

Malaria Funding Profile Against Disease Burden:Regression Analysis Case of Zambia, 2009 to 2018

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Abstract

Background: Zambia has made profound strides in reducing both the incidence and prevalence of malaria followed by reducing malaria related deaths between 2009 and 2018. The number of partners providing malaria funding has significantly increased in the same period. The increasing number of partners and the subsequent reduction of the number of reported malaria cases in the Ministry of Health main data repository Health Management Information System (HMIS) stimulated this research. The study aimed at (1) identifying major sources of malaria funding in Zambia; (2) describe malaria funding per targeted interventions and (3) relating malaria funding with malaria disease burden.

Methods; Data was collected using extensive literature review of institutional strategic document between the year 2009 to 2018. The National's Health Management Information System (HMIS) provided information on malaria hospitalization data, incidence and mortality data. The statistical package for social sciences (SPSS) alongside Microsoft excel was used to analyze data in the year 2019.

Results: The investigation observed that about 30% of the funding came from PMI/USIAD, 26% from the global funds. The government contributed 17% with other partners sharing the remaining 27%.

Regression Analysis Model indicated a positive association between reducing malaria disease burden and increasing funding towards ITNs, IRS, MDA, and Case Management $r^2=77\%$ ($r^2>0.77$; 95% CI: 0.72 - 0.81). Furthermore IRS showed a p-value 0.018 while ITNs, Case Management and MDA having 0.029, 0.030 and 0.040 respectively.

Conclusion: Our findings highlight annual funding towards specific malaria intervention produces desired results.

Background

Malaria is a potentially life-threatening disease caused by infection with plasmodium protozoa transmitted by an infective female Anopheles mosquito [1], [2]. The disease occurs in more than 100 countries and territories globally [3]. Notable millstones have been recorded in the fight against malaria in most of the malaria prone areas world-wide [4]. Zambia is one of the countries in the malaria prone zones which has made profound strides in reducing both the incidence and prevalence of malaria followed by reducing malaria related deaths between 2009 and 2018 [5], [6], [7]. Despite scoring notable successes in reducing the disease burden over the years, malaria is endemic throughout the country, with the main transmission season being November through to March every-year with the county's average parasite rate of 10% and some parts of the country reporting less than 1%, while others still have high parasite prevalence rates of up to 20%-30% [8], [9]. The goal of the National Malaria Elimination Strategy 2017–2021 is to eliminate local malaria by 2021 and to maintain malaria free status and prevent reintroduction and importation of malaria into areas where the disease has been eliminated.

The county has shown strong economic growth reaching lower-middle-income status [10]. However, the health sector still continues to dependent on external resources, which accounted for over 60% percent of health sector expenditure in recent years [11], [12]. The study thus aimed at (1) identifying major sources of malaria funding in Zambia; (2) describing malaria funding per targeted interventions and (3) relating malaria funding with malaria disease burden between 2009 and 2018.

Methods

A retrospective cross sectional study was used to follow events in the period 2009–2018. The District Health Information Management System (DHIS) was the main source of data for malaria disease burden and mortality accessed on <http://www.dhis2.org.zm/hmis>. Data elements relating to malaria admission, discharge and death were isolated according to province and period. Secondary data was also collected to substantiate reported parameters as well as providing explanations to observed data fluctuations in the reference period.

The statistical package for social sciences (SPSS) alongside Microsoft excel was used to analyze data in the year 2019. Multiple linear regression model explained the linear relationship between the explanatory (independent) variables and response (dependent) variable [13]. In essence, prior building the model, scatter plots and coefficients of determination were constructed to illustrate the linear relationship and highlight the closeness between dependent and independent variables.

Ensured that results have both internal and external validity through rigorous application of context and content analysis with systematic pretesting of the research instruments [14]. Prior to data collection, ethical clearance was sought in China from the institutional Review Board of China pharmaceutical University and approval from relevant authorities including Ministry of Health Public Health and Research Unit Zambia.

