Measuring the impact of global research and development investment in product development partnerships: a case study on return on investment in antimalarial drug development

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Summary

Background Product development partnerships (PDPs) are non-profit organisations that bridge the gap between the need for new treatments for poverty-related diseases and the resources available to develop them, leveraging a mix of public, philanthropic, multilateral, and private sector funding. We aimed to calculate two financial metrics to estimate the return on investments of drugs developed by the PDP Medicines for Malaria Venture (MMV) as a case study.

Methods The internal rate of return (IRR) and benefit–cost ratio (BCR) were used to estimate the economic return on investment for the PDP. IRR was based on total investments from 2000 to 2023 and health gains derived from PDP-supported drugs, measured as monetised disability-adjusted life-years (DALYs) minus the delivery cost of the products. BCR was calculated by dividing the present value of monetised DALYs by the present value of cost, indicating the overall efficiency and impact of the investments received by MMV.

Findings Total investment received was US$2·3 billion over the study period, and the antimalarial drugs developed and launched with the support of MMV averted an estimated 1·6 million deaths and 87 million DALYs for a cost of delivery estimated at $785 million. The IRR for the base scenario was 52·13% (95% uncertainty interval 52·11–52·16) and the BCR 12·99 (12·92–13·06).

Interpretation The substantial IRR and BCR generated by investment in antimalarial drug development suggest that the PDP model has a potentially pivotal role to play in global health.

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Introduction

Product development partnerships (PDPs) are non-profit organisations that bridge the gap between public health needs and market-driven incentives by coordinating and financing the research, development, and delivery of new health products for diseases of poverty.[1,2] They were developed to address market failures—specifically, the gap between the unmet need for new treatments and interventions for poverty-related and neglected diseases in low-income and middle-income countries, and the resources available to develop them.[3] PDPs are non-profit organisations that derisk the product development process by bringing together partners including pharmaceutical companies, research organisations, academic institutions, multilateral agencies, and other stakeholders such as user and advocacy groups.[1,2] The funding of PDPs is based on a mix of resources combining public sector funding from governments, philanthropic foundations such as the Gates Foundation, multilateral organisations, and the private sector, with pharmaceutical and biotechnology companies providing various kinds of contributions.[4]

Since 2010, a coalition of 12 leading PDPs has delivered nearly 80 new health technologies reaching over 2·4 billion people.[3] Quantifying the impact of funding PDPs in the context of new health technology development and increased access is essential. Additionally, understanding the return on investing in PDPs in monetary terms enables comparisons with other potential uses of funding for global health and development more broadly.[5] Direct commercial returns or profit are not a marker of success for PDPs; returns on investment must therefore be demonstrated using approaches that extend beyond cash flows. These commonly include health metrics such as cases averted, lives saved, disability-adjusted life-years (DALYs) averted, quality-adjusted life-years gained, or cost-effectiveness estimates.[3,4,6]

Return on investment estimates often forecast bold and convincing cases for funding global health interventions.[7,8] The importance of investing in research and development (R&D) has been proven across a range of diseases. A recent high-profile modelling analysis forecasting the health economic and social impact of

Research in context

Evidence before this study

We searched PubMed and manually inspected the results using "internal rate of return", "IRR", "benefit-cost ratio*", "BCR", "return on investment", "ROI", "product development partnerships", and "PDP" as keywords, in English, up to Feb 21, 2025. We also performed a search in the grey literature and included in our review reports and articles published by consulting organisations, funders, government organisations, and development banks. Both internal rate of return (IRR) and benefit–cost ratio (BCR) are widely used to inform investment decisions in the public and private sector. The need for better data to inform global health research and development (R&D) investments is long recognised and our searches indicate a continued lack of consensus on the preferred metrics and methods. A recent scoping review showed that there were inconsistencies in the calculation and interpretation of return on investment associated with public health interventions. The authors called for more transparency when reporting underlying assumptions. Most economic evaluations focused on cost-effectiveness estimates of specific interventions or products in low-income and middle-income countries. Literature on the BCRs and estimates on the value of global health investments in monetary terms are uncommon. Moreover, understanding the return on investing in global R&D is rarer still. In the UK, a series of influential analyses using the IRR demonstrated the economic returns of medical research funding for four diseases (cancer, mental health, cardiovascular diseases, and musculoskeletal diseases). To date, no peer-reviewed publications have evaluated the return on investment in the R&D generated by product development partnerships (PDPs).

Added value of this study

This paper contributes to knowledge in several ways. First, from an empirical perspective, we learn that investing in malaria research and development through the PDP model has resulted in a positive return on investment, driven by providing access to effective antimalarial treatments, averting 1·6 million deaths. Second, we demonstrate that a rigorous analysis of PDP returns on investment can be conducted using routine data and standardised methods to inform both productive and allocative efficiency decisions. Finally, from a policy perspective, this paper is able to show that investment in R&D, and PDPs specifically, are a competitive investment when compared with other health and non-health investments.

