REPORT OF FIELD AND LABORATORY EVALUATION OF THE EFFICACY AND ACCEPTABILITY OF **MOSKEETO ARMOR®** AGAINST MALARIA TRANSMISSION IN NIGERIA

Pre- and post-intervention RDT status and hemoglobin concentrations of children wearing and not wearing Moskeeto Armor®, a protective clothing against mosquito bites.

Dr. Bamgboye Morakinyo Afolabi

MBBS, M.Phil (Lagos) MPH (Liverpool); Dr. PH(Hawaii);
CMRF (Nigerian Institute of Medical Research); CRM (India)

	Mean	Std. Deviation	N
Disease	4.17	1.169	6
Malaria	4.17	1.169	6
Mosquitoes	4.00	1.265	6
Prevention	3.67	.816	6

Inter-Item Correlation Matrix

	Disease	Malaria	Mosquitoes	Prevention
Disease	1.000	-.024	-.135	.489
Malaria	-.024	1.000	.541	.698
Mosquitoes	-.135	.541	1.000	.581
Prevention	.489	.698	.581	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Disease	11.83	7.767	.072	.666	.798
Malaria	11.83	5.367	.529	.674	.484
Mosquitoes	12.00	5.600	.401	.582	.589
Prevention	12.33	5.467	.908	.845	.311

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
16.00	9.600	3.098	4

The hypothesis this study proposed to test is as stated below.

Null hypothesis:

1. There is no difference in the hemoglobin concentration of children wearing just "Moskeeto Armor®" regularly at the beginning and at the end of the study.

2. There is no difference in the hemoglobin concentration of children wearing "Moskeeto Armor®" regularly and sleeping under LLIN at the beginning and at the end of the study.

3. There is no difference in the hemoglobin concentration of children wearing "Moskeeto Armor®" regularly compared with the hemoglobin concentration of children who wore Moskeeto Armor® regularly and also slept under LLIN at the end of the study.

4. There is no difference in the hemoglobin concentration of children wearing "Moskeeto Armor®" regularly compared with the hemoglobin concentration of children not wearing "Moskeeto Armor®" at all at the end of the study.

5. There is no difference in the RDT status of children wearing "Moskeeto Armor®" alone at pre and post intervention.

6. There is no difference in the RDT status of children wearing "Moskeeto Armor®" and sleeping under LLIN at pre- and post-intervention consultations.

RESULTS

A total of 119 children, 51 (42.9%) males and 68 (57.1%) females participated in the study (Table 2).

The means of age (months), weight (kg), height (cm), temperature (˚C) and body mass index (BMI) of all the participating children were 67.3, 17.4, 102.6, 36.5 and 16.0 respectively. There were no

significant differences in the means of age, weight, BMI and other variables among male and female participants.

Table 2. Pre-intervention demographic and anthropometric characteristics of children (n=119; male=51, 42.9%; female=68, 57.1%) who participated in the study.

	Mean	±SEM	95% Confidence Interval
Age			
All	67.3	3.3	60.7, 73.9
Male	67.1	5.0	57.2, 77.0
Female	67.4	4.5	58.4, 76.3
Weight (kg)			
All	17.4	0.6	16.2, 18.7
Male	17.2	0.9	15.5, 18.9
Female	17.6	0.9	15.8, 19.4
Height (cm)			
All	102.6	1.7	99.2, 106.1
Male	102.3	2.4	97.5, 107.0
Female	102.9	2.5	98.0, 107.8
Temperature (˚C)			
All	36.5	0.1	36.4, 36.6
Male	36.5	0.1	36.4, 36.6
Female	36.5	0.1	36.4, 36.7
Body Mass Index			
All	16.0	0.2	15.7, 16.4
Male	16.1	0.2	15.6, 16.5
Female	16.0	0.3	15.5, 16.6

Table 3 illustrates the pre-intervention RDT status of the study children. In all 56 (47.1%) children were RDT positive and 63 (52.9%) RDT negative. Among those who were RDT positive, 26 (46.4% were males and 30 (53.6%) were females while among those who were RDT negative 25 (39.7%) were males and 38 (60.3%) were females. Among the males 26 (51.0%) were RDT positive and 25 (49.0%) were RDT negative while among the females 30 (44.1%) were RDT positive while 38

(55.9%) were RDT negative. There was no significant difference in the proportion of males and females who were RDT positive or RDT negative.

