The Open COVID Journal
DOI: 10.2174/0126669587433466260604055556, 2026, 6, e26669587433466
ISSN: 2666-9587

EDITORIAL **OPEN ACCESS**

Repurposed Drugs and Pandemic Preparedness: Lessons from the COVID-19 Pandemic

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Cite as: Ramakrishnan J, Pulidindi I, Muthu S. Repurposed Drugs and Pandemic Preparedness: Lessons from the COVID-19 Pandemic. Open COVID J, 2026; 6: e26669587433466.
http://dx.doi.org/10.2174/0126669587433466260604055556

Received: July 27, 2025
Revised: October 29, 2025
Accepted: January 23, 2026
Published: June 15, 2026

1. INTRODUCTION

The COVID-19 pandemic tested global health systems by presenting a diagnostic and therapeutic vacuum. During the early stages of the outbreak in Wuhan, China, there were no specific antivirals. To fill the therapeutic vacuum, the scientific and medical communities rapidly began to repurpose drugs. Encouraging the identification of new indications for already approved drugs, drug repurposing has become a valuable tool to bridge the gap between urgent clinical needs and the long processes of traditional drug development. This article evaluates the drug repurposing activities attempted during the COVID-19 pandemic, focusing on their pharmacological and clinical insights and the role of technology in shaping pandemic response. While the idea of drug repurposing existed before the COVID-19 pandemic, the COVID-19 pandemic highlighted the relevance of the idea. It demonstrated the alignment of medical and administrative systems in even the most advanced countries, such as the US and China. The rapid shift of existing pharmacological agents to address an emerging infectious disease demonstrated the need for modern biomedicine and the importance of interdisciplinary efforts during a crisis. Traditionally, therapeutic breakthroughs have occurred as a result of drug repurposing. Some examples include the use of sildenafil to treat erectile dysfunction and duloxetine to treat stress urinary incontinence, which illustrate the innovative capability of existing therapies [1, 2]. These findings helped us figure out a plan for conducting research that can skip toxic-substance checks and speed up the path to human trials. The conventional process of developing drugs from scratch is time-consuming, often taking more than ten years, and is associated with substantial costs. Using drugs that are already known to be safe, which is called repurposing, is different. Repurposing involves the use of drugs that have already been proven to be safe. This means we can shorten parts of the research process, which is very helpful when we have big health problems, like COVID-19, and need to solve them soon. Repurposing is one way to do this, as it saves time and money [3].

During the pandemic, some existing drugs were found to have potential for combating the virus. Researchers considered drugs that could possess immunomodulatory properties. Three drugs were much in the spotlight globally: remdesivir, dexamethasone, and tocilizumab. Remdesivir was originally developed to treat Ebola. It was found to work against SARS-CoV-2 in lab tests. Studies in hospitals showed that remdesivir helped patients recover faster. It took patients who received remdesivir 11 days to

recover, versus 15 days for those who did not in the ACTT-1 trial [4, 5]. Its approval under the U.S. FDA's Emergency Use Authorization marked a moment in the timeline of pandemic medicine [6]. Dexamethasone is a potent anti-inflammatory agent and has been shown to be beneficial in patients with severe COVID-19. The RECOVERY trial demonstrated that dexamethasone reduced mortality by up to 35% in critically ill patients with COVID-19 [7]. Dexamethasone is an affordable medicine. It costs more than two United States dollars for a ten-day course. Dexamethasone is available in over 120 countries. This makes Dexamethasone more accessible than medicines like molnupiravir. Molnupiravir is very expensive. It costs over seven hundred United States dollars for one course. Tocilizumab, originally developed for the treatment of rheumatoid arthritis, exerts its effects by inhibiting the excessive inflammatory response associated with severe illness. It has been shown to effectively reduce systemic inflammation, and when used in combination with dexamethasone, it improves clinical outcomes in patients with severe disease. Moreover, this combination therapy has been associated with improved survival in critically ill patients. Studies such as REMAP-CAP and RECOVERY have demonstrated that the combination of tocilizumab and dexamethasone improves survival in patients with severe COVID-19. This combination therapy has been reported to reduce mortality by 15–30% [8]. These successes highlighted the potential of repurposing existing drugs to address disease mechanisms within a relatively short period. Researchers employed computational simulations and molecular studies to identify compounds with therapeutic potential. This assisted in validating available drugs and some newer ones as well. These drugs were repurposed to target novel mechanisms of the disease. Computer modelling and molecular dynamics studies validated existing SARS-CoV-2 targets and new leads identified from repurposed drugs [9-11].

