TECHNICAL REPORT
SEVENTH ROUND
2018-2019

EXTERNAL QUALITY ASSURANCE PROGRAM FOR MALARIA MICROSCOPIC DIAGNOSIS

REGIONAL MALARIA PROGRAM
NEGLECTED, TROPICAL AND VECTOR-BORNE DISEASES
COMMUNICABLE DISEASES AND HEALTH ANALYSIS
PAN AMERICAN HEALTH ORGANIZATION

October, 2019

INDEX

INTRODUCTION

One of the objectives of the Pan American Health Organization's Plan of Action for Malaria Elimination (2016-2020) is to ensure "*Universal access to good quality malaria prevention, integrated vector management interventions, **malaria diagnosis** and treatment*". (1)

Implementation of policies which ensure effective treatment is based on the existence of a healthcare system that offers prompt access to reliable (precise and accurate) diagnosis for better surveillance, prevention, and control of malaria in the Americas. (2)

The program for external quality evaluation has been developed because of the need for national reference laboratories to have an External Quality Assurance Program (EQAP), to contribute to the improvement of microscopic diagnosis of malaria. This effort will not only improve malaria diagnosis at the level of reference laboratory but shall also allow the transfer of skills and the upgrading of resources throughout the country.

Technical work in a laboratory should always be subject to constant supervision using quality control procedures. Such supervision is not possible without quality control which allows for evaluation of the work done by the laboratories. Success in the face of new challenges in improving the efficiency of public health response will partly depend on the quality and performance of the *LABORATORY NETWORKS.*

OBJECTIVES

GENERAL OBJECTIVES

To establish technical procedures for the organization, design, and evaluation of the microscopic diagnosis of malaria for the National Reference Laboratories of the countries in the Region, with the objective of maintaining an efficient quality management system and contributing to the strengthening of monitoring malaria diagnosis in the Region of the Americas.

SPECIFIC OBJECTIVES

1. Evaluate result concordance based on reproducibility of positive or negative results.
2. Evaluate species concordance in participating laboratories.
3. Evaluate stage concordance in participating laboratories.
4. Evaluate parasite density concordance in participating laboratories.

SLIDE PANEL CHARACTERISTICS

- Slides of the species present in the Region: *Plasmodium vivax; Plasmodium falciparum;* and mixed slides (P.f./P.v.).
- Slides with different parasite densities: low, medium and high density.
- Stages: asexual and sexual stages of *P. vivax* and *P. falciparum*.
- Negative slides.
- Number of slides per panel: 20.
- Groups of uniform panels, with respect to the characteristics of the positive slides (species, stage, and parasitaemia) and negative slides, were used so that the evaluation can be compared across different laboratories and years.
- Giemsa stain was used in the preparation of the slide panel.

PARAMETERS EVALUATED

1. Results: Refers to detection of positive and negative slides, regardless of species.
2. Species: Refers to detection of *P. vivax*, *P. falciparum*, or mixed infections.
3. Stage: Refers to detection of asexual and sexual stages (*P. vivax* and *P. falciparum* gametocytes).
4. Parasite density: Refers to quantitative detection of parasites, independent for each stage of the species, calculated according to the established formula. (3-4)

$$Parasite\ Density = \frac{\text{No. of parasites}}{\text{No. of leukocytes}} \times 6000$$

In the analysis of Parasite Density concordance between the evaluated laboratory and the evaluating laboratory, a slide shall be considered concordant if the number of parasites reported by the evaluated laboratory is ±50% of the value reported by the evaluating laboratory.

RATING SCALE

Parameters Evaluated	Rating
Results concordance	Acceptable: 95 - 100 %. Unacceptable: < 95%
Species concordance	Acceptable: 95 - 100 %. Unacceptable: < 95%
Stage concordance	Acceptable: 80 - 100 %. Unacceptable < 80%
Parasite density concordance	Acceptable: 80 - 100 %. Unacceptable < 80%

