Laboratory Diagnosis of Malaria
Conventional and Rapid Diagnostic Methods

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Context.—The global control of malaria is more challenging than that of many other infectious diseases: malaria is vector borne, it is caused by 5 species of *Plasmodium* with different geographic distributions, infection is widespread in many regions, drug resistance is common, and the disease overlaps clinically with other infectious diseases. Therefore, malaria control programs, in addition to diagnosis and testing, must also target limiting spread of the disease through vector control. Although malaria control efforts have been successful in some regions, malaria remains one of the most important causes of death in sub-Saharan Africa, particularly in women and children.

Objective.—To review the current literature regarding diagnostic methods available to detect clinical malaria, with an emphasis on comparing the strengths and limitations of each method.

The 2010 World Health Organization (WHO) report on malaria notes that there are 106 malaria-endemic countries or regions with half of the world’s population at risk for acquiring malaria (Figure). The most recent WHO data indicate that during 2009 there were 225 million cases of malaria, resulting in 781 000 deaths, followed by marked improvement in 2010, when the number of cases declined to 216 million and the number of deaths to 655 000. The largest decrease in deaths was in Africa, where 11 countries have decreased the number of malaria cases and deaths by half. In addition, 8 countries are now in the prevention of reintroduction phase of malaria control, 8 countries are in the pre-elimination phase of malaria control, in 2010 both Morocco and Turkmenistan were certified as free of malaria, and only 176 indigenous cases of *Plasmodium falciparum* malaria were reported in the European region. Despite this global progress in malaria control, the African region accounts for 81% of all malaria cases and 91% of all malaria deaths, many of which occur in women and children in sub-Saharan Africa.

The WHO malaria control strategy has 2 key components. The first is vector (mosquito) control, which itself has 2 components: indoor residual spraying and the widespread use of long-lasting insecticide-treated mosquito nets, both of which have been used widely and successfully in Africa. The second component is to improve diagnosis and treatment, with a specific emphasis on the increased use of diagnostic tests, particularly malaria rapid diagnostic tests (MRDTs). As with vector control efforts, there has been substantial progress in this area during the past few years, as described in the WHO’s World Malaria Report 2011. Effective malaria diagnosis is important first for the obvious reason that it is necessary to identify cases to treat patients effectively, but also to limit treatment to patients who have malaria and not other febrile illnesses. This is important both to restrict use of antimalarial drugs to patients who will benefit from the therapy and to delay development of drug resistance. This is of increasing importance because the presence of widespread chloroquine resistance means that empiric use of chloroquine-based therapy no longer is safe or effective, and thus there is a need for use of antimalarial combination therapy. Because artemisinin combination therapy is more expensive than chloroquine and must be used correctly (eg, the drugs should not be used individually), and there are concerns about emerging drug resistance of artemisinin combination therapy, there is a need for rapid diagnostic tests to identify cases of malaria to ensure appropriate antimalarial therapy.

Data Sources.—Current World Health Organization malaria control report and other information, recent meta-analyses of diagnostic tests, primary literature concerning the performance characteristics of different tests, and primary literature concerning how diagnostic tests are used in daily practice.

Conclusions.—The most commonly used method for identifying cases of malaria remains microscopic examination of peripheral blood, but there is growing use of malaria rapid diagnostic tests in many regions. One of the most important findings in the recent literature is that despite the widespread use of diagnostic tests, treatment is too often based on clinical findings rather than on results of diagnostic tests.

resistance, it is crucial that artemisinin combination therapy be reserved only for patients with clinical malaria.

CURRENT STATE OF DIAGNOSTIC TESTING

At the present time there are a limited number of methods for the diagnosis of malaria. Conventional methods include clinical diagnosis by history and physical examination, empirical/syndromic diagnosis (mainly the presence of fever in endemic areas), and use of light microscopy to examine infected peripheral blood smears. Histopathology plays a limited role, but although it is useful in some situations, it is not useful in malaria control programs. Nucleic acid amplification tests play almost no role in malaria diagnosis, as these assays are limited to a few large public health laboratories and are not available commercially. As with other common infectious diseases, a number of rapid diagnostic tests have been developed and marketed. Referred to as MRDTs, they potentially could have the most impact on malaria diagnosis and treatment programs of all the available diagnostic techniques.

