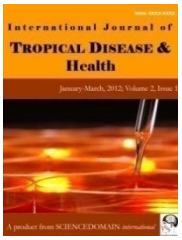

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Cost Effectiveness of Intermittent Preventive Treatment of Malaria in Infants in Ghana

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ABSTRACT

Aim: In order to integrate malaria Intermittent Preventive Treatment in infants (IPTi) into the Ghana national immunization programme, there was the need to evaluate the feasibility of IPTi by assessing the intervention operational issues including its implementation costs, and its cost effectiveness.
Study Design: Cross-sectional study.
Place and Duration of Study: Upper East Region, Ghana, between July 2007 and July 2009
Methods: We calculated the costs of administrating IPTi during vaccination sessions; the costs of programme implementation during the first year of implementation (start-up costs) and in routine years (recurrent costs). For the purposes of cost-effectiveness analysis, all economic costs (including financial and opportunity costs) and the net cost were estimated. To estimate the cost effectiveness ratios of IPTi, the aggregate cost of providing the intervention for a reference target population of 1,000 infants was divided by its health outcome. Sensitivity analyses were carried out to understand the results robustness.

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Results: IPTi gross costs in start up and in routine years were estimated at 70.66 cents and 29.72 cents per dose, or $2.0 and $0.87 per infant, respectively. The gross cost per DALY saved was estimated at $3.49 and the net cost of IPTi for 1,000 infants was $-3,416.38 in the routine years rending IPTi a highly cost saving intervention. Sensitivity analyses showed that the cost per DALY saved never went up more than $4.50 maintaining the intervention still highly cost effective.
Conclusion: IPTi in Ghana is a highly and robust cost effective intervention. The intervention is cost-saving and should be scaled up nationally to save children's health and economic capital.

Keywords: Malaria; intermittent preventive treatment in infants; health outcome; direct delivery cost; indirect delivery cost; economic cost; incremental costs; cost effectiveness analysis.

1. INTRODUCTION

In 2008, there were an estimated 243 million cases of malaria worldwide; the vast majority (85%) in the African Region. Malaria accounted for estimated 863,000 deaths, of which 89% were in Africa (WHO 2009). In Ghana, malaria is hyperendemic in all parts of the country, with the entire population of about 23.5 million at risk (GHS, 2008). Transmission occurs all-year round with seasonal variations during the rainy season. According to the Ghana Health Service (GHS 2008), malaria is the number one cause of morbidity, accounting for about 38% of all outpatient illnesses, 36% of all admissions, and 33% of all deaths in children under five years (GHS 2008).

The cost of treatment of malaria in infant, the most vulnerable age group, can result in serious economic implications on households and the health system. Hence there is a need for malaria prophylaxis interventions that reduce its health problems and its social and economic costs.

Intermittent Preventive Treatment in infants (IPTi) is a malaria prophylaxis strategy consisting of intermittent administration of three doses of a long-lasting anti-malaria drug, sulphadoxine – pyrimethamine (SP) to infants in the 1st year of life through the routine immunizations of the Expanded Programme of Immunization (EPI) concomitantly with the DTP2, the DTP3 and measles vaccinations. Children receive ¼ or ½ of one tablet of SP (containing 500 mg of sulphadoxine and 25 mg pyrimethamine) at approximately the ages of 3, 4 and 9 months, in the health facilities where immunizations are offered. IPTi with SP has shown to reduce infant's clinical malaria by 30.3%, anemia by 21%, and hospitalizations associated with malaria parasitemia by 38% during the first year of life (Aponte et al., 2009). IPTi was recommended by WHO and endorsed by the Expanded Programme on Immunization (EPI) and UNICEF (de Sousa et al., 2010) for implementation at scale in malaria endemic countries.

This study is part of a larger operational research study that is aimed at evaluating how to most efficiently implement this intervention in order to achieve a rapid universal and equitable coverage. The study included the estimation of the cost of IPTi implementation for start up and recurrent years as well as its cost-effectiveness. This is the rationale of this research. Other IPTi cost-effectiveness studies had been conducted based on estimations of

malaria costs and of operational costs of implementation (Hutton et al., 2009). This study is, to the best of our knowledge, the first study where operational costs were calculated based on real life implementation and on real costs of malaria treatment.

