CASE REPORT

Annals of Agricultural and Environmental Medicine
www.aaem.pl

Osteomyelitis caused by co-infection of *Citrobacter freundii* and *Morganella morganii* following soil exposure – Case Report and Clinical Insights

Huijing Zheng[1,A,D], Hao Yang[2,B], Yu Liu[1,B], Xiaofeng Chen[1,B], Qian zhangqian[1,A], Zhiyong Gao[1,A], Wenfeng Huang[1,B], Xia Luo[3,B-C], Changqiang Li[1,E], Yang Xu[1,F]

[1] *Department of Dermatology, 4th Affiliated Hospital of Southwest Medical University (TIANFU Affiliated Hospital), China*
[2] *Orthopaedics Department, Renshou County Traditional Chinese Medicine Hospital, China*
[3] *Department of Neurology, 4th Affiliated Hospital of Southwest Medical University, China*
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Huijing Zheng, Hao Yang, Yu Liu, Xiaofeng Chen, Qian zhangqian, Zhiyong Gao, Wenfeng Huang, Xia Luo, Changqiang Li, Yang Xu. Osteomyelitis caused by co-infection of *Citrobacter freundii* and *Morganella morganii* following soil exposure – Case Report and Clinical Insights. Ann Agric Environ Med. doi:10.26444/aaem/220866

Abstract

Introduction. Soil harbours diverse bacteria and antibiotic resistance genes. This report describes a rare co-infection with *Citrobacter freundii* (*C. freundii*) and *Morganella morganii* (*M. morganii)* causing hand osteomyelitis in an elderly farmer, highlighting dynamic pathogen shifts and management challenges.

Case Report. An 85-year-old farmer developed a thumb felon after fieldwork. Treatment failure and non-compliance led to progression. Despite repeated drainage and antibiotics, osteomyelitis developed. Sequential cultures showed a shift from *C. freundii* to *M. morganii*. Distal thumb amputation was ultimately required, resulting in permanent disability.

Results and Conclusions. Soil exposure can cause sequential polymicrobial infections. Inadequate treatment disrupts local ecology, favouring resistant bacteria. Dynamic microbiological monitoring is essential. A strategy of 'continuous monitoring + ecological antimicrobial selection + proactive MDT involvement' is recommended for high-risk individuals.

Key words

Citrobacter freundii, *Morganella morganii*, osteomyelitis, soil exposure, case report

INTRODUCTION

Soil constitutes a complex and dynamic micro-ecosystem, containing tens of thousands of bacteria in each gram of soil as well as the most diverse antibiotic resistance gene pool, far surpassing other environments such as the ocean or the gut microbiota [1, 2]. This presents a latent threat to individuals with regular exposure to soil, such as farmers and gardeners. *Citrobacter freundii* and *Morganella morganii* are both opportunistic pathogens within the Enterobacteriaceae family, and both bacteria can be detected in soil [3, 4]. However, their co-occurrence as etiologic agents of hand osteomyelitis related to soil exposure is exceptionally rare [5, 6, 7, 8].

Elderly individuals are particularly susceptible to skin and soft tissue infections (SSTIs) due to age-related changes in skin structure and immune senescence [9]. Clinical presentations in this population can be atypical, often lacking classic signs of inflammation, which may lead to underestimation of severity and delayed intervention [10]. This case report details the clinical course of an elderly farmer with a progressive hand infection, illustrating the temporal shift in pathogens and analyzing the therapeutic missteps. A comprehensive management strategy is proposed to guide the care of similar complex infections.

CASE REPORT

On 30 June 2025, an 85-year-old male farmer with a 10-year history of hypertension (on amlodipine 5 mg daily) presented with severe burning pain and diffuse swelling in his left thumb after 5 hours of farm work (turning soil, planting vegetables). Key clinical events and microbiological test results are summarized in Figure 1.

On July 3, the symptoms worsened, with periungual erythema (redness around the nail), nail darkening, subungual turbidity (cloudiness under the nail), and tenderness to palpation (Fig. 2).

On July 4, a local clinic prescribed oral roxithromycin (150 mg twice daily) and topical erythromycin ointment. The patient continued farm labour without rest.

