

# Model Matematika Penyebaran Koinfeksi Penyakit Tuberkulosis dan Covid-19 = A Mathematical Model of the Spread of Tuberculosis and Covid-19 Co-infection

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## Abstrak

Terdapat cukup banyak penyakit berbahaya yang menular melalui udara, diantaranya adalah Tuberkulosis dan Covid-19. Tuberkulosis (TB) merupakan penyakit yang disebabkan oleh bakteri *Mycobacterium tuberculosis*. Berbeda dengan TB, Covid-19 merupakan penyakit menular yang disebabkan oleh virus SARS-CoV-2. Tuberkulosis dan Covid-19 merupakan penyakit yang cukup serupa. Selain penularannya yang sama-sama melalui udara, secara umum kedua penyakit ini sama-sama menyerang pernapasan manusia. Koinfeksi dari kedua penyakit ini membuat situasi semakin memburuk. Pada skripsi ini, dikonstruksi model matematika penyebaran koinfeksi penyakit TB dan Covid-19. Dari model tersebut, dilakukan kajian analitik yang meliputi analisis eksistensi dan kestabilan titik keseimbangan penyakit serta analisis dan interpretasi bilangan reproduksi dasar  $R_0$ . Selain itu, diteliti juga mengenai bilangan reproduksi dasar invasi antar kedua penyakit. Kemudian dilakukan simulasi numerik yang mencakupi analisis elastisitas dan sensitivitas serta simulasi autonomous dari model. Analisis pada submodel single infection, yaitu model TB saja dan Covid-19 saja, juga dilakukan untuk melihat dinamika keberadaan kedua penyakit secara bersamaan. Dari kajian analitik yang dilakukan, diperoleh titik bebas penyakit yang stabil asimtotik lokal saat  $R_0 < 1$ . Namun, bifurkasi mundur mungkin terjadi saat  $R_0 = 1$  sehingga titik bebas penyakit tidak stabil secara global. Titik endemik model ada dan stabil asimtotik lokal saat  $R_0 > 1$ . Berdasarkan kajian numerik, diperoleh hasil bahwa perubahan laju infeksi TB dan Covid-19 secara bersamaan dapat memberikan pengaruh terhadap keberadaan penyakit TB-Covid-19 di populasi.

.....There are quite a number of dangerous diseases that are transmitted through the air, including Tuberculosis and Covid-19. Tuberculosis (TB) is a disease caused by the *Mycobacterium tuberculosis* bacteria. Unlike TB, Covid-19 is an infectious disease caused by the SARS-CoV-2 virus. Tuberculosis and Covid-19 are quite similar diseases. Apart from being transmitted through the air, these two diseases attack human respiration. The co-infection of these two diseases makes the situation even worse. In this thesis, a mathematical model for the spread of co-infection with TB and Covid-19 is constructed. From this model, an analytical study was carried out which included an analysis of the existence and stability of the disease equilibrium point as well as an analysis and interpretation of the basic reproduction number ( $R_0$ ). In addition, the invasion reproduction number between the two diseases was also investigated. Then a numerical simulation is carried out which includes elasticity and sensitivity analysis as well as autonomous simulation of the model. Analysis of the single infection submodel, namely the TB-only model and Covid-19-only model, was also carried out to see the dynamics of the coexistence of the two diseases. From the analytical study conducted, a local asymptotically stable disease-free equilibrium was obtained when  $R_0 < 1$ . However, a backward bifurcation may occur when  $R_0 = 1$  so the disease-free equilibrium is not globally stable. The endemic equilibrium exists and is locally asymptotically stable when  $R_0 > 1$ . Based on a numerical study, the results obtained were that changes in the infection rate of TB and Covid-19 simultaneously could have an impact on the presence of TB-Covid-19 disease in the population.