Implications of all the available evidence

In a funding environment where large-scale investments are increasingly coming under scrutiny, this work demonstrates that it is possible to calculate the return on investment from PDPs using routine data and standardised methods. This paper offers a retrospective and conservative view of what has been achieved. Even with this more conservative methodology, it is clear that the investment received by Medicines for Malaria Venture allowed it to respond to existing market failures and develop a portfolio of drugs that have positive health and economic returns. Our paper is an example of how global health investments can assess their returns on research investment in a transparent and robust way to inform policy making and funding allocation.

20 years of investment in global health R&D across multiple diseases showed impressive returns on investments.[9] This analysis estimated that every US$1 invested in neglected disease R&D could generate a return of $405 by 2040, and that at least 40·7 million lives could be saved for the period 2000 to 2040, averting 2·83 billion DALYs. The analysis provided strong justification for continued investment across a range of diagnostics and treatments for multiple neglected diseases in global health R&D; however, it did not investigate contributions at the individual PDP level.

In this study, we estimate the returns from investing in a PDP using two widely accepted financial metrics: the internal rate of return (IRR) and the benefit–cost ratio (BCR).[6,10–12] Using the PDP Medicines for Malaria Venture (MMV)—a not-for-profit organisation whose mission is to deliver a portfolio of accessible medicine with the power to treat, prevent, and eliminate malaria—as a case study, we assess the benefits of PDP investments in terms of health and economic gains achieved per dollar invested, while acknowledging potential risks such as inefficient resource use or delayed access to innovations.

Methods

Overall approach

The IRR and BCR were used to estimate the efficiency of funding received by MMV over time. Most commonly used in the private sector, IRR values have also informed policy decisions in the public sector. For example, the UK Government determined the IRR achieved by medical research in four disease areas to estimate the economic returns of public investment.[6,10] The BCR is a metric frequently used to estimate the return on investment of public health interventions (table 1).[11,12]

Returns from the PDP's product portfolio were estimated as the monetised value of DALYs averted minus the costs of product delivery in malaria-endemic countries. The steps to estimate the IRR and BCR are described below (panel).

Step 1: Calculating total investment costs

Total investment costs (C_0) consisted of the funding received by MMV to develop antimalarial drugs for the period 2000 to 2023 (as provided by MMV) and expressed in 2023 US dollar prices. Total investment costs included investment for products that did not make it to market, as well as those that were still in development at the time of the analysis and those already launched. Comparing the total funding received by the PDP with the benefits generated by products that successfully reached the market ensures that the analysis accounts for the full cost of the R&D process, including both successful and unsuccessful development efforts. The time periods spanned from the creation of the PDP in 2000 to 2023, the most recent year for which costs of delivering products were available at the time of writing.

Step 2: Estimating the number of deaths averted

The first step in the calculation of the health gain (the C_t component of the equation) is to estimate the number of deaths averted. To achieve this, the volumes of the PDP-supported products procured and sold cumulatively since date of market entry or WHO prequalification were obtained from manufacturers based on routine data collection from MMV. A timeline showing the year of entry of each product is provided in the appendix (p 1). This approach accounts for product use in both public and private settings. Volumes are converted into number of treatments provided based on the estimated number of doses required per treatment and for each molecule. This generates a theoretical number of people treated or protected, which is further adjusted for wastage of volume sales and appropriate use to obtain the estimated number of people effectively treated or protected.[13] To estimate the number of deaths averted, the protective effect of each product is compared with the most likely counterfactual. The efficacy parameters used in the model were derived from peer-reviewed literature and systematic reviews used by WHO to update their malaria guidelines as available at the time of the study. Table 2 presents the assumptions used in the model to convert the volumes of each product into the number of cases and deaths averted. The model followed a conservative approach by only estimating the number of deaths averted up until 2023, not taking into account any future deaths averted from PDP-supported products.

Step 3: Estimating and monetising DALYs

The model calculates the number of DALYs averted based on the estimated number of lives saved, and uncomplicated and severe cases averted. Neurological sequelae were the only disabilities included, as they represent the most clinically relevant long-term outcome of severe malaria. However, their contribution to total DALYs is small relative to the burden arising from premature mortality (years of life lost).[19,20] Assumptions for average life expectancy among children aged 1–4 years in high-burden populations was based on Pfeil and colleagues' study.[21] The adjustments for neurological sequelae were based on work by Okebe and Eisenhut[19] and Lubell and colleagues.[20]

Value of statistical life (VSL) was used to translate the DALYs into economic terms. Recognising that VSL can vary subtantially with income levels, we adjusted the base US VSL to reflect the economic context of each country in our analysis (appendix p 2). This adjustment uses a formula that incorporates the country's income level and the income elasticity of VSL. This approach is consistent with the method used by others and is aligned with *Reference Case Guidelines for Benefit-Cost Analysis in Global Health and Development* (appendix pp 3–5).[9,22] This allowed us to estimate VSL for each country and subsequently determine the overall economic value of the health gains achieved.