By July 12, the patient presented with swelling extending to the distal interphalangeal joint, severe burning pain (VAS 8/10), and localized throbbing pain. Another hospital performed abscess incision and drainage and prescribed oral cefaclor (0.25 g twice daily) and topical norfloxacin cream. No laboratory tests or imaging studies were conducted. Symptoms recurred overnight (Fig. 3).

✉ Address for correspondence: Yang Xu, Department of dermatology, 4th Affiliated Hospital of Southwest Medical University (TIANFU Affiliated Hospital), China
E-mail: xxff2007@163.com

Received: 18.09.2025; accepted: 19.04.2026; first published: 28.04.2026

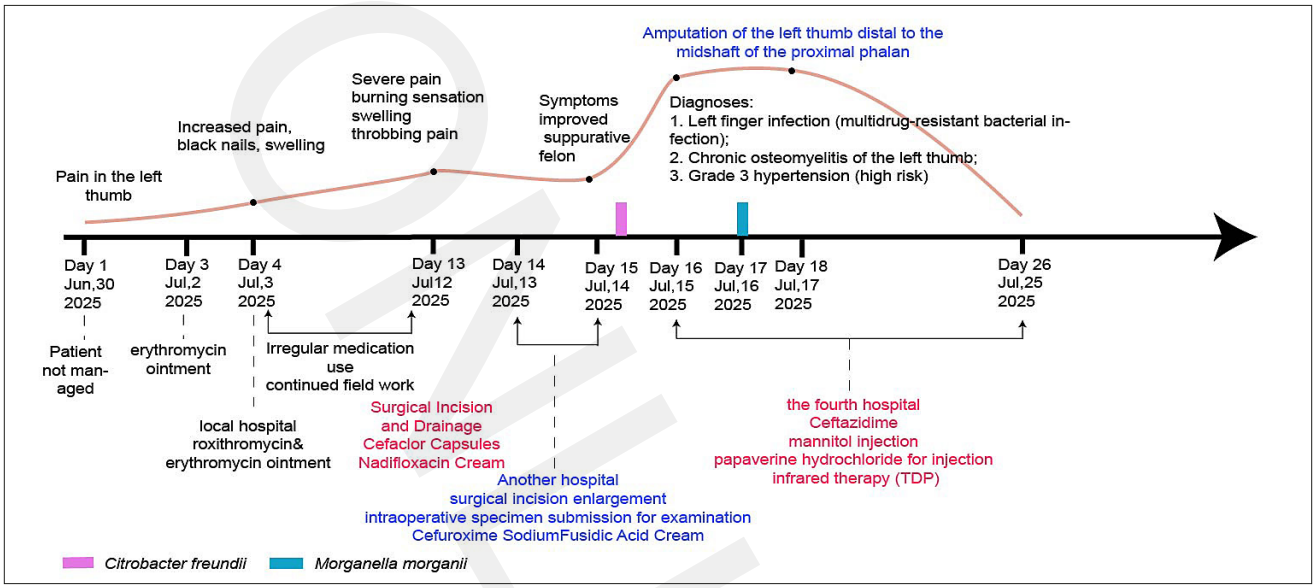

Figure 1. Timeline of key clinical events and microbiological findings

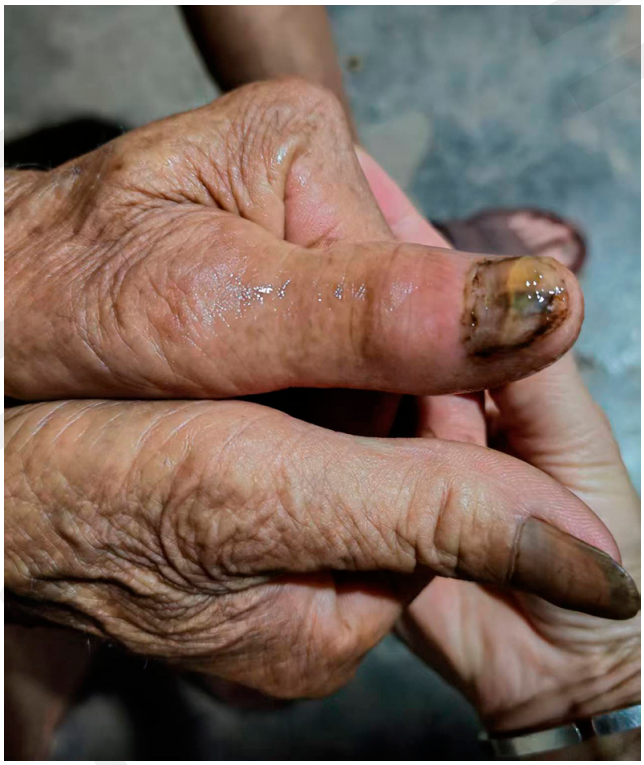

Figure 2. Clinical presentation on Day 4 showing periungual inflammation

13 July. The patient was transferred to a tertiary hospital and diagnosed with suppurative felon. Vital signs were stable. White blood cell count was 7.79×10^9/L (normal range: 3.5–9.5×10^9/L) with 72% neutrophils (40–75%), but high-sensitivity C-reactive protein (hs-CRP) was elevated at 13.26 mg/L (<6mg/L). (Patient's laboratory parameters are shown in Table 1). Treatment included extended incision and drainage, intravenous cefuroxime sodium (0.75 g twice daily), and topical fusidic acid cream. Symptoms significantly improved by the next day (swelling reduced by 50%, VAS 3/10) (Fig. 4).

14 July. Pus culture from surgery identified *C. freundii* via Matrix-Assisted Laser Desorption/Ionization Time of Flight

Figure 3. Clinical presentation on Day 13 showing diffuse swelling

Table 1. Laboratory parameters of the patient

Parameter	7.13 Finding	7.15 Finding	Unit	Reference Range
