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# ASSESSING ECONOMIC BENEFITS FOR GOVERNMENT AND SOCIETY ATTRIBUTED TO MALARIA INVESTMENT STRATEGIES: AN EXPLORATORY ANALYSIS BASED ON MALARIA VACCINATION

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## BACKGROUND

- Negative association between malaria morbidity and the growth rate of Gross Domestic Product (GDP) per capita (McCarthy, 2000).
- A number of countries that managed to eliminate malaria have had more rapid economic growth than their neighbours (Gallup, 2001).
- In the absence of malaria in Africa economic growth would have been 1.25% higher than observed (Artadi, 2003).
- Reduced malaria case rates and morbidity are likely to have implications on government expenditure that can inform resource allocation and budgeting decisions.

## OBJECTIVES

- To assess lifetime economic returns from investing in malaria vaccination programs from the government and societal perspectives.
- To explore the economic consequences of reduced malaria morbidity and mortality on future labour productivity and government social transfers (e.g., healthcare spending, education, pensions).

## METHODS

- A prototype microeconomic health investment model was developed for assessing malaria reduction strategies in an African country.
- The model was evaluated using published efficacy rates for a pre-erythrocytic vaccine in children under 5 years of age. Vaccine efficacy was constrained to five years in the absence of long-term vaccine effectiveness data.
- The framework is complementary to cost-effectiveness analysis and budget impact analysis. It looks at the impact of malaria vaccine investment on lifetime returns.
- The model replicates the average life course for a cohort of 100,000 citizens (unvaccinated and vaccinated) in a highly-endemic African country over many generations using a range of clinical, economic and social parameters.

Table 1 Key input variables health investment model[1]

| Epidemiology | Input | Source |
|---|---|---|
| Age-related malaria related mortality | Life table | Bawah |
| Uncomplicated malaria case rate per year 0 -5 y.o. | 1.2300 | WHO |
| Uncomplicated malaria case rate per year > 5 y.o. | 0.1600 | WHO |
| Case rate severe (i.e. hospital) malaria cases per year 0-5 y.o. | 0.0344 | Oduro |
| Case rate severe (i.e. hospital) malaria cases per year >5 y.o. | 0.0004 | Oduro |
| **Cost inputs** | **US$ (in 2009)** | |
| Cost per clinical malaria case child[2] | $7.05 | Asante |
| Cost per clinical malaria case working age[2] | $7.05 | Asante |
| Cost per severe malaria case child[2] | $14.00 | Assumption |
| Cost per severe malaria case working age[2] | $14.00 | Assumption |
| Productivity days lost per malaria case- adult | 5.00 | Ikechukwu |
| Health cost per capita (non-malaria related) | $15 | GSS |
| Price per vaccination | $1-20 | Assumption |
| Vaccination programme costs[3] | $10 | Assumption |
| **Health Investment variables** | | |
| Nominal discount rate | 10% | Ghana BoF |
| Expected inflation | 7% | Ghana BoF |
| Discount rate | 3% | Ghana BoF |
| Average tax rate | 15% | Estimate |
| Pension tax rate | 0% | Estimate |
| Total unemployment | 11.2% | GSS |
| Age entering workforce | 15 | GSS |
| Average pension | $800 | Derived wages |
| Proportion receiving pension at age 60 (year 2070) | 1 | Assumption |
| Retirement age | 60 | GSS |
| Age of school enrolment | 6 | GSS |
| % school enrolment | 100% | Assumption |
| Average years of schooling | 8.60 | Sandefur |
| School years gained from malaria reduction | 1.090 | Lucas |
| Return per year of education | 0.097 | Sandefur |

[1] *Assumptions around efficacy rates are based upon trial efficacy data = 50% (Bejon et al 2008) less malaria overall. Some deaths, for example, are just delayed.*

[2] *Considers direct medical costs only.*

[3] *Includes costs of vaccine administration, delivery, cold chain, etc*

- Model reflects economic consequences of changes to malaria case rates in an African country.
- It was possible to develop a model using data from Ghana.
- Two perspectives were considered in the model:

Table 2 Description of perspectives applied in health investment model

| Perspective | Research aim | Description |
|---|---|---|
| *Government* | Estimate future net tax revenue in vaccinated and unvaccinated cohorts to establish whether investing in malaria vaccination represents a positive return for government | Model calculates the return on investment for government based on future 'net tax' revenues paid by vaccinated and unvaccinated cohorts after deducting social transfers (e.g., education, healthcare, allowances). |
| *Societal* | Estimates societal benefits in economic terms to establish whether investing in malaria vaccination represents a positive return on investment | Reflects economic benefits for society attributed to changes in malaria incidence rates in vaccinated and unvaccinated cohorts after deducting social transfers. |

- Model replicates the average life course for a cohort of 100,000 citizens (unvaccinated and vaccinated) in a highly-endemic African country over many generations using a range of clinical, economic and social parameters.