Results

Sources of malaria funding in Zambia

Ministry of Health Zambia receives overwhelming financial and logistical support from its partners in the fight against malaria. In the period under review, the major contributors to malaria funding for malaria prevention, treatment and control in Zambia included Presidential Malaria Initiative (PMI-USIAD), Global Fund (GF), World Bank (WB), World Health Organization (WHO), United Nations International Children's Emergency Fund (UNICEF), Program for Appropriate Technology in Health (PATH), Malaria Control and Elimination Partnership in Africa (MACEPA) and Department for International Development (DFID) among others [15],[16]. Key partners have been cited to provide financial and logistical support towards the fight against malaria in Zambia as shown in Figure 1 [17], [18] [19], [20], [21].

There is a huge and continues fluctuation in the annual funding disbursement received from partners [22], [23]. The study indicated that about 30% (95% CI: 24.43 – 33.62) of the funding came from PMI/USIAD, 26% (95% CI: 24.72 – 28.53) from the global funds. The government contributed 17% (95% CI: 16.03 – 18.46) with other partners sharing the remaining percentage as evidenced by [24], [25], [26].With support from the listed partners, Ministry of Health ensures constant and adequate availability of drugs and malaria related logistics through procurement of key malaria preventive and treatment commodities (Artemisinin-based combination therapies - ACTs, rapid diagnostic tests - RDTs, long-lasting insecticide-treated nets - LLINs, and IRS) [27]. Literature suggests an increase in the operational and logistical cost in the past few fiscal years (\$24 million – \$27 million – 2014, and is \$28 million in 2015, \$28.5 million in 2016, and \$29 million in 2017) [28], [29][30][31].

Notwithstanding the huge difference in terms of amount of funds received per intervention, procurement of ITNs, IRS and anti-malaria drugs received more funds.

Malaria disease burden

The District Health Information Management System (DHIS) indicated a systematic decline in number for patients admitted with malaria. Trend analysis of malaria admission showed over 60% (95% CI: 56.42 – 62.32) reduction of malaria related admission from 176,664 admissions in 2009 to 68,898 in 2018 and an average reduction of 140,533 with provincial variations. Similarly, mortality data also conforms to the same pattern with geographical variations across the years as presented in Table 1.

Relationship between funding and reducing malaria burden

The single factor analysis of variance performed to test equity of variances of reported malaria admissions by province indicated that there is sufficient evidence to suggest that reported malaria cases by provinces are statistically different (p-value 7.857). Comparably, malaria mortality data also suggest a variation in reported malaria deaths by province is not due to chance as depicted in Table 2.

Predictor variables were used to explain the relationship between funding and malaria disease burden namely; insecticide treated bed nets (ITNs), indoor residual spray (IRSs), malaria case management (ACT/RDT), monitoring and evaluation (M &

E), information education and communication (IEC), mass drug administration (MDA) and entomological studies (ES) and were tested for correlation with the dependent variable using scatter plots. This practice is necessary in assessing the assumptions of linearity and homoscedasticity of variables [32], [33].

The regression equation between annual malaria and provision of insecticide treated nets indicated a downward slope depicting a negative relationship with $R^2=0.45$ (95% CI: 0.31 – 0.58), provision of Indoor residual spray (IRS) $R^2=0.19$ (95% CI: 0.17 – 0.22), Malaria case management (ACT/RDT) $R^2=0.13$ (95% CI: 0.15 – 21). On the contrary, a positive relationship between provision of M&E, indicating that the number of reported malaria cases increased as funds to monitor collection of such data increased. A weak positive relationship for information education communication implying that the more the community is informed or educated about malaria, the more likely they will visit the hospital to seek medical services as such the number of reported cases is expected to increase.

However, the relationship between reduced disease burden and the provision of MDA and conducting ES did not produce a clear relationship due to missing data values in other years. Having established that the seven (7) predictors are all related to the dependent variable in some way, we adopted and included all the seven in the model.

