Institution: Imperial College London

Unit of Assessment: 02 Public Health, Health Services and Primary Care

Title of case study: Saving lives by increasing international investment for malaria control and elimination

Period when the underpinning research was undertaken: 2009 - 2015

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Tom Churcher	Reader	2006 - present
Azra Ghani	Chair in Infectious Disease Epidemiology	2007 - present
Jamie Griffin	MRC Research Fellow	2007 - 2015
Lucy Okell	Senior Lecturer	2009 - present
Hannah Slater	Imperial College Research Fellow	2013 - 2018
Patrick Walker	Lecturer	2010 - present
Peter Winskill	Imperial College Research Fellow	2014 - present

Period when the claimed impact occurred: 2013 - 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Malaria remains a major cause of childhood mortality. Imperial researchers developed a mathematical modelling framework for malaria to generate estimates of the impact of past and future investments in malaria control. The model was used to underpin the WHO Global Technical Strategy for Malaria 2016-2030 and The Global Fund investment cases for 2017-2019 and 2020-2022, resulting in successful replenishments ($12.9 billion and $14.02 billion respectively) and thereby contributing to the 38,000,000 lives estimated to have been saved by Global Fund investments across HIV, TB and malaria (with approximately 800,000 lives saved from malaria in 2018 alone).

2. Underpinning research (indicative maximum 500 words)

From 2009 Imperial researchers have developed a programme of work applying mathematical modelling to inform malaria control and elimination planning. The team developed the first comprehensive mathematical model of *Plasmodium falciparum* malaria transmission in which the effectiveness of the full suite of current interventions (long-lasting insecticide treated nets, indoor residual spraying, chemoprevention and first-line treatment) could be explored (1). From 2011 to 2015 the modelling framework was further developed to capture local differences in the epidemiology of the disease in terms of vector species and their bionomics, transmission intensity, and the resulting age-dependent patterns of asymptomatic infection (determining the infectious reservoir), clinical disease and severe disease and death.

Working closely with the WHO Global Malaria Programme, this modelling framework was developed still further to explore a range of global strategies for malaria control and elimination, parameterising and applying the model at the sub-national level and taking into account prior patterns of intervention scale-up (2). This work demonstrated that substantial reductions in case incidence (59%) and mortality (74%) could be achieved between 2015 and 2030 if coverage of existing interventions could be scaled to high levels. Vector control was found to achieve most of this impact in all settings and the work illustrated the importance of achieving the highest coverage in areas with high endemicity (sub-Saharan Africa). It also showed for the first time that up to 20 countries could potentially eliminate malaria over this time. In collaboration with WHO, the Imperial

team developed a costing framework attached to these modelling trajectories to obtain an estimate of the global funding required over the period 2016-2030 to achieve these levels of burden reduction and elimination (3).

Global funding for malaria remains significantly below the requirements identified in the 2015 global investment target (3). An additional development of the global modelling framework therefore considered how best to maximise impact in resource-constrained settings. We showed that substantial gains in allocative efficiency could be made if National Malaria Control Programmes prioritise intervention packages at the sub-national level rather than aiming to apply all interventions equally across a country (4). By linking this framework to the key malaria funding sources in each country (The Global Fund, US President's Malaria Initiative and domestic financing), we demonstrated the importance of sustained international aid in maintaining the reductions in malaria burden that have been achieved over the last decade and demonstrated the cost-effectiveness of malaria control (5).

3. References to the research (indicative maximum of six references)

(1) Griffin, J.T., Hollingsworth, T.D., Okell, L.C., Churcher, T.S., White, M., Hinsley, W., Bousema, T., Drakeley, C.J., Ferguson, N.M., Basanez, M-G., & Ghani, A.C. (2010). Reducing Plasmodium falciparum Malaria Transmission in Africa: A Model-Based Evaluation of Intervention Strategies. *PLoS Medicine* 7(8): e1000324. DOI.

(2) Griffin J.T., Bhatt S., Sinka M.E., Gething P.W., Lynch M., Patouillard E., Shutes E., Newman R.D., Alonso P., Cibulskis R.E., Ghani A.C. (2016). Potential for reduction of burden and local elimination of malaria by reducing Plasmodium falciparum malaria transmission: a mathematical modelling study. *Lancet Infectious Diseases* 16: 465-472. DOI.

(3) Patouillard, E, Griffin, J, Bhatt, S, Ghani, A, Cibulskis, R. (2017). Global investment targets for malaria control and elimination between 2016 and 2030. *BMJ Global Health;* 2(2): e000176. DOI.

(4) Walker, P.G., Griffin, J.T., Ferguson, N.M., Ghani, A.C. (2016). Estimating the most efficient allocation of interventions to achieve reductions in Plasmodium falciparum malaria burden and transmission in Africa: a modelling study. *Lancet Global Health;* 4: e474-484. DOI.

(5) Winskill, P., Slater, H.C., Griffin, J.T., Ghani, A.C., Walker, P. (2017). The US President's Malaria Initiative, *Plasmodium falciparum* transmission and mortality: a modelling study. *PLoS Medicine;* 14(11): e1002448. DOI.