RESULTS

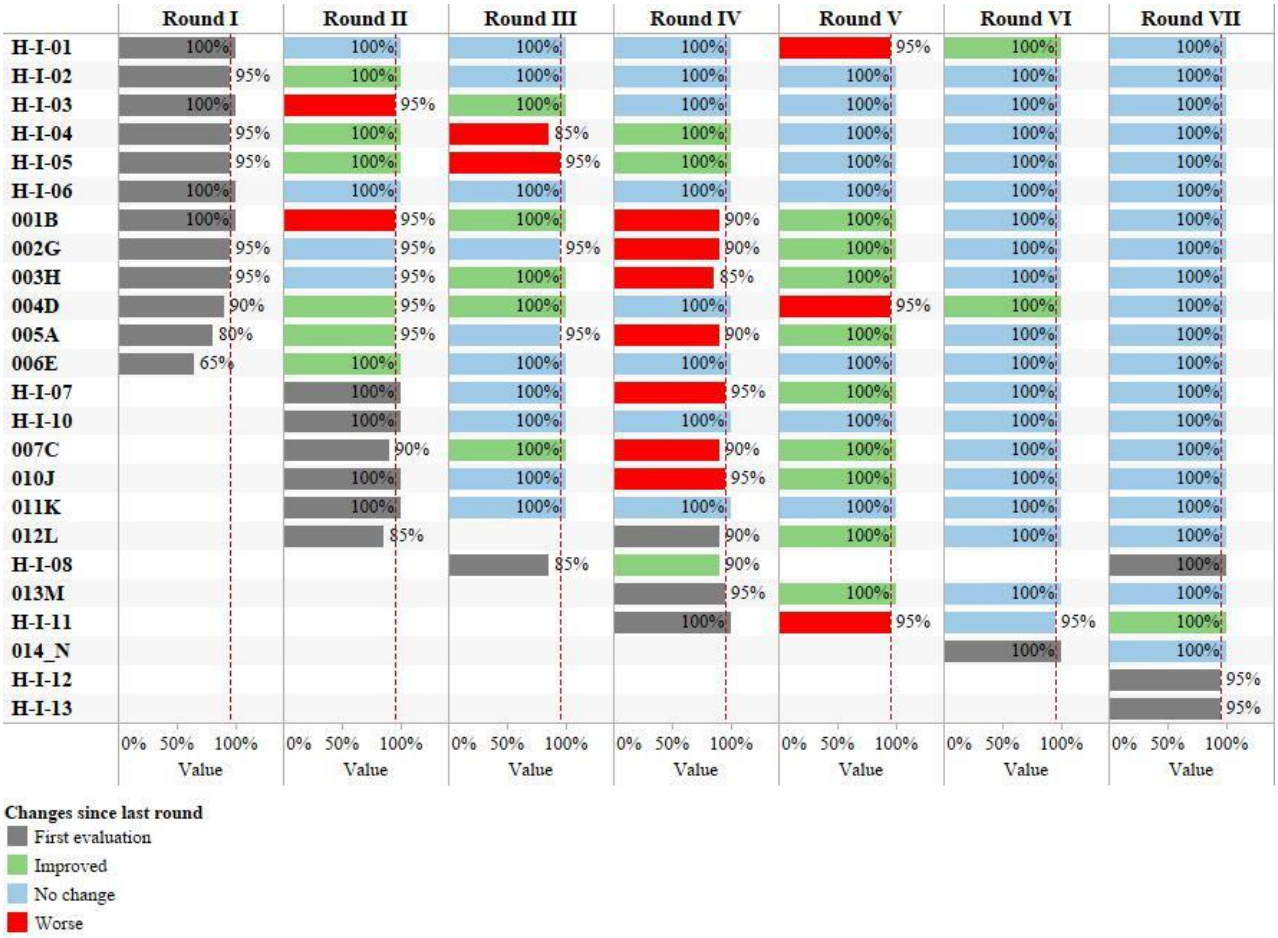
Twenty-four reference laboratories from the Region of the Americas participated in this seventh round: twelve from Mesoamerica and the Caribbean and 12 from South America. The analysis and results of the current report represents the 24 National Reference Laboratories or designated for this exercise in de Americas Region.

Preliminary results were generated by the online NETLab system (5) for each of the participating laboratories as soon as the data was entered and provided quick results for each of the four parameters evaluated were provided.

As a second step, all participating laboratories will receive this final report compiling results from the two supranational laboratories, thus obtaining an overall result of these seventh round. In this report, laboratories are identified by their codes to ensure anonymity of results.

The results of round VII for the first parameter evaluated, concordance of results, as illustrated in Figure 1, was: of the 24 participating laboratories, all attained ≥95% concordance, deemed as acceptable. Of these, 22 with a maximum percentage of 100% and two with 95%, no problems were observed in relation to this first parameter.

Figure 1. Percentage concordance for Results parameter.