Empiric/Syndromic Diagnosis

One widely used method to diagnose malaria is empiric/syndromic diagnosis, in which the diagnosis is made on the basis of clinical history, signs, and/or symptoms. In many endemic areas without adequate diagnostic capacity, patients with a febrile illness are likely to receive the diagnosis of malaria. There are a number of pitfalls associated with this approach. First, there is significant clinical overlap among febrile illnesses; fever alone is too nonspecific to make any particular diagnosis. Second, coinfections can and do occur, and treatment for one obviously does not treat the other. Third, malaria parasitemia can occur that is not the cause of the febrile illness. Last, relying on clinical diagnosis alone results in treatment of patients with antimalarial drugs for illnesses other than malaria. The WHO recommends against this practice when and where malaria diagnostic tests are available.

Microscopic Slide Examination

In most endemic areas, microscopic slide examination of peripheral blood remains the most widely used test as well as the gold standard for detecting malaria parasitemia. The 2011 WHO report indicates that in 2010 there were a total of 165 million microscopic slide examinations worldwide. Estimates of diagnostic sensitivity of microscopic slide evaluation vary according to the type of infecting species, geographic area, and other factors, but in general diagnostic sensitivity is thought to be no higher than 75%. This figure is based on the rate of detection of parasitemia in patients with clinical malaria. For patients with nonfalciparum malaria, low-level parasitemia, or partial immunity, or those who have been partially treated for malaria, the diagnostic sensitivity is likely to be even lower than 75%. Even so, microscopy offers significant advantages over other methods, and, where it can be done correctly and with good

quality assurance, it remains the gold standard against which other methods are compared.

Microscopy is based on examination of both thick and thin films made from the same sample of peripheral blood. Thin films are prepared in the same way as for any peripheral blood smear. A number of different stains can be used, but it is important to remember that not all stains allow detection of some of the characteristic features of malaria (eg, Schüffner dots). It is also important to remember that stains can vary in quality and consistency, and that adequate quality control and experience both are needed to provide optimal stains. Thick films are made by placing a few drops of blood on a glass slide, allowing the blood to dry, and then lysing the blood (usually with water) before staining. Although thick films are more sensitive for detecting the presence of malaria parasites, they are not very useful in speciating the parasites, which should be done using the thin films. Even though the technology of microscopy is simple and straightforward, making and interpreting malaria smears requires adequate training and experience.

The diagnostic advantages of microscopy are that it (1) permits definitive identification of infecting species as well as mixed infections; (2) can be used to determine the magnitude of parasitemia; (3) can be used for serial examinations to monitor the efficacy of therapy; (4) requires little laboratory infrastructure; and (5) is comparatively inexpensive. Microscopic slide examination does have diagnostic disadvantages, including (1) it does not detect very low parasitemias; (2) errors in interpretation are most common with either very low or very high parasitemias (for which accurate diagnosis is very important); (3) mixed infections are often missed; and (4) it is not as useful in areas without endemic malaria because of the inability of persons reading smears to remain sufficiently competent to make accurate and reproducible diagnoses.

Microscopic slide examination also has nondiagnostic advantages and disadvantages. Among the advantages are that the microscope and trained personnel can be used to diagnose other infectious diseases, slides can be retained to create a permanent record for quality control, excess microscope slides can be reused or recycled, and the method requires only minimal laboratory infrastructure. Among the nondiagnostic disadvantages are that the method is labor intensive; it is relatively slow (particularly for thick films); the variable stains and methods result in variable smear quality; the method requires adequate training; and for an area that previously did not use the method, acquiring the necessary equipment and training personnel can be expensive. The difficulty in learning to interpret malaria smears is generally overstated as a limitation, as even individuals without a laboratory background can be trained to read smears in a reasonable amount of time and with good success.

**RAPID METHODS**

**Characteristic of an Optimal Rapid Diagnostic Test**

In a recent review of rapid malaria tests, Murray et al described the characteristics of an optimal rapid diagnostic test. Briefly, an optimal diagnostic test would use simple technology; would be readily learned by users; would have results that are easy to interpret (both by users and by providers who ordered the test) and reproducible; would not require electricity to run the assay; would not require refrigerated storage; and, obviously, would be rapid. These characteristics apply to any rapid diagnostic test: the clinical setting where rapid testing is needed, whether for the diagnosis of malaria, human immunodeficiency virus, or tuberculosis, is one where interventions need to be done immediately and without any significant delay.