Table 3. Pre-intervention RDT status of children (n=119) who participated in the study.

		RDT +ve Freq. (%)	RDT –ve Freq. (%)	Total (%)
All		56 (47.1)	63 (52.9)	119 (100.0)
Male		26 (46.4/51.0)	25 (39.7/49.0)	51 (42.9)
Female		30 (53.6/44.1)	38 (60.3/55.9)	68 (57.1)
Pearson's χ^2	0.5509			
P-value	0.458			
Odds ratio	1.3			
CI	0.6, 2.7			

Table 4 is an assessment of the pre-intervention means of random blood sugar and hemoglobin concentration of participating children. In all, the mean (±SEM) random blood sugar (RBS) of the children in the study was 91.4 (1.0) distributed among male and female participants as 92.8 (1.6) and 90.4 (1.4) respectively. The mean (±SEM) hemoglobin concentration (g/dl) of all the children was 10.1 (0.1) while that of male was 10.0 (0.2) and that of female was 10.2 (0.2) respectively. There was no significant difference in the mean RBM or in the mean hemoglobin values of males and females.

Table 4. Assessment of pre-intervention means of random blood sugar and hemoglobin of children who participated in the study.

	Pre-intervention data
Random Blood Sugar	

All
Mean (±SEM)	91.4 (1.0)
95% C I	89.4, 93.5

Male
Mean (±SEM)	92.8 (1.6)
95% C I	89.7, 95.9

Female
Mean (±SEM)	90.4 (1.4)
95% C I	87.7, 93.1

Hemoglobin

All
Mean (±SEM)	10.1 (0.1)
95% C I	9.9, 10.3

Male
Mean (±SEM)	10.0 (0.2)
95% C I	9.6, 10.3

Female
Mean (±SEM)	10.2 (0.2)
95% C I	9.9, 10.5

Table 5 illustrates the pre-intervention urine status of the participating children. Most urinary values were within normal range. However, 24 (20.9%) of the participants presented with urinary pH of 5 while 6 (5.2%) and 1 (0.9%) presented with urinary pH of 8 and 9 respectively. In all, 8 (7.0%) children presented with turbid urine while 2 (1.7%), 1 (0.9%), 4 (3.5%), 2 (1.7%) and 1 (0.9%) presented with traces of proteinuria, glycosuria, hematuria ketonuria and nitrite correspondingly. All participating children had negative urobilirubin. The mean specific gravity of the urine of all children was 1.0.

Table 5. Evaluation of pre-intervention (n=119)* urine status of children who participated in the study.

Pre-intervention

	Frequency	Percentage
Color		
Pale yellow	86	74.8
Yellow	24	20.9
Amber	1	0.9
Colorless	4	3.5
Odor		
Pungent	115	100.0
pH		
5	24	20.9
6	69	60.0
7	15	13.0
8	6	5.2
9	1	0.9
Turbidity		
Turbid	8	7.0
Clear	107	93.0
Proteinuria		
Negative	113	98.3
Trace	2	1.7
Glycosuria		
Negative	114	99.1
Trace	1	0.9
Hematuria		
Negative	111	96.5
Trace	4	3.5
Ketonuria		
Negative	113	98.3
Trace	2	1.7
Bilirubinemia/Urobilinuria		
Negative	115	100.0
Nitrite		
Negative	114	99.1
Trace	1	0.9
Specific Gravity		
1.00	8	7.0
1.005	18	15.7
1.01	36	31.3
1.015	20	17.4
1.02	9	7.8
1.025	7	6.1
1.03	17	14.8

- 4 children did not produce urine for analysis. Mean Specific gravity of urine was 1.0 (0.0). Thereafter, 51 (42.9%) of the children were given Moskeeto Armor® (MA), the intervention material, to wear while 68 (57.1%) were given both MA to wear and Long Lasting Insecticide

Treated Nets (LLIN) to sleep under. They or their guardians/care-givers were given clear and understandable instructions concerning when to wear the MA and when to go under the LLIN. For example they were instructed to wear the MA as from 4.00 pm till 9 am except during the school hours and those who have LLIN should sleep under it when they go to bed for the night.