The negative predictive value (NPV) for the laboratories evaluated was 100%, for 23 of 24 participant laboratories demonstrating that only one laboratory had problems in reading and identifying negative slides with an 83% (Table 1). For the positive slides, 23 of 24 participant laboratories obtained a positive predicative value (PPV) of 100% and just one obtained 93%. A Kappa (K) index value greater than 0.8 shows good concordance among evaluators of the slides; it demonstrates that most laboratories have good concordance with the regional reference laboratories, as shown in Table 1.

Table 1. Predictive Values & Kappa for Results parameter.

Result			
Laboratories	**NPV**	**PPV**	**Kappa**
006-E	100%	100%	1.00
005-A	100%	100%	1.00
001-B	100%	100%	1.00
004-D	100%	100%	1.00
002-G	100%	100%	1.00
003-H	100%	100%	1.00
H-I-02	100%	100%	1.00
H-I-01	100%	100%	1.00
H-I-03	100%	100%	1.00
H-I-04	100%	100%	1.00
H-I-06	100%	100%	1.00
H-I-05	100%	100%	1.00
H-I-10	100%	100%	1.00
H-I-07	100%	100%	1.00
011-K	100%	100%	1.00
010-J	100%	100%	1.00
012-L	100%	100%	1.00
007-C	100%	100%	1.00
H-I-08	100%	100%	1.00
H-I-11	100%	100%	1.00
013-M	100%	100%	1.00
014_N	100%	100%	1.00
H-I-13	100%	93%	1.00
H-I-12	83%	100%	0.88

*NPV- Negative Predictive Value, PPV- Positive Predictive Value

As can be observed in Figure 2, the results for the second parameter evaluated, species concordance, in round VII were: 16 of the 24 participating laboratories obtained an acceptable result (percentage greater than 95%), while the remaining eight had concordance rates below the required standard (five with 93%, one with 89%, another one with 79% and one with 71%).

Comparing these results with those of previous rounds, it can be observed that most of the participating laboratories improved their concordance rates for this parameter. Five demonstrated a

decline, three improved, 13 maintained the same concordance and three laboratories are participating for the first time.

Analyzing the data using predictive values and the Kappa index, it can be observed that 22 out of 24 participating laboratories do not had problems in identifying positive slides for *P. falciparum* (<80% PPV) and two had problems for the identification of this specie. Just only one laboratory had problems reading negative slides for this specie (see Table 2). Although some of these laboratories belong to non-endemic countries for *P. falciparum*, the results of this evaluation demonstrate high levels of sensitivity and specificity for the diagnosis of positive cases of this specie. For *P. vivax,* 23 out of 24 laboratories presented good results higher than 80% for both positive (PPV) and negative slides (NPV). It is worth mentioning that one laboratory reported *P. vivax* where it did not exist, as well as another one not detecting this specie in positives slides.

As seen in Table 2, the kappa index demonstrates in detail that only the same two laboratories had problems in the identification of *P. falciparum* and *P. vivax* negative and positive slides, reporting rates below 0.8 but higher than 0.5 compared to the previous rounds.

Figure 2. Percentage concordance for species type.