**Additional Characteristics of MRDTs**

In addition to characteristics common to any rapid diagnostic test, MRDTs have additional performance characteristics that are of importance. Most important is the ability to distinguish among species, both because of the prognostic importance of distinguishing between *P falciparum* and other forms of malaria and because of the therapeutic importance of identifying cases of *Plasmodium ovale* or *Plasmodium vivax* malaria, for which treatment with primaquine is needed. The ability to detect mixed infections is of importance for the same reasons. Defining the sensitivity and specificity for detecting each species is important for malaria control programs to be able to select the assay best suited for specific geographic areas.

**MRDTs: Current State**

A large number of rapid methods have been developed and marketed, many of which are in clinical use. The most recent WHO report notes that global use of MRDTs has expanded rapidly, particularly in sub-Saharan Africa, the Southeast Asia region, and the Eastern Mediterranean region.

Early MRDTs were problematic: (1) there were rapid changes in the assays by manufacturers, often without subsequent controlled clinical trials to evaluate the new versions; (2) inconsistent manufacturing standards existed in many parts of the world; (3) use of MRDTs in the field often was accompanied by inadequate quality control; and (4) assays showed variable product stability once they were shipped from manufacturing facilities. Even today, in many countries regulatory oversight of manufacturing continues to be inadequate or lacking altogether, and there remain serious concerns about the quality of many of these products. Nonetheless, a wide variety of test methods are available commercially: WHO estimates that there are at least 60 brands offering more than 200 commercial MRDTs worldwide.

**MRDTs: Biochemical Basis**

The currently available MRDTs generally detect malaria-specific protein antigens or enzymes. The most important of these are the *P falciparum* histidine-rich protein 2, which is specific to *P falciparum*, and *Plasmodium* spp lactose dehydrogenase, which may be species-specific or pan-specific (ie, may detect all species). Some MRDTs detect the presence of aldolase, which is not species specific but rather is found in all malaria species.

Most MRDTs currently in use are immunochromatographic strip assays, a technology that allows for mass production of assays. Mass production, in turn, should allow for lower manufacturing and distributing costs, a simplified supply chain, easier training of users, standardization of result interpretation, and easier use in countries or regions where multiple languages are spoken (thereby requiring less complex assays to minimize training and education costs).

The technology is generally similar for most of these assays, although there are some variations. In general, the liquid specimen is applied to one end of the strip, where it
mixes with lysing agents, buffer, and labeled antibody. The labeled antibody then binds to parasite antigens. The fluid mixture then migrates across the nitrocellulose membrane to a point where antibodies fixed on the strip surface can bind to a different set of epitopes on parasite antigens. If the fluid mixture is captured by these fixed antibodies, indicator antigens bound to the labeled indicator antibodies will create a line on the strip, giving a positive test result. It should be emphasized, however, that there are many variations in the exact way immunochromatographic strip assays are designed and used. There are at least 7 broad categories of immunochromatographic strip MRDTs, each containing varying combinations of antibodies to detect different antigens.6,4

**Performance Evaluations of MRDTs**

Clinical evaluations of MRDTs are difficult to conduct and to standardize, whether using microscopy as a gold standard or simply comparing one assay with another. There are a number of reasons for this. First, the epidemiology of malaria in study populations varies substantially: geographic regions even short distances apart may have different types of malaria, varying prevalence and incidence rates, variable access to diagnosis and treatment facilities, and highly variable patient populations because of migration, political instability, or other factors. Second, both malaria-naïve and semi-immune patients live in the same areas, where tests designed to detect the presence of malaria antigens may be positive in patients who have low-level malaria parasitemia but who do not have clinical disease. Third, whether patients have had prior treatment is not always apparent because of the lack of good medical records in many areas. Fourth, antigenemia can persist following adequate treatment, leading to false-positive test results. Because malaria enzymes are cleared faster than antigens, assays that detect enzymes may yield negative test results when compared with assays that detect antigens. Last, environmental factors can affect assays differently, leading to more rapid degradation of one assay compared with another. These factors, combined with the high number of assays currently available commercially, make designing and conducting controlled clinical trials challenging. As a result, other approaches are needed to determine the performance characteristics of MRDTs and to compare different assays against one another.