2. MATERIALS AND METHODS

2.1 Study Site, Sampling and Data

In Ghana, the Ministry of Health (MOH) implemented IPTi in the Upper East Region (UER) since 2007. The Upper East region was selected for the project because it is the only region that has been implementing the full package of Accelerated Child Survival and Development Project (ACSD) since 2003. This is the context within which the UNICEF IPTi operational research in Ghana was conducted, drawing on the resources, structures and capacity building of the ACSD programme in order to explore, resolve and disseminate the major operational issues related to IPTi. The estimated birth cohort in the Upper East is about 40,000 per year. These infants are the primary beneficiaries of this project. The study lasted two years.

The region is located in the north-eastern corner of Ghana, bounded by Burkina Faso to the north and the Republic of Togo to the East. There is intense movement of people, goods and services along these borders. The region's size is 8,842 sq. km (about 3.7% of the country) and is divided into eight districts, 54 sub-districts and 911 communities (Ghana Statistical Service, 2000). Population of the region from the 2000 census is 920,089 (4.8% of total population of Ghana) and was estimated at 993,317 in 2007at a growth rate of 1.1%. The household sizes mostly consist of 8 individuals and more. The Upper East Region has 1 regional hospital, 5 district hospitals, 30 health centers and 87 clinics and maternity homes.

The Upper East Region is characterized by predominantly peasant labour intensive agricultural economy. Agriculture and agricultural related workers make up 66.4% of the occupation of the economically active population. The rest are production and transport equipment workers (14.7%), sales workers (9.6%), service workers (4.0%), and professional, technical and related workers (3.8%).

Stratified sampling was used in the data collection since representatives from each subgroup within the population in the region need to be represented in the sample and also because the sample frame does not constitute a homogenous group this technique was adopted to ensure that, a representative sample is obtained in order to satisfy the need for a mix of a diversity of ethnic groupings, rural, peri-urban and urban districts. By the stratified sampling technique, the region was divided into 8 subgroups (strata) based on the number of districts and on mutually exclusive criteria. Random sampling technique was then deployed in selecting the sample units for the various surveys including time and motion, cost of implementing IPTi, cost of managing malaria in infants and health outcome of IPTi among others in each stratum (subgroup).

Both primary and secondary data was used in this study. The primary data collected consist of cross sectional observations in the years 2006 and 2007 on the health facilities in the Upper East Region. The information gathered included detailed financial information about cost level and structure of each health facility visited, information on the routine EPI/IPTi activities, the health outcomes of IPTi, the regional demographic as well as socioeconomic data.

2.2 Method of Cost Estimation

For the purposes of estimating the cost of IPTi implementation for start up and recurrent years, the cost has been categorized into Direct Delivery Cost and Indirect Delivery Cost. Direct delivery costs refer to all costs at the point of IPTi delivery which include cost of management and administration of IPTi at EPI clinics and cost of consumables such as drugs. An indirect delivery cost refers to costs incurred at a level other than the delivery point of the intervention to beneficiaries. Such costs included items such as planning, advocacy, training, supervision, and communications. To calculate the intervention's cost-effectiveness, economic costs (financial and opportunity costs) were collected. Financial costs refer to the monetary expenses used in implementing IPTi. Opportunity costs which is the value of a product forgone to produce or obtain another product refers in this case to the costs already covered by the health systems when providing immunizations services that do not require additional monetary investment to add an intervention such as IPTi.

Costs saved for infants receiving IPTi was calculated from the unit costs of simple and complicated malaria episodes for both households and institutions, and the number of care-seeking episodes averted. The net cost of IPTi for infants treated was calculated from the gross cost of the intervention (direct and indirect delivery costs) minus the economic gains of the intervention (cost of management of both simple and complicated malaria cases averted).