Step 4: Estimating the costs of delivery

To estimate the cost of delivery, we identified the 15 countries with the highest malaria burden in the regions

	IRR	BCR
Output format	Percentage (%)	Ratio (eg, a BCR of 1·5 means $1·50 of benefit is generated from every $1 spent)
Focus	Annualised rate of return over time	Value gained per dollar (unit of currency)
Time consideration	Considers timing of cash flows	Does not factor in time, focus is total values
Decision criteria	Compares IRR with a target rate	BCR >1 indicates a good project
Context most often used	Business and private sector projects where the timing of cash flows is an important consideration; comparison of projects, often at similar scales	Public sector or social projects where benefits are non-monetary and impact is not purely financial; to assess accountability to taxpayers and other relevant stakeholders; assessment of whether large capital investments are worth undertaking

BCR=benefit–cost ratio. IRR=internal rate of return.

Table 1: **IRR and BCR characteristics**

***Panel:* Formulae**

IRR calculation

$$\text{NPV} = \sum \frac{C_t}{(1+\text{IRR})^t} - C_0 = 0$$

Where NPV is the net present value; C_t is the net cash inflows during the period t; C_0 is the total initial investment costs; IRR is the internal rate of return; and t is the number of periods. The IRR is the discount rate at which the NPV of all cash flows equals zero—ie, the rate that equates the present value of benefits and costs over time.

BCR calculation

$$\text{BCR} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}}$$

Where BCR is the benefit–cost ratio; B is benefits, in our case the monetised disability-adjusted life-years; C is the cost of delivery plus cost of investment received by Medicines for Malaria Venture; r is the discount rate; t is the year; and n is the analytical horizon (in years).

See Online for appendix

	Assumptions for converting volumes of drugs to estimated number of people receiving them			Assumptions for estimating cases and deaths averted		Region of distribution*	References
	Doses needed per person	Wastage	Appropriate use†	Counterfactual	Efficacy parameters and value‡		
Sulfadoxine–pyrimethamine and amodiaquine	4 doses	5%	100%	None	RR for incidence of clinical malaria: 0·27 (all age groups); RR for incidence of severe malaria: 0·57 for age <5 years, 0·44 for age 4–10 years	African countries	Thwing et al (2023)[14]
Artemether–lumefantrine dispersible	1 treatment	5%	75%	Artemether–lumefantrine tablet	ACT failure rate: 6%; case fatality rate: 10·90%	Global	Zani et al (2014);[15] Pryce et al (2022);[16] Sinclair et al (2009);[17]
Artesunate–amodiaquine	1 treatment	5%	75%	Artemether–lumefantrine tablet	ACT failure rate: 3·50%; case fatality rate: 10·90%	African countries	Zani et al (2014);[15] Pryce et al (2022);[16] Sinclair et al (2009);[17]
Artesunate–mefloquine	1 pack	5%	75%	Artemether–lumefantrine tablet	ACT failure rate: 2·30%; case fatality rate: 10·90%	Non-African countries	Zani et al (2014);[15] Pryce et al (2022);[16] Sinclair et al (2009);[17]
Dihydroartemisinine–piperaquine	6·16 tablets	5%	75%	Artemether–lumefantrine tablet	ACT failure rate: 4·30%; case fatality rate: 10·90%	Global	Zani et al (2014);[15] Pryce et al (2022);[16] Sinclair et al (2009);[17]
Artesunate–pyronaridine	1 treatment	5%	75%	Artemether–lumefantrine tablet	ACT failure rate: 5·20%; case fatality rate: 10·90%	Non-African countries	Zani et al (2014);[15] Pryce et al (2022);[16] Sinclair et al (2009)[17]
Injectable artesunate	6 vials	5%	68%	Intravenous quinine	Assumed risk of deaths for intravenous quinine: 10% for children, 24·1% for adults; relative risk of deaths: 0·76 for children, 0·61 for adults	Global	Sinclair et al (2012)[18]
Rectal artesunate	1·08 capsules	5%	100%	None	Assumed risk of deaths versus placebo: 4·10%; relative risk of deaths: 0·74	African countries	Okebe and Eisenhut (2014)[19]

ACT=artemisinin combination therapy. RR=risk ratio. *Region of distribution identifies the region where the products were predominantly used since their launch. This information was used to estimate the costs of delivery specific to each region. †Appropriate use reflects the percentage of treatments that were effectively delivered to people presenting with malaria or at risk of malaria. ‡The quantitative efficacy parameter used in modelling impact is shown. For preventive products (eg, sulfadoxine–pyrimethamine and amodiaquine), values represent RRs for the incidence of clinical or severe malaria relative to no intervention. For therapeutic products (eg, ACTs or injectable or rectal artesunate), values represent treatment efficacy assumptions—specifically the ACT failure rate or the case fatality rate associated with untreated or comparator regimens. For injectable and rectal artesunate, the value represents the assumed risk or relative risk of death versus the comparator (intravenous quinine or placebo).

