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Evaluating the value for money of global fund's expenditures (2017–2019)

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Abstract

Background The Global Fund to Fight AIDS, Tuberculosis, and Malaria is one of the world's largest global health donor agencies, playing a key role by filling recipient countries' domestic health financing gaps; however, little is known about how well it achieves value for money. Given the current uncertainty regarding global health development assistance, it is critical to understand how to prioritize external donor funding allocations in an effort to maximize health impact.

Methods In this study, we evaluated 66 recipient countries' efficiency relative to peers in achieving improvement in health outcomes for TB, malaria, and HIV given their 2017–2019 Global Fund expenditures for (1) health products, (2) program activities, and (3) program management. Using a combination of frontier analysis, linear regression, and cluster analysis, we examined how macroeconomic conditions, epidemiological context, health system factors, and Global Fund spending decisions explain variation in country program performance.

Results For malaria and HIV, we found a negative relationship between Global Fund spending on program activity and health product costs respectively and countries' efficiency at translating funds to health impact. For malaria and HIV, there was also significant variation in efficiency across countries according to their economic capacity, disease burden, and most prominent spending area.

Conclusions Our results suggest possible structural inefficiencies in country program management, dampening the health impact of frontline programs. The lack of broad patterns to predict performance signals the importance of tailoring spending strategies to country-specific contexts.

Keywords Population health, Disease, Foreign aid, International development organizations, Economic planning

Introduction/background

The Global Fund to Fight AIDS, Tuberculosis, and Malaria ("The Global Fund") is one of the world's largest global health donors, spending more than 5 billion USD in aid annually to fill domestic financing gaps and support country-run programs. Since its creation in 2002, The Global Fund has invested over 65 billion dollars [1], substantially scaling up treatment for patients with AIDS, tuberculosis (TB), and malaria and expanding access to life-saving treatment [2, 3]. The Global Fund operates as a demand-driven financing mechanism that provides funding directly to principal recipients, such as government

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agencies, based on performance and without maintaining an in-country presence [2, 4, 5] Funding proposals are developed through country coordinating mechanisms, ensuring country ownership and multi-stakeholder involvement, while technical review panels assess proposals before the board makes final funding decisions. At the time of creation, this model represented a new and innovative form of development assistance, but over time it has also been the source of debate. In particular, there are questions about how much value for money their expenditures produce, how sustainable this funding model is moving forward, and how best to evaluate impact to secure fund replenishment for global health relief [6, 7, 8]. Additionally, the US contributes 33% of Global Fund's funding [9], making Global Fund's funding prioritization increasingly important to preserve essential health services amidst reductions in development assistance.

Achieving value for money means achieving the greatest health impact for every available dollar, saving as many lives as possible [10]. The Global Fund expands on this concept by defining five dimensions of value for money: effectiveness, investing in the most impactful interventions; efficiency, optimally allocating and utilizing resources; economy, optimizing procurement and resources; equity; and sustainability, enabling the health system to maintain and scale up interventions for disease control [4]. This definition highlights the many facets of value for money—it serves as both a measure of efficiency and performance when evaluating investments and of health impact when evaluating the effectiveness of funds to better health outcomes.

Given potential limitations of low- and middle-income recipient countries' health systems, which may be broadly weak in infrastructure, common concerns question whether Global Fund expenditures maximize value for money in achieving better health outcomes when implementation of funded activities could undermine national health systems and distract from their strengthening [2, 11]. However, these claims of negative health system effects remain unsubstantiated, as there is a paucity of conclusive, empirical evidence and of studies to assess health impact, effectiveness, and efficiency of external funding [12, 13]. Additionally, some work has evaluated countries' relative efficiencies in using external funding to achieve sustainable development goals (SDGs) and disease program targets using data envelopment analysis (DEA)[14, 15]. However, few studies examine country contextual factors' impact on efficiency, and no existing work examines multiple disease programs or how different expenditure types may influence efficiency of development assistance in achieving the greatest health impact.

Therefore, in this study we examined the value for money attained from recipient countries' expenditure of Global Fund funds from the 2017–2019 grant cycle across the three disease areas in a total of 66 low- and middle-income countries (LMICs). We sought to answer the following key questions. First, how efficient were recipient countries at maximizing the value of Global Fund's expenditures, and did this differ according to their economic capacity and disease burden at baseline? Second, given the wide range of recipient LMICs and their different health system contexts and expenditure decisions, what type of expenditures conferred the most benefit within country TB, malaria, and HIV programs, and how were different expenditure types associated with efficiency? Finally, in addition to baseline economic capacity and disease burden, did countries who predominantly spent on the same expenditure type perform similarly in achieving health impact specific to the three diseases?

Methods

Overview

The primary analysis of this paper examined recipient countries' efficiency scores—a metric produced by DEA representing how well recipient countries translated total expenditures of Global Fund investments into health impact. We examined differences in efficiency scores by clusters of recipient countries according to baseline economic capacity and disease burden, the association of different expenditure types and other contextual factors with efficiency, and differences in efficiency scores by country clusters of most predominant expenditure type, in addition to economic capacity and disease burden.

Country selection

We evaluated Global Fund's expenditures for the 2017–2019 grant period (eMethods 1) to ensure an adequate follow-up period to observe health outcomes given available data and to be able to utilize data regarding grant expenditures by type. We included 66 recipient countries from Africa, the Americas, Asia, Eastern Europe, and Oceania. Multi-country, multi-disease, and general health system strengthening grants were excluded from our analysis, and some recipient countries were excluded due to our data preprocessing criteria for missingness (eMethods 1). Of these 66 countries, 30 received funding for TB, 40 for malaria, and 40 for HIV, with some overlap for countries having received funding for more than one disease.

Data

We utilized publicly available data from Global Fund's website on grant expenditures (USD) by recipient country, disease, and expenditure type for the 2017–2019 grant cycle [1]. The three major expenditure types were:

(1) health products, commodities, and equipment; (2) program activity costs; and (3) program management costs (eTable 1). Expenditures on health products, commodities, and equipment also include associated procurement and supply chain management costs. Program activity related costs include expenditures on capacity building and technical assistance, human resources for health, living support to the target population, and communications. Program management expenditures include indirect and overhead costs, human resources including fiscal agents, and infrastructure. We also used domestic general government health expenditures per capita from the WHO Global Health Expenditures database to adjust for countries' own domestic health spending [16].