2.2.1 Direct delivery cost

The resources necessary for administering IPTi at the point of delivery involve human resources, consumables, transportation, building and equipment costs. The financial costs and opportunity costs were estimated from observations of immunization sessions. The financial costs evaluated include the estimation of all costs of programme activities necessary to achieve a successful implementation of IPTi during the first year of implementation (start-up costs) and only those activities necessary in the routine years (recurrent costs). These comprise micro-planning, advocacy to civil and health authorities, training and supervision of health staff, and communication of the intervention to communities. The incremental costs to administered IPTi correspond to the additional resources mobilized to implement IPTi during EPI sessions, and were calculated from the health system's perspective. Four immunization sessions made up of 2 each of fixed and outreach strategies were observed in each district. Fixed" sessions refers to the clinics where both immunizations and IPTi were administered in "fixed" health centers. "Outreach" sessions are the clinics where health workers administered immunizations and IPTi in a location other than the health center and closer to distant communities where health workers visited regularly by motor bikes or bicycles.

The cost of the intervention's human resources corresponds to the extra work of the health staff administering IPTi during the immunization sessions. Human resources costs represented only an opportunity cost since health workers were not offered additional wages for the extra work they were asked to perform. By means of a Time and Motion (T&M) study (unpublished), the time spent to immunize children, to administer IPTi, and the time spent on other activities was estimated. Activities that could not be attributed exclusively to IPTi, EPI or other clinical activities, but were common to all of them (such as opening the health center, preparing the room, screening and registering children, managing consumables, and the health education to communities) were added up and distributed according to a proportional distribution key (determined by the proportion of time spent on each activity).

Measuring the personnel time spent administering IPTi and calculating their hourly labour cost, enabled the assessment of the cost of human resources in administering IPTi. To calculate the unit labour cost, the composition of the immunization staff present during the immunization sessions was observed and for each category of personnel, their respective monthly salary was applied. The staff monthly salary was converted into cost per second on the basis of 245 working days a year and of 8 hours a day to estimate unit cost of labour for each category of health personnel.

The cost of consumables consisted on the cost of the drugs (SP) procured and distributed; the utensils specifically purchased for IPTi administration such as cutters for the tablets and spoons and cups to mix the drugs with water and administer the solution to infants; and the intervention's monitoring tools. The total consumable costs used in each immunization session was calculated by summing up the costs of all the individual consumables used and divided by the number of infants treated in the same sessions to obtain the cost per infant and per dose treated. The costs of tablet cutters, spoons and cups were calculated for the overall pilot implementation and divided by the number of doses offered in a year to the target population. In addition to the drugs consumed, the cost of consumables per infant treated also included the drugs wasted or lost during the administration of the drug.

The cost of transportation of health staff and materials from the health facilities to the outreach locations were calculated by adding the cost of fuel used to drive from the health center to outreach facilities, the motorcycle maintenance cost and depreciation from the purchase price. Fuel expenses were estimated by calculating the distance covered to reach the outreach centers, the average vehicle fuel consumption and the cost of one liter of fuel. To calculate depreciation, an amortization rate of 3 years for motorcycles and of 6 years for cars was applied. The cost of usage per Km was calculated by dividing the sum of amortization and maintenance costs by the number of Km covered yearly. The total usage cost was obtained from the cost of usage per Km by the distance covered to reach the outreach facilities. As these costs are shared with EPI clinics, the total costs of transport dedicated to IPTi was calculated by applying the same distribution key as in the calculation of human resources time. There was no transportation costs involved when the intervention was offered to infants that came to the health centers.

The cost of the part of the health center building used for IPTi was estimated for fixed immunization clinics only, since in Ghana outreach clinics are performed in open air. The building cost was divided by the lifespan of the building (estimated at 30 years) to obtain the daily cost of one square meter, then multiplied by the floor area used in the immunization sessions, and by the percentage of time used for IPTi during immunizations.

