MALARIA MICROSCOPY COMPETENCY IN LIBERIA

MOH/ NMCP/USAID/CDC/IMAD LIBERIA APRIL 2010

MAIN POINTS

- **Liberia's NMCP and the Improving Malaria Diagnostics project facilitated refresher training courses in malaria microscopy in October 2009 and January 2010 at the LIBR.**
- **Twenty-four participants were trained in 2009 and twenty-one in 2010.**
- **Competence doing microscopy improved rapidly.**
- **There are now two accredited expert microscopists.**
- **There are two areas in need of improvement : identifying parasite species and malaria parasite counting.**

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Description of Activities

"If you cannot not measure it, you cannot improve it"
Lord Kelvin

The Improving Malaria Diagnostics project (IMaD) is USAID's flagship project for malaria diagnostics. IMaD assesses diagnostic capabilities, and works with the NMCP and partners to refine and adapt standardized training materials, training plans and supervisory/quality assurance plans.

Following this mandate, IMaD conducted the assessment and training described in this report.

Prior to this refresher training in malaria microscopy, training emphasis was in strengthening competence using rapid diagnostic tests (RDTs). RDTs are sensitive and specific but they cost more than microscopy and cannot inform about species or parasite density.

Refresher training courses , like the one described in this report, aim to improve competence in malaria microscopy. NMCP and other stakeholders agreed on the curriculum, training methodology, the list of participants, and how progress was going to be measured.

Facilitators of the first course (October 2009) were Mr. T. Henry Kohar (NMCP), Mr. Emanuel Yamo (AMREF/IMaD), and Mr. Rodgers Dena (AMREF/IMaD).

The second course (February 2010) was facilitated by Mr. Emanuel Yamo, Mr. T. Henry Kohar, Ms. Vera Yatta Walker, Mr. Tobias Johnson, Dr Philiph Sahr, and Dr Fatorma Boley. Training was conducted in the Liberian Institute of Biomedical research (LIBR) complex. 24 laboratory technicians participated in the 1st course and 21 in the 2nd course. Mr. Kohar also provided invaluable assistance as NMCP point-person for laboratory training activities with assistance from Ms. Nicole Whitehurst (MCDI/IMaD)

Participants were challenged with a knowledge test and with a pre-training slide set. They, then, participated in a 5-day training course (page 6) that finished with a post-training assessment of competence which included 24 slides of known composition.

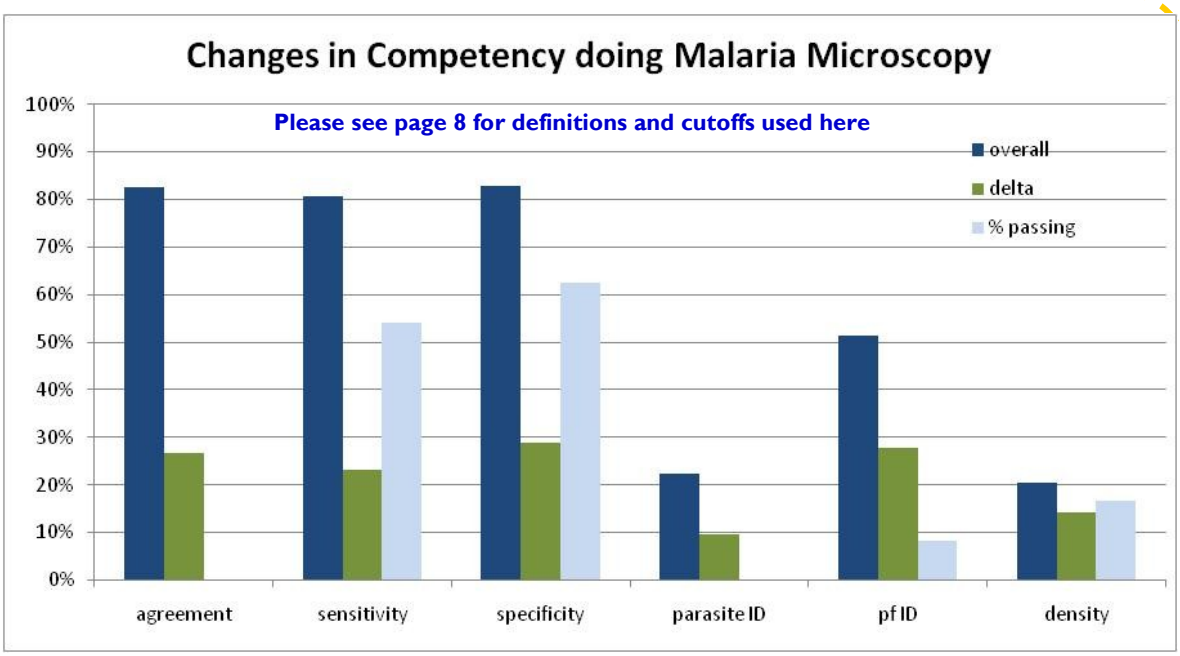
Results on competence were manually graded every night and the next day participants had the opportunity to review slides which they had failed the previous day.

A secondary analysis of data on competence was done with computer support and included a comparison of competence by six participants who attended both refresher training courses.