**WHO Evaluations of MRDTs**

Because of the aforementioned difficulties in designing and conducting field trials of MRDTs, the WHO has undertaken extensive evaluations to identify tests that show the best performance characteristics.6 This has been a collaborative effort between WHO, the Foundation for Innovative New Diagnostics, the Centers for Disease Control and Prevention, and the Special Programme for Research and Training in Tropical Diseases. The evaluations were based on a complex study design consisting of 2 parts. The first part of the evaluation was to determine which commercial manufacturers could meet specific quality manufacturing requirements. For products that met this criterion, the second part of the evaluation consisted of testing the MRDTs using stored donor blood seeded with parasites.6 In the first round, a total of 41 assays from 21 manufacturers were tested using cultured *P. falciparum* isolates. In the second round, a total of 29 assays from 13 manufacturers were evaluated. In round 3, a total of 50 assays from 23 manufacturers were evaluated. Of the 120 assays tested, 118 were selected to be evaluated for detection of wild *P. falciparum* and *P. vivax*, with control testing of blood not seeded with parasites. Heat stability was also evaluated. Results of this third round of the evaluation were published in the document *Malaria Rapid Diagnostic Test Performance: Results of WHO Product Testing of Malaria RDTs: Round 3 (2010–2011).*6 The results of this evaluation showed that, as a group, MRDTs exhibit wide variability in performance at low parasite concentrations, better performance at high parasite concentrations, wide variability among products, and even some variability among lots.6 It should be emphasized that these evaluations were not field trials, but rather in vitro evaluations of commercial products using seeded specimens. Even so, the results show that only a small number of assays show acceptable performance characteristics and should be considered for clinical trials or procurement programs.

**Controlled Clinical Trials of MRDTs**

A recent meta-analysis7 published by the Cochrane Collaboration regarding MRDTs for detection of *P. falciparum* included an analysis of 74 papers. The papers were selected on the basis of a number of variables: methods were included that detected histidine-rich protein 2 antigen or *Plasmodium* spp lactate dehydrogenase antigen; the studies were conducted in *P. falciparum*-endemic areas; MRDTs were compared against either microscopy or a polymerase chain reaction–based assay; and the patients evaluated were selected either randomly or consecutively.7 For histidine-rich protein 2 assays, the overall average sensitivity and specificity were 95.0% and 95.2%; for *Plasmodium* spp lactate dehydrogenase antigen assays, the overall average sensitivity and specificity were 93.2 and 98.5%.7 Thus, in this meta-analysis, histidine-rich protein 2 assays were found to be more sensitive but *Plasmodium* spp lactate dehydrogenase antigen assays were found to be more specific. In the conclusion to the meta-analysis, it was emphasized that histidine-rich protein 2 antigenemia “persists even after effective treatment and so is not useful for detecting treatment failures.”7

Even with the benefit of a thorough meta-analysis, evaluating results of clinical trials is challenging. First, many MRDTs are manufactured in a number of countries, and therefore may not be subject to rigorous manufacturing or regulatory oversight. Because of this, it is not always apparent when a given product has been modified intentionally, raw materials used in manufacturing have changed, or other changes have been made that could affect performance characteristics of assays.4 Second, the multiplicity of study designs and combinations of products studied is a common feature of this body of literature. Third, many studies lack sufficient detail regarding materials and methods, making it difficult or impossible to assess their validity, let alone to replicate them. Fourth, different patient populations studied and geographic variation (with corresponding variability in the species of malaria in each area) makes it difficult to compare results of one study against another. Last, lack of methodologic rigor makes some studies of dubious scientific validity.

Published data regarding performance characteristics of MRDTs can be summarized as follows. First, as with any diagnostic laboratory test designed to be a screening test, performance characteristics of MRDTs are better in malaria-endemic areas.5 This is because most rapid tests are
designed to detect the presence of malaria, not to exclude its presence. Second, tests that are manufactured in areas with adequate manufacturing and regulatory oversight are likely to perform better, or at least more consistently, through time. Third, as previously stated, none of the MRDTs should be used to assess response or lack of response to antimalarial therapy. Fourth, there are some specific performance issues that merit consideration. For example, patients with high levels of \( P. falciparum \) parasitemia may give false-positive results with tests designed to detect \( P. vivax \). As another example, a report from Peru indicated that a large proportion of \( P. falciparum \) isolates in that area lack \( P. falciparum \) histidine-rich protein 2 and \( P. falciparum \) histidine-rich protein 3, which means that MRDTs targeting detection of those antigens will yield negative test results. Therefore, in that geographic area, use of either microscopy or MRDTs that target detection of lactate dehydrogenase or aldolase should be used. Fourth, none of the existing MRDTs is specific for infections caused by \( P. ovale \), \( Plasmodium malariae \), or \( Plasmodium knowlesi \). Last, there are relatively few published data regarding use of MRDTs for specific patient populations or in specific geographic areas.