The analyses below illustrate pre-intervention data from children who were given the MA. They were segregated into (i) children who wore the MA regularly (ii) children who did not wear the MA and (iii) children who did not wear the MA at all during the period of study.

i. Children who wore the Moskeeto Armor® Regularly

A total of 18 (35.3%) children (7 males, 11 females) who were given the MA wore the protective clothing regularly, as instructed. The means of their age, weight, height, temperature and body mass index are as shown in Table 6. There was no significant difference in the means of age, weight, height and temperature except in body mass index (t=-2.3, df=13.5, p=0.02), of this group of children.

Table 6. Pre-intervention demographic and anthropometric characteristics of children (n=18) who wore the Moskeeto Armor® regularly during the study period relevant to their gender.
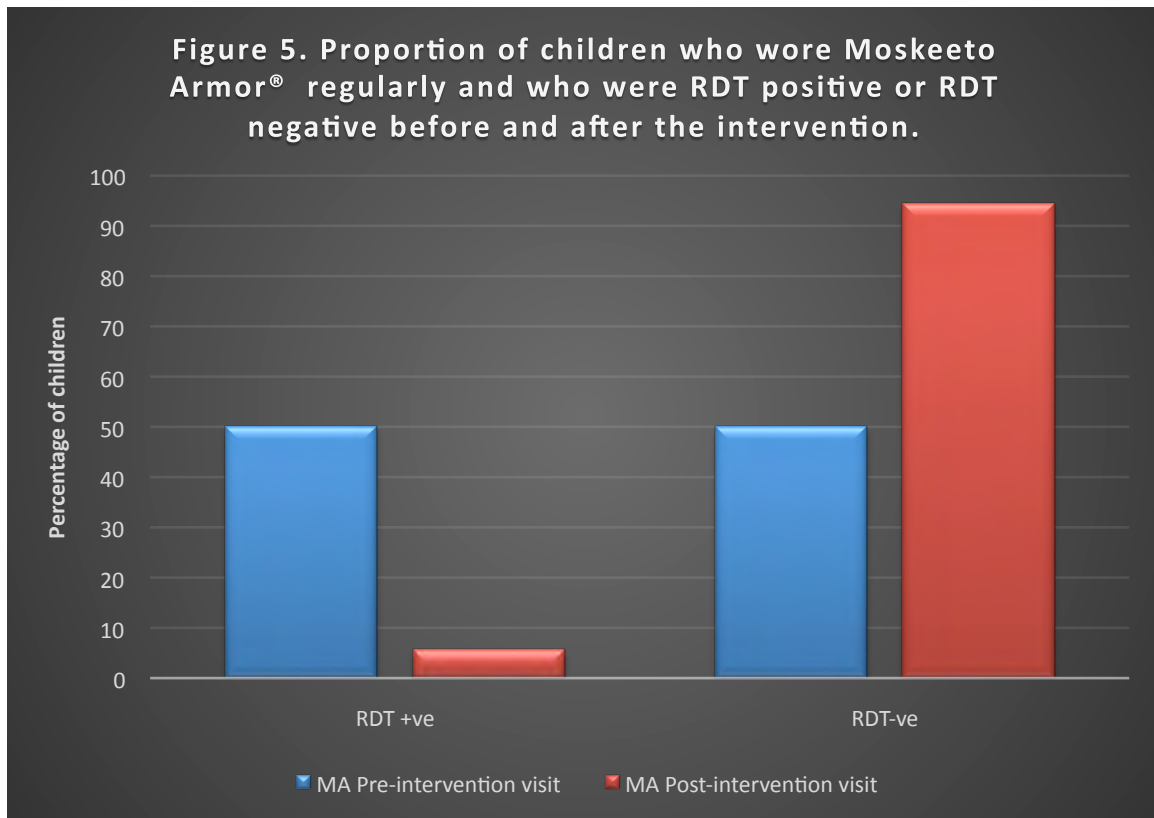
	Mean	±SEM	95% Confidence Interval
Age			
All	59.9	8.0	43.0, 76.8
Male	68.6	11.9	43.4, 93.8
Female	54.4	10.8	31.6, 77.1
Weight (kg)			
All	16.8	1.5	13.7, 20.0
Male	18.3	2.2	13.6, 23.0
Female	15.9	2.0	11.7, 20.1
Height (cm)			
All	99.1	4.5	89.5, 108.
Male	107.0	6.0	94.5, 119.5
Female	94.0	6.1	81.2, 106.8
Temperature (°C)			
All	36.4	0.1	36.2, 36.7
Male	36.4	0.2	36.0, 36.8
Female	36.5	0.1	36.2, 36.7
Body Mass Index			
All	16.8	0.4	15.9, 17.8
Male	15.7	0.6	14.4, 17.0
Female	17.5	0.5	16.4, 18.6