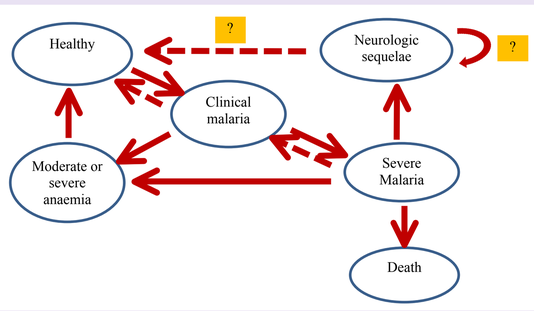
- The net fiscal balance of vaccinated and unvaccinated cohorts at any period of time is estimated in the health investment models simply as the discounted sum of all economic components at any given age. Specifically, the net present value (NPV) for both cohorts is defined as discounted sum of all revenues to government at all ages minus social expenditures, includingvaccine price, at all ages defined using the following equation (Connolly, 2008):

$$\mathrm{NPV} = \sum_{t=0}^{T} \left( \frac{R_t - E_t}{(1+r)^t} \right) - K_o$$

*Rt* = *Sum of all economic benefits accruing to society or future taxes in government perspective model*
*Et* = *Sum of direct government expenditure per individual over lifetime*
*r* = *rate of discount*
*K* = *vaccine price*
*T* = *Life expectancy*

- Model considers different malaria health states including clinical malaria, severe malaria, neurological sequelae, anaemia, and death.

Figure 1 Malaria health states applied in model



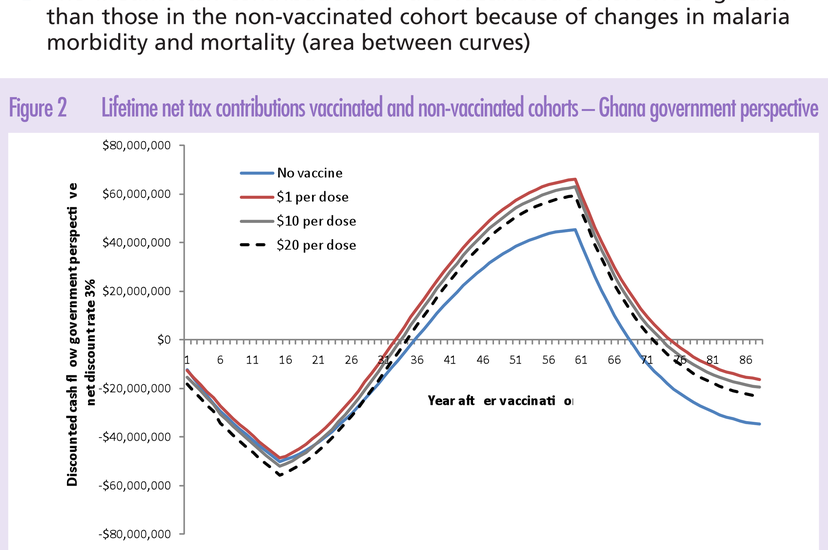

- For each malaria health state we estimated direct medical costs (e.g. Clinicvisits, treatments and hospitalisation) and indirect costs that included lost productivity of parents caring for children with malaria and lifetime lost earnings attributed to mortality.
- Wages are an important component of the health investment model as they define economic benefits associated with changes in malaria morbidity and mortality between the vaccinated and unvaccinated cohorts. In the health investment model we used age-adjusted wages that were inflated for improved education associated with reduced malaria rates (Lucas, 2005).

## RESULTS

### *Government perspective*

- Costs to government in the first 5 years of the model were comparable for vaccinated and unvaccinated cohorts. This finding was dependent on the price of the vaccine and delivery costs included in the model.
- The differential NPV between vaccinated and unvaccinated cohorts was cost-saving with the first 4 years because of reduced healthcare spending in the vaccinated cohort.
- In the first two decades of life the net balance for the government is negative for both vaccination and unvaccinated cohorts because of direct government transfers for education, health and allowances. Over time the balance shifts in favour of government as the cohort ages, enters employment and starts to pay taxes.
- Achieving a positive fiscal balance with government occurred earlier in the vaccinated cohort.
- The average age at which a child reaches the breakeven point (age at which a child has paid for his own costs of vaccination in addition to all previous government transfers) is 32 years (vaccinated) and 34 years (unvaccinated). Breakeven ages are consistent with previously published data applying this methodology for IVF-conceived children in the United States and Western Europe (Connolly et al, 2008; Svensson et al, 2008).
- Health care costs consumption is greater in the non-vaccinated cohort compared with the vaccinated cohort even after factoring in the vaccine costs. This is because of reduced malaria cases and healthcare costs consumed in the vaccinated cohort.
- After 50 years the profitability index measured as the discounted lifetime net taxes relative to the initial vaccine costs is 5 times the initial malaria vaccine investment.
- The lifetime tax contributions in the vaccinated cohort were greater than those in the non-vaccinated cohort because of changes in malaria morbidity and mortality (area between curves)