To evaluate these expenditures' health impact, we used disease burden data from the WHO for TB [17], malaria [18], and HIV [19] as outputs in our DEA model, calculating the change in the log for each health outcome over the implementation period 2018–2021, or 2015–2021 for HIV due to data constraints. For TB, we examined the change in the log for TB incidence rate per 100,000 population, TB case fatality ratio, TB mortality rate per 100,000 population, and TB case detection. For malaria, health outcomes included change in the log for malaria incidence rate per 1,000 people at risk, malaria mortality rate per 1,000 at risk, the proportion of total malaria cases which were indigenous, and the proportion of indigenous malaria causes from *P. falciparum*, a severe malaria strain. Health outcome measures for HIV were the change in the log for people of all ages living with HIV per 100,000 population, new HIV infections per 1,000 uninfected population, HIV deaths per 1,000 people of all ages living with HIV, and the percentage of HIV antiretroviral therapy coverage for people of all ages living with HIV. Additionally, we used World Bank gross national income (GNI) per capita data, in current year USD, as a measure of recipient countries' economic capacity [20]. Again, due to data constraints, the baseline economic capacity was set as 2015 for HIV, rather than 2016 for TB and malaria.

In the second-stage ordinary least squares (OLS) regression models following DEA, we included covariates regarding the recipient countries' specific health system contexts, other macroeconomic variables, and indicators of disease-specific country contexts. In all three disease analyses, these covariates included GNI per capita from World Bank and the Healthcare Access and Quality (HAQ) Index from the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease Study [21]. Also from IHME, we included disease-specific covariates. TB-specific covariates included urbanicity, measured as the proportion of the country with a population density of over 1000 people per square kilometer; indoor air pollution, measured by household prevalence of cooking with coal or biomass fuel; and age-standardized smoking prevalence for both sexes combined. Malaria-specific covariates were population-weighted mean temperature and population-weighted rainfall (mm/yr). HIV-specific covariates were average (across both sexes) syphilis seroprevalence proportion and age-standardized proportion of the population using intravenous drugs. All covariates were converted to the change in the log for that indicator over the implementation period 2018–2021.

Analysis

First, we calculated the adjusted change in the log for each health outcome to control for countries' domestic government health spending over the grant period. We also specified countries' expenditures per different populations for each disease, as TB spending is typically for treatment, malaria spending for prevention, and HIV spending for disease management. We calculated countries' expenditures by expenditure type per incident case (TB), per person at-risk (malaria), and per prevalent case (HIV), dividing total expenditures (USD) by the number of incident disease cases, at-risk population, and number of prevalent cases in 2016, which we defined as the baseline year immediately prior to the grant cycle (Fig. 1).

Next, we quantified the value for money achieved by recipient countries' Global Fund expenditures with data envelopment analysis (DEA) for each disease. Frontier analysis is currently the most reliable empirical method [10, 22–25] for examining the relationships between inputs (e.g., total expenditures) and outputs (e.g., disease burden), and this method has been used to evaluate efficient use of development assistance [14, 15]. We chose DEA rather than stochastic frontier analysis (SFA) as DEA is nonparametric and allows for multiple inputs and outputs to be assessed simultaneously [22, 23]. For each disease, we evaluated a country's performance relative to peer countries in maximizing desired outputs—health impacts, measured as the adjusted change in the log for every included health outcome for each disease over the grant implementation period—given the input of recipient countries' total Global Fund expenditures per incidence case (TB), per person at-risk (malaria), and per prevalent case (HIV) respectively.

We specified all DEA models with variable returns to scale (VRS), which assumes that not all countries operate at optimal scale, and an input orientation, as we wanted to optimize expenditures to maintain or exceed a country's achieved health impact. Additionally, we employed bootstrapping with 1000 repetitions to bias-correct all efficiency scores produced from the DEA models, ensuring that our results were robust with 95% confidence. All DEA relative weights were non-negative and consistent with expectations. Efficiency scores represented the ability of countries to maximize the health impact of Global

