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A mathematical model for diabetes presence with two control strategies - an optimal control approach

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Diabetes has emerged as a global health concern that occurs when there are problems with insulin production or effectiveness. Long-term uncontrolled diabetes can cause some complications, such as heart disease, kidney disease, nerve damage, and vision issues, that may need to be amputated. However, with effective management of diabetes, individuals with diabetes can lead healthy and fulfilling lives. In this study, we developed a mathematical model of optimal control by utilizing two strategies for controlling the growth of the diabetic population. Our control strategies were an awareness program by raising awareness of the importance of following a diet plan along with maintaining good health care and regular testing, and an awareness program for diabetes without complications. We derive the optimality system using Pontryagin's maximum principle, and then we solve the system numerically using the fourth-order Runge-Kutta method. According to our model results, an optimal control can reduce the overall burden of diabetes by limiting the number of pre-diabetics and diabetics with and without complications. By applying these two controls number of pre-diabetics, diabetes without complications, and diabetes with complications decreased by 44%, 78%, and 76% respectively in 50 years.

Keywords: Diabetes, Mathematical Model, Optimal Control, Runge-Kutta method, Pontryagin's maximum principle

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