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The Role of Interferon Therapy in Stabilizing Metabolic Liver Diseases

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INTRODUCTION & AIM

Metabolic diseases such as diabetes, obesity, and insulin resistance pose significant global health burdens. These conditions adversely affect liver function, often leading to complications like non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH). The liver, as a central organ in glucose and lipid metabolism, is particularly vulnerable to such disruptions. Interferon therapy has shown promise in mitigating liver damage and modulating immune responses. This study aims to develop a mathematical model to capture the dynamics of liver disease progression influenced by metabolic disorders. The model incorporates the effect of interferon therapy on disease transmission and treatment outcomes. The objective is to identify conditions that ensure disease control and guide effective therapeutic strategies.

MODEL EQUATION

We consider a compartmental model with the following state variables:

$$\frac{dS}{dt} = \Lambda - \beta SI - \mu S$$
$$\frac{dI}{dt} = \beta SI - (\gamma + \delta + \mu)I$$
$$\frac{dT}{dt} = \gamma I - (\mu + \rho)T$$

$$S_0 \geq 0, \quad I_0 \geq 0, \quad T_0 \geq 0$$

S(t) : Susceptible individuals with metabolic conditions (at risk of liver complications)
I(t) : Infected individuals (with liver complications such as NAFLD/NASH)
T(t) : Treated individuals receiving interferon therapy

Table 1. Description of parameters used in the model.

Parameter	Description	Unit
Λ	Recruitment (entry) rate into susceptible class	individuals/day
β	Transmission rate from susceptible to infected	1/(individual·day)
μ	Natural death rate	1/day
δ	Disease-induced death rate (from liver complications)	1/day
γ	Rate of starting interferon therapy	1/day
ρ	Recovery rate due to interferon therapy	1/day

RESULTS & DISCUSSION

Equilibrium Analysis:

$$\text{DFE} = \left(\frac{\Lambda}{\mu}, 0, 0\right)$$

EE

$$S^* = \frac{\gamma + \delta + \mu}{\beta}$$
$$I^* = \frac{\Lambda}{\gamma + \delta + \mu} - \frac{\mu}{\beta}$$
$$T^* = \frac{\gamma I^*}{\mu + \rho}$$

Using the next-generation matrix method, the basic reproduction number is:

$$R_0 = \frac{\beta S^*}{\gamma + \delta + \mu} = \frac{\beta \Lambda}{\mu(\gamma + \delta + \mu)}$$

STABILITY ANALYSIS

1. If $R_0 < 1$, the disease-free equilibrium is locally asymptotically stable, and the disease will die out.
2. If R_0 >1, the disease-free equilibrium is unstable, and the disease may persist.

CONCLUSION

This study presents a mathematical model to analyze liver complications arising from metabolic diseases and assesses the impact of interferon therapy. The model identifies critical thresholds, particularly the basic reproduction number R_0 to determine disease persistence or elimination. Interferon therapy effectively reduces R_0 promoting stability in liver health. The findings offer insights into optimizing treatment strategies for better disease control. This work contributes to informed public health interventions targeting metabolic-related liver diseases.

REFERENCES

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