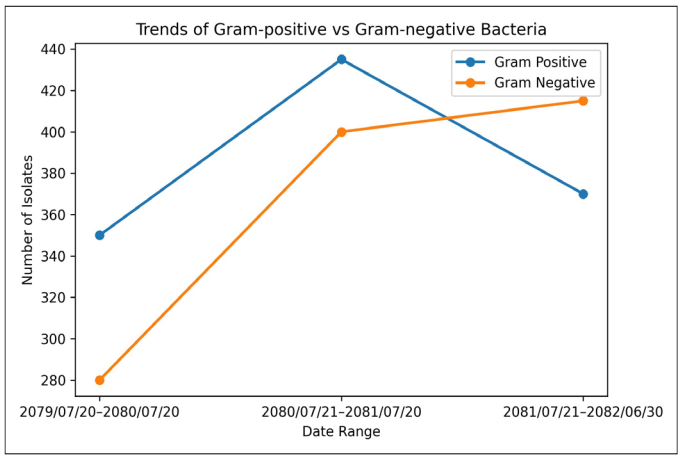


***Figure 2: Trends of Gram-negative vs gram positive bacteria***

| Age Group | Multidrug Resistant n (%) | Non-Multidrug Resistant n (%) | Total | p-value | Remark |
|---|---|---|---|---|---|
| Pediatric (<15 yrs) | 226 (36.7%) | 390 (63.3%) | 616 | <0.05 | Significant |
| Adult (15–59 yrs) | 825 (54.2%) | 697 (45.8%) | 1522 | | |
| Elderly (≥60 yrs) | 450 (83.3%) | 90 (16.7%) | 540 | <0.05 | Significant |
| Total | 1501 (51.6%) | 1177 (48.4%) | 2678 | | |

***Table IV: MDR according to age-group***

## DISCUSSION

This study showed 32.7% of bacterial growth in the infected lesions. The positivity rate is comparable to finding from other studies on pus/wound infections of south-Asian countries where the rate ranges from 25-40%.[8] The culture positivity in almost 1/3 of the samples reflects the burden of pyogenic infections and need for appropriate measures for the control. A slight male predominance was observed where 56.87% of male population showed culture-positivity. This predominance is relatable to the studies reporting men to more frequent exposure to outdoor activities and risky occupations leading to trauma and injuries.[16]

**Organisms:**

The predominance of gram-positive organisms (55.5%), especially *Staphylococcus aureus* as the most common isolate (33.79%) is in accordance to the global data[17] where *S. aureus* has been persistently identified as the main organism responsible for causing wound and soft tissue infections. The presence of gram negative organisms like *Klebsiella pneumoniae* (9%), *Proteus spp., Pseudomonas spp*. and *Acinetobacter spp.* which are usually found in hospital-acquired infections indicates the importance of GNB pathogens in wound infections. Similar observations has been found in other studies from India and Nepal as well.[18] Its detection has highlighted the importance of gram negative organisms in pus/wound infection in hospital settings.

**Antibiotic Sensitivity patterns:**

Among gram positive organisms, *S. aureus* was highly sensitive to cloxacillin (97.2%) amoxicillin-clavulinic acid (85.5%) and moderately sensitive to erythromycin (60.6%) and ciprofloxacin (47.4%). This trend in sensitivity of gram positive organisms indicates that the dominance of methicillin-susceptible strains is still prevalent in hospital settings. Prior studies from Nepal also shows similar results.[19] The prevalence of MRSA was very low (0.07%) and this demonstration can be considered as a positive sign. The principal drugs used for the MRSA isolates like vancomycin and linezolid[20] demonstrated high susceptibility with Linezolid being 90.7% susceptible and vancomycin being 79.2% susceptible. Global reports demonstrating vancomycin-sensitive Enterococci (VSE)[21] aligns with our findings that show high sensitivity to gentamicin (89.4%), vancomycin ( 87.8%) and linezolid (93.7%).

Gram negative bacteria, mostly *E. coli, Citrobacter* and *K. oxytoca* showed high sensitivity to gentamicin with sensitivity of 84.8%, 89.5% and 100% respectively. The uprising strains of carbapenem-resistant enterobacterales (CRE)[22] is quite notable and should not be ignored. Cotrimoxazole and cefepime has proven to be not much effective overall, especially against *E. coli* and *acinetobacter* indicating widespread trends in resistance to the antibiotics.[23] Colistin, which is often considered as last-resort antibiotics demonstrated reduced effectiveness in our study which is a matter of concern worldwide.[24]

**Multidrug resistance**

Multidrug resistance was observed across all age groups. The widespread existence of this multidrug resistant strains is quite alarming. Among pediatric, adult and old age groups, MDR infections were more frequent among old age groups. This finding were also observed in other studies[25] where comorbidities and frequent exposure to antibiotics might have been its cause.

## LIMITATIONS

This study has some limitations. Its retrospective design restricts further processing of the clinical samples for more accurate results. Even if our hospital is the main tertiary care center and covers large area and population, it is considered as a single center study-so, the results might not reflect/ cover the situation of our country as a whole.

## CONCLUSION

The findings in this study has reflected typical patterns of bacterial microorganisms that are isolated in pus and wound infections where *Staphylococcus aureus* and *Enterobacterales* were the main bacterial pathogens. Antibiotic resistance trends from this study reflects the disturbing rise of the MDR microorganisms and need for urgent address to this situation.

