Corrigendum: Immune Responses to Gametocyte Antigens in a Malaria Endemic Population—The African *falciparum* Context: A Systematic Review and Meta-Analysis

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A Corrigendum on

Immune Responses to Gametocyte Antigens in a Malaria Endemic Population—The African *falciparum* Context: A Systematic Review and Meta-Analysis

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In the original article, there were errors in Tables 1, 2 and 3, and to the text. In Table 1, one of the two study sites from Amoah et al.’s study (Parasites & Vectors, 2018) was erroneously excluded from the table hence the study was presented as one site, the age range of study participants from the Stone et al. (Nature Communications, 2018) study site “Haute-Bassins (Burkina Faso)” was mistakenly indicated as “2–74” instead of “5–14” years and the reference for Skinner et al. given as “35” instead of “33”. These errors have been corrected and the amended table appears in this article.

Furthermore, owing to the omission of the study site from Amoah et al.’s study, the figures quoted in the text on the overall number of study sites and the total number of study sites reporting seroprevalence to Pfs230 and Pfs48/45 were incorrect. The total number of study sites for Pfs230 was given as “14” instead of “15” and for Pfs48/45 given as “14” instead of “13”. Also, we inadvertently provided the total number of individual study locations (“23”) instead of the study sites—based on administrative region—(“17”) when providing a summary of the 12 studies that we included in the analysis. In addition, the citation for “Amoah et al.” was incorrectly cited as “Acquah et al.” in the Results section, sub-section Pfs230, Seroprevalence, Paragraph 1.

These errors have been corrected and amendments made to the relevant result sections, given below.

Results section, sub-section Study Selection and Characteristics, Paragraph 1:

“The 12 studies were carried out across 17 study sites, majority of which were in West Africa (Burkina Faso, Senegal, Gabon, Cameroon, Ghana, and Mali) with only one study site in East Africa (Tanzania) and two study sites in Southern Africa (Zimbabwe) (Table 1). Ten articles (from 15 study sites) measured responses to Pfs230 and nine articles (13 study sites) measured responses to Pfs48/45. Six studies were longitudinal studies spread over the malaria transmission season with all but one measuring responses to both Pfs230 and Pfs48/45. Studies predominantly used ELISA as the immunoassay with only one study measuring responses using protein microarrays.”
TABLE 1 | Characteristics of studies included in the systematic review and meta-analysis.