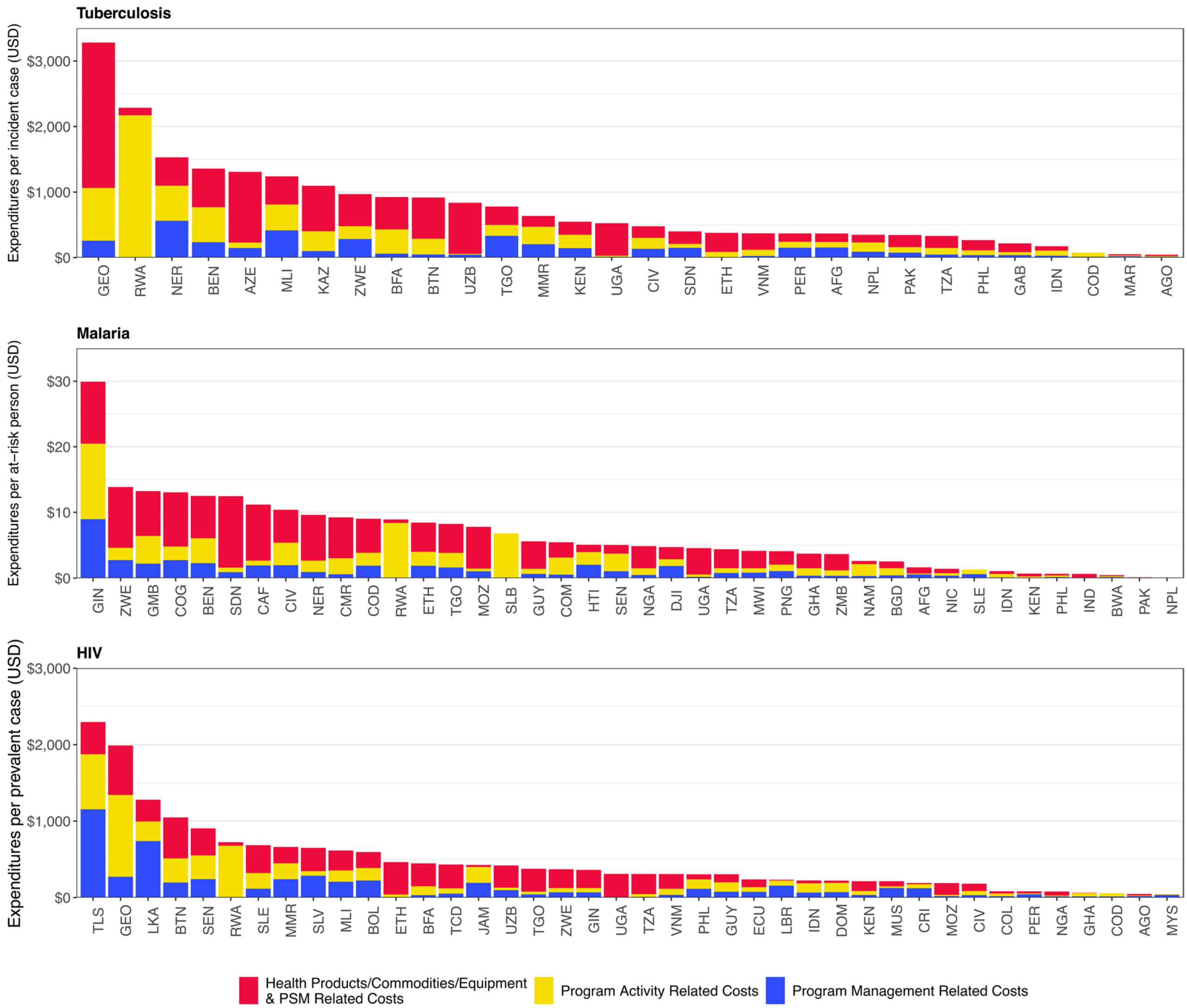

Fig. 1 Spending of Global Fund Investments (USD) by Expenditure Type, 2017–2019 Notes: Authors' analysis of Global Fund expenditures and WHO tuberculosis, malaria, and HIV data. Expenditures by type were specified per different populations depending on the disease to reflect the differences in who expenditures are primarily used for (i.e., Spending for tuberculosis is primarily for treatment, for malaria expenditures are mostly for prevention, and for HIV expenditures are typically for managing the disease among people living with it). Therefore, tuberculosis expenditures were converted to per incident case terms, malaria expenditures to per person at risk terms, and HIV expenditures to per prevalent case terms (y-axis)

Fund dollars relative to other countries, and they cannot quantify an amount of expenditure associated with better outcomes. An efficiency score of 1 indicated that a country spent funds to maximize health impact relatively efficiently compared to peer countries, with 1 being on the efficient frontier and representing the best performance; a score less than 1 indicated relative inefficiency, with 0 indicating the least possible level of relative efficiency. Differences in efficiency reflected differences in countries' translation of expenditures into changes in health outcomes.

After running these DEA analyses across all recipient countries for each disease to obtain efficiency scores, we clustered countries for each disease based on their baseline GNI per capita and disease incidence at baseline, 2016, prior to the grant period (Table 1). We categorized each country as low, lower-middle, or upper-middle income using their GNI per capita relative to the Work Bank's Analytical Classifications for calendar year 2016 [26], and we determined low and high disease burden relative to the median incidence among study countries. This resulted in six clusters for each disease: (1) low income and high incidence, (2) low income and low incidence, (3) lower-middle income and high incidence, (4) lower-middle income and low incidence, (5) upper-middle income and high incidence, and (6) upper-middle income and low incidence. We compared the efficiency scores within and between clusters with analysis of

Table 1 Study recipient countries by disease: economic Capacity, disease Incidence, greatest expenditure Type, and total global fund allocation amounts for 2017–2019 (USD)

Disease	Country Name†	Abbrv‡	Economic Capacity§	Relative Incidence¶	Greatest Expenditure Type	Global Fund Allocations for Disease, 2017–2019 (USD)
TB						
	Uganda	UGA	LI	High	Health products	$21,101,922
	United Republic of Tanzania	TZA	LI	High	Health products	$25,849,887
	Democratic Republic of the Congo	COD	LI	High	Program activities	$56,656,946
	Nepal	NPL	LI	High	Program activities	$16,138,548
	Afghanistan	AFG	LI	High	Program mgmt.	$14,964,754
	Burkina Faso	BFA	LI	Low	Health products	$7,000,000
	Ethiopia	ETH	LI	Low	Health products	$51,599,381
	Mali	MLI	LI	Low	Program mgmt.	$1,839,749
	Rwanda	RWA	LI	Low	Program activities	$14,154,994
	Togo	TGO	LI	Low	Health products	$4,854,374
	Niger	NER	LI	Low	Program mgmt.	$12,510,177
	Viet Nam	VNM	LMI	High	Health products	$47,281,094
	Philippines	PHL	LMI	High	Health products	$78,543,887
	Bhutan	BTN	LMI	High	Health products	$1,074,146
	Zimbabwe	ZWE	LMI	High	Health products	$23,775,807
	Pakistan	PAK	LMI	High	Health products	$130,163,215
	Angola	AGO	LMI	High	Health products	$6,080,400
	Myanmar	MMR	LMI	High	Program activities	$82,947,503
	Kenya	KEN	LMI	High	Program activities	$45,507,072
	Indonesia	IDN	LMI	High	Program activities	$102,416,537
	Côte d'Ivoire	CIV	LMI	Low	Health products	$13,921,205
	Benin	BEN	LMI	Low	Health products	$8,300,000
	Uzbekistan	UZB	LMI	Low	Health products	$21,640,400
	Sudan	SDN	LMI	Low	Health products	$12,262,049
	Morocco	MAR	LMI	Low	Program mgmt.	$2,100,000
	Gabon	GAB	UMI	High	Health products	$1,400,000
	Kazakhstan	KAZ	UMI	Low	Health products	$9,840,440
	Georgia	GEO	UMI	Low	Health products	$7,175,076
	Azerbaijan	AZE	UMI	Low	Health products	$6,529,446
	Peru	PER	UMI	Low	Program mgmt.	$7,199,291
Malaria						
	Togo	TGO	LI	High	Health products	$31,939,623
	Democratic Republic of the Congo	COD	LI	High	Health products	$347,651,023
	Mozambique	MOZ	LI	High	Health products	$167,870,339
	Niger	NER	LI	High	Health products	$56,747,651
	Malawi	MWI	LI	High	Health products	$70,670,374
	Central African Republic	CAF	LI	High	Health products	$30,409,209
	Uganda	UGA	LI	High	Health products	$188,322,878
	United Republic of Tanzania	TZA	LI	High	Health products	$145,258,808
	Guinea	GIN	LI	High	Program activities	$56,663,302
	Rwanda	RWA	LI	High	Program activities	$41,460,255
	Sierra Leone	SLE	LI	High	Program activities	$43,960,771
	Afghanistan	AFG	LI	Low	Health products	$27,112,391
	Gambia	GMB	LI	Low	Health products	$15,293,792
	Ethiopia	ETH	LI	Low	Health products	$129,849,218
	Nepal	NPL	LI	Low	Program activities	$4,208,547
	Nigeria	NGA	LMI	High	Health products	$313,409,111