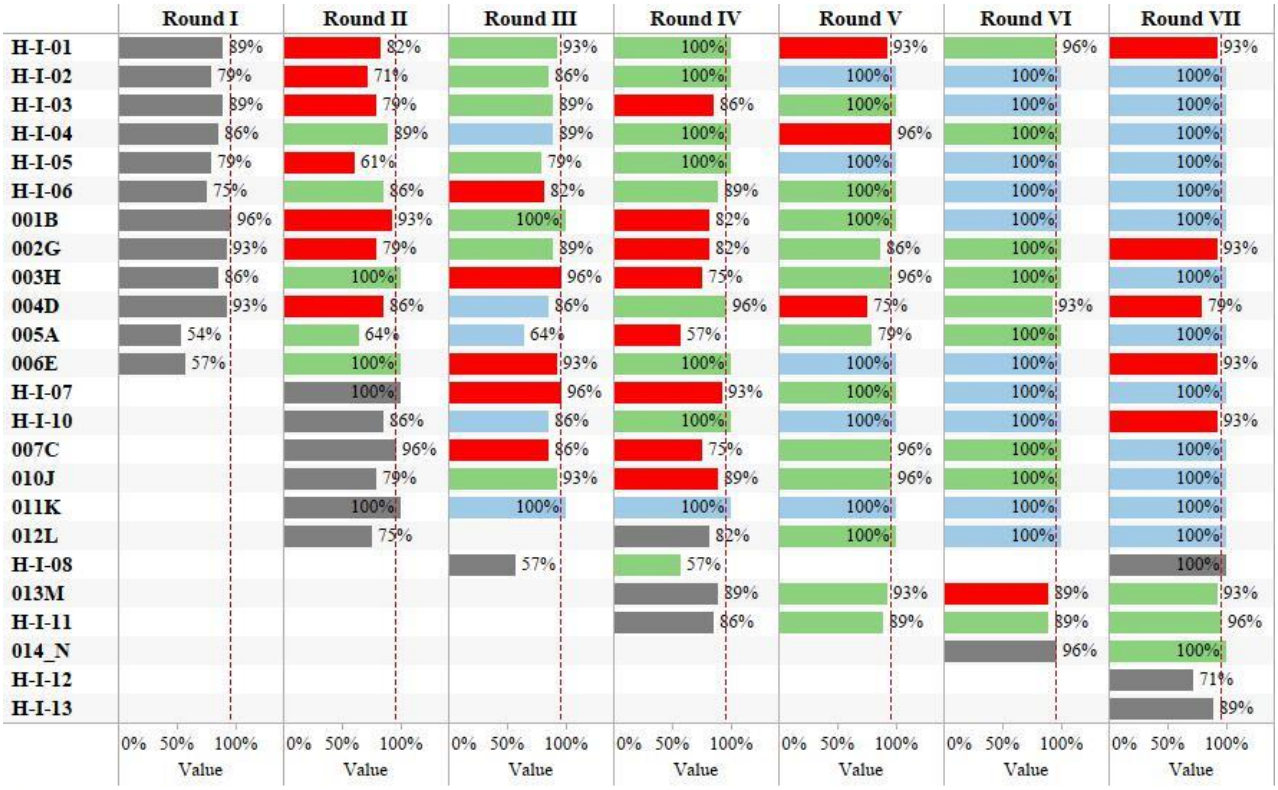


Table 2. Predictive values & Kappa for species type.

Laboratories	*P. falciparum*			*P. vivax*		
	NPV	PPV	Kappa	NPV	PPV	Kappa
006-E	91%	100%	0.90	100%	89%	0.90
005-A	100%	100%	1.00	100%	100%	1.00
001-B	100%	100%	1.00	100%	100%	1.00
004-D	73%	100%	0.71	100%	67%	0.69
002-G	91%	100%	0.90	100%	89%	0.90
003-H	100%	100%	1.00	100%	100%	1.00
H-I-02	100%	100%	1.00	100%	100%	1.00
H-I-01	100%	89%	0.90	100%	89%	0.90
H-I-03	100%	100%	1.00	100%	100%	1.00
H-I-04	100%	100%	1.00	100%	100%	1.00
H-I-06	100%	100%	1.00	100%	100%	1.00
H-I-05	100%	100%	1.00	100%	100%	1.00
H-I-10	100%	89%	0.90	91%	100%	0.90
H-I-07	100%	100%	1.00	100%	100%	1.00
011-K	100%	100%	1.00	100%	100%	1.00
010-J	100%	100%	1.00	100%	100%	1.00
012-L	100%	100%	1.00	100%	100%	1.00
007-C	100%	100%	1.00	100%	100%	1.00
H-I-08	100%	100%	1.00	100%	100%	1.00
H-I-11	100%	100%	1.00	100%	89%	0.90
013-M	91%	100%	0.90	100%	89%	0.90
014_N	100%	100%	1.00	100%	100%	1.00
H-I-13	100%	100%	1.00	100%	78%	0.79
H-I-12	91%	67%	0.59	64%	89%	0.51

*NPV- Negative Predictive Value, PPV- Positive Predictive Value

Results for the third parameter evaluated, stage concordance, as observed in Figure 3, show that 22 out of 24 participating laboratories obtained acceptable results (≥80% concordance,) and two obtained a percentage below the acceptable result (73%). In general, a maintenance can be observed in this parameter in comparison to the previous rounds.

A more detailed analysis of the results by species and stage concordance shows that one of the problems is the non-identification of certain stages when they do exist, as seen in Table 3. In regard to *P. vivax,* challenges were greater in the detection of sexual stages where in 11 of the 24 participating laboratories obtained Kappa indices of substantially less than 0.8, and three of them less than 0.5, indicating less than 50% concordance of slides examined with the Regional reference laboratory, and two of those three with serious problems not identifying this stage in any of the positive slides, and one laboratory with troubles reporting this stage on negative slides. For the

asexual stage, 22 of the 24 laboratories obtained Kappa index ≥0.8 and only two obtained indices below the acceptable but greater than 0.5, one for NPV and another for the PPV.

