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Cost-Effectiveness Analysis of the Piloting of Malaria Rapid Diagnostic Test kits within Region 8, Guyana

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Abstract

The objective of this study was to conduct a Cost-Effectiveness Analysis (CEA) of piloting Rapid Diagnostic Test (RDT) kits in Region 8 of Guyana. The primary aim was to assess whether the introduction of RDTs provided good value for money and whether it could be considered a cost-effective intervention for malaria diagnosis in remote, high-burden areas. A quantitative analysis approach was employed, utilizing secondary data collected from multiple authorized sources, including government agencies such as the Ministry of Health. The data included expenditure records, payment vouchers, project reports, and receipts, providing critical financial information to estimate costs associated with the RDT pilot and microscopy testing. The results revealed that the total cost of implementing the RDT pilot project was USD 67,161, with the majority of expenditures allocated towards human resources. The estimated cost for administering a single RDT was USD 13.23. The findings demonstrated that the community-based approach was more cost-effective because it avoided additional expenses related to the construction and operation of new health facilities and hiring of personnel. By comparison, the cost of microscopy testing was estimated at USD 31.44 per patient, with the principal cost drivers identified as human resource salaries and facility operational expenses. Based on the Incremental Cost-Effectiveness Ratio (ICER) analysis, the intervention was deemed highly cost-effective. When compared to Guyana's GDP per capita, which was USD 3,883 in 2017 according to the Guyana Bureau of Statistics, the piloting of RDTs was shown to be a financially sustainable and impactful approach to strengthening malaria diagnosis in underserved regions.

Keywords*: Cost-effectiveness, Economic Evaluation, Guyana, Malaria, Rapid Diagnostic Test,*

Introduction

In 2016, Malaria accounted for 455,000 deaths worldwide [1], with young children in sub-Saharan Africa accounting for most morbidities and mortalities [2]. However, this number showed a decline from the estimated 800,000 who died globally from the disease in the year 2010 [3]. Though Malaria-related deaths have been reducing, the number of new cases has remained relatively constant globally. Estimates stood at 216,000,000 new cases of Malaria in 91 countries in 2016 [1], a 2% increase from 2015. Malaria remains a priority on the global health agenda, as captured in Sustainable Development Goal Three, which aims to end the epidemic of Malaria by 2030 [4, 5].

Malaria is a significant public health issue in Guyana. Established in the early 1950s, the National Malaria Programme was created with an emphasis on reducing Malaria in the sugar plantations of Guyana's coastal regions, ultimately reducing cases to just 72 in the entire country [6]. Of the ten administrative regions, Regions 1, 7, 8 & 9 (Hinterland Regions) are the known endemic Malaria regions. According to the National Census (2012), the Hinterland Regions had a population of 81,333 people, or

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11% of the country's total population, with a population density of 8.6 persons per km2. The incidence of the disease, however, increased in 2007, ultimately peaking in 2013, with a high prevalence in the malaria-endemic hinterland regions. It is thought that the rise in global gold prices served as a pull factor, attracting more people to the hinterland regions [7].

The pillars of Guyana's economy/Gross Domestic Product (G.D.P.), are agriculture and extractive industries such as mining and forestry. 31% of the G.D.P. is made up of the agricultural and mining sector industries, both of which occur in the same areas that are natural habitats of the Anopheles mosquitoes, the vector that transmits Malaria [8].

Method

This study will employ CEA to determine whether the introduction of RDTs in Guyana provides value for money to Guyanese taxpayers. CEA brings together data on demographics, the burden of disease, the impact of the intervention, and costs within a reference framework. These analyses contextualize whether a response is worthwhile relative to others, contributing to the decision about which interventions should be given priority across different budget thresholds.

The methodology was guided by the CEA design articulated in "Operationalization of the National Malaria Strategy in Guyana: A Pilot Project in Region 8 (Potaro-Siparuni) and its progressive scale-up to all malaria-endemic regions." Secondly, the report of the pilot of the RDTs as also used to estimate the number of RDTs and other resources. Data was also gathered from the Management Information System Unit (MISU)-VCS [19].

