Analisis Keefektifan Biaya pada Model Pencegahan Malaria = Cost-effectiveness Analysis Problem Arises from Malaria Transmission Model

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Abstrak

Malaria merupakan salah satu penyakit menular yang disebabkan oleh gigitan nyamuk Anopheles betina dan seringkali ditemukan di daerah tropis dan subtropis. Malaria ditularkan oleh nyamuk Anopheles betina yang terinfeksi parasit Plasmodium. Berbagai pendekatan matematika dengan variasi kombinasi intervensi telah digunakan untuk menganalisis penyebaran malaria. Dalam penelitian ini, dikonstruksi model transmisi penyebaran malaria dengan mempertimbangkan empat intervensi, yaitu vaksinasi, penggunaan kelambu berinsektisida, pendeteksian dini, dan fumigasi. Dari model yang telah dikonstruksi, dihitung bilangan reproduksi kontrol dan mencari eksistensi dan analisis kestabilan dari titik-titik keseimbangan bebas penyakit. Kemudian, dilakukan pembentukan model masalah kontrol optimal bertujuan untuk meminimumkan jumlah manusia terinfeksi dan nyamuk dengan biaya intervensi yang paling minimum. Model ini dibangun menggunakan prinsip maksimum Pontryagin dengan mempertimbangkan semua intervensi bergantung pada waktu. Simulasi numerik dilakukan dengan empat skenario kombinasi intervensi, yaitu kombinasi satu intervensi, dua intervensi, tiga intervensi, dan empat intervensi. Analisis keefektifan biaya dihitung dengan tiga indikator, yaitu infection averted ratio (IAR), average cost-effectiveness ratio (ACER), dan the incremental cost-effectiveness ratio (ICER). Dari hasil simulasi numerik, dapat disimpulkan bahwa intervensi yang paling efektif dalam hal biaya adalah intervensi pendeteksian dini. Namun, intervensi yang paling efektif dalam hal jumlah individu terinfeksi yang terhindarkan adalah kombinasi intervensi vaksinasi, penggunaan kelambu berinsektisida, dan fumigasi.
.....Malaria is a mosquito-borne infectious disease that is often found in tropical and subtropical regions. Malaria is transmitted by female Anopheles mosquitoes that are infected with the Plasmodium parasite. Various mathematical approaches with variations in intervention combinations have been used to analyze the spread of malaria. In this study, a malaria transmission model was constructed considering four interventions, namely vaccination, insecticide-treated bed nets, early detection, and fumigation. The constructed model was used to calculate the basic reproduction control and to identify the existence and stability of disease-free equilibrium points. Then, an optimal control problem model was developed with the objective of minimizing the number of infected humans and mosquitoes with the minimum intervention cost. The model was built using the Pontryagin’s maximum principle, considering all interventions over time. Numerical simulations were performed with four intervention combination scenarios, namely one-intervention, two intervention, three-intervention, and four-intervention combinations. Cost-effectiveness analysis was calculated using three indicators, namely infection averted ratio (IAR), average cost-effectiveness ratio (ACER), and incremental cost-effectiveness ratio (ICER). The numerical simulation results showed that, if considering interventions from a cost perspective, the use of early detection intervention is the optimal intervention because it has the minimum cost (cost-saving). However, in terms of infection averted, the combined use of vaccination, the use of insecticide-treated bed nets, and fumigation is the most optimal strategy.