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Editorial

Antimicrobial Resistance in the Time of COVID-19

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The world is presently dealing with two pandemics—COVID-19 and antibiotic resistance (AMR)—that constitute a serious menace to public health on a worldwide basis [1]. The World Health Organization (WHO) designated COVID-19 as a pandemic on 10 March 2020, and despite the discovery of extremely effective vaccines and both pharmaceutical and non-pharmacological therapies, this virus has persisted in causing illness and social disruption on an unprecedented scale [2]. SARS-CoV-2 virus infection is the cause of COVID-19 [3]. COVID-19 can cause moderate respiratory sickness, severe lung injury, systemic inflammation, and even death.

At the start of the pandemic, the studies conducted by Bengoechea and Bamford [4] and Cantón et al. [5] emphasized the connection between COVID-19 and AMR. COVID-19 patients from German intensive care units had vanB clones of *Enterococcus faecium* [6]. Four out of every five severely ill COVID-19 patients admitted to the medical center died as a result of the isolation of *Enterobacter cloacae*, which produced New Delhi metallo-beta-lactamase (NDM) from these patients [7]. The outcomes of these patients were affected by NDM-beta-lactamase-producing carbapenem-resistant *Enterobacterales.* Extended hospital stays enhance the risk of contracting bacterial infections. Along with that, COVID-19 patients have an elevated risk of invasive fungal infections. A fatal COVID-19 case was reported by Posteraro et al. [8] from Italy, where the patient was co-infected with pan-echinocandin-resistant *Candida glabrata* and resistant bacteria, leading to the death of the patient. Antimicrobial therapy for *Aspergillus* infections has also been demonstrated to be ineffective in several investigations [9].

The WHO has put forth guidelines to prevent antimicrobial infections. Antibiotics are prohibited to be used by patients having minor bacterial co-infections, whereas empirical antibiotics can be employed in cases with severe COVID-19 symptoms [10]. The rules for enhancing antimicrobial stewardship and preventing AMR have been appropriately outlined. Furthermore, the antimicrobial stewardship program will undoubtedly be detailed and will raise awareness of AMR by outlining a few rules, such as infection prevention and control [11].

Furthermore, the COVID-19 pandemic has raised awareness of a few general hygiene practices that are critical for monitoring infections, including hand hygiene, hand social distancing, and surface disinfection, all of which lowers the likelihood of AMR. It is possible that the overuse of antibiotics during this pandemic reduced some medications' effectiveness against particular microorganisms. Current antibiotics are losing their effectiveness since no new ones are being developed, which will have terrible long-term effects [12].

This Special Issue on "Antimicrobial resistance in the time of COVID-19" discusses how the threat caused by COVID-19 is further complemented by the increased bacterial resistance against the already known and used antibiotics, inviting a hidden pandemic called AMR. Five articles were collected following rigorous peer review. These articles cover the antimicrobial prescription following COVID-19 and healthcare-acquired infections (HAIs) caused by the high-priority bacterial agent *Pseudomonas aeruginosa*, which frequently

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results in serious infections and a poor prognosis in susceptible individuals. They also cover use of disinfectants containing benzalkonium chloride (BAC), consisting of both ammonium chloride molecules and alkyl benzyl dimethyl in greater quantities during COVID-19, which could aid in the emergence of cross-resistance and antimicrobial tolerance, the use of probiotics as a substitute to chemical disinfectants, and microbes associated with the lower respiratory tract of the COVID-19 infected patient.

The study of Celaya Corella et al. [13] set out to identify the most prevalent bacteria found in COVID-19 patients at the General Hospital of Mexicali. In the two previous worldwide pandemics brought on by viruses, bacterial co-infections have been documented. Retrospective observational research data from 1979 patients were gathered. They were all exhibiting signs of respiratory illnesses, and the authors used nasopharyngeal swab samples for real-time polymerase chain reaction testing. Out of 1979 patients, 319 tested negative, and they were not included. A total of 1063 patients showed positive COVID-19 test findings; 102 (or 10.34%) of them also had respiratory co-infections. They examined and identified the microbes in patients who were co-infected. Numerous microbes, such as fungi and bacteria, were discovered. *Acinetobacter baumannii* was the most common of all the species, found in 64 patients (37.2%).

