

Optimal Drug Usage for Cancer Treatment

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Countries grappling with dollar shortages and economic crises are encountering challenges in meeting the demand for medicines, particularly drugs used in cancer treatment. To control the spread of tumor cells, treatment should be given. When the treatments are increased the tumor cells will be reduced, but the side effects will be increased and the drug availability will be decreased. To compromise between these competing factors optimal control strategies can be used. A mathematical model was established using optimal control theories for the above scenario. Tumor density was modeled as the state variable while the side effects and drug availability were taken as the control variables. The objective is to study how to optimize the treatment where tumor density is minimized while the drug effects and the drug availability are maintained at an optimal level. While drug shortage is being an issue, overstocking of drugs is also a problem which is considered in the model. A set of necessary conditions namely the adjoint equation, transversality condition, optimality condition, and state equation were obtained via Pontryagin's principle and a function called the Hamiltonian. In the solving process, the differential equations were solved numerically. The optimal control variables with corresponding state variable that optimize the treatment were obtained. Finally, simulations were carried out to interpret the outputs. One simulation can be stated where the model suggests using less drugs with higher strength to reduce more tumor density when the weight on minimizing tumor density is increased gradually. Similarly, the weights on minimizing drug effect and drug shortage also can be varied and interpreted. The research extends the existing understanding of cancer models by incorporating the notion of control variables, allowing for a more accurate representation of real scenarios.

Keywords: Optimal control model, Drug availability, Side effects, Tumor cells