Key Funding: Bill and Melinda Gates Foundation

4. Details of the impact (indicative maximum 750 words)

Global Technical Strategy for Malaria 2016-2030

Through close collaboration with the World Health Organisation Global Malaria Programme, the Imperial team provided sustained support for the development of the Global Technical Strategy for Malaria (GTS) 2016-2030 endorsed by the World Health Assembly in May 2015. From 2013-2015 Prof Ghani was a member of the Steering Committee for the GTS and from 2016 onwards has been a member of the WHO Malaria Policy Advisory Committee. Drs Churcher, Okell, Winskill, Walker and Slater have been members of WHO Malaria Evidence Review Groups.

The mathematical modelling, co-authored with WHO [(1) above], was used as one of three pieces of evidence to support the setting of targets for reductions in malaria case incidence, mortality rates and elimination in the WHO GTS for Malaria, 2016-2030 [**A**]. The modelling also underpinned the development of the costing of the strategy - "*WHO took into account three sources of information in developing the proposed goals, milestones and targets…3. Mathematical modelling of P.falciparum malaria transmission performed by Imperial College, London*": [**A**, published by

WHO with Imperial co-authors in reference (3) above] and was used to support the estimate of the Return on Investment in malaria in the Roll Back Malaria Action to Investment [**B**].

The Global Fund Investment Case and Strategy

Since 2016 Imperial researchers have worked with The Global Fund to estimate the potential impact of global malaria funding on the burden of malaria. These estimates were used directly in the Investment Case for 2017-2020 [**C**] and the Investment Case for 2020-2023 [**D**] which are used to garner support from international donors for the 3-yearly replenishment conferences. This had direct impact in supporting both successful replenishments of $12.9 billion for 2017-2020 and $14.02 billion for 2020-2023 respectively.

Following the successful 2017 replenishment, the team undertook additional modelling to support The Global Fund Strategy for 2017-2022, providing impact estimates underpinning the quantitative performance targets [**E**]. The Global Fund provides 56% of all international financing for malaria [**F**]; they estimate that their investments have reduced malaria case incidence by 21% and malaria mortality by 31% between 2010 and 2018, saving approximately 800,000 lives in 2018 alone [**F**]. The Imperial research supporting the 2017-2022 investment case and strategy development directly informed the strategy resulting in the delivery of 160,000,000 bed nets, 8,000,000 structures sprayed and 11,000,000 pregnant women receiving preventative therapy in 2019. It also contributed to the estimated 38,000,000 lives saved by The Global Fund investments (across HIV, TB and malaria) up to the end of 2019 (malaria impact of all interventions on mortality independently calculated by WHO using parasite prevalence data) [**F**].

Country Support for Strategic Planning for Malaria Control and Elimination

The model was used to support country-level strategic planning, generating estimates of cases and deaths averted from prior investment and projecting future scenarios. Conceptual insight into this process was developed with the WHO Global Malaria Programme as part of their manual for Elimination Scenario Planning (ESP)[**G**]. Between 2015 and 2018 we worked directly with malaria-endemic countries. In Zambia, sub-national stratification estimates of impact were used in their National Malaria Elimination Plan (2017-2030), with the modelling used to define the packages of interventions required [**H**]. Using estimates of malaria deaths in the WHO Global Malaria Report 2020 (and a counterfactual of mortality rates in the year 2000 from this report), the Zambia National Malaria Elimination Centre has saved 15,500 lives between 2017 and 2019.

In 2016-2017 the researchers worked with Senegal and The Gambia National Malaria Control Programmes to support ESP through a series of workshops. Estimates of the past impact (cases and deaths averted) and cost-effectiveness of the programmes, and future scenarios were included in their funding applications to the Global Fund (referred to as ESP in Senegal evidence) [**I**]. The final joint workshop supported a cross-border collaboration plan. Modelling was used to demonstrate the need to align strategies in border areas, resulting in the first cross-border joint bed net distribution campaign [**I, J**]. Using estimates of malaria deaths in the WHO Global Malaria Report 2020, approximately 10,000 lives have been saved between 2017 and 2019 in these two countries from malaria elimination activities.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[**A**] Background brief on the proposed targets and estimated costs of implementation of the draft Global Technical Strategy for Malaria (2016-2030). Archived here.

[**B**] Action and Investment to Defeat Malaria, 2016-2030: For a Malaria-Free World. Appendix D: Methodology for Cost-Benefit Analysis. Archived here.

[**C**] Fifth Global Fund Investment Case. Annex 3: Summary of Impact Modelling Methodology. Archived here.

[**D**] Sixth Global Fund Investment Case. Annex 4: Methodology for Impact Modelling. Archived here.

[**E**] Fifth Global Fund Cycle: Modelling informing Global Fund strategy targets: Report to the Board. Annex 1 - Overview of models and methods for KPIs 1, 2 and 8. Archived here.

[**F**] The Global Fund Result Reports 2020. Archived here.

[**G**] WHO Guidance for Country Level Strategic Planning. Archived here.

[**H**] National Malaria Elimination Strategic Plan 2017-2021, National Malaria Elimination Centre, Zambia. Archived here.

[**I**] The Global Fund funding application for Senegal (archived here) and The Gambia (archived here).

[**J**] News item announcement of cross-border collaboration between Senegal and The Gambia (archived here).