Although drug repurposing holds promise, there are certain challenges. After an outbreak, the rush to find treatments led people to become overly enthusiastic about them prematurely. For instance, hydroxychloroquine and lopinavir/ritonavir were believed to be cure-all drugs, but these drugs did not provide any real benefits in large randomized trials [12]. Nevertheless, several challenges remain. Emergency Use Authorizations (EUAs) can facilitate access to drugs during public health emergencies; however, full regulatory approval requires extensive data on efficacy, safety, and manufacturing quality in compliance with regulatory standards. In addition, concerns regarding intellectual property and the limited financial incentives associated with drug repurposing, particularly for generic drugs, may discourage industry investment [13]. The pandemic has highlighted the need for rapid and effective responses based on the use of existing therapeutic agents rather than the development of new drugs. There should be a system to monitor the effects of drugs and identify their additional therapeutic applications. This would enable us to be better equipped for the future. In addition, dedicated databases or websites should be established to provide information on the observed effects of these drugs and the outcomes predicted by computational models [14-17]. Pharmaceutical companies are increasingly using computational approaches to identify new applications for existing drugs. Techniques such as molecular docking and artificial intelligence are employed to screen for potential therapeutic opportunities. These tools facilitate the identification of drug targets and the prediction of diseases for which existing drugs may be effective. Consequently, drug repurposing has become a more systematic and data-driven process. The continued advancement of computational technologies is further enhancing the efficiency and accuracy of drug repurposing strategies [14, 15]. The drug repurposing models that use artificial intelligence were evaluated by examining historical patient outcomes, such as those associated with remdesivir and baricitinib. To ensure the accuracy of these models, similar datasets are needed, along with experimental validation and open access to the data so that other researchers can reproduce the findings. During the COVID-19 crisis, drug repurposing enabled the use of drugs such as dexamethasone and tocilizumab, making them available to patients in both high- and low-income countries. This represents an important advantage of drug repurposing, as it facilitates global access to essential medicines, even when they are expensive or difficult to obtain during public health emergencies.The COVID-19 pandemic demonstrated that existing drugs can be highly beneficial during medical emergencies and can contribute to saving lives. The use of remdesivir, dexamethasone, and tocilizumab was particularly successful. These findings highlight that leveraging existing knowledge of medicines can improve patient outcomes while also reducing healthcare costs during pandemics such as COVID-19 [16-20].

CONCLUSION

This study proposes that drug repurposing is a core weapon for future pandemic prevention and control. However, to fully unlock its value, a mature system that integrates three types of supporting conditions must be established: regulatory flexibility with fast-track pathways, advanced computational tools, and mechanisms to guarantee equitable access, so that low-income countries are not left behind. Clinical practices from past global pandemics show that drug repurposing is not a one-size-fits-all solution: Remdesivir only delivers very limited mortality benefits; dexamethasone acts as a double-edged sword, with potential harm to non-hypoxemic patients who do not need oxygen therapy; and tocilizumab exhibits highly variable efficacy, which relies heavily on precise patient selection and whether it is used in combination with corticosteroids. In the future, we must shift from inflexible traditional trial models to adaptive trial designs and precise patient stratification to clarify the suitability of specific drugs for specific patient groups.

AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

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