Does reducing malaria's burden cause economic growth, or does growth reduce malaria?

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The correlation between poverty and malaria endemicity has been well established, but causal directionality has not. Understanding the extent to which malaria causes economic stagnation, and vice-versa, is important for an efficient allotment of development resources. Using 15 years of panel data from 27 malaria-endemic Sub-Saharan African countries, we carry out a Granger-causality analysis of the potential directional relationship between economic growth and a reduction in malarias prevalence. Having identified a temporally coherent health-to-wealth pathway, we then carry out a sensitivity analysis to test causality. Our results are robust, suggesting that development-oriented aid and investment in malaria-endemic countries should prioritize those interventions which reduce malaria directly.

Malaria | Economics | Development | Growth | Causality

Malaria causes more than a half million deaths worldwide every year (1). In addition to its devastating health effects, Malaria has a large economic impact. By reducing ones ability to work efficiently (2), if at all, malaria imposes a large financial cost on the infected (3) (4), and the toll trickles upwards to society at large (5). Not only does malaria likely has a negative effect on GDP and growth (5–8), in a classic feedback loop, low growth can keep societies in a resource-scarce state making interventions which target the control or elimination of malaria difficult (1, 9–11).

The correlation between poverty and malaria endemicity has been well established, but causal directionality has not. This lack of clarity may partially explain why there are two schools of thought in development circles regarding where resources should be directed. One school argues that a society must be brought out of poverty, after which gains in health are almost inevitable, but prior to which significant health improvements are nearly impossible (12). The other argues for a more holistic development approach, implicitly calling for resources to be devoted to areas believed to be pre-requiste to wealth acquisition, such as health (13, 14). Clarke et al. covers this distinction more thoroughly (15).

Though both schools acknowledge that the interaction between health and wealth is bi-directional, understanding the extent to which malarias burden affects the economy, and vice-versa, could shed light on areas where developmentalists should focus in order to break the vicious cycle. Particularly, knowing which kinds of improvements precede the other helps to guide policies which aim to improve well-being in the long-term. Since malarias economic effects are at the macro-scale, a randomized controlled trial to assess the extent to which a controlled shock to the burden of malaria or the economy is not feasible. Ample experiments and interventions exist at the sub-national level, and occasionally the national level, but these are generally carried out in isolation, lacking the plausible counterfactual with which to compare any observed improvement in malarias burden or economic growth. Additionally, at the sub-national and national levels, the amount of confounding factors (political changes, climate crises, etc.) are too great to isolate causal effects.

Given the impossibility of parsing these many complex factors at the micro-level, one approach for understanding causal directionality in the malaria-economy relationship is to zoom out to the macro-level and focus on simple temporality (ie, whether changes to the economy tend to preceed changes to malarias burden or vice-versa). By including many countries rather than just one, we cancel out each ones idiosyncracies, and by carrying out statistical precedence analysis, we can identify a potentially causal trend for further analysis.

Granger-causation analysis, a form of temporal precedence analysis, is a useful tool for doing this (15–19). In the field of Economics, it is commonly used with panel data to assess the directionality of a bi-directional relationship (20, 21). For ths specific link to health and growth, it has been used to examine the causal links between the health status and savings of elderly Europeans (22), general health and socieconomic status (23), and macro-level development and mortality (15). These studies found causal directionality to be ambiguous. No study, to the authors knowledge, has used Granger causality to examine the relationship between malarias burden and GDP. Sachs' seminal study on malaria's effect on the economy (5) focuses largely on societies where elimination of the disease was achieved, and on time-invariant factors such as latitude, distance to coast, colonial history.

Significance Statement

Though it is clear that malaria is a "disease of poverty", the extent to which malaria is the cause or effect of poverty is not fully understood. Identifying the direction of the causal relationship between health and wealth is vital to knowing where resources should be directed, ie whether interventions in poor, malaria-endemic societies should target the disease or the poverty. We analyzed the relationship between GDP growth and the prevalence of Plasmodium falciparum among children in 27 malaria-endemic African countries, and identified health to wealth as the primary causal pathway. Our findings suggest that scaling up investment in reducing malaria's burden could be a pre-requisite condition for enabling economic growth in Sub-Saharan Africa.

Fig. 1. Placeholder image of a frog with a long example caption to show justification setting.

Table 1. Comparison of the fitted potential energy surfaces and ab initio benchmark electronic energy calculations

Species	CBS	CV	G3
1. Acetaldehyde	0.0	0.0	0.0
2. Vinyl alcohol	9.1	9.6	13.5
3. Hydroxyethylidene	50.8	51.2	54.0

nomenclature for the TSs refers to the numbered species in the table.

Using 15 years of data from 27 malaria-endemic Sub-Saharan African countries, we carry out an analysis of the potential causal relationship between economic growth and a reduction in the prevalence of malaria. Having identified a temporally coherent health-to-wealth pathway, we then carry out a sensitivity analysis to provide further evidence for predemoninantly health-driven growth.

Methods

Data collection. Malaria prevalence from (24, 25). GDP data from World Bank (26).

Descriptive statistics.

Analysis.

Digital Figures. Figures and Tables should be labelled and referenced in the standard way using the `\label{}` and `\ref{}` commands.

Figure 1 shows an example of how to insert a column-wide figure. To insert a figure wider than one column, please use the `\begin{figure*}...\end{figure*}` environment. Figures wider than one column should be sized to 11.4 cm or 17.8 cm wide. Use `\begin{SCfigure*}...\end{SCfigure*}` for a wide figure with side captions.

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Single column equations. Authors may use 1- or 2-column equations in their article, according to their preference.

To allow an equation to span both columns, use the `\begin{figure*}...\end{figure*}` environment mentioned above for figures.

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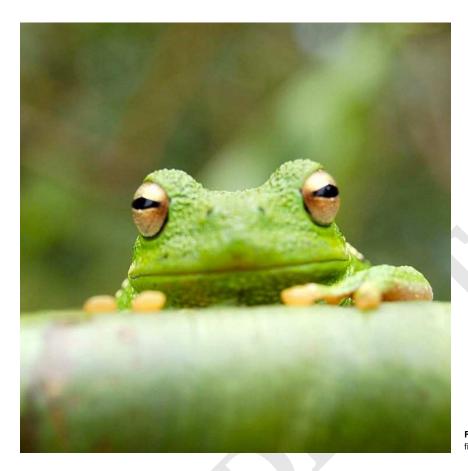
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Fig. 2. This caption would be placed at the side of the figure, rather than below it.

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\begin{aligned}
(x+y)^3 &= (x+y)(x+y)^2 \\
&= (x+y)(x^2+2xy+y^2) \\
&= x^3 + 3x^2y + 3xy^3 + x^3.
\end{aligned}
\tag{1}
$$

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