2.2.2 Indirect delivery cost

Indirect delivery costs on the other hand included costs incurred at administrative levels of the district, or central levels. Such costs included micro planning, advocacy, training, supervision, and communication activities. The micro planning costs incurred were valorized by the time the programme director and his/her assistants used in planning the programme and conceiving the necessary documents to enable the implementation.The cost of peripheral advocacy comprised the organization of meetings with district civil, religious and health authorities; the transportation costs, and drivers per diem; hall hire, and refreshments that were offered during advocacy meetings. The cost of communication included the cost of conception, production and deployment of activities such as radio programs, production of T-shirts, and organization of social gatherings or durbars. Health workers training activities

included the health workers allowances to attend the training sessions, their transportation to the training sessions, hall hire and refreshments offered during training conception, the production of training materials, and time of the trainees. Specific IPTi supervision was conducted monthly by the study team supporting the pilot implementation during the first six months of implementation after which the IPTi supervision activities were integrated in the formal health sector routine supervision and made by the EPI supervisor during his/her routine visits. Thus only financial costs of supervision activities incurred during the first six months of implementation were calculated and imputed to scale up costs in start up years.

2.3 Cost-Effectiveness Analysis

For the purpose of cost-effectiveness analysis (CEA), the economic cost was estimated. To calculate IPTi incremental costs, only financial costs were collected. Opportunity costs were calculated to estimate the intervention's economic cost. The net cost of IPTi was estimated as the economic cost of the intervention minus its economic gains. To estimate the cost effectiveness ratios of IPTi, the estimated health outcomes (effectiveness indicators) of IPTi were divided by the estimated aggregate cost of providing the intervention for a reference target population of 1,000 immunized infants.

2.3.1 Cost of IPTi implementation for start up and recurrent years

For a cohort of 1,000 infants, IPTi gross cost in start-up years was calculated based on the direct delivery cost to administer the number of IPTi doses that 1,000 infants received, and on the indirect delivery cost of programme activities necessary to administer those doses. In routine or recurrent years, programme activities were limited to EPI supervision. Analysis undertaken after one year of implementation showed no significant difference in knowledge and attitudes to IPTi between the population exposed and not exposed to the mass communication activities, and therefore these activities were not considered in routine years and their costs were not added to the intervention's recurrent cost estimation (author's unpublished data). Likewise, massive training of health workers showed to be effective to introduce efficient cascade training where most workers had a high understanding of IPTi administration, and thus also not repeated in recurrent years (author's unpublished data).

The number of IPTi doses administered was calculated on the routine immunization drop-out rates, since from the second month of pilot implementation, the IPTi coverage was nearly identical to that of the routine immunization. Within the IPTi region the drop-out rates between DTP2 and DTP3 was 3.18%, and between DTP3 and measles was -0.59%. The number of children who were immunized against measles increased compared to DPT2 because of the cross-border economic activities where mothers who cross into Ghana from neighbouring countries to trade, often bringing their older babies and have them immunized.

2.4 Health Outcome

The health outcome includes the number of malaria cases averted, the number of deaths due to malaria averted and the Disability Adjusted Life Years (DALY) gained due to the malaria averted.

The number of malaria cases averted for 1,000 infants treated was calculated based on the pooled analysis Protective Efficacy (PE) of 30% (Aponte et al., 2009), and on the malaria incidence rate per person-year in infants of 1.00 in the Northern Region of Ghana

(Chandramohan et al., 2005). The yearly percentage of complicated malaria cases to the total malaria cases reported since 2000 has not been stable. The percentage exhibited an upward trend since 2000 (5.1 and 3.1 for national and UER respectively) and reached a peak in 2004 (27.7 and 44.5 for national and UER respectively) and then plummeted between 2005 and 2007 (National Malaria Control Programme, MOH, Ghana 2007). Over the years, on the average, the national annual percentage of complicated malaria cases was 9.4% and therefore in this study, we estimated that 10% of all the malaria cases were complicated cases. Treatment-seeking rates of 50% for simple malaria cases treated at health facility level, and 90% for complicated malaria cases treated as inpatient cases were assumed. Thus for example, out of 100 malaria patients, 90 were simple malaria and 45 seek care as outpatient cases (83.3 % of the health-seeking episodes) and 10 were complicated cases of malaria, of which 9 were treated as inpatient (16.7%).

The deaths averted were deducted from the malaria cases averted and the case/fatality ratio of 2.6% reported for the UER (GHS, Upper East Region Annual Report 2007). The number of years of life saved is the product of the number of averted deaths by the years of life expectancy at the age of death estimated in Ghana at 57.3 years (Ghana Demographic and Health Survey, 2003).