Photo above: NMCP team. From left to right: Miss A. Sampson, Mr. H. Kohar, Mr E. Dahn, Miss T.Peaches, Dr. Joel Jones,Mrs. H. Jabateh and Mr. Paye Nyansaiye

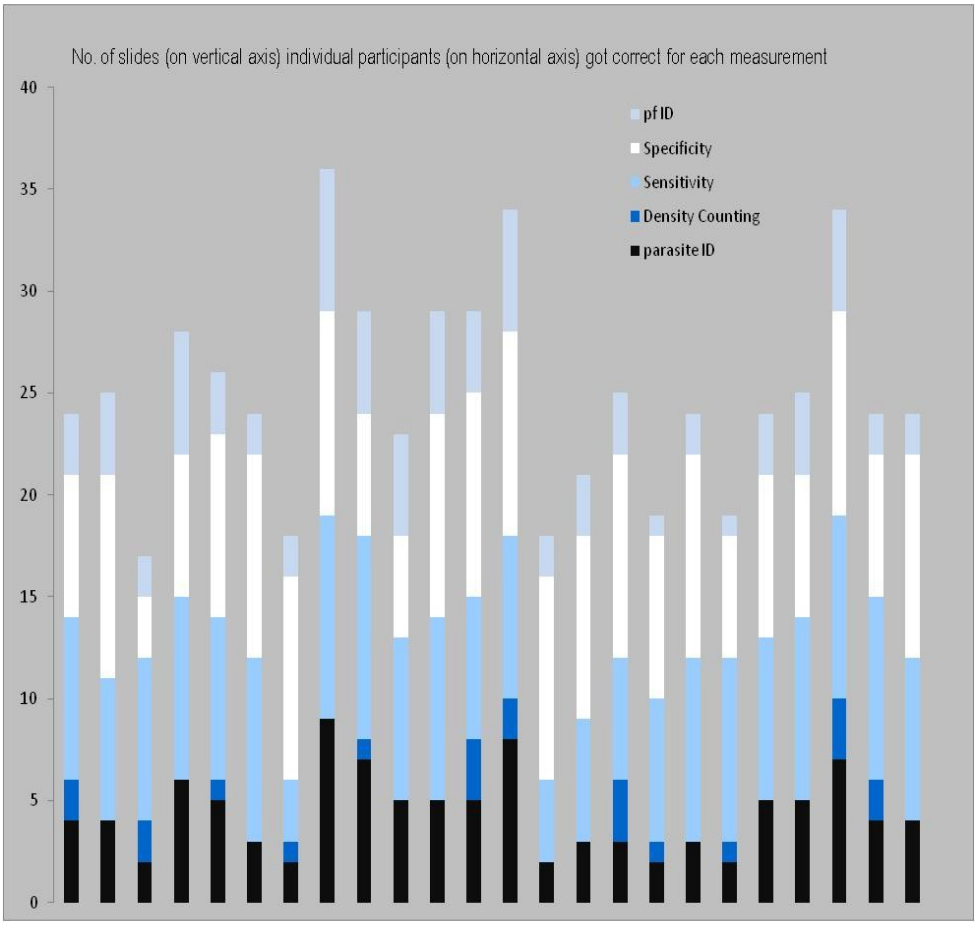
Summary of results of 1st refresher training course, Oct 2009

The figure below summarizes the changes in competency. The increase in overall agreement between microscopists and the gold standard was highly significant, in spite of baseline competence being higher than expected. The delta (increase in percentage points between pre- and post-training assessment) was also significant. Parasite identification and counting remain as areas that need more work.



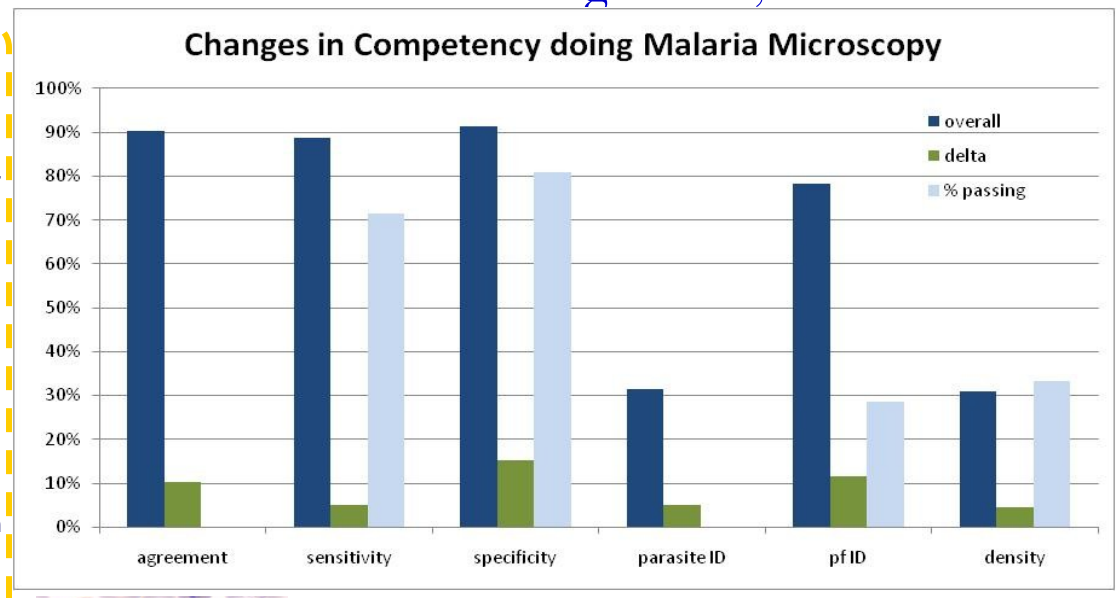
The figures show that overall, for the October 2009 training, course, the participants demonstrated improvement in every area of measurement with most achieving "passes" for Sensitivity and Specificity. Because Agreement is not a standard measurement, the percentage of people achieving "passes" was not determined. Clearly, parasite ID, P.falciparum ID, and counting are the most difficult skills to acquire as the percentage of people achieving "passes" was low even with the improvements that were made during the training.

