

Erratum to “Stability Analysis and Optimal Control of a Fractional-Order Glioma-Immune Model under Combined Therapy” [Journal of Applied Mathematics and Physics (2026) 190-230]

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The original version of this article (Azizi, S. (2026) Stability Analysis and Optimal Control of a Fractional-Order Glioma-Immune Model under Combined Therapy. *Journal of Applied Mathematics and Physics*, **14**, 190-230. [doi:10.4236/jamp.2026.141010](https://doi.org/10.4236/jamp.2026.141010)) was published, as some results data were reported mistakenly. The author wishes to correct the errors.

Abstract

This study presents a novel fractional-order mathematical model to investigate the dynamics of glioma-immune interactions under therapeutic interventions. Building upon and extending previous models by de Pillis *et al.*, we incorporate immune checkpoint inhibition and fractional-order derivatives to capture the memory-dependent behavior of immune responses. The model distinguishes between therapy-sensitive and resistant glioma cells and includes key immune components such as natural killer cells, cytotoxic T lymphocytes, cytokines, and exhausted effectors. The model distinguishes between therapy-sensitive and resistant glioma cells and includes key immune components such as natural killer cells, cytotoxic T lymphocytes, cytokines, and exhausted effectors. An optimal control problem is formulated with three control variables representing immunotherapy, virus therapy, and checkpoint blockade. The forward-backward sweep method is employed to compute optimal treatment strategies over a 50-day horizon. Numerical simulations demonstrate that the fractional-order framework significantly influences treatment outcomes, with lower fractional orders delaying immune activation and reducing therapeutic efficacy. The proposed optimal control strategy achieves superior

glioma suppression and immune activation compared to monotherapies and fixed-dose combinations. These findings highlight the importance of incorporating memory effects and multimodal control in the design of effective glioma treatment protocols.

Appendix

The table below lists the parameters used in the simulations, along with their descriptions, values, and units.

Parameter	Description	Value	Unit
α	Fractional order of the system	0.5 - 1.0	–
$T_s(0)$	Initial therapy-sensitive glioma cells	0.5	dimensionless
$T_r(0)$	Initial therapy-resistant glioma cells	0.2	dimensionless
$N(0)$	Initial NK cell population	1.0	dimensionless
$C(0)$	Initial CTL population	0.1	dimensionless
$I(0)$	Initial cytokine level	0.05	dimensionless
$E(0)$	Initial exhausted CTLs	0.01	dimensionless
$M(0)$	Initial drug concentration	0.0	dimensionless
$B(0)$	Initial virus concentration	0.0	dimensionless
$P(0)$	Initial checkpoint molecule level	0.1	dimensionless
β_1	Glioma proliferation rate	0.3	day ⁻¹
δ_1	Immune-induced glioma death rate	0.1	day ⁻¹
γ	Cytokine production rate	0.05	day ⁻¹
μ	Natural decay rate of immune cells	0.01	day ⁻¹
η	Checkpoint inhibition efficacy	0.2	dimensionless