The model took a form of standard multiple-linear equation of the form $Y = a + Bx_1 + Bx_2 + Bx_3$. Table 3

Discussion

Zambia has been divided into three malaria transmission zones following natural variations of the disease intensity; Zone 1: Areas where malaria control has markedly reduced transmission, and parasite prevalence in children less than five years of age is less than 1%. These places include Lusaka and its surrounding. Zone 2: Areas where sustained malaria prevention and control has markedly reduced transmission, and parasite prevalence is at or under 14% in children under five years of age at the peak of transmission and this includes provinces like Central, Copperbelt, Southern, and Western Provinces. And Zone 3: includes areas where progress in malaria control has been achieved but not sustained and lapses in prevention coverage have led to resurgence of infection and illness, and parasite prevalence in young children exceeds 14% at the peak of the transmission season such areas include Eastern, Luapula, Muchinga, Northern, and North-Western Provinces as illustrated in literature review [34], [35].

The Ministry of Health just like any other ministry in Zambia receives support from various partners and stakeholders in terms of logistical and financial support in the fight against malaria. In particular, partners have been cited to provide financial and logistical support towards prevention, treatment and control of malaria in Zambia.

Following the observed funding pattern across the years, it is clear to mention that without partner support the ministry of health would face countless challenges to provide appropriate treatment, prevention and control of malaria. This support is largely channeled towards procurement of key malaria preventive, treatment and control commodities such as ACTs, RDTs, LLINs, and IRS among other interventions. Thus, out of the seven identified malaria control interventions, 34.7% (95% CI: 22.8–37.3) of the total funding was towards provision of ITNs, 26.9% (95% CI: 24.1–27.7), and 19% (95% CI: 17.3–21.6) for IRS and Case Management respectively.

Ministry of health uses District Health Information Management System (DHIS) as its main data repository system. DHIS forms the core of the broader health management information system for the ministry with a mandate of collecting routine data on service coverage and disease burden. The analysis of malaria data from the DHIS indicated that there is a general decline in the number of reported malaria cases in the country. Trends of malaria admissions are falling over the years depicting over 60% (95% CI: 58.6–63.4) reduction in the study period. However, the declining malaria disease burden is associated with geographical location.

Single factor analysis of variance established significant geographical variations in the number of reported malaria cases countywide with Eastern province recording highest number of patients admitted, followed by Luapula, North Western,

Muchinga and Northern. On the other hand, Southern and Lusaka reported lowest number of cases and a similar decline in annual malaria incidence and malaria related deaths. Luapula Province reported highest number of malaria deaths per annum. It was observed that on average, about 4,392 people die due to malaria per year countrywide. Copperbelt, Northern and Eastern provinces also reported high numbers of malaria related deaths. Although the number of reported malaria hospital admissions and deaths are seemingly high, the trend analysis showed declining malaria admission and deaths across the ten (10) provinces [5].

Several predictor variables were used to illustrate the relationship between declining malaria disease burden (admission and deaths) and increasing financial/logistical support towards treatment, prevention and control of malaria. The study hypothesized that increasing annual funding towards key malaria activities will reduce the disease burden.

Scatter plots results showed a strong inverse relationship between increasing funding to procure ITNs and reducing malaria counts. Findings are in agreement with what was documented by Lengeler who documented that in areas of stable malaria transmission, provisions of ITNs have potential to reduced parasite prevalence by 13%, uncomplicated malaria episodes by 50%, and severe malaria by 45% compared to equivalent populations with no nets. Following this and other related studies, World Health Organization (WHO) now recommends ITNs as a core intervention for malaria control [36],[37][38].

Indoor Residual Spray is one of the effective malaria control method used in most of regions including central and southern Africa. This study established an association between IRS and reducing disease burden $R^2 = 0.19$ (95% CI: 0.18–0.27). Similarly, a research conducted in Northern Uganda that assessed the association between IRS and malaria morbidity, revealed a much greater decrease in the odds of malaria in patients less than 5 years of age following three rounds of IRS with bendiocarb (ORs 0.34, 0.16, 0.17 respectively, $p < 0.001$ for all comparisons). In this study however, the protection by IRS was more pronounced in patients greater than 5 years of age, up to 9 p.p. decrease [39], [40][41].