White Blood Cell (WBC)	7.79	8.47	×10^9/L	3.5–9.5
Neutrophil Count (NEU)	5.61	4.83	×10^9/L	1.8–6.3
Lymphocyte Count (LYM)	1.57	2.87	×10^9/L	1.1–3.2
Monocyte Count (MONO)	0.58	0.60	×10^9/L	0.10–0.60
Eosinophil Count (EOS)	0.03	0.16	×10^9/L	0.02–0.52
Basophil Count (BASO)	0.00	0.01	×10^9/L	0–0.06
Neutrophil Ratio (NEU-R)	72.00	57.00	%	40–75
Red Blood Cell (RBC) Count	4.38	4.54	Million/mm^3	4.5–5.5
Haemoglobin (HGB)	129↓	135	g/L	130–175
High-sensitivity C-reactive Protein (hs-CRP)	13.26↑	3.25	mg/L	0–6.0

Supplementary Notes
Detection methods: Routine blood tests were performed using a Sysmex XN-1000 automatic haematology analyzer; hs-CRP was measured by immunoturbidimetry.
Key note: hs-CRP on July 13 was 13.26 mg/L (reference range: 0–6.0 mg/L), indicating a significant inflammatory response.
All tests were completed within 2 hours after admission. Sample types: EDTA-anticoagulated venous blood for routine blood tests, and serum for hs-CRP detection.
HGB increased to 135 g/L on July 15, indicating alleviation of the body's stress response after inflammation control.

Figure 4. Clinical presentation on Day 15 Suppurative paronychia

Mass Spectrometry(MALDI-TOF MS). Minimum inhibitory concentration (MIC) results are shown in Table 2.

15 July. The patient was transferred to the Orthopaedic Department. Repeat blood tests showed a WBC of 8.47×10^9/L, 57% neutrophils, and hs-CRP of 3.25 mg/L. An anteroposterior X-ray of the left hand indicated osteomyelitis of the distal phalanx (Fig. 5). Besides abscess debridement, treatment was adjusted to intravenous ceftazidime (1 g every 12 hours), mannitol for oedema, and TDP therapy.

17 July. Deep wound tissue culture obtained via sterile debridement detected *M. morganii*. MIC results are shown in Table 2.