Table 2: **List of assumptions used to estimate the number of cases averted, severe cases averted, and deaths averted by product developed**

in which MMV's antimalarial medicines are marketed for every year of the time period since the launch of the first product in 2009. As this subset of countries changes from year to year, a total of 36 individual countries were included in the analysis, representing between 77% and 82% of global malaria cases annually.[23] This dynamic selection of the 15 highest-burden countries in any given year ensures the analysis remains relevant and reflects the shifting geographical distribution of malaria.

We used the WHO Choice Costing tool and Global Fund pricing data to estimate country-specific health-care delivery costs and costs of health commodities, respectively.[24,25] We then multiplied country-specific delivery costs, rapid diagnostic test costs, and treatment costs with the number of doses available to a country in a given year to arrive at an estimate of the total health system costs, sensitive to country-specific factors.[24,25]

Sensitivity analysis

The baseline analysis assumed a 3% discount rate, full attribution of investment returns to the PDP, an income elasticity of 1·2 for VSL, and a midpoint estimate of DALYs averted based on product-specific mortality reduction assumptions. These assumptions form the reference case against which all sensitivity analyses were compared.

We conducted a probabilistic sensitivity analysis to assess how uncertainty in treatment costs and health-care delivery costs impacts our results. These parameters were modelled using a beta-PERT distribution for probabilistic sampling, chosen to reflect realistic ranges and potential skewness. Bounds for treatment costs were derived from empirical data, while those for health-care delivery costs were based on WHO-CHOICE estimates, with upper and lower limits informed by their standard deviation.[25] We generated 1000 independent parameter sets via Monte Carlo simulation and calculated 95% uncertainty intervals from the 2·5th and 97·5th percentiles of the resulting distribution. We calculated *t*-tests and confidence intervals to quantify the uncertainty around the mean IRR and BCR estimates. Additionally, we conducted a one-way sensitivity analysis to examine the influence of individual assumptions on the base case estimates. Specifically, we adjusted the discount rate to 2% and 5%, reflecting commonly used lower and upper bounds in global health economic evaluations. The income elasticity of the VSL was varied to 1·5, a more conservative estimate frequently cited in the literature for transferring VSL across different income settings.[26] Additionally, we modified the estimated number of

DALYs averted based on product-specific clinical trial efficacy data, encompassing both low and high mortality impact scenarios.

The model was built using the statistical software R (version 4.5.1). The code and data are accessible on our GitHub repository.

Role of the funding source

There was no funding source for this study.

Results

A total of US$2·3 billion (2023 prices) was invested into MMV during the period 2000 to 2023 (Bonnaud G, MMV, personal communication). During that period, MMV was involved in the clinical development of over 45 products, with 16 products being commercially available and 12 generating sales by 2023 (appendix p 1).[27] The investment received, number of deaths averted, DALYs averted, monetised DALYs, and cost of product delivery are shown in table 3. In total, around 1·6 million deaths and 87 million DALYs were averted, with the cost of delivery estimated at around $785 million.

Our base case analysis finds an IRR of 52·13% (95% uncertainty interval 52·11–52·16) and a BCR of 12·99 (12·92–13·06; table 4). In other words, every dollar spent on MMV's R&D delivers an additional return of 52 US cents every year, for ever, and for every $1 invested in MMV for the period 2000 to 2023, $12·99 is recouped in monetary benefits. Varying the discount rate has minimal impact on IRR estimates, ranging from 52·30% to 51·27%, and BCR estimates ranging from 12·31 to 14·07 for the period 2000 to 2023. The only parameter to show any marked change to the base case results was when we tested an elasticity of 1·5. The IRR decreased to 33·86% and the BCR to 3·84 for the study period, representing a 35% and 70% decrease compared with the base case, respectively. The IRR varies from 48·06% in the low DALY scenario to 54·49% in the high DALY scenario, while BCR varied from 8·98 to 16·32 for the study period, respectively.