## REFERENCES


1. Maillard JY, Kampf G, Cooper R. Antimicrobial stewardship of antiseptics that are pertinent to wounds: The need for a united approach. JAC Antimicrob Resist. 2021;3(1):1-20. DOI
2. Bhatta CP, Lakhey M. The distribution of pathogens causing wound infection and their antibiotic susceptibility pattern. J Nepal Health Res Counc. 2007;5(1): 22–5. LINK
3. Negut I, Grumezescu V, Grumezescu AM. Treatment strategies for infected wounds. Molecules. 2018;23(9):2392. DOI
4. Sahle B, Merid Y. Prevalence and antibiotic resistance of Staphylococcus aureus in wound infections: A hospital study in Hawassa, Ethiopia. J Infect Dev Countries. 2024;18(10):1530-8. DOI
5. Ilyas F, James A, Khan S, Khan S, Haider S, Ullah S, Darwish G,et al. Multidrug resistant pathogens in wound infections: A systematic review. Cureus. 2024;16(4). Full text
6. Parajuli P, Basnyat SR, Shrestha R, Shah PK, Gurung P. Identification and Antibiotic Susceptibility Pattern of Aerobic Bacterial Wound Isolates In Scheer Memorial Hospital. JSM Microbiology. 2014; 2(2):1011. Full text
7. Yeong EK, Sheng WH, Hsueh PR, Hsieh SM, Huang HF, Ko AT, et al. The wound microbiology and the outcomes of the systemic antibiotic prophylaxis in a mass burn casualty incident. J Burn Care Res 2020;41(1):95-103. DOI
8. Divya P, Krishna S, Mariraj J et al. Aerobic Bacteriological Profile of Post-Operative Surgical Wound Infections and Their Antibiogram in A Tertiary Care Hospital. Journal of Medical Science and clinical Research. 2015; 3(6): 6310-6316. LINK
9. Li W, Sadeh O, Chakraborty J, Yang E, Basu P, Kumar P. Multifaceted antibiotic resistance in diabetic foot infections: A systematic review. Microorganisms. 2025;13(10):2311. DOI
10. Maharjan N. Bacteriological pofile of wound infection and antibiotic susceptibility pattern of various isolates in a tertiary care center. J Lumbini. Med Coll. 2020;8(2):218-24. DOI
11. Cheesbrough M. District Laboratory Practice in Tropical Countries. 2nd ed. Cambridge University Press; 2006. LINK
12. Tille PM. Bailey & Scott's Diagnostic Microbiology. 14th ed. St. Louis: Elsevier; 2017. LINK
13. Forbes BA, Sahm DF, Weissfeld AS. Bailey & Scott's Diagnostic Microbiology. 12th ed. St. Louis: Mosby Elsevier; 2007. LINK
14. Perilla MJ. Manual for the laboratory identification and antimicrobial susceptibility testing of bacterial pathogens of public health importance in the developing world: Haemophilus influenzae, Neisseria meningitidis, Streptococcus pneumoniae, Neisseria gonorrhoeae, Salmonella serotype Typhi, Shigella, and Vibrio cholerae. 2003. LINK
15. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing. 33rd ed. CLSI supplement M100. Wayne, PA: CLSI; 2023. LINK
16. Agbakoba NR, Enweani IB, Udeogu CV, Dilibe EA, Ekelozie IS, Chukwuma LN. Microbial population of wound isolates and sociodemographic characteristics in patients attending clinic in National Orthopaedic Hospital, Enugu, Nigeria. World J Adv Res Rev. 2024;21(2):1652–1659. LINK
17. Stevens DL, Bisno AL, Chambers HF, Dellinger EP, Goldstein EJ, Gorbach SL, et al. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014;59(2):e10-52. DOI
18. Mohanty S, Kapil A, Dhawan B, Das BK. Bacteriological and antimicrobial susceptibility profile of soft-tissue infections from Northern India. Indian J Med Sci. 2004;58(1):10-5. Pubmed
19. Khanal LK, Adhikari RP, Guragain A. Prevalence of Methicillin Resistant Staphylococcus aureus and Antibiotic Susceptibility Pattern in a Tertiary Hospital in Nepal. J Nepal Health Res Counc 2018 Apr-Jun;16(39): 172-4. LINK
20. Boucher HW, Corey GR. Epidemiology of methicillin-resistant Staphylococcus aureus. Clin Infect Dis. 2008;46(S5):S344-9. DOI
21. Arias CA, Murray BE. Enterococcal infections treatment and resistance. N Engl J Med. 2012;366:1995-2005. Full text
22. Logan LK, Weinstein RA. The Epidemiology of Carbapenem-Resistant Enterobacteriaceae: The Impact and Evolution of a Global Menace. J Infect Dis. 2017 Mar 28;215(Suppl 1):S28–S36. LINK
23. Wani FK, Bandy A, Alzeni MJS et al. Resistance Patterns of Gram-Negative Bacteria Recovered from Clinical Specimens of Intensive Care Patients. Microorganisms. 2021 Oct 28;9(11):2246. LINK
24. Binsker U, Kasbohrer A, Hammerl JA. Global colistin use: a review of the emergence of resistant Enterobacterales and the impact on their genetic basis. FEMS Microbiol Rev. 2021 Oct 6;46(1). LINK
25. Magill SS, Edwards JR, Bamberg W et al. Multistate point-prevalence survey of health-care–associated infections. N Engl J Med. 2014;370:1198-1208. Full text