For *P. falciparum* improvements are present in relation to the previous rounds. All participant laboratories had Kappa indices equal or greater than 0.8 for sexual stages or gametocytes, and four laboratories had problems with asexual stages with indices below than expected. Figure 3. Percentage concordance for stage type.

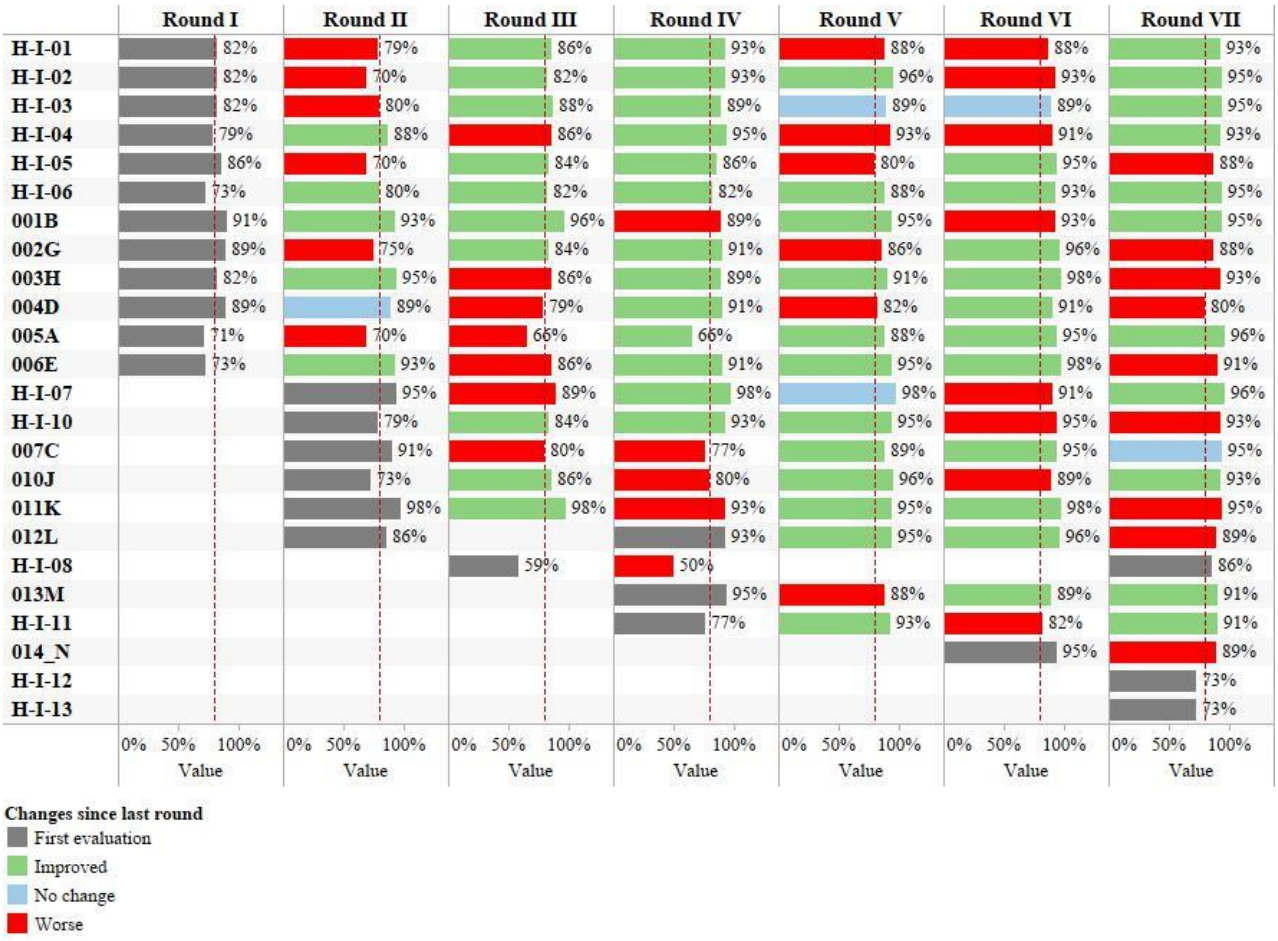


Table 3. Predictive Values & Kappa for stage type.