The Disability Adjusted Life Years (DALY) aims to quantify the amount of full health lost due to illness or injury occurring in the reference period, by adding the burden arising from deaths in that period to the burden of incident (new) cases of disease occurring in that same period. In the global study, discounting and age weighting were incorporated into the measure of the DALY (Lincoln and Muscatello, 2002). Though age weighting reflect both the relative economic contribution and the broader social welfare contribution at different ages, the formulae presented in this study incorporate discounting but do not incorporate age weighting because of the extensive disagreement in the global studies which Lincoln et al. (2002), clearly elaborated.

Ideal life expectancies are required in the calculation of the mortality burden to provide an estimate of the potential life span of a person in the absence of premature death. WHO provides information on the DALY burden of disease, which is calculated under the assumption that people would face a very favorable (Japanese) life expectancy in the absence of the disease and so global studies used Japanese life expectancies in the calculation of the burden of a disease (Lincoln et al., 2002). Since diseases affect countries where people face many other competing risks, the DALY burden will, in general, be greater than the number of DALYs saved by eliminating the diseases and this would bias estimated cost-effectiveness upward. In this study, the average life expectancy figure for Ghana was used and so the sex factor was not considered.

The total burden of a disease (DALY) is the sum of the Years of Life Lost (YLL) term which is the mortality burden component and essentially represents years of life lost due to premature death and the Years of Life Lived with Disability (YLD) term which is the morbidity burden component and essentially represents years of life lived with disability (YLD) resulting from non-fatal incidence of a condition.

Each of these terms is calculated separately and then summed to give the total burden for the disease. YLL and YLD formulae

$$YLL = D * \left\{ \frac{1 - e^{(-r*L)}}{r} \right\} \qquad YLD = I * W * \left\{ \frac{1 - e^{(-r*T)}}{r} \right\}$$

The quantities used in the formulae are:

- D, the estimated number of deaths caused by the disease or injury in that age group and sex.
- L, the overall 'ideal' life expectancy of that age group and sex. It represents the duration of the loss of healthy life.
- *r,* the discount rate.
- I, the estimated incidence of the disease stage for that age group and sex.
- W, the disability weight for the disease stage and, sometimes, age group and sex. This value is a constant between zero (perfect health) and one (equivalent to death).
- T, the duration of disability associated with the disease stage, and/or age group and, in some cases, sex.

The DALY saved was estimated using relevant formulas outlined by Murray and Lopez (1996), malaria episodes weight of 0.211, average duration of 0.01 years, constant of 0.1658 and discount rate of 0.03.

2.4.1 Net cost of IPTi implementation

The net cost of IPTi for 1,000 infants treated is the economic cost of the intervention minus its economic gains. To estimate the costs saved with IPTi, we calculated the number of treatment-seeking episodes averted and the unit cost of treating simple and complicated malaria episodes. We used both societal and health institution's perspectives and estimated the unit cost of treatment per care-seeking malaria episode (simple and complicated cases). This estimation was done through specific surveys (unpublished) in an outpatient setting (100 simple cases) and an inpatient setting (100 complicated cases).

The study sampled caregivers of 100 infant inpatients, representing complicated malaria cases, and caregivers of 100 infant outpatients, representing simple malaria cases, using two specifically designed questionnaires. These tools were adapted from questionnaires used by UNICEF Head Quarters (HQ) Health section to collect data on the various costs of treating malaria. The caregivers were questioned on their health-seeking itinerary—how and at what time the caregivers visited and left the facilities with their wards as well as the cost expended.

The cost of simple malaria episode for the health system was conducted in thirty (30) primary health centers in the study sites. Within these 30 health facilities, a survey on cost of management of simple malaria episodes from the caregiver's perspective was also carried out where a minimum number of caregivers of 3 infant outpatients (simple) were interviewed in each health facility.

A survey on cost of management of complicated malaria episodes from the caregiver's perspective was carried in 3 out of the 6 referral health facilities including the regional hospital in the region given that referral health facilities are the only health facilities mandated by the Ghana Health Service to manage complicated malaria cases in Ghana. The caregivers of 40 infant inpatients (complicated) were interviewed in the regional health facility and 30 each from the other two referral health facilities. The health system cost at higher level of services--the referral hospitals--was made using the newly generated "Lafarge tool". The tool refers to a questionnaire developed by Hervé Lafarge of the Université Paris-Dauphine, which is used to collect and categorize detailed data on the costs of treating malaria from health facilities at the referral level.