Discussion

PDPs have emerged as a pivotal strategy for donors to support research for neglected diseases of poverty. To our knowledge, this study is the first systematic bottom-up attempt to estimate the return on investment from a single PDP. Previous mixed-methods approaches have focused on describing the reach of PDPs but not quantified their impact in monetary terms across an entire portfolio.[1] Rather, examples of specific innovations supported by PDPs have been estimated.[4] Furthermore, our analysis is rare as we are able to base our findings on retrospective data of confirmed volumes of drugs distributed that were routinely collected by MMV, rather than the more common approach of projecting hypothetical product use into the future. With an IRR of 52·13%, our findings indicate that for every dollar

	Number of MMV-supported products*	Investment, US$	Deaths averted	DALYs averted	Monetised DALYs, US$	Cost of delivery, US$
2000	0	29 852 923	0	0	0	0
2001	0	50 108 598	0	0	0	0
2002	0	32 524 927	0	0	0	0
2003	0	61 183 848	0	0	0	0
2004	0	76 280 272	0	0	0	0
2005	0	114 095 421	0	0	0	0
2006	0	71 055 329	0	0	0	0
2007	0	173 925 704	0	0	0	0
2008	1	118 242 843	0	0	0	0
2009	0	85 861 725	0	0	0	0
2010	1	116 044 460	0	0	0	0
2011	1	128 294 997	0	0	0	1 245 178 150
2012	1	103 748 180	19 525	1 062 171	3 045 809 911	1 123 265 199
2013	0	106 873 147	21 339	1 160 843	3 294 351 524	986 884 769
2014	1	126 230 106	85 357	4 643 372	13 039 551 031	1 081 783 948
2015	3	135 116 139	67 167	3 659 388	10 128 422 953	887 511 105
2016	0	97 182 201	106 688	5 817 429	16 159 551 540	1 023 726 289
2017	1	120 315 216	122 252	6 669 136	18 557 295 136	1 441 757 632
2018	2	89 798 807	139 248	7 600 193	21 316 427 266	1 294 064 863
2019	1	93 514 565	145 246	7 945 798	22 487 299 754	1 316 807 567
2020	0	108 765 449	193 922	10 594 756	29 842 567 014	2 079 103 652
2021	0	100 845 446	240 314	13 172 803	37 559 448 069	2 037 310 875
2022	0	81 301 805	235 464	12 865 771	36 563 924 610	1 922 173 152
2023	0	77 988 063	214 947	11 737 376	33 277 928 600	2 399 686 171
Total	12	2 299 150 173	1 591 470	86 929 036	10 219 690 725	784 968 890

This table illustrates the lag time between investment in product development and realisation of the health gains. The first deaths averted by a product supported by a product development partnership (PDP) appeared 12 years after the creation of the PDP and initial investments in antimalarial drug development. Health gains from supported products increased steadily from 2011 to 2021. The reduction in deaths averted in 2022 and 2023 was due to delayed health gains following a spike of procurement of drugs for severe malaria in 2020 and 2021. DALY=disability-adjusted life-year. MMV=Medicines for Malaria Venture. *Indicates the year in which MMV-supported products were either launched or entered MMV's portfolio.

Table 3: **Yearly investments, deaths averted, DALYs averted, monetised DALYs, and cost of delivery—2000 to 2023 in 2023 US$**

	Assumptions	IRR	BCR
Base	Discount rate: 3%; elasticity: 1·2; DALYs: midpoint	52·13% (52·11–52·16)	12·99 (12·92–13·06)
Low discount rate	Discount rate: 2%; elasticity: 1·2; DALYs: midpoint	52·30% (52·27–52·33)	12·31 (12·24–12·39)
High discount rate	Discount rate: 5%; elasticity: 1·2; DALYs: midpoint	51·27% (51·25–51·30)	14·07 (13·99–14·14)
High elasticity	Discount rate: 3%; elasticity: 1·5; DALYs: midpoint	33·86% (33·8–33·92)	3·84 (3·81–3·86)
Low DALY	Discount rate: 3%; elasticity: 1·2; DALYs: low scenario	48·06% (48·03–48·09)	8·98 (8·93–9·03)
High DALY	Discount rate: 3%; elasticity: 1·2; DALYs: high scenario	54·49% (54·47–54·51)	16·32 (16·24–16·41)

Data in parentheses are 95% uncertainty intervals. BCR=benefit–cost ratio. DALY=disability-adjusted life-year. IRR=internal rate of return.

Table 4: **IRR and BCR for various scenarios**

For the **GitHub repository** see https://github.com/paulachristen/mmv_ror/

invested in the PDP to date, a return of 52 cents is expected every year into the future. In addition, a BCR of 12·99 indicates that for every $1 invested, society received $13 worth of health benefits in return for the period 2000 to 2023. Both metrics show that this PDP was a highly worthwhile investment.