Laboratories	*P. vivax* asexual		*P. vivax* sexual		*P. falciparum* asexual		*P. falciparum* sexual		Kappa			
	NPV	PPV	NPV	PPV	NPV	PPV	NPV	PPV	*P. vivax* asexual	*P. vivax* sexual	*P. falciparum* asexual	*P. falciparum* sexual
006-E	91%	100%	86%	100%	100%	89%	100%	80%	0.90	0.78	0.90	0.86
005-A	100%	100%	100%	78%	100%	100%	100%	100%	1.00	0.79	1.00	1.00
001-B	100%	100%	93%	83%	100%	100%	100%	80%	1.00	0.76	1.00	0.86
004-D	73%	100%	62%	100%	100%	67%	100%	100%	0.71	0.53	0.69	1.00
002-G	91%	100%	92%	75%	100%	78%	100%	80%	0.90	0.68	0.79	0.86
003-H	100%	100%	79%	100%	100%	89%	100%	100%	1.00	0.69	0.90	1.00
H-I-02	100%	100%	100%	63%	100%	100%	100%	100%	1.00	0.67	1.00	1.00
H-I-01	100%	89%	100%	100%	100%	89%	100%	75%	0.90	1.00	0.90	0.83
H-I-03	100%	100%	92%	75%	100%	100%	100%	100%	1.00	0.85	1.00	1.00
H-I-04	100%	100%	85%	71%	100%	100%	100%	100%	1.00	0.56	1.00	1.00
H-I-06	100%	100%	85%	86%	100%	100%	100%	100%	1.00	0.68	1.00	1.00
H-I-05	100%	100%	100%	0%	100%	100%	100%	100%	1.00	0.00	1.00	1.00
H-I-10	100%	89%	100%	89%	91%	100%	94%	100%	0.90	0.90	0.90	0.86
H-I-07	100%	100%	100%	78%	100%	100%	100%	100%	1.00	0.79	1.00	1.00
011-K	100%	100%	100%	89%	100%	89%	94%	100%	1.00	0.90	0.90	0.86