The cost involved in the treatment of malaria was categorized into direct costs and indirect costs borne by households and health institutions. Direct cost refers to cost of drugs, staff time, equipment etc (institutional cost) together with transport, out-of-pocket expenses etc (cost to patient) deployed in the treatment of the ailment. On the other hand, indirect costs refer to opportunity cost of time spent in seeking treatment.

The unit cost of an outpatient (simple) malaria treatment and inpatient (complicated) malaria treatment at the institutional level was performed by estimating the share of cost overheads attributable to hospital services for pediatric malaria cases. A survey at health centers undertaken to assess the annual number of malaria cases treated, the staff time necessary to treat one malaria case, and the annual consumption of anti-malarial drugs allowed the study to estimate the unit cost of treatment. The household cost of malaria treatment in infants represent the sum of cost of drugs purchased, fees paid for registration, consultation, accommodation, disposables, laboratory test, transportation and all out-of-pocket expenses made by the caregiver and indirect costs associated with lost income due to time spent during care seeking.

Ethical considerations were also addressed in this study, with the key issues being informed consent, confidentiality and anonymity. Microsoft Excel and Statistical Packages for Social Solutions (SPSS) were the statistical software deployed in the analysis of the data collected from the survey.

Though under the perspective of strict incremental cost, human resources, transportation, building and maintenance costs are included in the EPI, and thus no financial costs was incurred by the addition of IPTi, these opportunity costs were calculated to estimate the intervention's economic costs for the cost-effectiveness analysis.

2.5 Sensitivity Analysis

Sensitivity analysis was performed to show whether the parameters used in estimating cost-effectiveness ratios are robust to some degree of uncertainty. These parameters included the routine cost of IPTi, the incidence of malaria, IPTi protective efficacy, its case fatality, and the relaxation of key assumptions made in the estimation of the DALY. For each parameter, we estimated the change in the cost-effectiveness ratios.

3. RESULTS AND DISCUSSION

IPTi gross costs in start up and in routine years were estimated at 70.66 cents and 29.72 cents per dose administered respectively (Table 1). Based on the immunization drop-out

rates, it is estimated that for a cohort of 1,000 infants, 1,000 received IPTi1, 968 received IPTi2 and 974 received IPTi3, summing to 2,942 doses of IPTi. IPTi gross cost for a cohort of 1,000 infants was estimated at $2,079 and $875 in start-up and routine years respectively.

Table 1. Direct and Indirect Delivery cost per IPTi dose administered (cents)

Direct delivery costs	
Type of direct delivery cost	**Cost (cents)**
Human resources cost	18.35
Consumables cost (SP + utensils)	6.84
Transportation cost (advance)	0.41
Building cost	0.99
Subtotal incremental cost	26.59
Indirect delivery costs	
Indirect delivery cost activities	**Cost (cents)**
Social mobilization/Communication	15.27
Advocacy	4.53
Micro planning	7.32
Training	13.83
Supervision	3.13
Sub total cost	44.07
Start – up gross cost per dose administered	70.66
Routine gross cost per dose administered	29.72

Source: Field Data

The time and motion studies conducted showed that in Ghana, health workers spent 3.15 minutes to administer one dose of IPTi, three minutes of which on the average was used in crushing and dissolving the SP tablet.

The number of malaria cases averted for 1,000 infants due to IPTi was estimated at 135 for simple and 27 for complicated malaria. The unit costs to treat an episode of simple and of complicate malaria for the provider were estimated at $3.83 and $74.32 respectively. To treat a simple case, out-of-pocket payment for households averaged $6.18, and the indirect cost for households (lost income) was estimated at $4.02, summing $10.20. To treat a case of complicated malaria, out-of-pocket payments for households averaged $34.57 per case and the indirect cost for households was estimated at $12.05, totaling $46.62.