While both the BCR and IRR capture investment efficiency, they provide complementary perspectives. The IRR reflects the annualised rate of return, incorporating the timing of costs and benefits, and is therefore sensitive to the pace at which health gains are realised. The BCR, in contrast, expresses the total social value generated per dollar invested, irrespective of time. In contexts where benefits accrue gradually, as with most product development pipelines, the BCR can appear high even if returns are realised over decades. By contrast, the IRR is more informative for comparing investments with differing time horizons or cash flow patterns. Both metrics depend on the magnitude of health gains, but the IRR is particularly sensitive to when those gains occur. If malaria burden were to decline substantially in the future due to wider control measures, the realised BCR would remain unchanged for the period analysed (2000–23), but any prospective IRR incorporating future projections would decline as fewer DALYs could be averted by the same interventions. Conversely, if disease burden increased or PDP-supported products expanded coverage, the IRR for future periods would rise. Hence, while our retrospective analysis provides a conservative estimate of realised returns, future return on investment estimates will necessarily evolve with changes in disease epidemiology and product uptake.

It is useful to interpret these figures and situate them in the wider literature; however, comparing return on investment calculations is challenging due to different assumptions, across different timelines, with a range of approaches to discounting financial and health inputs and outputs.[5] Such variable methodologies often make direct comparations misleading. Even with all the caveats and cautions, there is value in drawing on the wider literature. Our findings are in line with previous studies which suggest that investing in scientific research yields returns that can largely exceed the initial costs. One highly influential UK report suggested that every £1 of public investment in medical research generated an additional 25 British pence annually in health gains and gross domestic product benefits.[28] While the authors acknowledged the challenges in directly comparing this return with other areas of public spending, they noted that it significantly exceeds the typical 6–8% annual return expected by the UK Government on public investments.[28] In 2024, a comprehensive study compared the estimated long-term health impact of new products for neglected diseases (launched since 2000 or projected to be launched before 2040) against the total global investment required for their development from 1994 to 2040.[9] This analysis included global funding across the full range of neglected diseases, including new vaccines for bacterial pneumonia and meningitis, cholera, rotavirus, malaria, typhoid, and tuberculosis; improved diagnostics for HIV and tuberculosis; improved drugs for HIV, tuberculosis, and malaria; and improved malaria vector control. They estimated that every $1 invested in neglected disease R&D generated a return on investment of $405, mainly due to the societal value of lives saved, timelines, and scope. In 2025, the same group estimated that the impact of the UK's £3·05 billion funding for neglected disease R&D would generate global social returns worth £1·39 trillion for the period 2000 to 2040.[29]

The method we adopted varies in two important ways from previous analyses. First, we did not forecast the health gains of existing and future products past 2023. In other words, we only calculated the IRR and BCR for the commercially available products that had been used by 2023, and we do not account for the future health gains of products already launched or currently under development. Many return on investment analyses are often framed from an advocacy perspective where the hypothetical benefits from a new intervention or strategy are modelled by forecasting potential future gains. For example, the projected return on investment of the RTS,S/AS01 malaria vaccine varied from 0·42 to 2·30 for the period 2021 to 2030, depending on the assumptions used for the calculations.[8] However, the actual return on investment for malaria vaccines, based on real-life data, has not yet been evaluated. Second, our case study differs from previous analyses by estimating the return on investment for the entire portfolio of products supported by a single PDP. In contrast, earlier studies have focused on individual products or interventions,[8,20,21] specific diseases,[6,10] or aggregated all contributors involved in the new product development.[9] Our case study demonstrates how standard metrics can be effectively applied to assess the returns generated by the PDP model.

Despite recognised limitations in disability weights, age weighting, and cultural context, we used DALYs, the most widely accepted and policy-relevant metric for global health evaluations, to ensure comparability with previous global health investment analyses.[5,9,10,22] Sensitivity analyses further highlighted that assumptions about elasticity had the greatest influence on the estimated returns. Elasticity reflects how strongly health benefits respond to changes in product coverage and uptake—in other words, how much impact an increase in access or use has on overall health outcomes. Because of this relationship, even small adjustments in elasticity values lead to disproportionately large shifts in the estimated return on investment.

It is also important to note that most PDP funding remains concentrated on R&D activities, while efforts related to product access and delivery continue to receive limited support. This imbalance constrains the realisation of full health and economic returns, as delays in ensuring widespread access slow the accrual of benefits. If access-related components—such as registration, supply chain strengthening, and health system integration—were adequately funded, a larger proportion of the target population could benefit earlier. In such scenarios, returns on investment would likely begin sooner than the 12-year average lag observed in our analysis and yield higher overall BCR and IRR values.