Study Setting

This research examined the cost-effective analysis of piloting of the RDT kits within Region 8 more specifically the 12 mining camps: B/K, Minne ha-ha, Tesouro, R/V, # 35 miles, Mouwsi, Takuba Lodge, White Water, Princeville, Pamela, Water Dog, Jumbie Creek and Eagle Mountain mining site. The study examined the costs of procurement and distribution of RDTS in Malaria Endemic Region #8 of Guyana. At the time of this study, the pilot had been completed (July to December 2016). The analysis covered a time horizon of two years, to allow capturing costs from procurement, implementation, and evaluation.

Study Design

This study was a cost-effectiveness analysis of a community-based approach in Guyana, using an economic evaluation. Also, a retrospective/observational component of the project focused on quantitative data and the estimation of cost-effectiveness as well as the outcome variables.

Study Perspective

The study perspective was from a provider or health system perspective, which accounted for travel costs, salaries, procurement of commodities, and health promotion, among others. All prices reflected in the study were converted to United States Dollars using the Bank of Guyana's average exchange rate.

Outcome Variable

The primary outcome measure was the number of diagnosed malaria cases within the study frame. The health outcome was not considered because of the pilot's short time frame. Secondly, the expectation is that malaria incidence will increase due to enhanced surveillance resulting from the piloting of RDTs in the 12 mining camps. The counterfactual will be a difference-in-differences analysis, which compares changes in outcomes over time between a population enrolled in a program (the treatment group) and a population not enrolled (the comparison group). To answer the impact question, which is the impact or causal effects of a programme (P) on the outcome of interest (Y), which had the intervention, the formula below will be used.

$$\Delta = (Y \mid P = 1) - (Y \mid P = 0)$$

Where: Δ is impacted

Y is the outcome

P is the programme

The indicator to measure effectiveness would be Resource Adjusted Malaria Incidence (RAMI). RAMI will be given by:

$$(Weekly\ or\ monthly\ number\ of\ malaria\ cases\ /population\ at\ risk) /Quantity\ of\ resources\ used\ to\ detect\ malaria\ cases$$

The denominator will allow adjusting malaria incidence by the number of resources used and, therefore, will enable controlling for the potential increase in the number of malaria cases due to better diagnosis rather than to higher transmission. The effectiveness indicator hence, will be related only to the improvement in diagnosis and not to improved treatment or improved health results for those diagnosed.

Comparator

The comparator that was used with regards to the outcome variable was that an Incremental Cost-Effectiveness Ratio (ICER) was calculated, i.e. the additional effect (diagnosis) for additional cost compared to no campaign which would be the use of microscopy as done at a health facility.

The period before will be years 2014, 2015 and 2016 (until the introduction of the intervention); the period after will be the year 2016 (after the introduction of the intervention) and years 2017 and 2018.

$$ICER = (C_1 - C_2) / (E_1 - E_2) = \Delta C / \Delta E$$

Ci and Ei are the costs and effectiveness measure of alternative I The purpose is to compare the incremental costs to the incremental benefits.

Measure Cost-Effectiveness

The criteria to measure cost-effectiveness are based on Willingness-To-Pay thresholds (WTP) related to Gross Domestic Product (GDP), in accordance with the WHO's Commission on Macroeconomics. ICER describe the threshold for (WTP) for an additional year of life which is the maximum amount of money that society is willing to pay for an additional year of life.

Data Gathering

The researcher used quantitative methods by collecting secondary data such as reports which captured expenditure (payment vouchers, reports and receipts) from authorized sources within the MOPH, Regional Democratic Council of Region 8, Health Sector Development Unit-MOPH which is the execution agency of the Global Fund - AIDS, Tuberculosis and Malaria (GFATM) and the local organs of the financial system.

If the cost was not documented, the activity was approximated by the researcher using the ingredients approach where the unit activities were first determined and then the unit cost assigned to each activity for the total cost calculations. Secondly, the step-down costing method was used for cost activities that shared other responsibility, not only the RDTs pilot. The steps were given by expert opinion in the form the Director of Vector Control Unit.