Mass drug administration is also a well know malaria prevention and control intervention worldwide. A community randomized step-wedged control trail was conducted in Southern Zambia to access effectiveness of population-wide malaria testing and treatment with rapid diagnostic tests and Artemether-Lumefantrine showed a strong inverse relationship [42]. A clear relationship between provision of MDA and reducing malaria burden was not established due to limited data. However, other studies indicate that Mass Drug Administration has a strong power to prevent the spread of the disease [43], [44].

Using the 95% confidence interval, the overall regression predictive model found a positive association between increasing funding towards IRS, ITNs, Case Management, MDA, and reducing malaria disease burden in Zambia $r^2 = 77\%$ ($r^2 > 0.77$; 95% CI: 0.72–0.81). The model suggest that IRS has a huge impact in reducing disease burden p-value = 0.018, ITNs p-value 0.029, Case Management p-value 0.030 and MDA p-value 0.041. This translates that increasing the annual funding towards malaria prevention and control activities results into the reduction of reported malaria cases thereby reducing incidence and mortality rates [45]. The Zambia national malaria program performance review report of 2010, confirms that combined funding for malaria prevention methods (IRS, ITNS, and other vector bone methods) are more compared with treatment and diagnostics methods due to their huge impact on the disease burden [46].

Limitations

Due to lack of external funding, the study did not collect extensive data on other known malaria prevention and control methods. As such, data on mass drug administration and entomological studies was missing. However, the missing data did not affect the overall results of the study but rather highlighted needy areas.

Conclusion

Malaria is not just a public health concern in Zambia but also one of the top 5 causes of hospitalization and deaths in Zambia [47]. Luapula, Muchinga, Northern, North-Western and Eastern Province experience high malaria cases throughout the reference period as evidenced by other reports [48].

Zambia like Many developing countries in Central and Southern Africa, receives funding/support for prevention, treatment and control of malaria from various partners [49]. This support is largely targeted towards Mass Drug Administration, Indoor Residue Spray, Insecticide treated bed nets, Clinical case management (provision of anti-malarial drugs, laboratory diagnostic equipment), entomological intervention, Monitoring and Evaluation, Information Education and Communication.

The overall regression predictive model indicated that about 77% of variations in malaria disease burden is attributed to increasing funding towards provision of ITNs, IRS, Case Management and MDA. Thus, increasing the annual funding towards malaria prevention and control activities results in reducing the number of reported malaria cases and consequently reduce incidence and mortality rates [50], [51][52][53]. The report also recommends an extensive study looking at the relationship between all know malaria interventions against disease burden.

Acronyms And Abbreviations

DHIS District Health Information System

GRZ Government of the Republic of Zambia

IRS Indoor Residual Spraying

ITNs Insecticide-Treated bed-Nets

LLINs Long Lasting Insecticide Nets

MACEPA Malaria Control and Elimination Partnership in Africa

PATH Program for Appropriate Technology in Health

RDTs Rapid Diagnostic Tests

USAID United States Agency for International Development

UNICEF United Nations International Children's Emergency Fund

WHO World Health Organization

Declarations

Ethics approval and Consent to participate

This study received ethical approval in China from the institutional review Board of China Pharmaceutical University(Nanjing, China).while in Zambia from the National Health Research Authority(NHRA), Ministry of Health Public Health and Research Unit and relevant authorities at the Ministry of Health.

Consent for Publication

Not applicable

Availability of data and Materials

The dataset used/analysed are available from the corresponding author on request.

Competing Interests

The authors declare that they have no competing interest

Funding

There is no funding for this study.

Author's Contributions

MM and WX contributed to the conceptualization of the study. The design by MM, JLM and DWW. Data collection by MM and JLM. MM and JLM analysed and interpreted the data. MM and XZY wrote the first draft of the manuscript. XZY, DWW and WX revised the article for important intellectual content. All authors read and approved the final manuscript.