A key feature of the PDP model is the ability to pool funds across different donors and de-risk the development of unsuccessful projects.[4] This approach avoids the need for funders to make early judgments about individual product lines. PDPs receive investment either as restricted grants—designated for specific programmes or objectives as defined by the donor—or as unrestricted funding, which allows them to allocate resources flexibly across operational priorities. PDPs engage in all stages of the product development cycle, from early-stage research through to regulatory approval, often advancing products more rapidly and cost-effectively than either academic institutions or private sector entities. Unrestricted funding provides PDPs the flexibility to reallocate resources efficiently across projects based on progress toward defined milestones and target product profiles.[1] PDPs adopt a portfolio approach across an entire product class (such as antimalarials) and can make data-driven decisions to advance or discontinue candidates according to scientific outcomes. Furthermore, increased coordination and pooling of donor resources serve to reduce the risks associated with developing products that might not be commercially lucrative. This approach incentivises pharmaceutical industry engagement and helps to address market failures. By convening a diverse set of partners and technical expertise, PDPs can accelerate the timeline from discovery to clinical evaluation, licensure, and delivery of affordable, safe, effective, and high-quality health products.

Our approach has its limitations. First, a VSL approach was used to translate the DALYs into economic benefits. We appreciate that this represents population-level willingness to pay to reduce the risk of death, not the value of an individual life. It is common and appropriate to adjust the US reference VSL to reflect income levels of other countries, especially in global health economic analysis, as recommended by the Organisation for Economic Co-operation and Development, World Bank, etc. It helps ensure that benefit estimates are contextually realistic and not overstated to allow for fairer comparisons across countries with different income levels. However, we recognise that the debate continues on the ethical and equity implications of this approach.

An additional limitation concerns the estimation of delivery costs. Comprehensive data on the cost of health-care delivery of antimalarial drugs have not been consistently available across all countries since 2000. Consequently, our analysis focused on the 15 countries with the highest annual malaria burden and where MMV-supported products were deployed. While this approach likely underestimates the total cost of delivery, these countries accounted for at least 77% of global malaria cases in any given year, thus capturing the majority of the disease burden. Moreover, the calculated IRR and BCR pertain specifically to the portfolio of products developed with PDP support.

Finally, the assessment of the potential health impact resulting from the delivery and distribution of the PDP-supported products relies on routinely available data to estimate the proportion of malaria treatments administered to patients with malaria. As with all modelling efforts, a key area of uncertainty lies in the extent to which health system inefficiencies might hinder the effective translation of distributed treatments into actual coverage and clinical impact.

Our aim was to adapt existing methods for estimating the return on investment from global health research using malaria medicines as a case study. This study has also enabled us to highlight some of the methodological and data challenges that could be explored in future research, allowing us to investigate the extent to which our findings are generalisable. In a world where there are likely to be far fewer donor resources for development, it is important that the full impacts of different investments are quantified. It is hoped that this study will help inform approaches on the evaluation of R&D investments and will add to the academic literature and evidence base on the potential cost–benefit of development interventions and programmes, including research. Also, from an empirical perspective—even in the context of some very conservative assumptions—our analysis confirms the value of investment in this area.

Contributors

CvD and OB-H acted as consultants for this work and developed the model estimating the lives saved and DALYs, with guidance and inputs from CA. PC calculated the IRR and BCR with guidance and inputs from LC and J-AM. PC, CA, J-AM, and LC conceptualised the paper and assembled the first draft. All authors reviewed the results and contributed to the manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

This study did not involve the collection of individual participant data. A data dictionary defining all fields in the study dataset will be made publicly available via GitHub to support reproducibility. No de-identified or identifiable participant data are included. Additional study materials, including the statistical analysis code and a README describing the structure and use of the dataset, will also be available. These materials are already accessible and will remain available indefinitely from https://github.com/paulachristen/mmv_ror/. All shared resources will be openly accessible and may be used by any researcher without restriction, in accordance with principles of reproducible research. No prior approval or data access agreement will be required.

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References

1 Boulton I, Meredith S, Mertenskoetter T, Glaue F. Evaluation of the Product Development Partnerships (PDP) funding activities. 2015. https://assets.publishing.service.gov.uk/media/57a0897140f0b649740000b0/Evaluation_of_the_Product_Development_Partnerships_funding_activities.pdf (accessed Oct 7, 2024).

2 Hoogstraaten MJ, Boon WP, Frenken K. How product development partnerships support hybrid collaborations dealing with global health challenges. *Glob Transit* 2020; **2:** 190–201.

3 Keeping the Promise. Impact and future of PDPs. 2023. https://www.keepingthepromisereport.org/impact (accessed April 17, 2025).

4 Bulc B, Ramchandani R. Accelerating global health R&D: the role of product development partnerships. 2021. https://www.mmv.org/sites/default/files/uploads/docs/publications/Accelerating-global-health-RD_The-role-of-product-development-partnerships_BBulc_RRamchandani_March2021.pdf (accessed Feb 21, 2025).

5 Turner HC, Hori Y, Revill P, et al. Analyses of the return on investment of public health interventions: a scoping review and recommendations for future studies. *BMJ Glob Health* 2023; **8:** e012798.

6 Glover M, Montague E, Pollitt A, et al. Estimating the returns to United Kingdom publicly funded musculoskeletal disease research in terms of net value of improved health outcomes. *Health Res Policy Syst* 2018; **16:** 1.