| Study (Reference) | Year | Country | Region of study site$^c$ | Sample size | Age group (years) | Antigen detected | Seasonality tested (Y/N) | Assay cut-off | Negative control$^d$ | Selective recruitment$^e$ |
|-------------------|------|---------|--------------------------|-------------|------------------|------------------|-------------------------|-------------|------------------|------------------------|
| Amoah et al. (34)$^a$ | 2018 | Ghana (Abara) | Central | 65 | 6–12 | Pfs230 | No | ELISA$^R$ | 2 SD | Naïve | No |
| Amoah et al. (34)$^a$ | 2018 | Ghana (Obom) | Greater Accra | 75 | 6–12 | Pfs230 | No | ELISA$^R$ | 2 SD | Naïve | No |
| Lamptey et al. (35) | 2018 | Ghana | Greater Accra | 338 | 2–65 | Pfs230 | Yes | ELISA$^R$ | 3 SD | Test sample | No |
| Stone et al. (20)$^b*$ | 2018a | Burkina Faso Hauts-Bassins | | 33 | 5–14 | Pfs230 and Pfs48/45 | No | ELISA$^R$ | 3 SD | Test sample | Yes |
| Stone et al. (20)$^b*$ | 2018b | Burkina Faso Centre-Nord | | 38 | 2–10 | Pfs230 and Pfs48/45 | No | ELISA$^R$ | 3 SD | Test sample | Yes |
| Stone et al. (20)$^b*$ | 2018 | Cameroon | Centre | 140 | 5–16 | Pfs230 and Pfs48/45 | No | ELISA$^R$ | 3 SD | Test sample | Yes |
| Bansal et al. (42) | 2017 | Zimbabwe | Mashonaland Central | 181 | 6–14 | Pfs48/45 | No | ELISA$^R$ | 2 SD | Naïve | No |
| Paul et al. (43) | 2018 | Zimbabwe | Manicaland | 150 | 6–16 | Pfs48/45 | No | ELISA$^R$ | 2 SD | Naïve | No |
| Ateba-Ngoa et al. (44)$^a$ | 2016 | Gabon | Moyen-Ogooue | 286 | 3–50 | Pfs230 and Pfs48/45 | Yes | ELISA$^R$ | 3 SD | Test sample | No |
| Jones et al. (19)$^b$ | 2015 | Burkina Faso | Nord | 200 | 5–16 | Pfs230 and Pfs48/45 | Yes | ELISA$^R$ | 3 SD | Test sample | No |
| Jones et al. (19)$^b$ | 2015 | Ghana | Greater Accra | 108 | 5–17 | Pfs230 and Pfs48/45 | Yes | ELISA$^R$ | 3 SD | Test sample | No |
| Jones et al. (19)$^b$ | 2015 | Tanzania | Tanga Region | 202 | 3–15 | Pfs230 and Pfs48/45 | Yes | ELISA$^R$ | 3 SD | Test sample | No |
| Skinner et al. (43)$^a$ | 2015 | Mali | Koulikoro 3 and Bamako | 225 | 2–25 | Pfs230 and Pfs48/45 | Yes | Microarray$^R$ | 2 SD | No | No Template |
| Niura et al. (45) | 2013 | Mali | Kayes 2 | 45 | 18–60 | Pfs230 | No | ELISA$^R$ | 3 SD | Naïve | No |
| Ouedraogo et al. (24)$^a$ | 2018 | Burkina Faso Centre-Nord | | 128 | 1–55 | Pfs230 and Pfs48/45 | Yes | Two-site ELISA$^Ga$ | 3 SD | Naïve | No |
| Ouedraogo et al. (16)$^a$ | 2011 | Burkina Faso Centre-Nord | | 296 | 1–15 | Pfs230 and Pfs48/45 | Yes | Two-site ELISA$^Ga$ | 2 SD | Naïve | No |
| Van der Kolk et al. (46) | 2006 | Cameroon | Centre | 236 | 5–14 | Pfs230 and Pfs48/45 | No | Two-site ELISA$^Ga$ | 2 SD | Naïve | No |

$^a$Seroprevalence data provided by authors upon request.
$^b$Seroprevalence data calculated from data provided by original authors, or from data available on public repositories.
$^R$Citation also includes citation of repository from which data was retrieved.
$^c$Administrative region of study site from which participants were drawn, this was used infer predicted parasite prevalence rates standardized in 2 – 10-year olds (PfPR$^2$–10) that was then used to assign transmission intensity at the time of sampling.
$^d$Negative control refers to the comparator used to assign seropositivity in the immunoassay. Naïve – malaria naïve volunteers; Sample – a proportion of statistically – defined seronegative individual; No template - a ‘no DNA control’ used to detect reactivity to the expression vector used to produce protein for the array.
$^e$Selective recruitment refers to studies that only recruited parasite positive individuals for antibody measurements.
$^R$Recombinant protein; $^Ga$gametocyte extract.
SD, standard deviation.