Table 1 (continued)

Disease	Country Name†	Abbrv‡	Economic Capacity§	Relative Incidence¶	Greatest Expenditure Type	Global Fund Allocations for Disease, 2017–2019 (USD)
	Côte d'Ivoire	CIV	LMI	High	Health products	$124,696,572
	Benin	BEN	LMI	High	Health products	$36,949,701
	Papua New Guinea	PNG	LMI	High	Health products	$23,563,097
	Zambia	ZMB	LMI	High	Health products	$69,000,000
	Congo	COG	LMI	High	Health products	$14,208,223
	Ghana	GHA	LMI	High	Health products	$111,531,421
	Cameroon	CMR	LMI	High	Health products	$73,453,444
	Solomon Islands	SLB	LMI	High	Program activities	$4,852,890
	Nicaragua	NIC	LMI	Low	Health products	$6,435,536
	Philippines	PHL	LMI	Low	Health products	$10,662,817
	Zimbabwe	ZWE	LMI	Low	Health products	$53,685,777
	Pakistan	PAK	LMI	Low	Health products	$39,232,878
	Djibouti	DJI	LMI	Low	Health products	$2,731,792
	India	IND	LMI	Low	Health products	$65,006,452
	Kenya	KEN	LMI	Low	Health products	$63,225,487
	Sudan	SDN	LMI	Low	Health products	$98,522,995
	Comoros	COM	LMI	Low	Program activities	$4,588,919
	Bangladesh	BGD	LMI	Low	Program activities	$30,000,000
	Senegal	SEN	LMI	Low	Program activities	$40,804,408
	Indonesia	IDN	LMI	Low	Program activities	$53,644,906
	Haiti	HTI	LMI	Low	Program mgmt.	$21,600,000
	Guyana	GUY	UMI	Low	Health products	$1,612,021
	Namibia	NAM	UMI	Low	Program activities	$1,823,454
	Botswana	BWA	UMI	Low	Program mgmt.	$1,287,500
HIV						
	Togo	TGO	LI	High	Health products	$30,858,946
	Guinea	GIN	LI	High	Health products	$40,598,457
	Mozambique	MOZ	LI	High	Health products	$289,889,134
	Chad	TCD	LI	High	Health products	$35,365,870
	Mali	MLI	LI	High	Health products	$51,808,127
	Uganda	UGA	LI	High	Health products	$255,632,244
	Sierra Leone	SLE	LI	High	Health products	$40,265,850
	United Republic of Tanzania	TZA	LI	High	Health products	$408,487,081
	Rwanda	RWA	LI	High	Program activities	$154,462,907
	Liberia	LBR	LI	High	Program mgmt.	$24,833,450
	Burkina Faso	BFA	LI	Low	Health products	$36,760,555
	Ethiopia	ETH	LI	Low	Health products	$194,160,288
	Democratic Republic of the Congo	COD	LI	Low	Program activities	$122,678,456
	Nigeria	NGA	LMI	High	Health products	$239,781,871
	Côte d'Ivoire	CIV	LMI	High	Health products	$74,113,356
	Angola	AGO	LMI	High	Program mgmt.	$25,110,399
	Viet Nam	VNM	LMI	Low	Health products	$56,638,006
	Bhutan	BTN	LMI	Low	Health products	$1,081,903
	Uzbekistan	UZB	LMI	Low	Health products	$13,928,377
	Senegal	SEN	LMI	Low	Health products	$24,540,785
	El Salvador	SLV	LMI	Low	Health products	$14,481,816
	Philippines	PHL	LMI	Low	Program activities	$8,483,242
	Indonesia	IDN	LMI	Low	Program activities	$91,934,562
	Bolivia (Plurinational State of)	BOL	LMI	Low	Program mgmt.	$9,175,449

Table 1 (continued)

Disease	Country Name†	Abbrv‡	Economic Capacity§	Relative Incidence¶	Greatest Expenditure Type	Global Fund Allocations for Disease, 2017–2019 (USD)
	Timor-Leste	TLS	LMI	Low	Program mgmt.	$2,312,598
	Myanmar	MMR	LMI	Low	Program mgmt.	$123,102,465
	Dominican Republic	DOM	UMI	High	Program activities	$15,994,956
	Guyana	GUY	UMI	High	Program activities	$3,993,335
	Jamaica	JAM	UMI	High	Program activities	$9,930,638
	Mauritius	MUS	UMI	High	Program mgmt.	$2,487,917
	Ecuador	ECU	UMI	Low	Health products	$5,328,421
	Colombia	COL	UMI	Low	Program activities	$10,014,581
	Georgia	GEO	UMI	Low	Program activities	$8,412,986
	Peru	PER	UMI	Low	Program mgmt.	$6,264,586
	Malaysia	MYS	UMI	Low	Program mgmt.	$4,031,592
	Sri Lanka	LKA	UMI	Low	Program mgmt.	$6,948,047
	Costa Rica	CRI	UMI	Low	Program mgmt.	$2,120,098