**Effect of MRDTs on Treatment of Patients**

As stated previously, for any diagnostic test to be useful the results of the test must impact the treatment decisions made by the person(s) ordering the test. The published data regarding the impact of MRDTs on malaria have yielded variable results. In one recent study\(^{10}\) in Tanzania, more than half of the patients who had a negative test result, either microscopy or MRDT, still received antimalarial therapy. In that study, more than 90% of the prescriptions for antimalarial drugs were for patients who had a negative test for malaria.\(^{10}\) For children younger than 5 years, those who had a negative rapid test result were more likely to be prescribed antimalarial drugs than were children who had a negative microscopic test.\(^{10}\) In another recent study\(^{11}\) from Ghana, the introduction of a rapid test was evaluated in 2 settings: 1 location where microscopy already was in use and 3 others where treatment was based on clinical diagnosis. Introduction of MRDTs in the setting where microscopy already was in use had little impact on treatment decisions, again with more than half of patients who had a negative test still being treated with antimalarial drugs. In contrast, where treatment had previously been based on clinical findings, introduction of MRDTs resulted in a significant reduction in the overprescription of antimalarial drugs.\(^{11}\) The results of this study were similar for both children and adults. Although some other studies have come to the opposite conclusion, namely that use of MRDTs does result in use of antimalarial drugs more often in those patients with a positive test result,\(^{10}\) most published observations are in keeping with the most recent WHO recommendations for using MRDTs (see below).

**Use of MRDTs to Detect Malaria in Women and Children**

Relatively few controlled clinical trials have been performed regarding use of MRDTs in women and children. The available data support use of these assays in children.\(^{1,3,12}\) In the same way, relatively few controlled clinical evaluations of MRDTs have been conducted with women. For pregnant women, symptoms consistent with malaria are common, but in one study less than a third of these women had parasitemia.\(^{15}\) Another potential use of MRDTs for pregnant women is indicated by the observation that assays specific for \( P. falciparum \) are more sensitive than is microscopy, and thus can be used to identify placental malaria when microscopy does not identify parasitemia. Because most malaria deaths occur in children, and pregnant women who do not have malaria do not need and should not be given antimalarial therapy, there is a need to better characterize the performance characteristics of MRDTs used to diagnose malaria in children and pregnant women.

**Postmortem Diagnosis of Malaria Using MRDTs**

There are only limited clinical trial data regarding this application of MRDTs, data that suggest that these assays can work as part of a postmortem examination.\(^{16}\) Because so many patients die of febrile illnesses in resource-limited areas where there is limited access both to health care and to pathology services, this is one potential way to help clarify the cause of death without the need for a complete autopsy.

**Field Use of MRDTs**

Rapid diagnostic tests have the potential to improve the detection of malaria parasitemia where it is needed most—in the field—but there are practical issues that need to be addressed for MRDTs to be used effectively.\(^{3,4}\) First, there needs to be a supply chain that is appropriate and adequate for the product being used. In some cases this requires temperature control throughout the shipping and storage process. Second, the persons using the tests need adequate training and supervision, and must have readily available written instructions. Third, adequate quality control and quality assurance programs must be in place. Fourth, the tests must be used in context with other components of a malaria control program, and, in particular, there must be the necessary drugs to treat patients based on the results of the test. Fifth, MRDTs must be selected based on the specific needs of a region, in particular the degree of endemicity and type(s) of malaria species present.\(^{17}\) Last, MRDTs must provide test results that are consistent and reliable for local users to gain confidence in them to the point where they will act on test results consistently.\(^{18}\)

**MRDTs: Recommended Use**

The current WHO recommendation is that, if there is no other diagnostic support, it is appropriate to use MRDTs. If, however, microscopy is available, both should be used to detect malaria parasitemia. In addition to using 2 tests to improve the case detection rate, the use of microscopy serves other purposes. First, microscopy can be used as a quality control mechanism for MRDTs, to determine both whether the MRDTs are detecting malaria and whether they are detecting the correct species. Second, microscopy is useful when rapid test results are negative, which can occur when a species-specific test does not detect other species. Third, because MRDTs cannot be used to determine the magnitude of parasitemia, microscopy is still needed. Last, microscopy can help with resolution of confusing cases, such as with mixed infections.

**HISTOPATHOLOGIC DIAGNOSIS OF MALARIA**

Despite the primary advantage of histopathology, being able to characterize the disease process, it is not a first-line diagnostic method in malaria control programs. This is for
the obvious reasons: the method is insensitive for detecting parasites, identifying species generally is not possible, and the method is too slow and too expensive. Nonetheless, it remains an important diagnostic method for determining the cause of cases of fever of unknown origin in patients from areas where there are multiple causes of febrile illnesses, it is an important part of the autopsy and determining cause of death, it can play an important role in the quality control of research on malaria diagnosis and treatment, and through all these mechanisms it can contribute to public health epidemiology.