As shown in Table 7 and Figure 5, 9 (50.0%) of the children who regularly wore MA were RDT positive pre-intervention appointment among whom were 4 (44.0%) males and 5 (56.0%) females. Nine (50.0%) children were also RDT negative among whom were 3 (33.0%) males and 6 (67.0%) females. However, post intervention visit showed that only 1 (5.6%) child in this group was RDT positive while 17 (94.4%) were RDT negative. The reduction rate in RDT positivity and consequent increase in RDT negativity among the children was 8/9*100 or 88.9% indicating that about 90% of the children were saved from malaria infection due to regular use of MA. This increase in RDT negativity between pre and post intervention consultations was statistically significant (χ^2=8.86, p=0.003, OR=17.0, CI 1.8, 156.3). The Odds ratio of 17 specify that children are 17 times more likely to be RDT positive when they do not wear the MA. This rejects Null hypothesis 5 and accepts

alternative hypothesis that there is a difference in the pre- and post-intervention RDT status of children wearing only Moskeeto Armor®.

Table 7. Pre- and post-intervention RDT status of children (n=18; 35.3%) who wore Moskeeto Armor® regularly during the study period.

	Pre-intervention	Post-intervention
RDT +ve		
All		
Frequency	9	1
%	50	5.6
Male		
Frequency	4	0
%	44	0.0
Female		
Frequency	5	1
%	56	100.0
RDT −ve		
All		
Frequency	9	17
%	50	94.4
Male		
Frequency	3	7
%	33	41.2
Female		
Frequency	6	10
%	67	58.8
Pearson's χ^2	8.86	
P-value	0.003	
Odds ratio	17.0	
CI	1.8, 156.3	

Figure 5. Proportion of children who wore Moskeeto Armor® regularly and who were RDT positive or RDT negative before and after the intervention.

Consequent upon the children's pre- and post-intervention RDT status, Table 8 illustrates the means of Random Blood Sugar and Hemoglobin concentration of the children who regularly wore the MA. There was a noteworthy difference (t=-3.7; df=31.9; p=0.004) in the pre- and post-intervention random blood sugar levels of this group of children. The difference was due to very early arrival of participants at the very first consultation. Mothers and guardians were eager to bring their wards to the investigation team before taking the children to school. There was a difference in the pre- and post-intervention hemoglobin concentration levels of children who wore the "Moskeeto Armor®" regularly. Therefore the Null hypothesis is rejected and the alternate hypothesis that there is a difference in the hemoglobin levels though the difference did not reach a level of significance (t=-1.3; df=30.3; p=0.09).

Table 8. Comparison of pre and post intervention means of hemoglobin and random blood sugar of children who wore the Moskeeto Armor® regularly during the study period relevant to their gender.

	Pre-intervention		Post-intervention
Random Blood Sugar (mg/dl)			
All			
Mean (±SEM)	86.2 (2.4)		101.1 (3.1)
95% C I	81.2, 91.4		94.5, 107.8
Student's t-test		-3.7	
Satterthwaite's df		31.9	
P-value		0.004	
Male			
Mean (±SEM)	90.1 (4.6)		110.9 (3.3)
95% C I	80.5, 99.8		103.9, 117.8
Female			
Mean (±SEM)	83.8 (2.6)		94.9 (3.7)
95% C I	78.3, 89.4		87.1, 102.7
Hemoglobin			
All			
Mean (±SEM)	10.6 (0.3)		11.1 (0.2)
95% C I	9.9, 11.3		10.6, 11.5
Student's t-test		-1.3	
Satterthwaite's df		30.3	
P-value		0.09	
Male			
Mean (±SEM)	11.0 (0.6)		11.3 (0.4)
95% C I	9.7, 12.3		10.4, 12.1
Female			
Mean (±SEM)	10.4 (0.4)		10.9 (0.3)
95% C I	9.6, 11.1		10.4, 11.5

There was no substantial change in the pre- and post-intervention urinalysis of this group of children. For example, only 2 (11.8%) of the children had pre-intervention urine turbidity while none had post-intervention urine turbidity. All the study children in this group had negative proteinuria, glycosuria, ketonuria, hematuria and urobilinuria at pre- and post-intervention visits (Table 9).