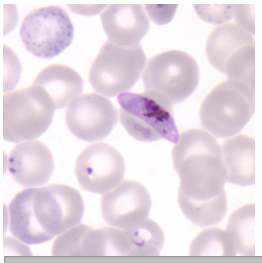
The stacked bars (at right) display results at individual level in terms of the number of slides correctly classified for each measurement. The colors within the graph represent the different areas of measurement and classifications for the results of the individual slides. Pf ID is a count of the number of times that a participant correctly identified that Pf was present, Specificity is a count of the number of True Positive (TP) results, Sensitivity is a count of the number of True Negative (TN) results, Density Counting is the number of slides where the parasite count by the participant was correct, and Parasite ID is the number of slides where the participant correctly identified the parasite species. The stacking of the bars gives a sense of how well the group performed and which participants stood out from the rest; while the different colors give a sense of areas of excellence for the group or areas where improvement is needed. For example, the height of dark blue bars reflects competence in counting parasite density. The maximum height of a dark blue bar can be six slides. For this training, most participants counted parasite density accurately in less than half of the possible slides. Therefore, the conclusion is that post-training competence counting density is still incipient.



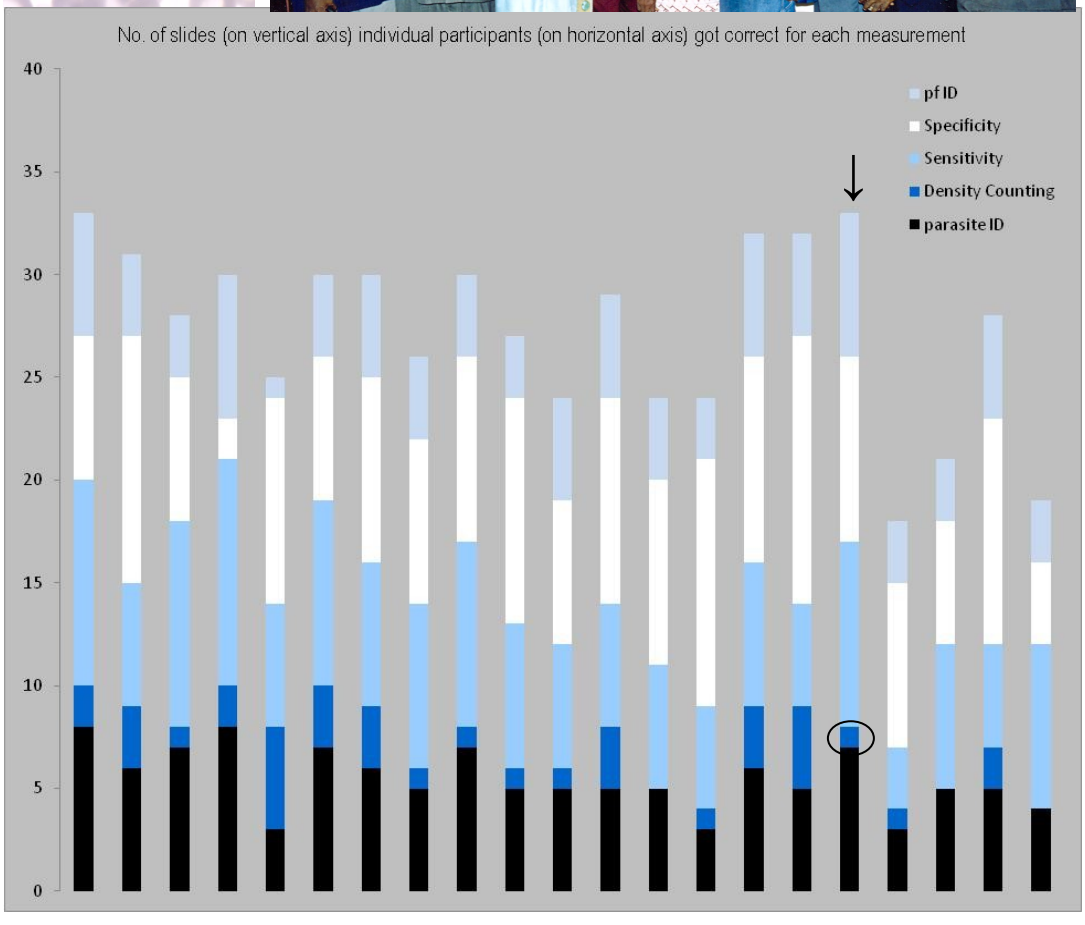
Summary of results of 2nd refresher training course, Feb 2010

Like the October 2009 training, the training in February 2010 resulted in very high levels of competence for Sensitivity and Specificity while emphasizing the difficulty of learning to perform parasite ID and density counting. The 2010 group started with a greater knowledge base than the individuals in October 2009 and so had a higher proportion that passed for Pf ID and parasite counting even though the gains (deltas) of the group in each category were smaller than the gains seen in October 2009.





The stack bar graphs can also be used to compare the competence of a given microscopist with his/her peers at the end of the refresher training. However, competence pre-training (not shown) did not predict competence post-training. Participants that had a low grade were able to catch up and surpass other participants with better pre-training grades (see Personal Stories box, page 4). In the post-training assessment, one of the participants–marked by a black arrow - working at the reference laboratory - got the largest number of slides correct (33) but only one slide correct for parasite counting (circled in black). This means that this participant was best overall but can still improve in parasite counting. Practicing parasite counting will improve this participant's chances of achieving level 1 in the WHO accreditation course.