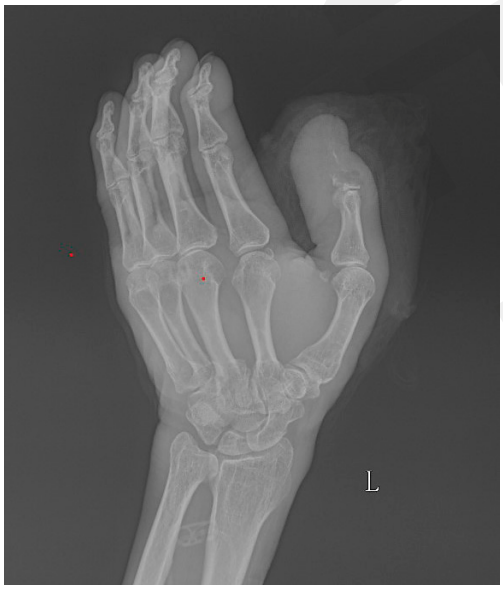

Figure 5. AP X-ray suggestive of osteomyelitis

Table 2. Microbiological results and antimicrobial susceptibility testing

Antimicrobial Agent	(7.14) *C. freundii* (MALDI-TOF MS)	MIC (μg/mL)	(7.17) *M. morganii* (Pure Culture)	MIC (μg/mL)
Ticarcillin/clavulanic acid	S	≤8	-	-
Piperacillin	S	≤4	-	-
Amoxicillin/clavulanic acid	R*	4	-	-
Piperacillin/tazobactam	S	≤4	S	≤4/4
Cefepime	S	≤1	S	≤0.12
Cefotaxime	S	≤1	S	≤0.12
Ceftriaxone	S	≤1	-	-
Cefotetan	R*	≤4	-	-
Cefizoxime	S	≤1	-	-
Cefuroxime	R*	4	R	≥64
Cefuroxime axetil	R*	4	-	-
Ceftazidime	S	≤1	S	≤0.5
Cefpodoxime	S	2	-	-
Aztreonam	S	≤1	-	-
Doripenem	S	≤0.12	-	-
Ertapenem	S	≤0.5	S	≤0.015
Imipenem	S	≤0.25	I	=2
Meropenem	S	≤0.25	S	≤0.06
Gentamicin	S	≤1	S	≤1
Amikacin	S	≤2	R	≥64
Ciprofloxacin	I	0.5	-	-
Levofloxacin	I	1	S	≤0.12
Nalidixic acid	-	≥32	-	-
Norfloxacin	-	2	-	-
Trimethoprim-sulfamethoxazole	S	≤1	-	-
Tigecycline	S	≤0.5	-	-
Cefalotin	-	32	-	-
Nitrofurantoin	-	≤16	-	-
Ticarcillin	-	≤8	-	-
Moxifloxacin	-	2	-	-

Susceptibility interpretation follows Clinical and Laboratory Standards Institute [CLSI] M100-S34 standard for execution.
Abbreviations: *C. freundii* = *Citrobacter freundii*; *M. morganii*=*Morganella morganii*; MIC= minimum inhibitory concentration; S = Susceptible [MIC≤breakpoint], I = Intermediate [MIC between breakpoints]; R = Resistant [MIC≥ breakpoint].

Final diagnoses. 1) Multidrug-resistant bacterial infection of the left thumb; 2) Chronic osteomyelitis of the left thumb; 3) Grade 3 hypertension. Amputation distal to the mid-segment of the proximal phalanx was performed on 17 July (Fig. 6. Intraoperative photograph during amputation). Postoperative antibiotic therapy was continued (Fig. 7). Postoperative anteroposterior appearance on July 18)

21 July. Pathology confirmed the diagnosis of osteomyelitis (Fig. 8). Photomicrograph of pathological specimen confirming osteomyelitis (H&E stain, magnification×100).

Outcomes. No infection recurrence was observed at the one-month follow-up (Fig. 9). One-month follow-up, showing a well-healed amputation stump). Unfortunately, the patient was rated with a Grade 10 disability according to the *Chinese Classification of Human Injury and Disability* [11].

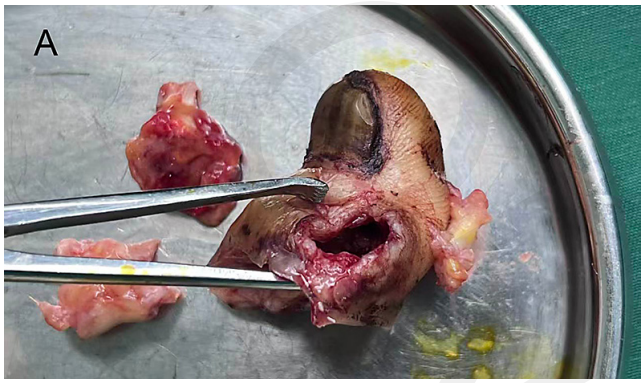

Figure 6. A. Left thumb amputation distal to the middle segment of the proximal phalanx, intraoperative photos