Figure 2 Lifetime net tax contributions vaccinated and non-vaccinated cohorts – Ghana government perspective

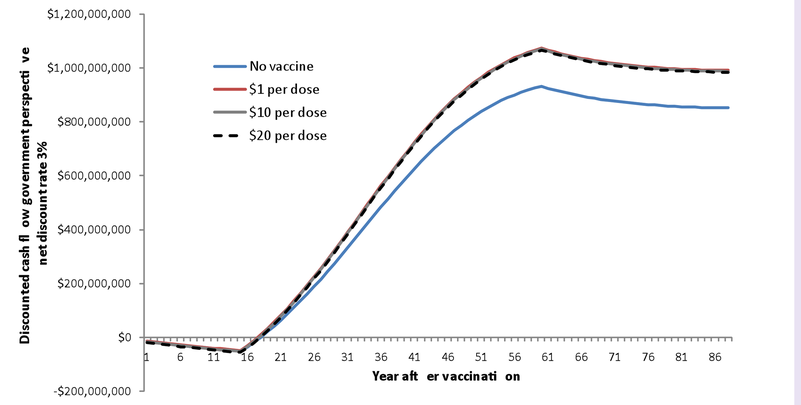



### *Societal perspective*

- In the societal perspective model the economic benefits are much greater compared with the more limited government perspective model.
- The average age at which a child achieves positive societal benefits was the same in both the vaccinated and non-vaccinated cohorts at age 17. This suggests the vaccine investment costs are minimal in the context of lifetime social benefits.
- After 50 years the profitability index measured as the lifetime societal benefits was 37 times the initial malaria vaccine investment.

- The price per malaria vaccine dose had limited impact on societal benefits and in each case was substantially greater than the unvaccinated cohort.

Figure 3 Lifetime economics of vaccinated and non-vaccinated cohorts – Ghana societal perspective




- **The area between the curves presented in Figures 3 and 4 represents the different economic positions achieved in the vaccinated and unvaccinated cohorts based on different costs per vaccine dose.**
- **The findings reported above are preliminary and will be updated as more information pertaining to clinical and economic data become available.**

## DISCUSSION

- With a judicious mix of data sources, it is possible to develop a malaria health investment model in an African country, using data from Ghana. However, future versions of the 'government perspective' model will consider a framework that assigns economic value to malaria reduction in less developed countries that often lack structured national tax collection.
- The health investment approach addresses fundamentally different questions from that of cost-effectiveness or budget impact analyses often used by stakeholders for making resource allocation decisions regarding malaria.
- The choice of methodologies for evaluating malaria reduction strategies should not be mutually exclusive. Rather these methodologies can be used to inform resource allocation decisions.
- The health investment modelling approach can help national and international stakeholders address the return on investment from malaria investment strategies as discussed within the Malaria Vaccine Decision-Making Framework (MVDMF).
- Early investment may accelerate early benefits such as better school programmes, improved health care programmes – a snowball effect – way of getting out of poverty.

### *Model Limitations*

- It is important to note that the health investment framework undervalues benefits attributed to malaria vaccination as it only values human life in economic terms. Consequently, this framework does not take into consideration the intangible benefits that people assign to being healthy and reducing malaria mortality and morbidity.
- It only focuses on one disease area and one approach.
- Priority setting compared with other health programmes overall is not addressed.
- Broader macroeconomic changes in the economy are not considered, therefore the framework likely underestimates true economic value of reduced malaria related morbidity and mortality.
- Assumptions about the following model variables were made: collectability of taxes and African tax structures overall; underlying GDP and economic growth; malaria changes and/or how these relate to various epidemiological settings; malaria cases progress; translation of a trial outcome to an effectiveness and public health outcome and therefore impact on malaria disease.

## CONCLUSIONS

- Unique framework
  - ➤ Considers future tax revenue for governments from vaccinated and unvaccinated cohorts in Ghana.
  - ➤ It is part of a comprehensive malaria health economic plan that will address questions of cost-effectiveness and affordability.
  - ➤ Explores how reduced malaria morbidity/mortality influences future labour productivity and government social transfers (e.g., healthcare, education, pensions).
- Complementary approach
  - ➤ Addresses different questions from cost-effectiveness and budget impact analyses (e.g., what happens after vaccination)
  - ➤ Looks at return on investment at various points in time (e.g., 25 years, 50 years, 75 years, 100 years after vaccination)
- Future model considers framework that assigns economic value to malaria reduction in least developed countries with less structured national tax collection systems

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