For a cohort of 1,000 infants, the cost saved due to IPTi to providers and households was estimated at $5,159.43 and the net cost at $-4284.43. In the routine years the net cost of IPTi for 1,000 infants was $-3,416.38.

The number of malaria cases averted for 1,000 infants receiving IPTi was 300 cases, the number of deaths averted 8 and life-years gained 458.4. The total burden of malaria is the sum of the Years of Life Lost - YLL (discounted at 3%) term (250.37) and the Years lost due to disability/being sick - YLD term (0.05) giving the total number of DALYs saved of 250.42. The cost per DALY saved in start up and routine years were $8.51 and $3.73 respectively. Other cost effectiveness ratios are presented in Table 2.

Table 2. IPTi cost-effectiveness ratios

Effectiveness Indicators	CE Ratios
Number of deaths averted	8
Life years gained	458.4
Gross cost per 1,000 infants treated ($)	2079
Net cost per 1,000 infants treated ($)	-3080.43
Gross cost per averted death ($)	259.86
Net cost per averted death ($)	-385.05
Gross cost per averted Life years gained ($)	4.54
Net cost per averted Life years gained ($)	-6.72
Routine gross cost per 1,000 infants treated ($)	875
Net routine cost per 1,000 infants treated ($)	-4284.43
Gross routine cost per averted death ($)	109.38
Net routine cost per averted death ($)	-535.55
Gross routine cost per averted Life years gained ($)	1.91
Net routine cost per averted Life years gained ($)	-9.35
Total DALY saved ($)	250.42
Gross cost per DALY saved ($)	8.30
Net cost per DALY saved ($)	-1.54
Routine gross cost per DALY saved ($)	3.49
Net routine cost per DALY saved ($)	-17.11
Net routine cost (based on direct cost saved only) per DALY saved ($)	-13.64

Source: Analyzed Data

The sensitivity analysis is presented in Table 3. Starting with the key assumptions; K (age weighting modulation factor), r (discount rate) and B (parameter from age weighting function), it was realized that their relaxation led to a 13% increase in the cost per DALY saved. Increasing the discount rate deployed in the estimation of the DALY saved from 3% to 6% and from 3% to 9%, increased the cost per DALY saved by approximately 87% and 200%, respectively. The sensitivity of cost per DALY saved to changes in the routine cost of IPTi which is made up of cost of consumables, cost of associated activities and cost of human resource was also analyzed. Increasing the gross routine cost of IPTi by 10%, 20% and 25%, increased the cost per DALY saved by 10% (3.84), 20% (4.19) and 24% (4.37) respectively. Decreasing the case fatality rate also shown an appreciation in the cost per DALY saved. Finally, decreasing the incidence rate by 20%, 30% and 50%, and the protective efficacy (P.E.) of SP by 33% (P.E. 20%) and 17% (P.E. 25%) had no significant effect on the cost per DALY saved.

The study of the estimated cost of adding a new intervention to the EPI and the health outcome provided was the basis for assessing its cost effectiveness. This assessment may in turn be used as evidence for policy decisions on priority setting. Cost of $8.51 per DALY saved and $3.73 per DALY saved in start up and routine years respectively render IPTi highly cost effective. This is supported by the World Bank which defines health interventions as “highly cost- effective” if costing is less than $100 per disability-adjusted life year; Murray and Lopez (1996).

The net cost of IPTi strategy for 1,000 infants treated was estimated in the start up year at $-4284.43 and in the routine years at $-3416.38. The negative signs show that the intervention is highly cost-saving even in the routine years and this may be due to high hospital costs per malaria episode managed and the high malaria incidence. In Ghana IPTi is a highly cost-saving intervention probably due to the low cost of administration, the many opportunity costs, and mainly due to high hospital costs per malaria episode managed, and the high malaria incidence observed.

