Determining Cost Effectiveness of Malaria Rapid Diagnostic Tests in Rural Areas with High Prevalence

BACKGROUND

Early diagnosis and appropriate treatment are essential to addressing the global burden of malaria. Current outpatient diagnostic practice in sub-Saharan Africa is based largely on symptom-based or ‘presumptive’ treatment (PT) of fever with anti-malarial drugs. This strategy leads to significant over-diagnosis of malaria due to the overlap of symptoms between malaria and non-malarial febrile illnesses. As a result, anti-malarial drugs are over-prescribed, and non-malarial febrile illnesses are under-diagnosed and inappropriately treated. Moreover, many countries in sub-Saharan Africa have recently changed first-line malaria treatment to more costly artemisinin-based combination therapies (ACT), increasing the financial implications of wasted anti-malarial drugs. Parasite-based diagnosis, based on rapid diagnostic tests (RDTs) or microscopy, can ensure appropriate use of these new drugs. While microscopy has advantages over RDTs in many situations, RDT-based diagnosis is easier to support at peripheral health facilities, and therefore may facilitate access to accurate malaria diagnosis in areas where this was not previously possible.

The modelling of cost-effectiveness of malaria diagnosis presented here uses decision-tree analysis to estimate the cost-effectiveness of three malaria diagnostic strategies relative to each other: RDT, PT and field microscopy. The modelling of the reference case assumes that all patients diagnosed with malaria receive ACT, and all those diagnosed malaria negative receive antibiotics. Models inevitably serve as simplified approximations of epidemiology and behaviour, and data are very limited for some parameters, especially those related to the probabilities of severe disease and death. The results are therefore tested across different epidemiological settings and according to variations in key parameters. In addition, there is likely to be variation between decision-makers in their valuation of health improvement and attitudes towards risk (i.e. the degree of certainty they require.

The cost of field microscopy is very closely linked to the number of febrile patients diagnosed at a health facility per year because fixed costs – such as the microscope, staff training, and laboratory supervision – remain the same regardless of laboratory throughput. Fixed costs are distributed more widely across diagnoses as case-load increases, thus reducing the cost of each individual diagnosis.

FIGURE 1.

The model assumes that all health workers follow the diagnostic test result in prescribing treatment, and that adequate training and quality assurance for RDT use are in place. Parasite-based diagnosis is likely to be less cost-effective where this is not the case. The model assumes that 40-91% of patients adhere to appropriate therapy. Microscopy accuracy is based on actual field data from sites with variable quality assurance programmes are in place. Microscopy has additional advantages in monitoring treatment, distinguishing plasmodium species, and in identifying non-malarial illnesses. These benefits are not incorporated in the analysis, but in settings where they are important could improve the cost-effectiveness of this method.
that an intervention is cost-effective before making a policy decision. Uncertainty around these factors is also considered.

A comprehensive description of the model methods and results is presented in the full report (www.wpro.who.int/sites/rdt), and key findings are presented here. An interactive version that can be adjusted to local conditions can also be downloaded from the same website.

**ESTIMATION OF COST-EFFECTIVENESS**

Due to the high costs of maintaining equipment and a technician, the costs of field microscopy per case are very high at low fever prevalence, compared to RDTs (Figure 1). At higher diagnostic throughput, the microscopy cost per case falls while the RDT cost per case remains fixed. In some settings, good quality microscopy can also have other advantages, including parasite quantitation and diagnosis of other diseases, that increase its value and are not taken into account here. The following modelling assumes a case load of over 1,200 diagnoses per centre each year, with field microscopy cost per test estimated to range between $0.32 and $1.27 depending on throughput, with a best estimate of $0.53. Estimates of diagnostic cost are combined with data on test accuracy and epidemiological, clinical, behavioural and treatment cost parameters to estimate the net costs and DALYs averted with each diagnostic strategy (see full report at www.wpro.who.int/sites/rdt).

Firstly, at a cost of $0.60 per RDT, Figure 2a shows the combinations of ACT cost and malaria prevalence among febrile outpatients at which RDTs would be considered cost-effective relative to PT assuming that decision makers are able to pay $150 for each year of healthy life gained, as suggested by the Ad Hoc Committee on Health Research Priorities (WHO 1996). For example, at a cost per ACT adult dose of $1.70 we can be 95% sure RDTs are cost-effective below a threshold of 64% malaria prevalence and 99% sure below 20% prevalence. RDTs become more cost-effective as the cost of ACT increases. At an ACT cost of $2.70 we can be 95% sure RDTs are cost-effective below 72% malaria prevalence and 99% sure below 43% prevalence. This implies that in the majority of African settings RDTs would be considered cost-effective, as rates of over-diagnosis with PT are frequently very high and the range of ACT and RDT costs used in the model reflects current prices. The cost-effectiveness of RDTs reflects mainly improved treatment and health outcomes for non-malarial febrile illnesses and anti-malarial drug cost savings. RDTs are also robustly cost-effective relative to field microscopy at this cost per test, reflecting the higher estimated accuracy of RDTs in peripheral health facilities, despite their generally higher cost (Figure 2b). If the cost of RDTs increases to $1, they become slightly less cost-effective relative to $1, they become slightly less cost-effective relative to PT and field microscopy,
shifting these malaria prevalence thresholds to the left (Figure 3a and 3b).

Sensitivity analysis shows that cost-effectiveness is most affected by malaria prevalence among febrile outpatients, the cost of the diagnostic test, the cost of ACT, and adherence to antibiotics for, and factors which influence the severity of, non-malarial febrile illnesses. Adherence to ACT and the proportion of patients with negative diagnoses that receive antibiotic treatment have moderate impacts on results. Policy makers’ valuation of health improvement for a year of healthy life is relevant when it is at low levels (Figure 4). Variations in the acceptable level of risk affect diagnostic policy decisions in a wide range of conditions.

Both malaria and non-malarial febrile illnesses such as pneumonia have simple, inexpensive, and cost-effective treatments, but current diagnostic practice is very inaccurate. There are therefore substantial potential gains to be made by improving diagnosis of both conditions. Our results show that RDTs are cost-effective relative to PT and field microscopy across a wide range of malaria prevalence among febrile patients in sub-Saharan Africa, if adequate conditions of quality of use are met, and these results are relatively robust to extensive sensitivity analysis. While conditions will vary in different malaria-endemic areas, the analysis and predictions in the following charts give a useful guide to likely cost-effectiveness when parasite-based diagnosis is introduced.

**FIGURE 3. Cost-effectiveness when RDTs cost $1.00 per test**

Cost-effectiveness of RDTs at varying levels of malaria prevalence and cost of ACTs per adult dose, assuming decision makers are able to pay $150 for each year of healthy life gained. (It is assumed that field microscopy is used for malaria diagnosis only)

**FIGURE 4. Cost effectiveness of RDTs according to willingness to pay for health gain**

Cost-effectiveness of RDTs at varying levels of malaria prevalence and decision makers’ valuation of a year of healthy life gained. This analysis assumes reference case costs for RDTs and ACTs according to the full report (www.wpro.who.int/sites/rdt). RDT costs are uniformly distributed from $0.60-1.00, and ACT costs are uniformly distributed between $1.00-$2.40. (It is assumed that field microscopy is used for malaria diagnosis only)