† Some countries may appear more than once in this table if Global Fund allocated grant funding to them in multiple disease areas

‡ Abbreviations for countries are International Standards Organization (ISO) 3-digit alphabetic codes (ISO3)

§ Countries are categorized as low-income (LI), lower-middle income (LMI), or upper-middle income (UMI) using their GNI per capita (USD) relative to the World Bank's Analytical Classifications for calendar year 2016

¶ Relative incidence was assigned to a country as "High" if the country's initial incidence (in 2016 for TB and malaria and in 2015 for HIV due to data constraints) was at or above the median incidence among all included study countries. A country was assigned a "Low" relative incidence if its initial incidence was below the median incidence. For TB, incidence was measured as the rate of incident cases per 100,000 people in the country's general population. For malaria, incidence was the number of incident cases per 1,000 people in the at-risk population. For HIV, incidence was measured as the number of incident HIV infections per 1,000 uninfected people

variance (ANOVA), as well as a post-hoc Tukey Honest Significant Difference (HSD) test examining all pairwise comparisons.

Next, we employed linear regression as a second stage following DEA to examine the association of each expenditure type with efficiency, as well as what contextual factors of recipient countries were associated with efficiency. We regressed on the efficiency scores with log-transformed expenditures by type (and per incident case for TB, per person at risk for malaria, and per prevalent case for HIV), macroeconomic and country health system contextual variables, and disease-specific predictors.

Finally, in addition to clustering by GNI per capita and baseline disease incidence, we further clustered countries for each disease based on the expenditure type they spent the most on, resulting in 18 total clusters (eTable 2). Again, we compared the efficiency scores within and between clusters with ANOVA and Tukey HSD to understand if recipient countries with different economic capacities, disease burdens, and expenditure compositions performed differently.

All analyses were conducted in R Version 4.5.0 [27].

Results

Differences in efficiency clustered by economic capacity and disease burden

Bias-corrected efficiency scores varied for each disease and were low on average. On average, countries' efficiency scores for tuberculosis (Mean [SD]: 0·29 [0·25]) and HIV (0·30 [0·23]) were relatively higher than countries' efficiency scores for malaria (0·15 [0·20]). For TB, 12 out of the 30 countries performed with over 50% efficiency (eFigure 1), for malaria only 7 out of 40 countries (eFigure 2), and only 11 out of 40 countries for HIV (eFigure 3).

Examining the difference in efficiency scores across economic capacity and disease burden clusters for each disease (eTable 2), there were consistently both high and low performing recipient countries across income-incidence clusters for each disease, though some clusters appeared to have more countries on the higher end, such as lower-middle income countries with relatively high TB incidence, or the lower end than others, such as lower-income countries with relatively high malaria incidence (Fig. 2). An ANOVA for each disease comparing differences in mean efficiency scores within and between clusters revealed that recipient countries' performance did not significantly differ according to their baseline income and disease incidence, though clusters accounted for a different percentage of the total variance in efficiency scores for each disease (eTable 3). For TB and HIV, most of the variation in efficiency scores was due to within-group differences (64% and 71%, respectively), with between-group variance explaining less (36% and 29%). In contrast, for malaria, between-group variance and (56%) within-group variance (44%) were almost balanced.