PERSONAL STORIES

Above: Ms.Walker and Mr. Yamo

After the refresher training conducted by IMaD in 2009, both Ms. Vera Yatta Walker and Mr. Tobias H. Johnson became top performers. Ms. Yatta and Mr. Tobias used the feedback provided during the Oct 2009 training to improve their performance in parasite ID and density counting.

IMaD supported Ms. Yatta's and Mr. Tobias' attendance to the stringent and demanding WHO malaria microscopy accreditation course in Nairobi in January 2010. Both Yatta and Tobias attained the expert microscopist level one certification. Such competent staff will assist future NMCP/IMaD refresher training and supervisions.

Both are an example of the eagerness of Liberian microscopists to improve their competence and their ability to learn quickly. Liberia seems to be an extremely fertile ground for joint NMCP and IMaD efforts to improve the quality of malaria microscopy.

Photo below: Dr Philip Sarr, Ms.Vera Yatta Walker, Dr Joel Jones, Mr Tobias Johnson and Mr. Paye Nyansaiye

A Comparison of Refresher Trainings

Pre-training assessment (labeled "before") was done with a small number of slides, with only 2 used to assess competency in parasite counting. Even so, the trend (when assessing collective competence of the whole class) is suggestive of rapid improvement in most dimensions being assessed, with the exception being parasite species identification and parasite counting. Non-falciparum species are rare in Liberia and this may explain the low competence identifying species. As per parasite counting, this is not routinely done in Liberia and most technicians are not experienced in its use.

Mr. Kohar, IMaD point person at the NMCP, presenting on malaria Standard Operating Procedures.

Please see page 8 for definitions and cutoffs used here

1ST TRAINING (Oct. 2009)

Changes in Competency doing Malaria Microscopy

	agreement		sensitivity		specificity		parasite ID		pf ID		density	
	before	after	before	after	before	after	before	after	before	after	before	after
lower bound %	22%	55%					0%	10%	0%	17%	0%	0%
95% CI - low	51%	80%	51%	77%	47%	79%	9%	20%	16%	46%	0%	15%
overall	56%	83%	58%	81%	54%	83%	13%	22%	23%	51%	6%	20%
95% CI - high	61%	85%	64%	84%	61%	86%	16%	25%	31%	57%	12%	26%
upper bound %	90%	100%					33%	45%	75%	100%	100%	60%
delta (%)		27%		23%		29%		10%		28%		14%
% passing			8%	54%	33%	63%	0%	0%	0%	8%	10%	17%
n slides	207	472	207	472	207	472	207	472	64	160	33	108
n students	24											
Ttest	6.8981E-16											

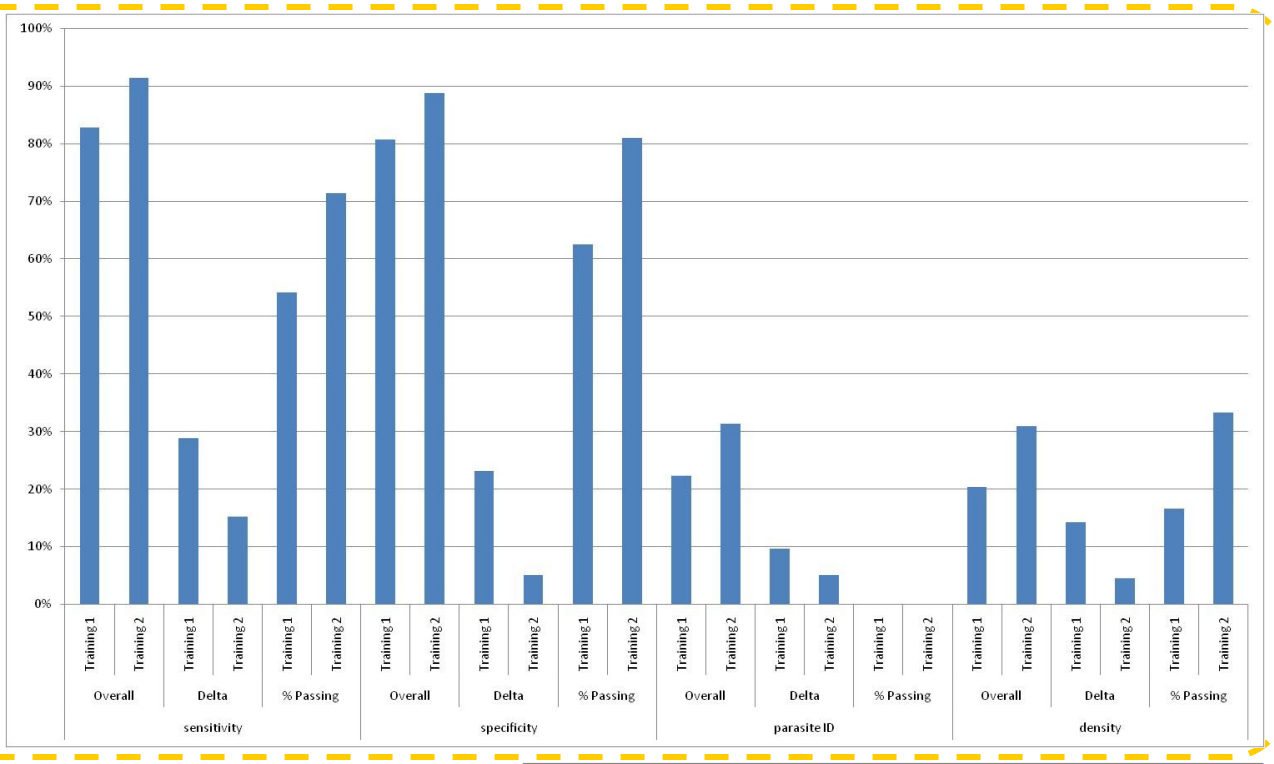
2ND TRAINING (Jan. 2010)