Sensitivity Analysis

A one-way sensitivity analysis was performed to examine the robustness of the critical assumptions within the model. The outcome measure, that is, the number of tests done were varied to reflect the upper and lower limits (95% CI 501 to 612) [20]. The parameters have been varied to the extreme of their potential range based on a survey of literature and expert opinion. The cost of procurement would be increased by 10 %.

Results

The results shown in table 1 summaries that a total of 28 boxes of RDTs, each containing 25 cassettes, were distributed to the volunteers during the pilot in Region 8 between July and December 2016 and 14 boxes to the health facilities. Five hundred fifty-seven malaria RDTs were used during the pilot project [19]. In a total of 6 separate training sessions, 68 volunteers and 13 Health Care Workers (HCWs) personnel were trained between July and December 2022 [19]. Only the cost for the trainers was accounted, the mining camp bore the cost for the trainees. The HCWs were from Region 8 and Vector Control Unit comprising of 11 microscopist, 5 Community Health Care Workers (CWHs) and 1 General Doctor.

Table 1. Costing Results of Implementation

Line Item	Detail	Quantity	Unit Cost	Total Cost	Remark
1.1	Procurement of RDTs	557	1.5	836	
1.2.	Freight cost to the Region 8			500	This cost is assumed to be the cost of shipping the RDTS into the mining sites
1.3.	Other consumables			100	This cost is assumed to be the cost of sterile gloves, sharps and sharp boxes and cleaning agents
2.1.	Training Cost	6	762	4,571	In a total of 6 separate training sessions, 68 volunteers and 13 health staff personnel were trained between July and December 2016. Only the cost of the trainers was accounted, the cost for the trainers was borne by the mining camp.
2.2.	Training Materials			100	The estimate of the cost for pens, pens and other stationery
3.1.	Fuel			1,105	The fuel was purchased for a pick-up truck belonging to the Regional Health Department. The pick-up assisted with transportation for training and supervisory visits. Assumption: 4 drums (40 gallons per drum) of diesel was used at a unit cost of $ 58,000 per drum.
4.1.	Printing and distribution of S.O.P for storage of RDTs at National, Regional and Local Level according to WHO Guidelines.	24	64	1,536	24 posters printed Size 18"x24". Assumption: Two posters was given to each of the 12 sites.
4.2.	Surveillance forms	312	0.5	156	Reporting was done weekly. Therefore, a total of 312 surveillance was needed at a unit cost of $0.5

Line Item	Detail	Quantity	Unit Cost	Total Cost	Remark
4.3.	Computer	1	1000	1,000	To assist in data input of the surveillance data. The computer was for the Data entry clerk at Madhia Hospital.
5.1.	Supervisory visits (Weekly)	36		26,743	Local HCWs and VCS do Per-diem and logistics
6.1.	Personnel cost			24,406	This is for the supervisory visit and implementation.
7.1.	Overheads			6108	The overheads were estimated at 10 % of the total cost. This will account for any unaccounted cost.
	Total Cost			67,161	

Figure 1 shows the major cost category of the implementation of the RDT pilot within 12 mining camps in Region #8. The major cost contributors towards the pilot of the RDTs, the bulk of the cost went into the cost of personnel and supervisory visits with 77 % leaving 23 % of the total cost to be divided into the procurement of the RDTs with the lowest cost to implementation.