Table 3. Sensitivity Analysis of Parameters

Parameters	DALY saved	cost per DALY saved
Discount rate		
Increased by 6%	133.70	6.99
Increased by 9%	81.60	11.45
Case fatality		
Decreased by 5%	219.12	4.26
Decreased by 15%	219.12	4.26
Routine gross cost of IPTi		
Increased by 10%	250.42	3.84
Increased by 20%	250.42	4.19
Increased by 25%	250.42	4.37
Relaxation of K, B	221.87	4.21
Incidence rate		
Decreased by 20%	250.41	3.73
Decreased by 30%	250.4	3.73
Decreased by 50%	250.39	3.73
Protective efficacy SP		
P E of 25%	250.41	3.73
P. E. of 20%	250.40	3.73

Source: Analyzed Data

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Since malaria incidence and case-fatality rate are important input variables in the determination of DALY, and varies with geographical locations, it becomes thorny to compare cost-effectiveness studies of the IPTi intervention across countries. Depending on the case-fatality rate, the DALY averted could vary widely because the number of deaths averted. This notwithstanding, these findings of $8.51 per DALY saved and $3.73 per DALY saved in start up and routine years compares favourably with that reported by Guy Hutton et al. (2009), that cost per DALY averted was under US$ 12.

In all the sensitivity analyses made in this study, with exception of the discount rate, the cost per DALY saved never went up more than $4.50 rendering the intervention cost effective in all scenarios. Elsewhere, multivariate sensitivity analysis produced wide confidence intervals resulting from the ranges of four key input parameters. For example, the cost per DALY averted ranged from US$ 1.6 to US$ 12.2 in the United Republic of Tanzania and from US$ 3.6 to US$ 92.0 in Mozambique and even that, an upper confidence limit of US$ 12.2 per DALY averted in the United Republic of Tanzania and an upper confidence limit of US$ 92.0 per DALY averted in Mozambique, IPTi is still an attractive health intervention (Guy Hutton et al., 2009).

The Upper East Region is characterized by predominantly peasant labour intensive agricultural economy. A total unit cost of complicated malaria management of $46.62 which represents an amount that would be earned in 22 working days and 90% of monthly household income respectively must be of great concern to all. This could explain why in spite of the numerous poverty intervention strategies implemented in the region over the years, the number of the poor in the Northern Ghana between 1993 and 2006 rather increased by 0.9 million with the majority of the poor becoming more poorer (World Bank, 2011). The burden of malaria management on households is enormous and therefore calls for Government policies with regards to the control of malaria to be enhanced.

In spite of the gains derived from IPTi implementation, the cost of time spent by health workers administering IPTi represented the largest cost item out of the total cost attributed to the health system. The time of 3 minutes used to crush and dissolve the SP tablet is very distressing. Thus it would be desirable to have a paediatric formulation for SP that would facilitate administration to infants, reduce health workers time spent making a SP drinkable solution, reduce the risks of adverse effects due to the introduction of non-potable water, and ensure an easier and more efficient way to implement IPTi.

Many studies have reported on the protective efficacy and the cost effectiveness of ITNs, Wiseman et al. (2003). However, cost effectiveness of ITN in the UER was not part of this study thus making it difficult to do a rigorous comparison. This is one of the limitations of the study. This notwithstanding, IPTi is highly recommended for implementation at scale in countries like Ghana were malaria is highly endemic because IPTi is low cost and highly cost-effective.

4. CONCLUSION

IPTi gross costs in start up and in routine years were estimated at 70.66 cents and 29.72 cents per dose, or $2.0 and $0.87 per infant, respectively. The gross cost per DALY saved was estimated at $3.49 and the net cost of IPTi for 1,000 infants was $-3,416.38 in the routine years rending IPTi a highly cost saving intervention. The expectations of the implementation of any health intervention are that; the intervention must bring about an improvement in the health of the people, must emerge from a rational, well planned and evidence-based process and finally must be sustainable and not a "one shot" temporary effort that will not have enduring impacts. Cost-effectiveness and financial sustainability may have common characteristics, but there is distinct difference between them. It could be that an intervention is economically beneficial in that the estimation of benefits is greater than the costs. It is still necessary to identify resources from the government, donor agencies, community or individuals to finance the service. This will ensure that once the intervention is scaled – up, it will be sustained. Since IPTi is so highly cost-saving, sustainability issues are minimized. However, we do need to know when the intervention is no longer cost saving or even cost effective and the sensitive analysis showed that it takes a very important reduction of PE and/or incidence of malaria for this to be the case.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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