Changes in Competency doing Malaria Microscopy

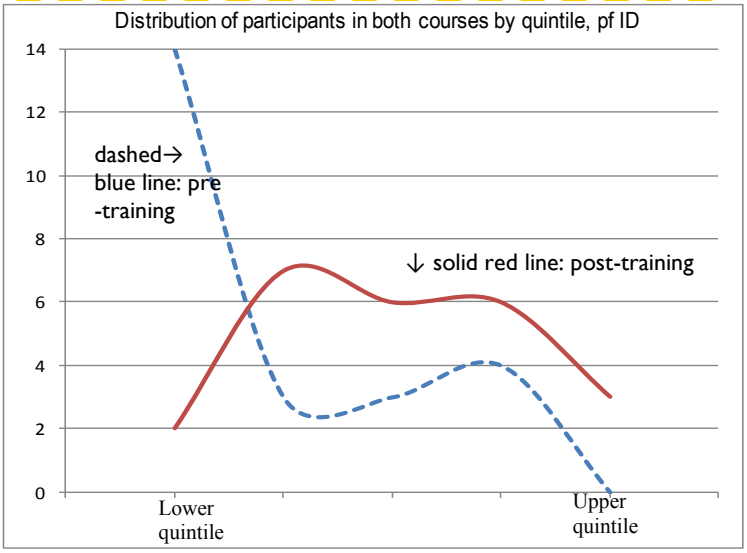
	agreement		sensitivity		specificity		parasite ID		pf ID		density	
	before	after	before	after	before	after	before	after	before	after	before	after
lower bound %	25%	67%					0%	17%	0%	25%	0%	0%
95% CI - low	76%	88%	78%	85%	70%	89%	21%	28%	58%	73%	16%	25%
overall	80%	90%	84%	89%	76%	91%	26%	31%	67%	78%	26%	31%
95% CI - high	84%	92%	89%	92%	83%	94%	31%	35%	76%	84%	36%	37%
upper bound %	100%	100%					50%	47%	100%	100%	100%	83%
delta (%)		10%		5%		15%		5%		12%		5%
% passing			48%	71%	62%	81%	10%	0%	50%	29%	37%	33%
n slides	164	367	164	367	164	367	164	367	54	115	38	123
n students	21											
Ttest	1.31684E-14											

"Lower bound" is the minimum value in the series. "95% CI-low" is the lower level for the confidence interval (true range where that measurement will fall, with 95% confidence) . "Overall" is the aggregate competence of all microscopists pooled. "95% CI-high" is the upper level of the confidence interval. "Upper bound" is the maximum value in the series. "% passing" is the proportion reaching the specified grade. "n slides" is the total number of slides used in that calculation, "n students" is the number of participants. "T test" is a paired, 2-tailed "Student" test for statistical significance.

Comparison of post-tests for 1st and 2nd refresher training courses



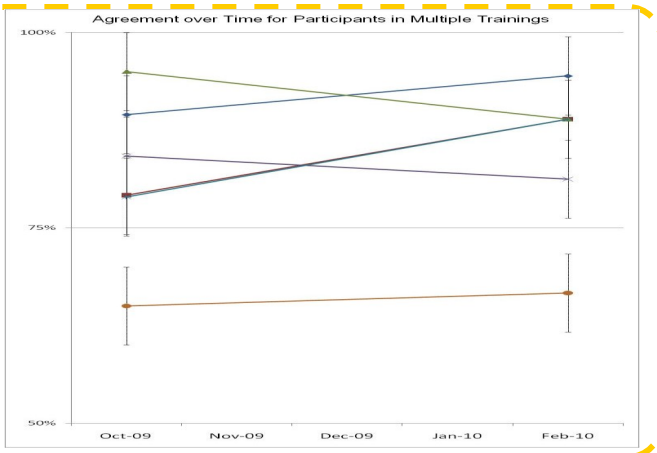
When placed side-by-side the results of different refresher training courses may not necessarily have an upwards trend. If a future refresher training couses is conducted in a rural facility whose staff is less experienced in malaria microscopy, then the trend in baseline competence may be downwards. Most participants in the 2nd training had not participated in the 1st. Therefore, a side-by-side comparison is not entirely a reflection of improvement of the same group of technicians over time. However, the height of the bars in the figure shown above indicate that participants in the 2nd training course performed better than participants in the 1st course. This may reflect that more competent microscopists were chosen for the 2nd training course, that participants in the 2nd training course prepared themselves prior to the training, or both. An analysis of pooled data (all training courses), stratified by level of staff and laboratory level would provide more useful information.



The distribution of participants in the 2010 training by quintile (Pf ID) was bimodal (i.e. two peaks) both in pre-and post training. This suggests that participants were a heterogeneous mix of high and low performers.