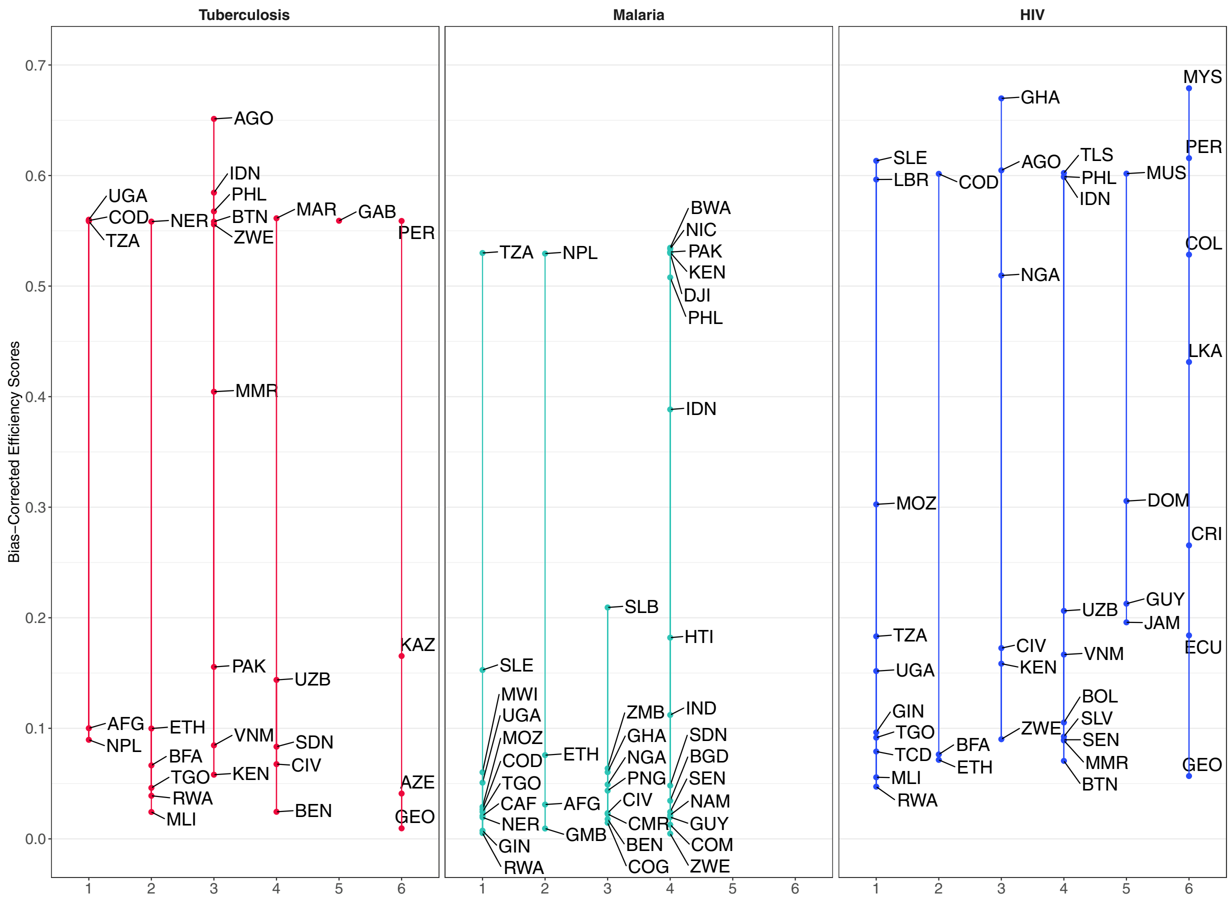

Fig. 2 Efficiency Scores Clustered by Economic Capacity and Disease Incidence, by Disease Notes: Authors' analysis of efficiency scores
Notes: There are six clusters shown here, numbered as follows: (1) low-income (LI) country and high disease incidence; (2) LI country and low disease incidence; (3) lower middle-income (LMI) country and high disease incidence; (4) LMI country and low disease incidence; (5) upper middle-income (UMI) country and high disease incidence; and (6) upper middle-income (UMI) country and low disease incidence

Relationship between expenditure type and efficiency and contextual enablers & barriers to efficiency

Table 2 presents the associations between expenditures by type, contextual covariates, and efficiency scores for each disease. In the fully adjusted models, higher program activity spending per at-risk person was significantly associated with lower efficiency for malaria, and higher spending on health products was significantly associated with lower efficiency for HIV. Though not significant associations, for TB all spending types were negatively associated with efficiency. For malaria, all spending categories were negatively associated with efficiency—except for program management expenditures, which has a very small positive coefficient whose confidence interval crossed zero—though none significantly. Similarly, for HIV, all expenditure categories showed negative associations, with only program management having a slightly positive association, though again with the coefficient's 95% confidence interval crossing zero. None of the covariates capturing macroeconomic conditions, health systems access and quality, or disease-specific predictors were significantly associated with efficiency in any of the models. Principal recipient of Global Fund investments (e.g., either the government, civil society organization, multilateral organization, or private sector organization who direct expenditures) also had no significant association with efficiency (eTable 4).

Differences in efficiency clustered by recipient countries' expenditure composition

To further explore heterogeneity in efficiency scores, we applied an alternative clustering approach based on countries' dominant area of spending across the three main functional categories, in addition to clusters by income and disease burden (Fig. 3). We observed significant differences in efficiency scores across clusters for malaria and HIV (eTable 5). No significant differences in efficiency scores were observed across clusters for any disease (eTable 5). Most clusters included both high and low performers, though Clusters 2, 4, and 7 for malaria only

Table 2 Post-DEA, Second-Stage linear regression on Bias-Corrected efficiency Scores, full model with all covariates

	Tuberculosis		Malaria		HIV	
Parameter	**β [95% CI]**	***P* Value**	**β [95% CI]**	***P* Value**	**β [95% CI]**	***P* Value**
Log-transformed total expenditures of Global Fund 2017–2019 investments on Health Products, Commodities, Etc., per disease case or person at risk†	−0·06 [−0·11 to 0·00]	0·06	−0·03 [−0·07 to 0·00]	0·07	−0·08 [−0·11 to −0·04]	< 0·001‡
Log-transformed total expenditures of Global Fund 2017–2019 investments on Program Activities, per disease case or person at risk	−0·03 [−0·12 to 0·06]	0·54	−0·06 [−0·10 to −0·02]	< 0·01	−0·05 [−0·12 to 0·01	0·12
Log-transformed total expenditures of Global Fund 2017–2019 investments on Program Management, per disease case or person at risk	−0·01 [−0·10 to 0·07	0·77	0·00 [−0·04 to 0·05]	0·87	0·05 [−0·01 to 0·12]	0·13
Change in the log for HAQ index over the implementation period 2018–2021	−1·91 [−6·45 to 2·63]	0·42	−2·11 [−5·13 to 0·91]	0·18	0·01 [−3·15 to 3·17]	1·00
Change in the log for GNI per capita over the implementation period 2018–2021	−0·04 [−0·84 to 0·76]	0·92	0·19 [−0·19 to 0·57]	0·33	−0·13 [−0·75 to 0·49]	0·69
Change in the log for urbanicity	−0·69 [−2·53 to 1·15]	0·47	··	··	··	··
Change in the log for indoor air pollution over the implementation period 2018–2021	−0·89 [−2·97 to 1·20]	0·41	··	··	··	··
Change in the log for age-sex standardized smoking prevalence over the implementation period 2018–2021	−4·73 [−9·44 to −0·02]	0·06	··	··	··	··
Change in the log for mean rainfall	··	··	−11·81 [−29·99 to 6·36]	0·21	··	·
Change in the log for mean temperature	··	··	6·27 [−34·95 to 47·50]	0·77	··	··
Average (of both sexes) change in the log for age-standardized proportion using intravenous drugs	··	··	··	··	0·99 [−1·91 to 3·88]	0·51
Average (of both sexes) change in the log for age-standardized syphilis seroprevalence proportion	··	··	··	··	0·00 [−1·46 to 1·47]	1·00

† Expenditures by type were specified per different populations depending on the disease to reflect the differences in who expenditures are primarily used for (i.e., Spending for tuberculosis is primarily for treatment, for malaria expenditures are mostly for prevention, and for HIV expenditures are typically for managing the disease among people living with it). Thus, tuberculosis expenditures by type (health products, program activities, and program management) were in per incident case terms, malaria expenditures by type in per person at risk terms, and HIV expenditures by type in per prevalent case terms. All expenditures by type were log-transformed in each regression model to scale the levels appropriately relative to the other variables

‡ Significant at the 99.9% level

included poor recipient countries with poor efficiency scores (Fig. 3). For malaria, between-group variance explained more of the total variation (64%) than within-group variance (36%) (eTable 5). For TB and HIV, within- and between-group variance each explained about half of the total variation in efficiency scores (eTable 5).