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Tables

Table 1
Annual Malaria Admissions (2009–2018)

Provinces										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Central Province	9,201	6,979	7,295	7,419	7,649	10,135	5,593	5,730	3,735	3,061
Copperbelt Province	29,396	31,552	28,597	27,726	23,723	21,265	18,548	15,671	11,009	8,675
Eastern Province	52,538	61,271	43,149	27,958	16,447	14,269	11,784	9,068	9,977	12,158
Lusaka Province	9,727	11,665	8,083	4,578	5,699	4,886	2,150	3,282	2,574	1,817
Luapula Province	23,754	24,269	21,290	24,415	27,532	25,415	18,359	16,306	11,287	13,456
Muchinga Province	10,506	25,125	22,448	17,496	19,320	15,238	12,507	11,884	8,486	7,726
Northern Province	8,560	14,876	20,836	18,467	20,952	22,635	12,821	10,969	10,910	7,813
N-Western Province	10,375	12,401	17,704	18,303	26,144	21,504	15,529	14,584	9,717	9,479
Southern Province	15,794	16,491	8,954	5,860	4,563	5,299	2,130	1,598	1,038	1,083
Western Province	6,813	8,676	10,218	13,857	11,535	8,903	8,206	7,131	6,110	3,630
Total	176,664	213,305	188,574	166,079	163,564	149,549	107,627	96,223	74,843	68,898

Table 2
Single Factor Analysis of Variance (malaria admission)

Anova: Single Factor						
SUMMARY						
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>		
Central Province	10	66797	6679.7	4899936.456		
Copperbelt Province	10	216162	21616.2	63846131.73		
Eastern Province	10	258619	25861.9	379115675.2		
Lusaka Province	10	54461	5446.1	11339140.1		
Luapula Province	10	206083	20608.3	30100553.79		
Muchinga Province	10	150736	15073.6	34927448.04		
Northern Province	10	148839	14883.9	30058974.32		
N-Western Province	10	155740	15574	29823030		
Southern Province	10	62810	6281	33294314.44		
Western Province	10	85079	8507.9	8365391.656		
ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit.</i>
Between Groups	4632659295	9	514739921.7	8.225696848	7.85687E-09	1.985594
Within Groups	5631935362	90	62577059.58			
Total	10264594657	99				

Table 3
Regression predictive model

<i>Regression Statistics</i>						
Multiple R	0.881493845					
R Square	0.777031399					
Adjusted R Square	0.331094197					
Standard Error	5.422704859					
Observations	7					
ANOVA						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	4	204.9542	51.23855	1.742468	0.039622	
Residual	2	58.81146	29.40573			
Total	6	263.7656				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	30.12836375	57.64544	0.52265	0.01653	-217.899945	278.1567
Insecticide Treated Nets	-2.02612E-07	1.32E-06	-0.1536	0.02892	-5.8782E-06	5.47E-06
Case Management	-2.58188E-06	9.36E-06	0.810269	0.03028	-3.2679E-05	4.78E-05
Indoor Residual Spray	-3.52625E-06	1.73E-06	-2.04049	0.01781	-4.0862E-05	3.91E-06
Mass Drug Administration	-1.37886E-08	6.58E-07	0.020958	0.04183	-2.8107E-06	2.84E-06
Monitoring & Evaluation	-3.77532E-09	5.98E-03	-2.8287	0.17882	-1.8634E-08	2.76E-08
Entomological	2.12326E-07	4.26E-05	0.586358	0.05739	-1.9876E-07	1.76E-05
IEC	-3.65433E-08	2.35E-05	-1.937635	0.07653	-2.5642E-09	3.12E-08
Note: Boldface indicates Statistical significance (P < 0.05).Estimates are expressed in OR with 95% CI.						