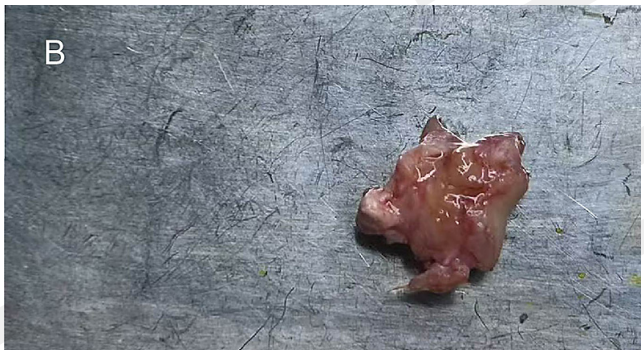

Figure 6. B. Left thumb amputation distal to the middle segment of the proximal phalanx, intraoperative photos

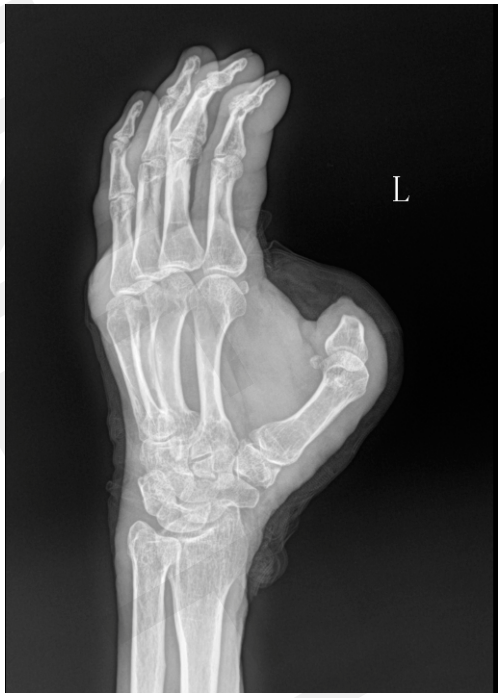

Figure 7. Postoperative AP X-ray. The proximal phalanx of the thumb, distal to its proximal end, is completely absent

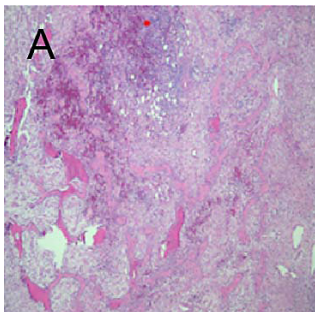

Figure 8. A. Pathological diagnosis (H&E stain, magnification×100)

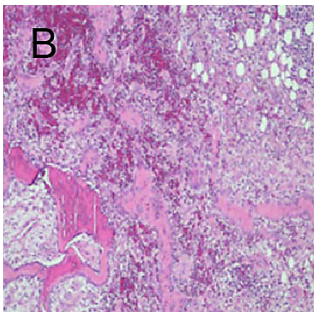

Figure 8. B. Pathological diagnosis (H&E stain, magnification×100)

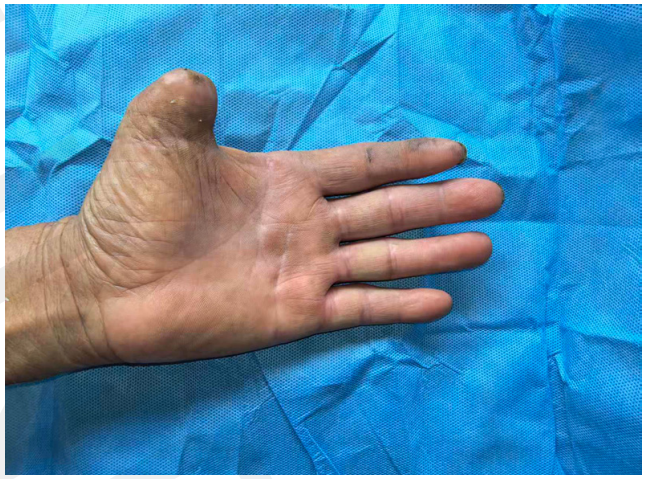

Figure 9. One-month follow-up, showing a well-healed amputation stump

DISCUSSION

Given the complexity of acute bacterial skin and skin structure infections, inappropriate management due to misdiagnosis, underestimation or overestimation of severity, failure to identify risk factors, or the use of incorrect types or durations of antibiotics, is not uncommon, regardless of whether the infection is acquired in the community or in a hospital setting [12]. This case illustrates how a minor soil-contaminated injury can progress to a devastating outcome due to a combination of clinical and management factors.