Discussion

This study examined how efficiently 2017–2019 Global Fund expenditures were spent across TB, malaria, and HIV programs in 66 recipient LMICs. We found no significant differences in efficiency scores among countries by income level or by disease burden at baseline. Importantly, efficiency did not appear to be determined by a country's economic capacity or baseline incidence, suggesting the potential for Global Fund to rethink its allocation methodology and how it establishes a country's level of need for the greatest impact, as this is currently mostly based on economic capacity and disease incidence [28]. Program activity spending was negatively associated with efficiency for malaria, signaling that funding could be better spent elsewhere, or alternatively that countries may face structural deficiencies that limit their ability to efficiently absorb funds for effective malaria programs. Spending on health products and equipment exhibited a negative association with efficiency for HIV, suggesting that there may be inefficiencies in how antiretroviral therapies and diagnostic tests are administered. These negative associations are further confirmed by significant differences in efficiency scores for malaria and HIV across recipient countries grouped by area of most spending, in addition to income level and disease burden. Contextual factors, though not statistically significant, appeared to shape patterns in efficiency in disease-specific ways. These results do suggest that Global Fund recipient countries have the potential to spend more efficiently.

For example, countries with similar profiles performed quite differently, highlighting that other unobservable

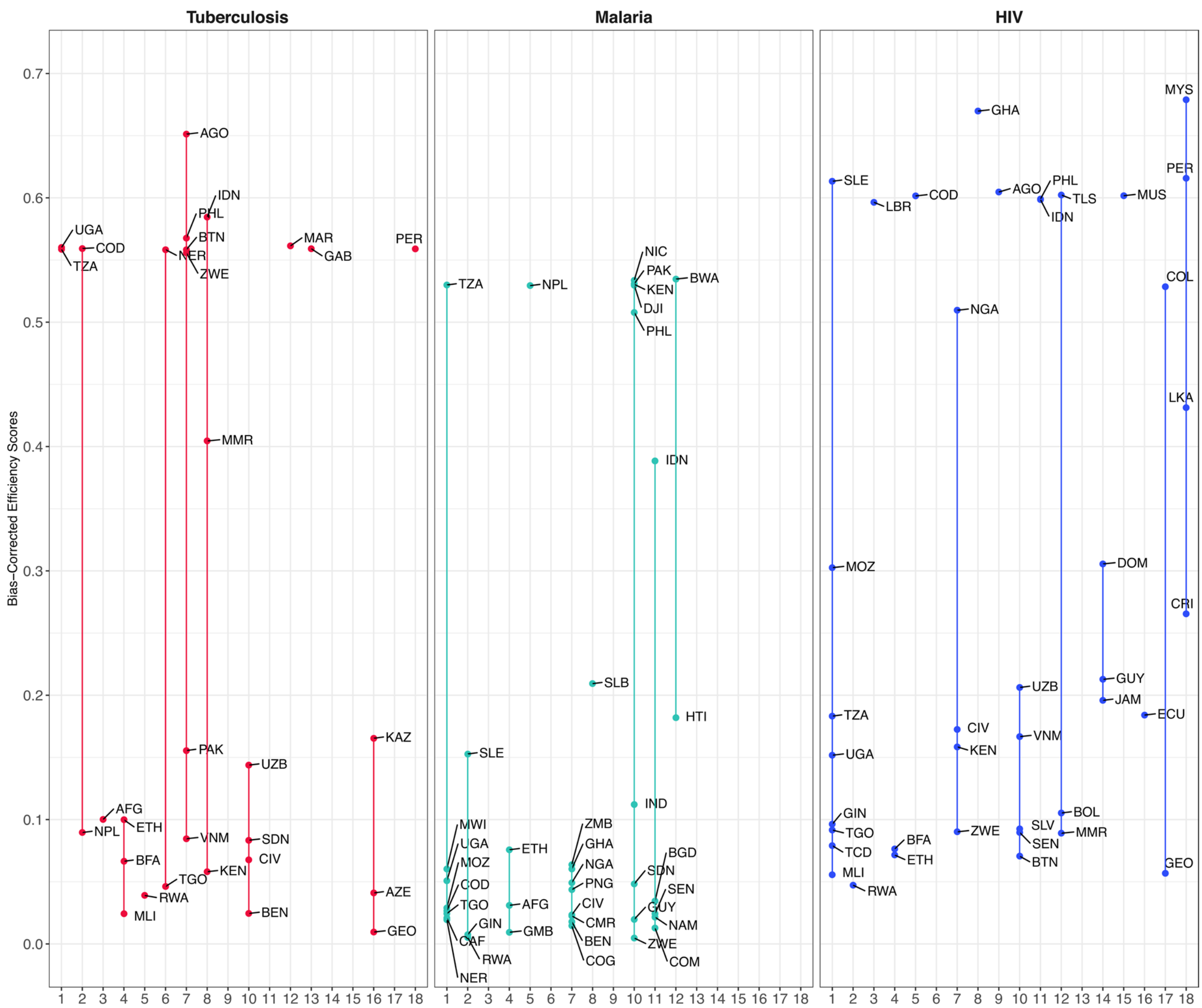

Fig. 3 Efficiency Scores Clustered by Economic Capacity, Disease Incidence, and Area of Most Spending. Notes: Authors' analysis of efficiency scores. There are eighteen clusters shown here, numbered as follows: (1) low-income (LI) country, high disease incidence, most spending on health products; (2) LI, high incidence, most spending on program activities; (3) LI, high incidence, most spending on program management; (4) LI, low incidence, health products; (5) LI, low incidence, program activities; (6) LI, low incidence, program management; (7) lower-middle-income (LMI) country, high incidence, health products; (8) LMI, high incidence, program activities; (9) LMI, high incidence, program management; (10) LMI, low incidence, health products; (11) LMI, low incidence, program activities; (12) LMI, low incidence, program management; (13) upper-middle-income (UMI) country, high incidence, health products; (14) UMI, high incidence, program activities; (15) UMI, high incidence, program management; (16) UMI, low incidence, health products; (17) UMI, low incidence, program activities; (18) UMI, low incidence, program management