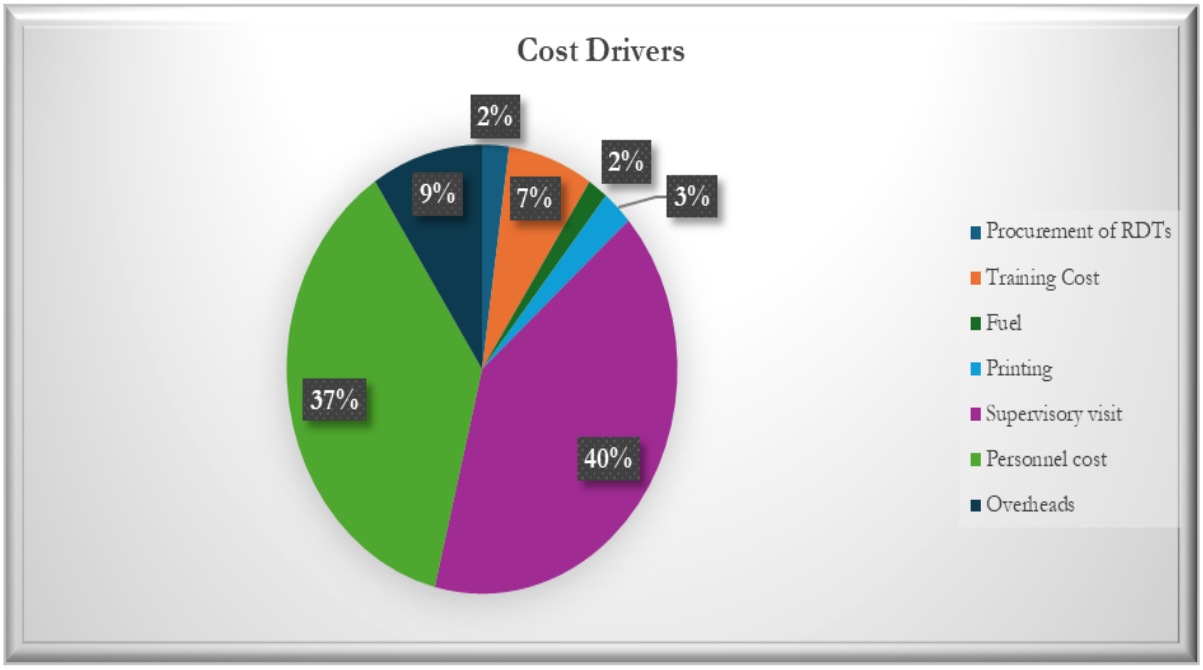

Figure 1. Cost Drivers

Training cost was 7 % while fuel and printing accounted for 5 % of the total cost. The average cost of using one RDT within the parameters of the pilot $ 121.00 however if the cost was only accounted for unitization and reporting it would have been $ 13.23.

Costing of Microscopy Testing

As mentioned before the comparator variable under this study is the cost to provide microcopy rather than RDTs at the mining sites. The average number of test done in 2022 was 615 as shown in table 2.

Table 2. Costing of Microscopy testing

Items	Pack size	Quantity	Unit Cost	Total cost	Remarks
Microscopist Salaries		2	362	9,412	Assumption: two Microscopist is employed per health facilities. One-year Salary is calculated.
Microscope, slides and stains		1	1,000	1,000	The cost of procurement of slides which will be disposed of after every test, one patient will use two slides per visit. The cost of procurement of a microscope is also accounted for.
Powder-Free Latex Exam Gloves	100	13	10	125	Consumables for testing.
Alcohol Prep Pad, Sterile, Medium	200	4	3	13	Consumables for testing.
Safety Boxes	1	4	1	4	Consumables for testing.
Reporting Forms		52	0.5	26	Surveillance from
Utilities			2,000	2,000	Cost took form the operating budget to run one health post in region 1
Maintenance cost			5,000	5,000	Cost took form the operating budget to run one health post in region 2
Overheads				1758	Unaccounted costs.
Total cost				19,338	

The calculation shows that on average; it will cost 19,338 to provide microscopy services per health facility. The average cost per patient will be the total cost divided by the total test done within 2016. Hence the researcher estimates that the average cost per patient would be USD 31.44.