TABLE 2 | Univariable meta-regression analysis of factors influencing reported seroprevalence to Pfs230.

| No. of studies (No. of Sites) | Coefficient ($\beta$) | Lower CI | Upper CI | $p$-value$^*$ | Residual $I^2$ | $I^2$ change (%) |
|------------------------------|----------------------|----------|----------|--------------|----------------|-----------------|
| Age                          | Children (ref.)      | 10 (14)  | 0.21     | 0.05         | 0.38           | 0.04            | 95.36           | 2.09          |
|                              | Adults               | 6 (6)    | 0.21     | 0.05         | 0.38           | 0.04            | 95.36           | 2.08          |
| Asexual parasite prevalence  | 6 (10)               | −0.001   | −0.005   | 0.002        | 0.51           | 95.37           | 2.08          |
| Gametocyte prevalence        | 4 (8)                | −0.002   | −0.004   | 0.001        | 0.38           | 92.54           | 4.50          |
| Transmission intensity       | Mesoendemic (ref.)   | 7 (8)    | −0.06    | −0.23        | 0.11           | 0.51            | 96.18           | 1.25          |

(Continued)
| TABLE 2 | Continued |

| No. of studies (No. of Sites) | Coefficient (β) | Lower CI | Upper CI | p-value* | Residual $I^2$ | $I^2$ change (%) |
|------------------------------|-----------------|----------|----------|----------|----------------|-----------------|
| **Season**                   |                 |          |          |          |                |                 |
| Dry (ref.)                   | 6 (9)           |          |          |          |                |                 |
| Rainy                        | 5 (7)           | 0.07     | −0.12    | 0.27     | 0.51           | 96.24           | 1.19            |
| **Assay**                    |                 |          |          |          |                |                 |
| ELISA (ref.)                 | 6 (11)          |          |          |          |                |                 |
| Microarray                   | 1 (1)           | 0.31     | 0.08     | 0.55     | 0.07           | 95.29           | 2.17            |
| Two-site ELISA               | 3 (3)           | 0.12     | −0.06    | 0.29     |                |                 |
| **Antigen**                  |                 |          |          |          |                |                 |
| Gametocyte extract (ref.)    | 3 (3)           |          |          |          |                |                 |
| Recombinant protein          | 7 (12)          | −0.06    | −0.25    | 0.13     | 0.51           | 96.31           | 1.12            |
| **Antigen concentration**    |                 |          |          |          |                |                 |
| 0.1 µg/ml (ref.)             | 3 (7)           |          |          |          |                |                 |
| 1 µg/ml                      | 3 (4)           | 0.26     | 0.09     | 0.43     | 0.04           | 93.52           | 3.98            |
| **Seropositivity cut-off**   |                 |          |          |          |                |                 |
| 2 SD (ref.)                  | 4 (5)           |          |          |          |                |                 |
| 3 SD                         | 6 (10)          | −0.22    | −0.37    | −0.06    | 0.04           | 95.16           | 2.30            |

*p-values adjusted using the Benjamini and Hochberg correction for multiple testing; values in bold p < 0.05.
+ Antigen concentration was only tested for studies using recombinant protein as antigen source.
CI, confidence interval; SD, standard deviation.

| TABLE 3 | Univariable meta-regression analysis of factors influencing reported seroprevalence to Pf48/45. |