The classic description of falciparum malaria in tissues is that of a small vessel disease due to involvement of capillaries and small vessels. These vessels may be filled with parasitized red blood cells, because of the expression of adhesion molecules on the surfaces of infected red blood cells that adhere to endothelial cells within small vessels. Microscopic examination of tissues from acute cases may show focal necrosis and acute inflammation, and the brain may show ring hemorrhages, but the histopathologic findings may be subtle. More chronic infections may show malarial pigment within cells of the reticuloendothelial system.

Many classic descriptions of the pathology of malaria remain valid, but they may not correlate with current knowledge of pathophysiology, immunity (especially partial immunity), treatment using contemporary drugs, and the synergy of malaria with human immunodeficiency virus infection. Clearly, research in the histopathology of malaria is still needed, particularly in the study of the effects of the disease in women and children. Research in the histopathology of malaria will continue to play an important role in evaluating treatment programs as a quality control mechanism, in helping clarify cause of death in areas where other causes of febrile illnesses are common, and in studying the pathophysiology of the disease.

NUCLEIC ACID AMPLIFICATION TESTS

At this time, there are no commercial nucleic acid amplification tests for the diagnosis of malaria. Because developing one of these tests requires expertise that generally is not available in most clinical or hospital laboratories, use of the few assays that do exist is restricted to larger public health laboratories. Not surprisingly, because of the cost of these tests and the long turnaround time to get test results, they are not used in malaria control programs except on a research or epidemiologic basis.

It is likely that some type of automated or point-of-care nucleic acid amplification tests will be developed in the near future, but whether such an assay will have a significant impact on malaria diagnosis is unknown. Issues of cost, requirements for laboratory infrastructure, and other factors will need to be considered carefully in the design, development, and use of such assays.

COST-EFFECTIVENESS OF MALARIA DIAGNOSTIC TESTS

As with any diagnostic laboratory test, testing for malaria should always be done using the most cost-effective method for the setting in which it is to be used. In many cases the most cost-effective test may not be the least expensive test. In general, a cost-effective test is one that requires only minimal laboratory infrastructure, requires little training to perform, is easy to use, has easily interpretable results, does not require refrigerated transportation or storage, has a long shelf life, and has sufficient diagnostic sensitivity and specificity to meet the needs of the providers who are ordering the test. For many health care settings, microscopy may be the most cost-effective diagnostic test, particularly in areas where microscopy already is in use and where introduction of MRDTs is not feasible. In areas where microscopy is not in use, it may be more cost-effective to introduce use of MRDTs without microscopy.

The most important consideration in determining cost-effectiveness of any component of a malaria control program is whether the component reduces morbidity and mortality from the disease. In terms of diagnostic tests, this is determined not only by the performance characteristics of the test, but also by how it is used, whether it is used in such a manner as to yield consistently accurate test results, and whether the results are used to guide appropriate therapy. In one economic model of cost-effectiveness, it was found that, in areas of low to moderate malaria transmission, both MRDTs and microscopy were more cost-effective than presumptive therapy, and MRDTs were more cost-effective than microscopy. As the prevalence of malaria increased, however, presumptive therapy became the more cost-effective approach. In all scenarios, however, it was emphasized that one of the critical factors was a consistent therapeutic approach based on test results. Thus, as with other rapid diagnostic tests, the cost-effectiveness of the test may depend less on the test per se and more on how it is used and what actions are taken based on the results of the test. This will be of particular concern as malaria control efforts become more successful, potentially resulting in more persons with low-level parasitemia. In these patients, MRDTs may be less useful.

SUMMARY

To be effective, global malaria control programs require the availability of adequate laboratory tests in the field. To date, microscopy remains the gold standard for the diagnosis of malaria, but MRDTs are rapidly becoming a primary diagnostic test in many areas, particularly where microscopy may not be available. Histopathology, although not a test of use in the immediate treatment of patients in malaria control programs, continues to play other roles in the diagnosis of malaria and in research programs. Nucleic acid amplification tests are of limited use, although newer technologies may result in the expansion of this testing in the future. Whether nucleic acid amplification tests will become a cost-effective approach to diagnostic testing in resource-limited regions remains to be seen.

References