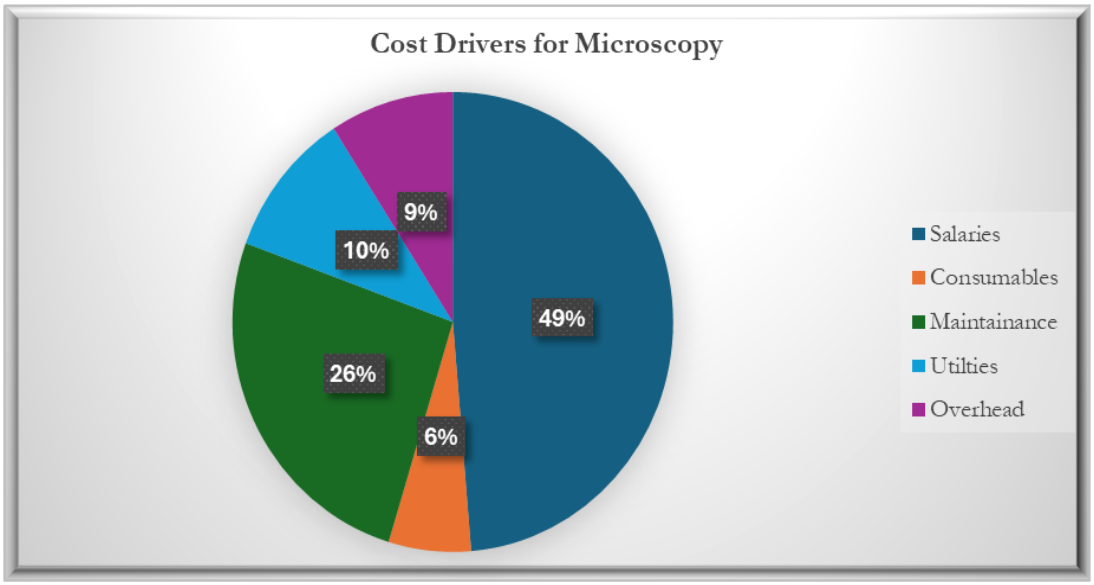

Figure 2. Cost Drivers of Microscopy

Figure 2 shows that the cost of human resource is almost half the cost of testing while the consumables cost is only 6%. The cost of maintenance and utilities of the health facilities is approximately 36 % of the total cost.

Sensitivity Analysis

Univariate sensitivity shown in table 3 was done on the following variables procurement cost of the outcome measure. The parameters have been varied to the extreme of their potential range based on a survey of literature and expert opinion. The outcome measure, that is, the number of tests done were varied to reflect the upper and lower limit (95% CI 501 to 612) [20].

Table 3. Sensitivity Analysis

Variable	Base Value	Value assumed	Cost per test
Procurement cost of RDTs	1.5	10 % increase in prices $1.13	13.38
Test was done using RDTS	557 test	501	12.17
Test was done using RDTS	557 test	612	14.54

Malaria Testing Data

The figure 3 shows the number of tests done by the endemic region. Region 1 had the most tests done but has a larger population than the other endemic Regions.

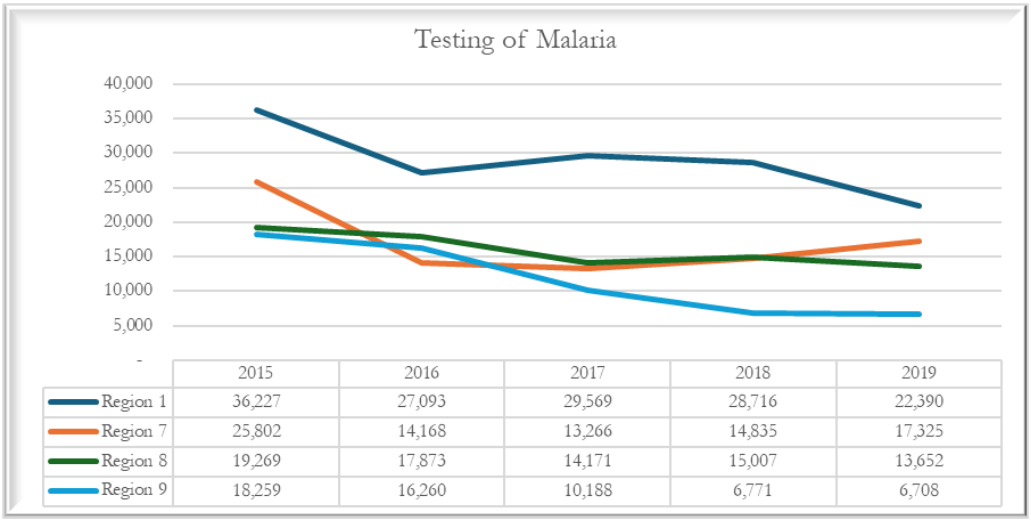

Figure 3. Malaria test is done from 2015 to 2019

Discussion

All of the regions have shown a decline in the total number of tests done except Region 7. The number of tests done in Region 9 reduces more than 60 % from 2015 to 2019. Region 8 saw a decrease in the number of tests done by 7.24 % in 2016 when compared to 2015, the number of tests declined further in 2017 by 21 % when compared to the previous year; however, a 6 % increase was noted in 2018.