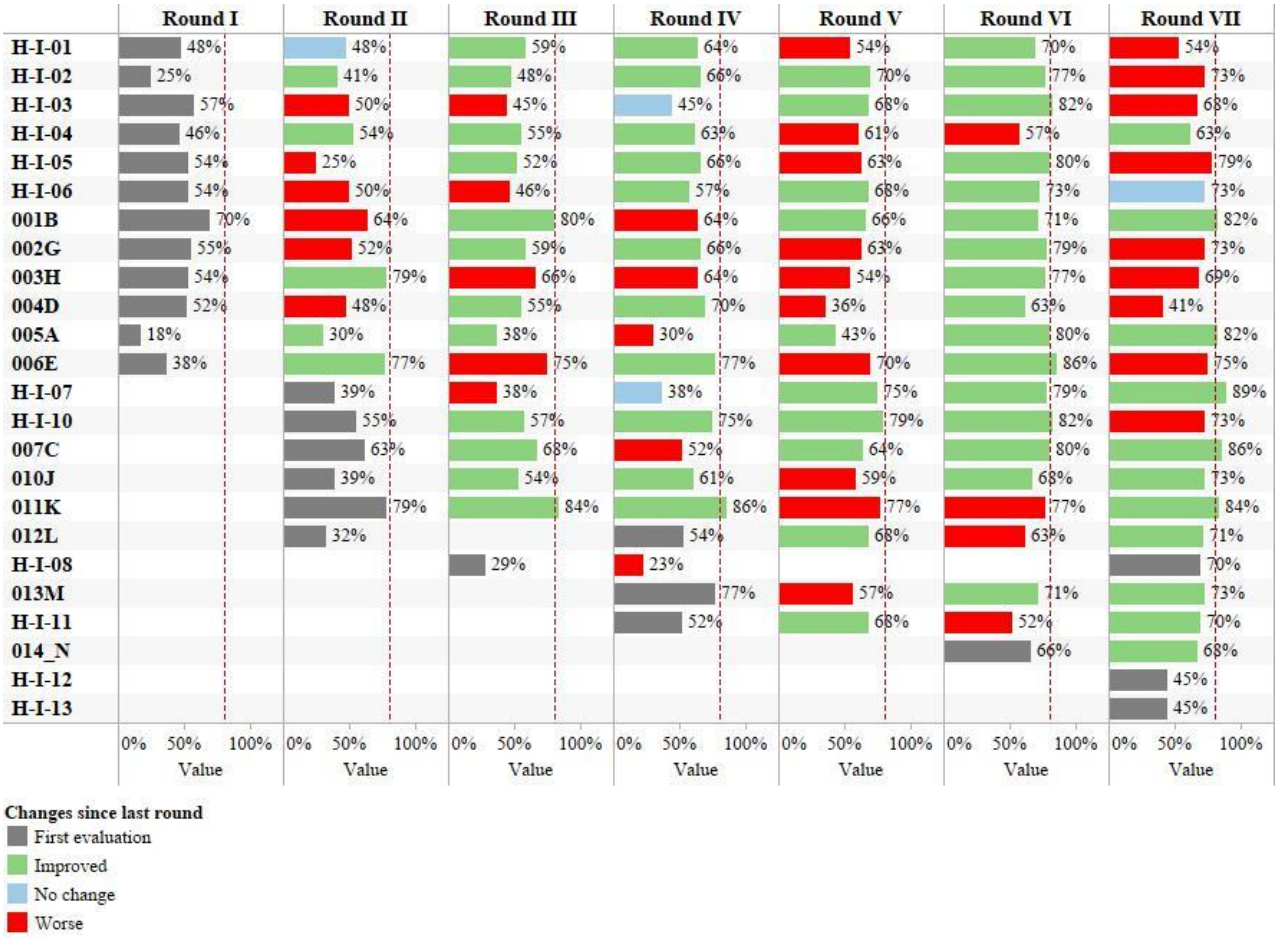
Laboratories	*P. vivax* asexual		*P. vivax* sexual		*P. falciparum* asexual		*P. falciparum* sexual		Kappa			
	NPV	PPV	NPV	PPV	NPV	PPV	NPV	PPV	*P. vivax* asexual	*P. vivax* sexual	*P. falciparum* asexual	*P. falciparum* sexual
010-J	100%	100%	92%	63%	100%	100%	100%	100%	1.00	0.57	1.00	1.00
012-L	100%	100%	79%	83%	100%	89%	93%	100%	1.00	0.57	0.90	0.88
007-C	100%	100%	79%	100%	100%	100%	100%	100%	1.00	0.69	1.00	1.00
H-I-08	100%	100%	85%	71%	100%	56%	100%	100%	1.00	0.56	0.58	1.00
H-I-11	100%	100%	79%	100%	100%	89%	100%	75%	1.00	0.69	0.90	0.83
013M	91%	100%	85%	100%	100%	89%	100%	80%	0.90	0.79	0.90	0.86
014N	100%	100%	73%	100%	100%	89%	100%	75%	1.00	0.58	0.90	0.83
H-I-13	100%	89%	92%	0%	100%	44%	100%	75%	0.90	-0.10	0.47	0.83
H-I-12	90%	66%	100%	37%	64%	78%	94%	100%	0.59	0.42	0.41	0.86

* NPV: Negative Predictive Value, PPV: Positive Predictive Value

For the fourth and last parameter evaluated, parasite density, results shown some improvement for most of the participating laboratories (figure 4). Although this parameter still needs strengthening, in this round 11 laboratories improved, nine achieved less than previous round, one maintained, and we have three new participants. Five of the 24 participant laboratories obtained acceptable results (≥80% concordance). In this parameter the difference of ±50% to the assigned value of the parasite density in each slide is considered. See Annex 1 for the details of the formulas used in the NETLab system for the calculation of concordance rates.

The major problem observed in this parameter was the incorrect use of the formula for calculation of parasite density by parasites per microliter of blood (p/µl). This is due to the fact that some laboratories are still using the 'plus' system which had been previously established for estimating parasite density. Currently, several of the national laboratories evaluated are implementing the counting of parasites per microliter (p/µl) and a noticeable improvement since the first round has been observed for most of these.

Figure 4. Percentage of parasite density concordance.



CONCLUSIONS

This program has made it possible to identify strengths and weaknesses in participant laboratories, which will be addressed individually with each one.

This program also had allowed the standardization of the processes for malaria microscopic diagnosis at the regional level. Participating laboratories, being national reference laboratories, should place emphasis on evaluating and supporting laboratories at the department and municipal level in order to improve and maintain high standards that assure the quality of malaria diagnosis at all levels of care in each participating country, be it endemic or non-endemic.

It is of utmost importance that an endemic or non-endemic country be able to rely on adequate diagnostic capabilities, under a framework that guarantees their quality. This ensures rapid diagnosis and appropriate treatment with the purpose of shortening time of transmission and preventing reestablishment of the disease in areas where it has already been eliminated.