7 DCP3. Economic evaluation methods. https://www.dcp-3.org/economic-evaluations (accessed Nov 15, 2024).

8 Mak J, Sriudomporn S, Moss WJ, Patenaude BN. An estimate of the return on investment of a malaria vaccine in 20 Sub-Saharan African countries, 2021–30. *Health Aff (Millwood)* 2023; **42:** 1091–99.

9 Impact Global Health. The Impact of Global Health R&D Hub. https://www.impactglobalhealth.org/insights/hubs/the-impact-of-global-health-rd-hub (accessed March 11, 2025).

10 Grant J, Buxton MJ. Economic returns to medical research funding. *BMJ Open* 2018; **8:** e022131.

11 Brousselle A, Benmarhnia T, Benhadj L. What are the benefits and risks of using return on investment to defend public health programs? *Prev Med Rep* 2016; **3:** 135–38.

12 Masters R, Anwar E, Collins B, Cookson R, Capewell S. Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health* 2017; **71:** 827–34.

13 Zurovac D, Machini B, Kiptui R, et al. Monitoring health systems readiness and inpatient malaria case-management at Kenyan county hospitals. *Malar J* 2018; **17:** 213.

14 Thwing J, Williamson J, Cavros I, Bhattarai A, Gutman J. Seasonal malaria chemoprevention for malaria in children in areas with seasonal malaria. https://zenodo.org/records/6535577 (accessed March 11, 2025).

15 Zani B, Gathu M, Donegan S, Olliaro PL, Sinclair D. Dihydroartemisinin-piperaquine for treating uncomplicated *Plasmodium falciparum* malaria. *Cochrane Database Syst Rev* 2014; **2014:** CD010927.

16 Pryce J, Taylor M, Fox T, Hine P. Pyronaridine-artesunate for treating uncomplicated *Plasmodium falciparum* malaria. *Cochrane Database Syst Rev* 2022; **6:** CD006404.

17 Sinclair D, Zani B, Donegan S, Olliaro P, Garner P. Artemisinin-based combination therapy for treating uncomplicated malaria. *Cochrane Database Syst Rev* 2009; **2009:** CD007483.

18 Sinclair D, Donegan S, Isba R, Lalloo DG. Artesunate versus quinine for treating severe malaria. *Cochrane Database Syst Rev* 2012; **2012:** CD005967.

19 Okebe J, Eisenhut M. Pre-referral rectal artesunate for severe malaria. *Cochrane Database Syst Rev* 2014; **2014:** CD009964.

20 Lubell Y, Riewpaiboon A, Dondorp AM, et al. Cost-effectiveness of parenteral artesunate for treating children with severe malaria in sub-Saharan Africa. *Bull World Health Organ* 2011; **89:** 504–12.

21 Pfeil J, Borrmann S, Bassat Q, Mulenga M, Talisuna A, Tozan Y. An economic evaluation of the posttreatment prophylactic effect of dihydroartemisinin-piperaquine versus artemether-lumefantrine for first-line treatment of *Plasmodium falciparum* malaria across different transmission settings in Africa. *Am J Trop Med Hyg* 2015; **93:** 961–66.

22 Robinson LA, Hammitt JK, Cecchini M, et al. Reference case guidelines for benefit-cost analysis in global health and development. *SSRN* 2022; published online Feb 7. https://doi.org/10.2139/ssrn.4015886 (preprint).

23 WHO. World malaria report. 2024. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2024 (accessed March 11, 2025).

24 Hutubessy R, Chisholm D, Edejer TT. Generalized cost-effectiveness analysis for national-level priority-setting in the health sector. *Cost Eff Resour Alloc* 2003; **1:** 8.

25 Bertram MY, Lauer JA, Stenberg K, Edejer TTT. Methods for the Economic Evaluation of health care interventions for priority setting in the health system: an update from WHO CHOICE. *Int J Health Policy Manag* 2021; **10:** 673–77.

26 Robinson LA, Hammitt JK, O'Keeffe L. Valuing mortality risk reductions in global benefit-cost analysis. *J Benefit Cost Anal* 2019; **10** (suppl 1): 15–50.

27 Medicines for Malaria Venture. MMV's pipeline of antimalarial drugs. https://www.mmv.org/mmv-pipeline-antimalarial-drugs (accessed March 28, 2025).

28 Policy Institute at King's College London, RAND Europe, Health Economics Research Group at Brunel University London. Medical research: what's it worth? 2017. https://acmedsci.ac.uk/file-download/54792223 (accessed Nov 14, 2024).

29 Impact Global Health. A stronger and safer United Kingdom through global health R&D investment. 2025. https://www.impactglobalhealth.org/insights/report-library/a-stronger-and-safer-united-kingdom-through-global-health-rd-investment (accessed April 28, 2025).