



**FIG. 1** Results of the primary infection case. The top-left graph is the concentration of susceptible cells ( $S(t)$ ) which is reduced to less than 350 Cells/ $\mu\text{L}$ -blood at the end of the treatment. The top right graph shows the concentration of infected cells ( $I(t)$ ) that has some fluctuations during the treatment and eventually reaches less than 0.3 Cells/ $\mu\text{L}$ -blood. Middle graphs are the concentration of free HCMV (*left*), and  $E_V(t)$  as the concentration of HCMV-specific CD8<sup>+</sup> T cells (*right*). Viral loads ( $V$ ) are more than their defined limit in about one month of the treatment period and show similar fluctuations to the infected cells' response. Bottom graphs are  $E_K(t)$ , the concentration of allospecific CD8<sup>+</sup> T cells that target kidney (*left*), and  $C(t)$ , the serum creatinine concentration (*right*). Response value for  $E_K(t)$  has tracked its desired value appropriately. The serum creatinine of the blood is also below its defined threshold for the whole treatment process. Solid lines are result values in response to the control input, dashed lines are the thresholds for viral load (3.5 Copies/ $\mu\text{L}$ -blood) and serum creatinine concentration (1.2 mg/dL) and dotted dashed line is the desired value of  $E_K(t)$ .

comparison with final values obtained in the original situation. All other variables have the opposite trend, in which the 30% increment in  $\lambda_{EK}$  results in 133%, 140% and 7% increase in the maximum populations of the infected cells, viruses and final value of the immunosuppressive drug, respectively. Viral load violated its threshold three times when the value of  $\lambda_{EK}$  is raised 30% and it never reached this threshold with the 30% reduction of  $\lambda_{EK}$  in both primary and reactivation cases. Also, the final value of the control signal has changed 16% compared to the final magnitude reached in the original situation, with a 30% reduction of  $\lambda_{EK}$ . Therefore, the value of  $\lambda_{EK}$  has a significant effect on both immunosuppression and antiviral therapies and it should be considered.

**Fig. 6** demonstrates the susceptible cells ( $S$ ), infected cells ( $I$ ), virions ( $V$ ) and control signals ( $\epsilon$ ) as four main variables that have noticeable changes in response to a 30% variation of  $\delta_{EK}$ . In both primary and reactivation cases, the final number of susceptible cells ( $S$ ) approximately increases 5.5% with increasing the magnitude of  $\delta_{EK}$  for 30% and vice versa (compared to the condition with original parameters). However, other variables  $I$  and  $V$  reduced 66%, 50% in their maximum values and  $\epsilon$  decreased 14% in its final value by 30% increment in  $\delta_{EK}$ , respectively. These trends are completely opposite to the ones observed in **Fig. 5** for the sensitivity analysis of  $\lambda_{EK}$ . This change is highly noticeable in viral load ( $V$ ) that its magnitude experienced a maximum around 14 Copies/ $\mu\text{L}$ -blood in both primary and reactivation