Malaria imposes a significant economic impact on the individual, the family and the economy [21]. This study estimated the cost-effectiveness of the introduction of RDTs in Guyana by looking at the cost of the pilot versus the cost of microscopy.

The cost of the pilot was USD 67,161, of which the lion shares of the cost went towards human resources and the cost of weekly supervision. The human resource cost was that of the HCW who was doing the follow-up with

the miner; no cost was estimated for miner's time to test and treat a patient using RDTs. Although, the pilot was only for six months (July to December 2016) 557 persons from 12 mining camps were tested using RDTs. This represents 3 % of the total malaria test done in Region 8 for 2016. The estimated cost for the administering of one RDTs is USD 13.23. This figure is derived by minus the cost of supervision and human resource otherwise during the pilot, it cost USD 121.00 per person. What makes the community-based approach more cost-effective is that no health facilities need to be constructed, no cost of operation and no human resources cost. However, the scale-up cost would be 13.23 because the need to supervise and the human resource cost would be significantly reduced. Ghana has an average cost for RDTs testing at USD 2.6 compared to 1.9 for microscopy from a societal perspective [16] while the country of Uganda had average cost for RDT testing at USD 1.29 and microscopy of USD 1.53.

The cost to treat one person by using microscopy was estimated from the health budget of Region # 1. The cost was estimated by using a health system perspective and using the step-down costing approach. The average cost was estimated by using the total number of tests done in 2016, divided by the cost of testing using microscopy. The cost of microcopy testing was estimated to be USD 31.44 per patient tested. The major cost drivers were the cost of human resources and operational cost of the health facility.

Limitations must be considered with an economic evaluation, whether it be a cost-benefit analysis, cost-minimization analysis or CEA. One limitation of this study was that no long term health outcome or a utility measure such as Disability Adjusted Life Year (DALYs) was included. The outcome measure for this study was the diagnosis of Malaria using the RDTs. However, based on the assumption articulated within the study, the ICER for the use of RDTs can be estimated as USD 13.23 versus the ICER of using microscopy at 31.44. The result of the sensitivity analysis shows that the variables are robust to changes. Also, without the absence of randomization, it reduces the power of the results. The study protocol assumed that testing would increase in the short term, but the opposite took place; analysis should be conducted to ascertain why the reduction in testing. Another limitation is the size of the sample, which was 3 % of the total testing done within 2016; it will be difficult to convince policymakers to invest in the provision of RDTs with a small sample population. Finally, another limitation was that the study perspective was from a provider or health system perspective where travel costs, salaries, procurement of commodities, health promotion among others were not accounted for from a societal perspective.

Conclusion

The Incremental Cost-Effectiveness Ratio (ICER), when calculated, showed that the intervention was very cost-effective when examining WTP which is Guyana's GDP per capita which according to the Guyana Bureau of Statistics stood at US$3,883 in 2017. The results of the univariate sensitivity showed that the impact of uncertainty on variables demonstrated that the results were robust to moderate changes, the results showed that the changes would not have any significant effect of not begin a cost-effective intervention. However, on the basis of the cost-effectiveness ratio, the researcher concluded that the intervention was cost-effective.

Recommendation

It is recommended that cost-benefit study be done to estimate the increase on investment of using RDTs and CEA be done from a societal perspective using microscopy, RDTs, presumptive diagnoses as outcome variables or a utility measure such as DALYs. Also, a Markov model and perspective economic model should be created using expert opinion

and other studies done with the subject area before scaling up the intervention.

Conflict of Interest

The author declares that there is no conflict of interest in this manuscript.

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