Figures

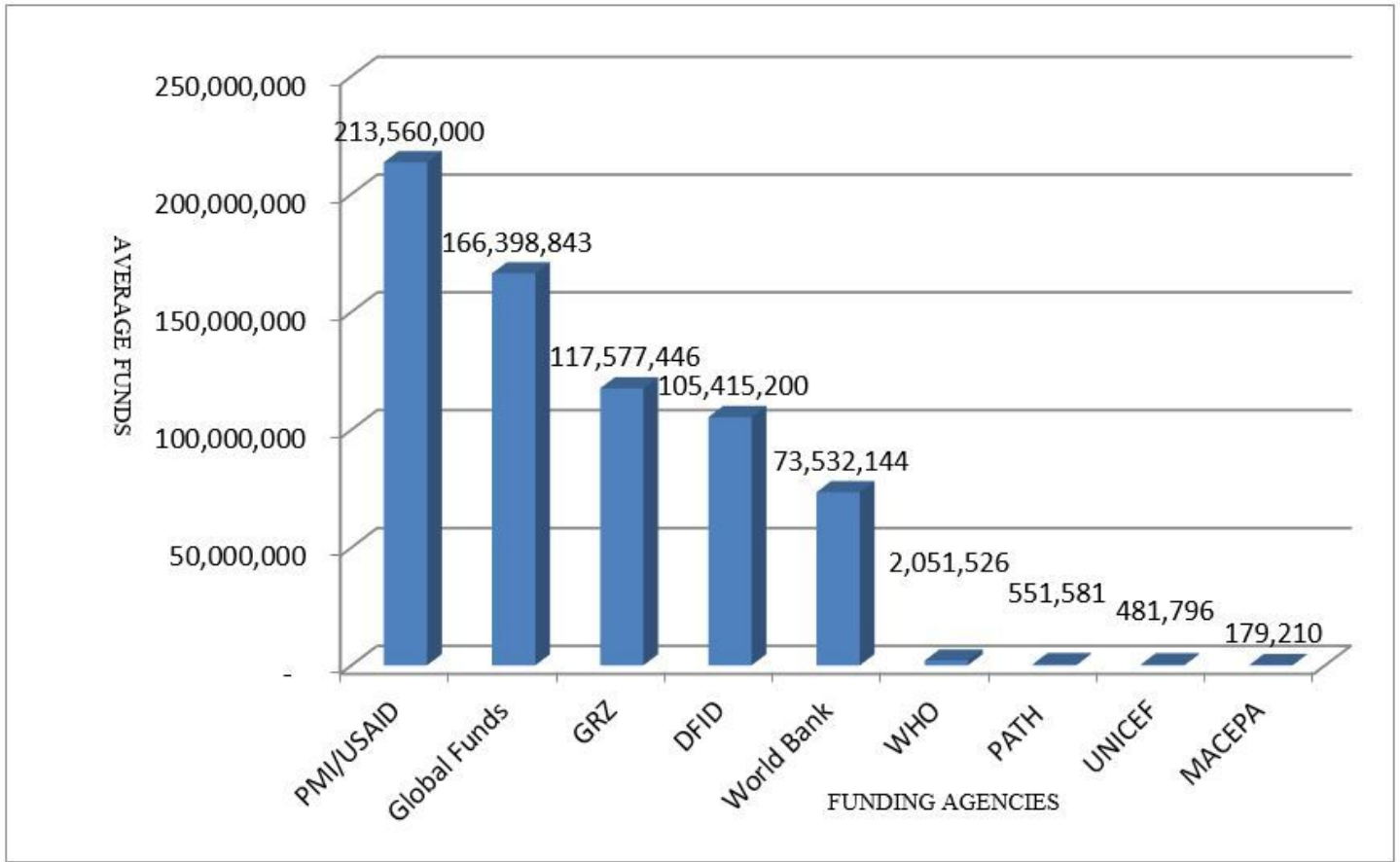


Figure 1

Sources of Malaria Funds in Zambia Source: NMCC 2019, PMI 2015, PATH 2015, NMCPS 2016, WHO 201, NMOP 2017 Note: Average Amount per Funding Period in USD