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Mathematics of a sex-structured model for Syphilis transmission dynamics

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Syphilis, a major sexually-transmitted disease, continues to pose major public health burden in both under-developed and developed nations of the world. This study presents a new two-group sex-structured model for assessing the community-level impact of treatment and condom use on the transmission dynamics and control of syphilis. Rigorous analysis of the model shows that it undergoes the phenomenon of backward bifurcation. In the absence of this phenomenon (which is shown to arise due to the re-infection of recovered individuals), the disease-free equilibrium of the model is shown to be globally-asymptotically stable (GAS) when the associated reproduction number is less than unity. Furthermore, the model can have multiple endemic equilibria when the reproduction threshold exceeds unity. Numerical simulations of the model, using data relevant to the transmission dynamics of the disease in Nigeria, show that, with the assumed 80% condom efficacy, the disease will continue to persist (i.e., remain endemic) in the population regardless of the level of compliance in condom usage by males. Furthermore, detailed optimal control analysis (using Pontraygin's Maximum Principle) reveals that for situations where the cost of implementing the controls (treatment and condom-use) considered in this study is low, channeling resources to a treatment-only strategy is more effective than channeling them to a condom-use only strategy. Furthermore, as expected, the combined condom-treatment strategy provides a higher population-level impact than the treatment-only strategy or the condom-use only strategy. When the cost of implementing the controls is high, the three strategies are essentially equally as ineffective.

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