Advocating an attack against severe malaria: a cost-effectiveness analysis

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Abstract
Background Recently a study found that the gut microbiota, Lactobacillus and Bifidobacterium, have the ability to modulate the severity of malaria. The modulation of the severity of malaria is not however, the typical focal point of most widespread interventions. Thus, an essential element of information required before serious consideration of any intervention that targets reducing severe malaria incidence is a prediction of the health benefits and costs required to be cost-effective.

Methods Here, we developed a mathematical model of malaria transmission to evaluate an intervention that targets reducing severe malaria incidence. We consider intervention scenarios of a 2-, 7-, and 14-fold reduction in severe malaria incidence, based on the potential reduction in severe malaria incidence caused by gut microbiota, under entomological inoculation rates occurring in 41 countries in sub-Saharan Africa. For each intervention scenario, disability-adjusted life years averted and incremental cost-effectiveness ratios were estimated using country specific data, including the reported proportions of severe malaria incidence in healthcare settings.

Results Our results show that an intervention that targets reducing severe malaria incidence with annual costs between $23.65 to $30.26 USD per person and causes a 14-fold reduction in severe malaria incidence would be cost-effective in 15-19 countries and very cost-effective in 9-14 countries respectively. Furthermore, if model predictions are based on the distribution of gut microbiota through a freeze-dried yogurt that cost $0.20 per serving, a 2- to 14-fold reduction in severe malaria incidence would be cost-effective in 29 countries and very cost-effective in 25 countries.

Conclusion Our findings indicate interventions that target severe malaria can be cost-effective, in conjunction with standard interventions, for reducing the health burden and costs attributed to malaria. While our results illustrate a stronger cost-effectiveness for greater reductions, they consistently show that even a limited reduction in severe malaria provides substantial health benefits, and could be economically viable. Therefore, we suggest that interventions that target severe malaria are worthy of consideration, and merit further empirical and clinical investigation.

Full Text
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However, the manuscript can be downloaded and accessed as a PDF.

**Figures**

Figure 1

Malaria incidence and DALYs over a period of five years. a) Predicted malaria incidence for the 41 considered countries in sub-Saharan Africa, b) total malaria incidence for the 41 considered countries in sub-Saharan Africa, c) the proportion of malaria incidence reported to a healthcare provider, and d) annual DALYs averted for given reduction factor. The mean for all countries (red line), and 95% quantiles (shaded region).
Figure 2

ICER, intervention cost and effectiveness, and sensitivity of cost-effectiveness to model parameters. a) Boxplots of ICER values based on sample sizes of 10,000 stochastic parameter samples with threshold lines for a cost-effective intervention (black dash dot line) and a very cost-effective intervention (black dashed line), respectively. b) Per person intervention costs for a cost-effective intervention and c) Per person intervention costs for a very cost-effective intervention. Colored regions correspond to a 14-fold reduction in severe malaria incidence (black), 7-fold reduction in severe malaria incidence (blue), and 2-fold reduction in severe malaria incidence (red). d) First order sensitivity indices for average
ICER. Calculations are based on sample sizes of 10,000, where the reduction factor of severe malaria incidence is $\phi \sim U[2,14]$.

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