factors related to governance and capacity may play an important role in determining how well resources are used. The negative association between program activity expenditures and efficiency for malaria suggests potential overinvestment in those programs, or structural deficiencies limiting how well funds are used for those programs, making the programs less effective and impactful. For HIV, the negative association between spending on health products and efficiency similarly suggests either overinvestment in this area or poor implementation and disbursement of therapies due to administrative challenges. For TB, consistently negative (though not significant) associations across all spending categories may reflect broader inefficiencies in delivery or unmeasured structural challenges within these types of programs, which is consistent with prior work which found governance indicators to be negatively associated with efficiency for national tuberculosis spending in LMICS [14].

Contextual factors—such as domestic health financing, changes in health system access and quality, and disease-specific risks—showed heterogeneous relationships with efficiency. While not statistically significant, the directions of associations offer clues. For example, growth in the health access and quality (HAQ) index was positively associated with efficiency for HIV but negatively for TB and malaria, suggesting that broader health system improvements may interact differently across disease areas. Similarly, while not significant, changes in environmental or behavioral risk factors—such as rainfall for malaria or intravenous drug use for HIV—may influence the effectiveness of spending. These patterns point to the importance of tailoring program strategies not only to disease characteristics but also to broader system and contextual dynamics.

When examining efficiency by area of most spending in addition to economic capacity and disease burden, variance between the clusters explained roughly 50% of the differences in efficiency scores for TB and HIV and over 60% for malaria. Country clusters were significantly different for malaria and HIV, demonstrating that recipient countries with different economic capacities, disease burdens, and spending decisions also may help determine unique considerations for operating country-run programs among recipient countries. For instance, the larger, significant between-group variance for malaria suggests that the most predominant expenditure type may be more impactful on efficiency for malaria than for TB or HIV. Identifying the different macroeconomic and health system contexts among recipient countries may guide countries within these groupings to find spending strategies that help them spend more efficiently given their unique contexts.

These results build on earlier studies examining the allocation [29, 30] and use [13, 31] of development assistance for health but extend this work by focusing explicitly on spending efficiency, particularly for different expenditure types. Whereas previous evaluations often emphasize total funding amounts or coverage targets, our analysis centers on the relationship between inputs and impact. Existing work has used DEA to examine how countries used funding to achieve SDGs and the factors associated with national tuberculosis spending efficiency, but there has not been a study examining spending efficiency across multiple disease areas or examining how different expenditure types contribute to efficiency. The clustering of countries by spending profile offers a new angle to understanding how similar countries make different choices—and how those choices translate into impact.

Several limitations warrant consideration. First, while DEA is a widely used method to assess efficiency, it is sensitive to outliers and does not account for stochastic variation. We applied bias correction through bootstrapping to mitigate this concern. Second, data constraints required us to use different baseline years for disease incidence across the three programs, though all reflect the pre-implementation period. Third, while we adjusted for a wide range of contextual factors, unobserved confounding may still influence the results, particularly in the second-stage regressions. Despite aiming to adjust for other factors, there are persistent methodological challenges to attribute health outcomes to external funding, especially attribution to specific agencies [31]. Furthermore, while we defined the implementation period (2018–2021) with a slight lag at the beginning and end relative to the grant period (2017–2019), this lag may not fully account for the reverberating effects of funding in the post-period.

Conclusions

Taken together, our findings suggest that the marginal gains associated with Global Fund budget allocations to recipient countries can vary substantially. This indicates that decisions about which countries receive funding and how that funding should be spent should be based on a more complex set of criteria, beyond simply country economic capacity and the level of disease burden. While these aforementioned factors may indicate countries and programs with a high degree of need for support, they do not appear to be adequate criteria to ensure resources are used efficiently. Rather, a better understanding of how well country programs can absorb external funds is needed to ensure that enabling factors are in place in countries to maximize the value of Global Fund and other external funding. Country-specific spending strategies, better alignment between funding and implementation, and careful attention to contextual enablers may all play a role in driving value for money. Opportunities exist for peer learning across settings—particularly among countries with similar profiles but divergent efficiency levels—to identify practices that enable greater impact from available resources. As already limited global health financial resources constrict even more, achieving the most impact for every dollar is crucial.

Abbreviations

ANOVA	Analysis of Variance
DEA	Data Envelopment analysis
Global Fund	The Global Fund to Fight AIDS, Malaria, and Tuberculosis
GNI	Gross National Income
HAQ	Healthcare Access and Quality (Index)
HIV	Human Immunodeficiency Virus
IHME	Institute for Health Metrics and Evaluation
LMIC	Low- and Middle-Income Countries
OLS	Ordinary Least Squares (Regression)
SDG	Sustainable Development Goal
SFA	Stochastic Frontier Analysis
TB	Tuberculosis
VRS	Variable Returns to Scale
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
JC and IP conceptualized the study and developed the research design. IP and MN conducted the literature search. MN extracted, cleaned, and assembled the data, which was verified by IP and JC. MN conducted the analysis and revised the methodology with suggestions form IP and JC throughout the process. MN created the visualizations and wrote the methods and results sections, and IP primarily wrote the introduction. MN wrote an initial interpretation of the results in the discussion section, and IP and JC provided critical insights and revisions. JC also contributed significantly to the manuscript revision process and provided insights from his expertise. MN prepared the manuscript and accompanying materials for submission. All authors had full access to all data in the study and read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from Global Fund Data Explorer, WHO Global Health Expenditure Database, WHO, World Bank, and IHME, all of which are publicly available.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
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