RECOMMENDATIONS

Looking towards overcoming the challenges found in the present evaluation, it is recommended that the personnel in charge of quality control for microscopic diagnosis of malaria read again the slides received in order to detect errors and thus improve detection capability. Tables with the detailed results can be found at the EQAP website using the username and password provided for this program (http:/www.netlab.ins.gob.pe/frmloginmalaria.aspx).

The previous report (9) as well as the current one can be downloaded from the following link, under *'Technical reports*:'

English:
https://www.paho.org/hq/index.php?option=com_docman&task=doc_download&gid=47073&Itemid=270&lang=en

BIBLIOGRAPHY

1. Pan American Health Organization. Plan of Action for Malaria Elimination 2016-2022; 2016.
2. WHO. Malaria Microscopy Quality Assurance Manual – Version 1. 2009.
3. WHO/HTM/RBM. Assessment and monitoring of antimalarial drug efficacy for the treatment of uncomplicated falciparum malaria, 2003.
4. WHO. Universal access to malaria diagnostic testing. An operational manual. 2011
5. NETLab System. National Institute of Health. Ministry of Health. Lima, Peru. http://www.ins.gob.pe/portal/home.
6. Pan American Health Organization. Technical Report: First Slide panel 2011-2012. External quality assurance program for microscopic diagnosis of Malaria. October 2012.
7. Pan American Health Organization. Technical report: Second Slide panel 2012-2013. External quality assurance program for microscopic diagnosis of Malaria. May 2014.
8. Pan American Health Organization. Technical report: Third Slide panel 2013-2014. External quality assurance program for microscopic diagnosis of Malaria. June 2015.
9. Pan American Health Organization. Technical report: Fourth Slide panel 2014-2015. External quality assurance program for microscopic diagnosis of Malaria. October 2015.
10. Malaria Microscopy Quality Assurance Manual. Version 2. WHO 2016.

ACKNOWLEDGEMENTS

We are grateful for the support and collaboration of the Regional Reference Centers, the Malaria Laboratory of the National Institute of Health, Peru, and the National Laboratory of Public Health, Ministry of Health, Honduras, in the preparation and sending of panels and the analysis of current results.

This program is being carried out thanks to the support and collaboration of the United States Agency for International Development (USAID), through agreement USAID/PAHO No. AID-OAA-IO-16-00003.

ANNEX

I. Formulas used by the NETLab system to calculate concordance rates.

1. Concordance in result

The software awards 1 point for every laboratory-tested slide consistent with the reference panel of evaluation laboratory.

Both positive and negative slides are counted.

The total score obtained by the evaluated laboratory is divided by 20 (total number of slides) and is expressed as a percentage.

2. Concordance in species

The software awards 1 point for every slide, for each individual species identified: *P. vivax* or *P. falciparum*; or in the case of mixed slides (containing *P. vivax* and *P. falciparum*), the software awards 0.50 points for each species per slide, identified by the evaluated laboratory and consistent with the reference panel of the evaluation laboratory.

Only positive slides that match the reference panel will be counted (concordance in result).

The total score obtained by the evaluated laboratory is divided by the total number of positive slides from the reference panel.

3. Concordance in stage

The software awards 0.25 points for each slide that the evaluated laboratory has identified one of the four stages (the sexual stages for *P. falciparum and for* P. *vivax* and the asexual stages for *P. falciparum* and *P.* vivax) and matches the reference panel from the evaluating laboratory. The software also awards 0.25 points when the slide does not have parasites in any of these stages and the evaluated laboratory correctly identifies the slide as such.

Up to 1, 0.25, 0.5, and 0.75 points can be awarded for each slide.

Only positive slides that match the reference panel are counted (concordance of species).

The total score for the evaluated laboratory is divided by the total number of positive slides from the reference panel.

4. Concordance in parasitaemia

The software awards 0.25 points when the number of parasites per microliter for each of the four stages (the sexual and asexual stages for *P. vivax* and *P. falciparum,* respectively) for each slide identified by the evaluated laboratory matches (with a variation of up to 50% above or below) the parasite density from the evaluating laboratory's reference panels. The software awards 0.25 points when a slide from the reference panel does not contain a parasite in any of its stages, and the evaluated laboratory indicates this by not entering an amount.

The software awards 0.25 points when there the reference panel has fewer than 50 parasites (in any stage) and the evaluated laboratory enters any amount between 01 and 75.

Up to 1, 0.25, 0.5, and 0.75 points can be awarded for each slide.

Only positive slides that match the reference panel are counted (concordance of species).

The total score for the evaluated laboratory is divided by the total number of positive slides from the reference panel.