Individual Follow-up

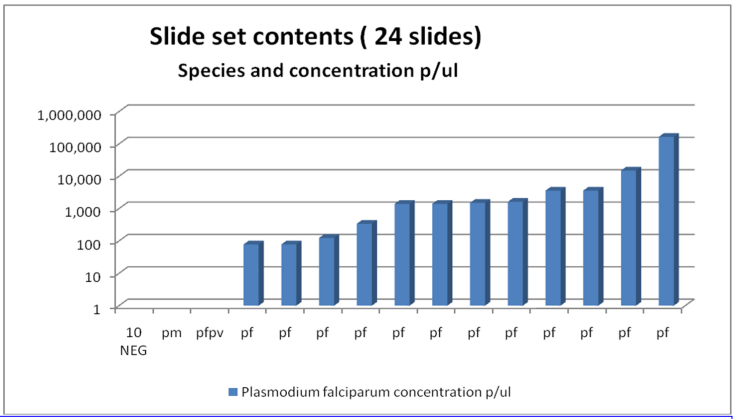
Out of six microscopists attending both refresher training courses in malaria microscopy, only two dropped in agreement with the gold standard and even these were between the 95% confidence interval (Fig. at right). Each horizontal line represent the percentage of slides where the participant agreed with the gold standard in distinguishing negative and positive slides. The vertical lines within the graph are the confidence intervals, a measure of the margin of error possible in our measurement. The confidence intervals are relatively wide. The reason for this is that our measurement of agreement uses only 18 slides in each post-training assessment. Therefore, the results should be analyzed with caution as random variation in competence makes estimates "jump" easily due to the number of slides used.

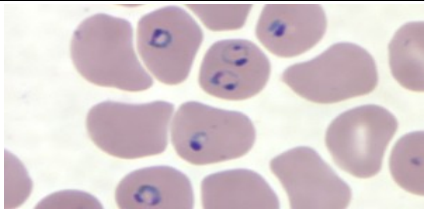


Training Schedule

The morning sessions started with a review of the test malaria slides from the previous day. This review was open, intensive and interactive, allowing for active participation which further added to the learning and consolidation aspects of the workshop. This was followed by presentations (primarily revision) on all aspects of malaria microscopic diagnosis and reporting. Particular emphasis was placed on new and revised procedures for malaria parasite species identification and quantification techniques. Wet practical sessions were conducted which emphasized preparation of thick and thin films and RDTs. The afternoons were reserved for examination of 24 test slides of known composition. Some participants stayed after supper for mentoring by a facilitator staying at LIBR. Next trainings will routinely offer catch up time to participants performing below average.

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8.00-9.00	Introductions	**Review of Pre-test slides**	**Review stained slides**	**Review of Test Slides**	**Review of Test Slides**
9.00-10.00	Ground rules Expectations	Collection of capillary & venous blood (Theory)	Artefacts, pseudoparasites; other blood parasites. Mixed infection (Theory)	Malaria RDT (Theory)	Microscope parts, maintenance& storage
10.00 – 10.30	Pre-test (theory)	Preparation of thick and thin blood films (Theory)	Counting techniques (Theory)	Malaria RDT (Practical)	Good clinical laboratory practice
10.30-11.00	**Tea break**				
11.00-12.00	Pre-test (Practical)	Preparation of thick and thin blood films (Practical)	Practice parasite counting (Practical)	Malaria RDT (Practical)	Malaria QA/QC
12.00-1.30	Pre-test (Practical)	Giemsa and Field staining (Practical)	Practice parasite counting (Practical)	Malaria RDT (Practical)	SOP development
1.30 – 2.30	**Lunch**				
2.30- 3.30	Malaria life cycle & Overview of malaria diagnostic methods	Practice slides – slides that have been prepared (Practical)	Post-test slide examination (Practical)	Post-test slide examination (Practical)	**Presentation of National/regional workplans**
3.30-4.30	Malaria parasite morphology: species & stages	Practice slides – slides that have been prepared (Practical)	Post-test slide examination (Practical)	Post-test slide examination (Practical)	**Presentation of National/regional workplans**
4.30 – 5.30	Preparation of Giemsa and Field stains (Theory)	Practice slides – slides that have been prepared (Practical)	Post-test slide examination (Practical)	Post-test slide examination (Practical)	**Closing**





Slide Sets Used

The figure included above shows the composition and parasite density in the slides used. This set was neither too easy nor too hard and considered adequate for the first training courses. The slide sets used in the assessments were composed of 24 test slides that included three of the four human malaria species (as well as mixed infections) and various malaria parasite densities. Each microscopist was given a box of 24 slides provided by Hydas World Health (HWH) and MR4. The 10-slide groups read during the pre- test were a subset of the of 24 slides. The slide sets utilized will evolve in terms of difficulty level, the number of mixed infections that are included, and diversity of parasite densities as competency improves.

Result of Knowledge Tests

In each training course, facilitators collect pre- and post-test knowledge questions. The pre-training knowledge test revealed a varied background. The mean grade was13.8 and the range 8 - 19.5, well below expectations. The post test mean grade was 19, with a range of 14 - 23.5. (Statistically significant, $p<0.0001$ in T test). Although the focus of the training is not knowledge but practical competence doing microscopy, knowledge tests are useful only to identify gaps in knowledge that upcoming training courses should address. This kind of test also helps customize training courses and job aids to the skills of the participants. For instance, if questions are phrased in a technical language or with complex grammar, a simplified version could be prepared so that participants with limited reading skills or limited vocabulary (In Liberia the war disrupted the educational system for a long period of time) will not be at a disadvantage. As shown at right, all participants expect for two improved their grades in the knowledge test after the training.