Healthcare-acquired infections (HAIs) are caused by *Pseudomonas aeruginosa*, resulting in poor prognosis and serious infections in susceptible individuals, as studied by Dos Santos et al. [14]. Growing AMR is connected to the São Paulo metallo-β-lactamase (SPM) emergence and poses a public health concern. Thus, the purpose of this study was to identify the genotyping characteristics, virulence, and antibiotic resistance of *P. aeruginosa* strains that produce SPM-1 in northern Brazil. The PCR method was employed to identify the presence of virulence and resistance genes, and the susceptibility profile of antimicrobials was obtained.

Disinfectants have been produced in greater quantities and used by consumers during the COVID-19 pandemic. The study by Pena et al. [15] showed that surface cleaning and disinfection products most commonly contain benzalkonium chloride (BAC), a combination of alkyl benzyl dimethyl ammonium chloride molecules. Due to this fact, BAC chemicals frequently come into contact with microbes in indoor settings, which could aid in the emergence of cross-resistance and antimicrobial tolerance. We exposed *Klebsiella pneumoniae*, *Staphylococcus epidermidis*, *Corynebacterium xerosis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* to BAC12–14 and purified a BAC16 mixture for studying the effect of BAC exposure on opportunistic and commensal bacteria with implications for public health. Antibiotic susceptibilities and minimum inhibitory concentrations (MICs) were measured prior to and after repetitive exposure to sublethal BAC concentrations. The MIC of Gram-negative bacteria was more than that of Gram-positive bacteria. Furthermore, opportunistic bacteria had BAC12–14 MICs that were noticeably higher, and tolerance to BAC was associated with cross-resistance to antibiotics. These findings warrant that widespread Gram-negative opportunistic pathogens may acquire antimicrobial tolerance preferentially after extended or recurrent exposure to BAC12–14. They may also be less susceptible to BAC inhibition than commensal species. It is necessary to reevaluate the concentration and formulation of goods containing *Bacillus cereus* to prevent the emergence of antibiotic co-resistance and antimicrobial tolerance.

Chemical disinfectants work well for immediate disinfection, but they can lead to recontamination and favor microorganisms resistant to antibiotics when applied to interior surfaces. A study by Ramoz and Frantz et al. [16] found that the use of traditional chemical disinfectants in built environments has significantly increased in reaction to the COVID-19 pandemic. As opposed to the conventional disinfection being used, probiotic-based sanitation (PBS) is predicated on the idea that probiotic bacteria, specifically apathogenic *Bacillus* spp., can outcompete and drive out infections when mixed with environmentally friendly detergents and sprayed on interior surfaces. Although the in situ studies evaluating the potential of PBS in healthcare settings are limited, the results have shown overwhelmingly beneficial outcomes, including a considerable decrease in pathogen burden, nosocomial infections, and antimicrobial-resistant genes.

In the Ghanaian community, headaches, *Moraxella catarrhalis* infection, and coughs are independent risk factors connected to SARS-CoV-2 infection. The study by Deberu et al. [17] revealed that *Pseudomonas* spp. and *Klebsiella* spp. are the predominant bacteria in the COVID-19 patient's sputum.

The articles in this Special Issue of this journal discuss the impact COVID-19 has posed on clinical care and healthcare settings, how antibiotic resistance has emerged as the hidden pandemic following COVID-19, disinfectants, and how disposable masks pose an AMR risk. This Special Issue aims to bring out the fact that AMR and COVID-19 are interacting emergencies that have an impact on one another when antibiotics are overprescribed and abused in the treatment of COVID-19 patients.

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