The initial breach in the skin barrier, likely caused by sharp soil particles, allowed for microbial invasion [13]. The non-adherence of the patient to rest recommendations exacerbated tissue damage [5]. A critical flaw in the initial management was the lack of deep microbiological sampling and the empirical use of cephalosporins (cefaclor, cefuroxime). This may have suppressed competing flora, eliminating the 'competitive exclusion' effect, and creating an ecological niche for the subsequent colonization by *M. morganii*, which possesses intrinsic resistance to many beta-lactams [14, 15, 16]. The co-occurrence of these bacteria suggests potential synergy, where *C. freundii* biofilm might provide a protective environment, and *M.morganii's* urease activity could further optimize the microenvironment for co-survival [17, 18].

The advanced age of the patient was a significant host factor. Immunosenescence and impaired skin barrier function predispose the elderly to severe infections, which often present with attenuated signs and symptoms, leading to diagnostic delay [9, 10, 19, 20].

The management of complex hand infections requires a multifaceted approach: thorough surgical debridement and drainage, targeted antimicrobial therapy based on culture and susceptibility results, and immobilization [21, 22]. The initial treatments in this case were insufficient in both surgical radicalness and antibiotic selectivity. The necessity is emphasized of 'dynamic microbiological monitoring' for soil-related infections failing initial therapy, with repeat deep tissue sampling every 48–72 hours to guide appropriate treatment [23, 24].

For high-risk populations like farmers, the focus should shift from treatment to prevention. Community health initiatives should promote 'wound protection and early management': using puncture-resistant gloves, avoiding direct contact with contaminated soil, immediate wound cleansing with soap and water followed by chlorine-based disinfectants, and seeking prompt medical attention [5]. For established severe infections, proactive consultation is recommended with a multidisciplinary team (MDT) – including infectious diseases, orthopaedics, microbiology, and rehabilitation – within 24 hours of admission to formulate an individualized plan.

CONCLUSIONS

This case reports a rare co-infection with *C. freundii* and *M. morganii* causing osteomyelitis after soil exposure. It underscores the dynamic nature of the pathogenic spectrum in complex wounds and the pitfalls of empirical therapy without adequate microbiological guidance. The proposed strategy of 'continuous microbial monitoring + ecologically rational antimicrobial selection + proactive MDT involvement' is essential for improving outcomes in high-risk individuals with agriculture-related infections.