Results of knowledge test, 2nd refresher training (Feb. 2010)

Participant No.	Pretest Results (out of 30)	Post test results (out of 30)	Change
1	17	21.5	4.5
2	15	14	-1
3	12.5	13.5	1
4	13	22.5	9.5
5	11.5	16.5	5
6	17.5	25	7.5
7	15	19	4
8	12	19	7
9	19.5	22	2.5
10	15	18	3
11	15	21	6
12	12.5	14.5	2
13	18.5	21.5	3
14	10.5	16.5	6
15	10	25	15
16	13.5	17	3.5
17	15	17.5	2.5
18	15.5	16	0.5
19	8	16.5	8.5
20	-	17.5	N/A
21	14	13	-1
22	11	20	9
23	12.5	23.5	11
24	-	25	N/A
Mean	13.8	19.0	4.7

WHO Accreditation Course Attended by Liberians

WHO Malaria Microscopy Accreditation Courses are being sponsored by IMaD as part of its efforts to strengthen the capacity of national reference laboratories to conduct External Quality Assurance in malaria diagnosis country-wide. WHO accreditation is extremely challenging and during the 1st course conducted for African participants in June 2009, none attained Level 1. So far AMREF –an IMaD partner– has conducted 3 courses in Nairobi. The latest accreditation course, conducted in 2010, included two participants from Liberia, Mr. Tobias Johnson and Ms. Yatta Walker. They were the only participants to attain Level 1(the highest) in this course.

Country	Microscopist (initials for those from other countries)	Species ID (%)	Quantitation (% +/- 25%)	Accreditation Level
Liberia	Tobias H. Johnson	100	60	1
Liberia	Vera Yatta Walker	100	53	1
Zambia	M[redacted]	98	40	2
Kenya	PM[redacted]	88	47	2
Kenya	EM[redacted]	85	47	2
Ghana	W[redacted]	81	53	2
Kenya	JO[redacted]	80	53	2
Zambia	M[redacted]	78	33	3
Kenya	JS[redacted]	88	33	3
Kenya	SM[redacted]	78	13	4
Ghana	EB[redacted]	69	7	4

IMaD, NMCP and LIBR/NPHRL Action Plan to Improve Malaria Diagnostics

1. Determine dates and participant list for Q3 refresher training; tentatively mid-June, 2010.
2. Continue with post training evaluations for Q1-Q2 courses.
3. Timeline for the development of laboratory policy guidelines: a technical working group workshop was held the week of March 16, (in process).
4. Procurement of equipment and laboratory supplies (in process).
5. Prepare the start of the Outreach Training and Support Supervision (OTSS) in the counties by identifying top performers at the October 2009 and January 2010 training at LIBR.
6. OTSS Training for Laboratory staff (first week of May)
7. Supervisory checklists will be adapted to the Liberian MOH/NMCP context, same with training manuals developed by IMaD in other PMI countries (Benin, Zambia, Ghana). The OTSS will be initiated by LIBR/NMCP/IMaD in a limited number of counties.
8. There is a great need for standard slide sets in Liberia and other countries. Having the advantage of 2 expert level microscopist means that the validation could be done in-country, following the current WHO protocol to develop and validate the slides. LIBR could be used as a resource to make the slide bank. 20 slide sets could be developed as a joint effort between the NMCP and LIBR. These slides could be used for training purposes, accreditation, and quality assurance.

Innovations to Show Impact of Training

Manual grading was found to be extremely laborious, prone to errors, and facilitators spent several hours at night to make sure feedback was provided to each participant the following morning. To address this, IMaD developed a template (at right) that any person with a basic command of Excel can use, which involves entering the number of each slide examined and the participant's response. The Excel template then calculates individual indexes (agreement, sensitivity, specificity, ability to report Pf when present, parasite ID, and parasite counting) as well as aggregate data, and compares pre- and post-test results, and even compares results over time if a participant attends further training.

Bottom line (evidence shown here):

Refresher trainings courses in malaria microscopy conducted in Liberia between October 2009 and February 2010 have provided evidence of a strong commitment by USAID/PMI/CDC/Monrovia and the NMCP (the National Malaria Control Program), LIBR and Liberian microscopists to improve the quality of malaria microscopy in Liberia.

Participant's Name
ID Number
Trainer's Name
Date (month/year)

Posttest

Detection and Identification

Slide ID #	Gold std	staff result (1 = true) + for pf	+ for non-pf	+ for mixed	negative (-)	TP, TN, FP, FN
[redacted]	n				1	TN
[redacted]	pf				1	FN
[redacted]						
[redacted]	pfpv	1				TP
[redacted]	pv				1	FN
[redacted]	pf			1		TP
[redacted]	pv	1				TP
[redacted]						
[redacted]	pm	1				TP
[redacted]	n				1	TN
[redacted]	pf	1				TP
[redacted]	pf	1				TP
[redacted]	n	1				FP
[redacted]						
[redacted]	n		1			FP
[redacted]	n	1				FP
[redacted]	pf		1			TP
[redacted]	n	1				FP
[redacted]	n		1			FP
[redacted]	pf			1		TP
[redacted]	n	1				FP
[redacted]	n				1	TN
[redacted]						
[redacted]	n	1				FP

Counting Answers

Slide ID #	Parasite Count	WBC Count	para/uL	True/False
[redacted]			4000	TRUE
[redacted]			546	TRUE
[redacted]			1683	FALSE
[redacted]			4000	FALSE