| No. of Studies (No. of Sites) | Coefficient (β) | Lower CI | Upper CI | p-value | Residual $I^2$ | $I^2$ change (%) |
|------------------------------|-----------------|----------|----------|---------|----------------|-----------------|
| **Age**                      |                 |          |          |         |                |                 |
| Children (ref.)              | 9 (13)          |          |          |         |                |                 |
| Adults                       | 4 (4)           |          |          |         |                |                 |
| Asexual parasite prevalence  |                 |          |          |         |                |                 |
| Gametocyte prevalence        | 4 (8)           | −0.003   | −0.006   | 0.0003  | 0.11           | 91.41           | 3.96            |
| **Transmission intensity**   |                 |          |          |         |                |                 |
| Hypoendemic (ref.)           | 1 (1)           |          |          |         |                |                 |
| Mesoendemic                  | 5 (6)           | −0.47    | −0.89    | −0.06   | 0.11           | 93.91           | 0.87            |
| Hyperendemic                 | 5 (6)           | −0.38    | −0.80    | 0.04    |                |                 |
| **Season**                   |                 |          |          |         |                |                 |
| Dry (ref.)                   | 4 (6)           |          |          |         |                |                 |
| Rainy                        | 6 (8)           | 0.07     | −0.09    | 0.24    | 0.47           | 93.12           | 1.70            |
| **Assay**                    |                 |          |          |         |                |                 |
| ELISA (ref.)                 | 5 (9)           |          |          |         |                |                 |
| Microarray                   | 1 (1)           | 0.36     | 0.15     | 0.56    | 0.016          | 91.99           | 2.89            |
| Two-site ELISA               | 3 (3)           | 0.09     | −0.07    | 0.24    |                |                 |
| **Antigen**                  |                 |          |          |         |                |                 |
| Gametocyte extract (ref.)    | 3 (3)           |          |          |         |                |                 |
| Recombinant protein          | 6 (10)          | −0.01    | −0.19    | 0.17    | 0.91           | 94.91           | −0.19           |
| **Antigen concentration**    |                 |          |          |         |                |                 |
| 0.1 µg/ml (ref.)             | 3 (7)           |          |          |         |                |                 |
| 1 µg/ml                      | 2 (2)           | 0.30     | 0.06     | 0.54    | 0.043          | 92.65           | 2.20            |
| **Seropositivity cut-off**   |                 |          |          |         |                |                 |
| 2 SD (ref.)                  | 5 (6)           |          |          |         |                |                 |
| 3 SD                         | 4 (8)           | −0.26    | −0.39    | −0.12   | 0.003          | 91.38           | 3.54            |

*p-values adjusted using the Benjamini and Hochberg correction for multiple testing; values in bold p < 0.05.
+ Antigen concentration was only tested for studies using recombinant protein as antigen source.
CI, confidence interval; SD, standard deviation.
Results section, sub-section Pfs230, Seroprevalence, Paragraph 1:
“Ten studies from across 15 study sites in Africa analyzed immune responses to Pfs230. The range of seroprevalence estimates was quite wide, ranging from 6% reported by Stone et al. in Soumousso and Dande villages, Burkina Faso (20) to 72% reported by Amoah et al. (34) (Figure 2). Significant heterogeneity was observed between the studies ($I^2 = 97\%$; 95% CI: 96–98%; $p < 0.01$) therefore, a pooled prevalence estimate was not calculated.”

Results section, sub-section Pfs48/45, Seroprevalence, Paragraph 1:
“A total of 9 studies carried out over 13 study sites measured immune responses to Pfs48/45. The range of seroprevalence estimates reported was 0% from Stone et al.’s study sites in Burkina Faso (20) to 64% reported by Paul et al. from their study in the Makoni district in Zimbabwe (43). As with Pfs230, there was significant heterogeneity between the studies, $I^2 = 96\%$ (95% CI: 95–97%), and hence no pooled estimate was calculated (Figure 3).”

Additionally, there were errors in Table 2 and Table 3, regarding the values for the No. of Studies (No. of Sites) under the variable Antigen. For Table 2, the numbers were switched around for gametocyte extract and recombinant protein and hence the numbers for Gametocyte extract read “7 (12)” instead of “3 (3)” and under the variable Recombinant protein read “3 (3)” instead of “7 (12).” For Table 3 one study was missing from the count hence the value for the No. of Studies (No. of Sites) under the variable Recombinant protein read “5 (10)” instead of “6 (10).” The corrected Tables 2 and 3 appear in this article.

The authors apologize for these errors and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

REFERENCES
34. Amoah LE, Acquah FK, Ayanful-Torgby R, Oppong A, Abankwa J, Obboh EK, et al. Dynamics of anti-MSP3 and Pfs230 antibody responses and multiplicity of infection in asymptomatic children from southern Ghana. Parasit Vectors. (2018) 11:5–13. doi: 10.1186/s13071-017-2607-5