REFERENCES

1. Roesch LF, Fulthorpe RR, Riva A, et al. Pyrosequencing enumerates and contrasts soil microbial diversity. ISME J. 2007;1(4):283–90. doi:10.1038/ismej.2007.53
2. Nesme J, Cécillon S, Delmont TO, et al. Large-scale metagenomic-based study of antibiotic resistance in the environment. Curr Biol. 2014;24(10):1096–100. doi:10.1016/j.cub.2014.03.036
3. Anedda E, Ekhlas D, Alexa E, et al. Characterization of antimicrobial resistant Enterobacterales isolated from spinach and soil following zinc amendment. Environ Pollut. 2024;361:124774. doi:10.1016/j.envpol.2024.124774
4. Liu H, Zhu J, Hu Q, Rao X. *Morganella morganii*, a non-negligent opportunistic pathogen. Int J Infect Dis. 2016;50:10–7. doi:10.1016/j.ijid.2016.07.006
5. Flevas DA, Syngouna S, Fandridis E, et al. Infections of the hand: an overview. EFORT Open Rev. 2019;4(5):183–93. doi:10.1302/2058-5241.4.180082
6. Stricker T, Fröhlich S, Nadal D. Osteomyelitis and septic arthritis due to *Citrobacter freundii* and *Haemophilus* influenzae type b. J Paediatr Child Health. 1998;34(1):90–1. doi:10.1046/j.1440-1754.1998.00161.x
7. Adhikari S, Kc S, Dev S, et al. *Citrobacter freundii*-associated osteomyelitis and thromboembolic events following Moderna COVID-19 vaccination: a rare case report from Nepal. Ann Med Surg (Lond). 2023;85(11):5789–94. doi:10.1097/MS9.0000000000001351
8. De A, Raj HJ, Maiti PK. Biofilm in osteomyelitis caused by a rare pathogen, *Morganella morganii*: a case report. J Clin Diagn Res. 2016;10(6):DD06–8. doi:10.7860/JCDR/2016/18666.7990
9. Lee H, Hong Y, Kim M. Structural and functional changes and possible molecular mechanisms in aged skin. Int J Mol Sci. 2021;22(22):12489. doi:10.3390/ijms222212489
10. Suaya JA, Eisenberg DF, Fang C, Miller LG. Skin and soft tissue infections and associated complications among commercially insured patients aged 0–64 years with and without diabetes in the U.S. PLoS One. 2013;8(4):e60057. doi:10.1371/journal.pone.0060057
11. Ministry of Justice of the People's Republic of China. Classification of human injury and disability [Internet]. Beijing: The Ministry; 2021 Apr 30 [updated 2021 Apr 30; cited 2025 Sep 10]. Available from: http://www.moj.gov.cn/pub/sfbgw/xxgkfd/202104/t20210430_150885.html
12. Pulido-Cejudo A, Guzmán-Gutierrez M, Jalife-Montaño A, et al. Management of acute bacterial skin and skin structure infections with a focus on patients at high risk of treatment failure. Ther Adv Infect Dis. 2017;4(5):143–61. doi:10.1177/2049936117723228
13. Uberoi A, McCready-Vangi A, Grice EA. The wound microbiota: microbial mechanisms of impaired wound healing and infection. Nat Rev Microbiol. 2024;22(8):507–21. doi:10.1038/s41579-024-01035-z
14. Gavish N. Revisiting the exclusion principle in epidemiology at the limit of a large competitive advantage. J Theor Biol. 2025;600:112045. doi:10.1016/j.jtbi.2025.112045
15. Letten AD, Hall AR, Levine JM. Using ecological coexistence theory to understand antibiotic resistance and microbial competition. Nat Ecol Evol. 2021;5(4):431–41. doi:10.1038/s41559-020-01385-w
16. Poirel L, Guibert M, Girlich D, et al. Cloning, sequence analyses, expression, and distribution of ampC-ampR from *Morganella morganii* clinical isolates. Antimicrob Agents Chemother. 1999;43(4):769–76. doi:10.1128/AAC.43.4.769
17. Giorgi F, Curran JM, Patterson EA. Real-time monitoring of the dynamics and interactions of bacteria and the early-stage formation of biofilms. Sci Rep. 2022;12(1):18146. doi:10.1038/s41598-022-22669-0
18. Young GM, Amid D, Miller VL. A bifunctional urease enhances survival of pathogenic Yersinia enterocolitica and *Morganella morganii* at low pH. J Bacteriol. 1996;178(22):6487–95. doi:10.1128/jb.178.22.6487-6495.1996
19. Falcone M, Tiseo G. Skin and soft tissue infections in the elderly. Curr Opin Infect Dis. 2023;36(2):102–8. doi:10.1097/QCO.0000000000000907
20. Gbinigie OA, Ordóñez-Mena JM, Fanshawe T, et al. Limited evidence for diagnosing bacterial skin infections in older adults in primary care: systematic review. BMC Geriatr. 2019;19:45. doi:10.1186/s12877-019-1061-y
21. Weeks LE, Scheker LR. Upper extremity wound management. J Ky Med Assoc. 1990;88(7):337–41.
22. Costa FG, Horswill AR. Overcoming pH defenses on the skin to establish infections. PLoS Pathog. 2022;18(5):e1010512. doi:10.1371/journal.ppat.1010512
23. Price LB, Liu CM, Melendez JH, et al. Community analysis of chronic wound bacteria using 16S rRNA gene-based pyrosequencing: impact of diabetes and antibiotics on chronic wound microbiota. PLoS One. 2009;4(7):e6462. doi:10.1371/journal.pone.0006462
24. Tipton CD, Mathew ME, Wolcott RA, et al. Temporal dynamics of relative abundances and bacterial succession in chronic wound communities. Wound Repair Regen. 2017;25(4):673–9. doi:10.1111/wrr.12555