Total TP	8
Total TN	3
Total FP	7
Total FN	2
agreement	11
% Agreement	55.00%

IMaD
Improving Malaria Diagnostics

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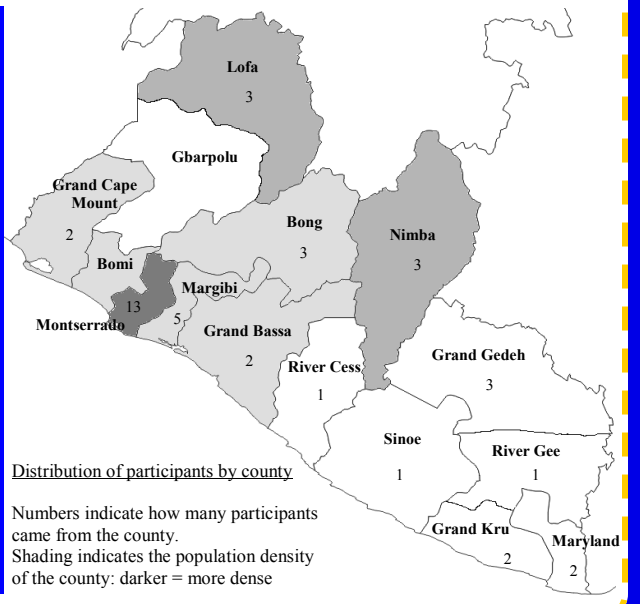
MOH Lab. Staff: Tobias Johnson.
NPHRL: Dr P. Sahr, Ms. Yatta Walker.
LIBR: Dr F. Boley and LIBR staff.
MENTOR Initiative: Dr. Y.Gari
SBA: Subah Bellah Associates.
DELIVER: Dr Emmanuel Taylor.
USAID/CDC: Dr Kassahun Belay, Dr Filiberto Hernandez, Kaa Williams, and Christopher McDermott.
WHO: Dr Moses Jeuralon.
AMREF: Emanuel Yamo, Rodgers Dena and Dr Jane Carter.
HWH: Dr W. Roy Prescott.
MR4: Dr Timothy Steadman.
IMaD/Liberia: Hannan Bestman RN.
MCDI Home Office: Dr Luis Benavente, Sean Fennell, Nicole Whitehurst, Chris Petruccelli, Matt Worges, Loso Boya, and Joseph Carter.

IMaD's mission is to increase the utilization of quality malaria diagnostics in making timely and rationale therapeutic decisions.

"IMaD is USAID's flagship project for malaria diagnosis and will assess the diagnostics, work with the NMCP and partners to refine and adapt standardized training materials, training plan and supervisory/ quality assurance plan".



Distribution of participants by county

Numbers indicate how many participants came from the county.
Shading indicates the population density of the county: darker = more dense

Definition of technical terms used in this report

Agreement is a combination of sensitivity and specificity that describes the number of correct answers given or the amount of agreement between the slides' gold standard and the participant's answers. So, both true negatives and true positives are counted toward this measurement. As a percentage, agreement represents the total of true positives and true negatives divided by the total number of slides tested. Agreement does not have a standard or cutoff for passing associated with it.

Delta - is the change between the pre- and post- tests expressed as percentage points. Delta is the pretest percentage subtracted from the post-test percentage. Because of this, pre-tests do not have a corresponding delta.

Overall (or Overall Performance) is an aggregate measure of correct agreement for all participants in a training course. When presented as an overall percentage, overall is the total number of participant responses that agree with the slide's true value (TP + TN) divided by the total number of slides read by all participants in a training course.

Parasite Counting (or Parasite Density) is the ability to determine the number of parasites per micro-liter of blood to within an acceptable percentage of the true count for each specific slide. For the purposes of grading and analysis, the acceptable range for a respondent corresponds to 99% confidence intervals about the mean number of parasites for the slide. A correct response is determined to be a response within this range. When presented as a percentage, parasite counting is the number of correct counts (counts within the range) divided by the total number of slides counted. The standard used to determine if a participant "passes" for this measurement is 50%, and it is not addressed by WHO.

Parasite ID is the ability to correctly distinguish between a Pf, a non-Pf, and a mixed infection. A correct identification of any of these types is counted toward this measurement. When presented as a percentage, parasite ID is the number of correct identifications of parasite type (Pf, non-Pf, or mixed) divided by the total number of slides tested. The standard used to determine if a participant "passes" for this measurement is 50%. This is a slightly different definition and a different standard to that used by WHO.

Percent Passing (% Passing) is the proportion of participants who passed the particular measurement according to the standards indicated above. As a percentage, % passing is the number of participants who succeeded in achieving the standards given for a particular indicator divided by the total number of participants in a training course.

Pf ID is the ability to identify *Plasmodium falciparum* (Pf) specifically when it is present. When presented as a percentage, Pf ID is the number of Pf positive slides correctly identified as Pf positive by the participant divided by the total number of Pf slides tested. Pf may be part of a mixed infection. The standard used to determine if a participant "passes" for this measurement is 95%. This is the same definition and standard as WHO uses.

Sensitivity is the ability to detect parasites when they are present. So, a result of True Positive (TP) is counted toward this measurement. When presented as a percentage, sensitivity represents true positives divided by the total number of true positives, false negatives, and blanks (included as part of this calculation to discourage participants from submitting non-responses and to avoid getting percentages that over-estimate the abilities of a group). The standard used to determine if a participant "passes" for this measurement is 90%. This is the same definition and standard used by WHO.

Specificity is the ability to correctly determine the absence of parasites. So, a result of True Negative (TN) is counted toward this measurement. When presented as a percentage, specificity represents true negatives divided by the total number of true negatives, false positives, and blanks. The standard used to determine if a participant "passes" for this measurement is 80%. This is a different definition but the same cutoff as WHO uses. (Malaria Microscopy Quality Assurance Manual version 1, Geneva 2009).