Table 9. Evaluation of pre- and post-intervention urine status of children who wore Moskeeto Armor® regularly during the study period.

	Pre-intervention (n=17) Freq. (%)	Post intervention (n=16) Freq. (%)
Color		
Pale yellow	15 (88.2)	13 (81.3)
Yellow	0 (0.0)	1 (6.3)
Colorless	2 (11.1)	2 (12.5)
Odor		
Pungent	17 (100.0)	16 (100.0)
pH		
5	3 (17.6)	3 (18.8)
6	12 (70.6)	12 (75.0)
6.5	0 (0.0)	1 (6.3)
7	1 (5.9)	0 (0.0)
8	1 (5.9)	0 (0.0)
Turbidity		
Turbid	2 (11.8)	0 (0.0)
Clear	15 (88.2)	16 (100.0)
Proteinuria		
Negative	17 (100.0)	16 (100.0)
Glycosuria		
Negative	17 (100.0)	16 (100.0)
Hematuria		
Negative	17 (100.0)	16 (100.0)
Ketonuria		
Negative	17 (100.0)	16 (100.0)
Bilirubinemia/Urobilinuria		
Negative	17 (100.0)	16 (100.0)
Nitrite		
Negative	16 (94.1)	16 (100.0)
Trace	1 (5.9)	0 (0.0)
Specific Gravity		
1.005	2 (11.1)	0 (0.0)
1.01	7 (38.9)	2 (11.8)
1.015	1 (5.6)	7 (41.2)
1.02	1 (5.6)	3 (17.7)
1.025	3 (16.7)	2 (11.8)
1.03	3 (16.7)	3 (17.7)

Mean (±SEM) specific gravity of urine and at pre- and post-intervention visits were 1.02 (0.0) and 1.02 (0.0) respectively. *Urine was not available for one child at pre-intervention and for 2 children at post intervention visits.

CONCLUSION

Findings in this study indicate that the first authentic protective fabric against the bite of mosquitoes – Moskeeto Armor® - provided protection to children who participated the study. The proportion of children who wore the protective fabric regularly and who were RDT positive was much lower at post-intervention visit than that at pre-intervention visit. The post-intervention hemoglobin concentration of children who wore the Moskeeto Armor® regularly was higher than that at pre-intervention visit. These results were even better when children wore the Moskeeto Armor® and slept under LLIN. For those who did not wear the Moskeeto Armor® regularly, who did not wear it at all, who did not wear it though they claimed they slept under LLIN, the outcome was not as favorable. There was no major alteration in the urinalyses of the study children at the beginning and at the end of the 2-month study and no children presented with any form of contact dermatitis throughout the study period. Within the period of study, the Moskeeto Armor® was effective in preventing malaria among children and in improving the hemoglobin concentration values of participants. Notwithstanding potential limitations, the data suggest that it is possible to educate individuals about malaria and to implement services geared towards wearing protective clothing in rural settings with restricted resources. Though LLINs are currently one of the most viable options for reducing malaria-related morbidity and mortality, a better outcome could be in the offing if LLIN is coupled with Mokeeto Armor®. Although LLIN use is the primary method recommended by the World Health Organization for malaria reduction and control, implementation worldwide has been slow.

There were no significant changes in the random blood sugar all the participating children at the beginning and at the end of the study, an indication that the breakdown of sugar to simple glucose was not interfered with. There was no significant alteration in the glucose, protein and blood in the urine of all the participating children demonstrating lack of alteration in the functions of the kidneys of the children who wore the Moskeeto Armor® during the period of the study. Also no participating child presented with any contact dermatitis on account of wearing the Moskeeto Armor during the period of the study therefore Moskeeto Armor® is safe to be worn.

Results from our study shows that Moskeeto Armor® is a probable candidate as effective, mobile, non-invasive physical and chemical barrier, an authentic Protective Clothing that prevents mosquito from landing on human skin thus preventing the deadly malaria illness.

The present study evaluated the efficacy of a novel protective fabric against malaria using a longitudinal study design. This study also demonstrates that change in behavior is difficult to achieve initially due to user errors. There is need to conduct more studies which combine program delivery using minimal resources with evidence-based appraisal to address major indigenous health issues in malaria-endemic sub-Saharan Africa.