Uptake of intermittent preventive treatment of malaria in pregnancy using sulfadoxine-pyrimethamine (IPTp-SP) in Uganda: a national survey

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Abstract

Background: In spite of the missed opportunities of sulfadoxine-pyrimethamine (IPTp-SP) in Uganda, scanty literature exist on malaria in pregnancy. To date, empirical national study utilizing the 2018-19 Uganda Malaria Indicator Survey to explore predictors of attaining three or more doses of IPTp-SP in the country is non-existent. This study investigated the factors affecting uptake of three or more IPTp-SP doses as recommended by the World Health Organization.

Methods: Data from the 2018–2019 Uganda Malaria Indicator Survey (2018-19 UMIS) was analysed. Adequate uptake of intermittent preventive therapy with IPTp-SP was the dependent variable for this study. Weighted frequencies and percentages were used to present the proportion of women who had adequate IPTp-SP uptake or otherwise with respect to the independent variables. A three-level multilevel logistic regression was fitted. The Bayesian Deviance Information Criterion (DIC) was used in determining the goodness of fit of all the models.

Results: Less than half of the surveyed women had three or more IPTp-SP doses during their last pregnancies (45.3%). Women aged 15–19 had less odds of receiving at least three IPTp-SP doses compared to those aged 45–49 \([aOR = 0.42, CrI = 0.33–0.98]\). Poor women \([aOR = 0.80, CrI = 0.78–0.91]\) were less likely to have three or more doses of IPTp-SP relative to rich women. Most disadvantaged regions were aligned with less likelihood of three or more IPTp-SP uptake \([aOR = 0.59, CI = 0.48–0.78]\) compared to least disadvantaged regions. The variation in uptake of three or more IPTp-SP doses was substantial at the community level \([\sigma^2 = 1.86; CI = 1.12–2.18]\) than regional level \([\sigma^2 = 1.13; CI = 1.06–1.20]\). About 18% and 47% disparity in IPTp-SP uptake are linked to region and community level factors respectively.

Conclusion: IPTp-SP interventions need to reflect broader community and region level factors in order to wane the high malaria prevalence in Uganda. Contextually responsive behavioural change communication interventions are required to invoke women's passion to achieve the recommended dosage.

Keywords: Malaria, Pregnancy, Public health, Maternal health, Uganda

Background

Malaria infection in pregnancy (MiP) is acknowledged as a weighty public health challenge and have ample dangers for the pregnant woman and her fetus [1–3]. The symptoms and complications of MiP fluctuate with respect to...
intensity of transmission within a defined geographical area as well as a woman's level of acquired immunity [1, 2]. Nineteen countries within sub-Saharan Africa (SSA), with Uganda inclusive, and one Asian country account for 85% of the global malaria burden [1]. In 2018 alone, about US$ 2.7 billion investment was made into malaria control and elimination globally and three-quarters of this was directed to the World Health Organization (WHO) African Region. In spite of this, malaria continues to take a heavy toll on government and household expenses in Uganda [4]. Pregnant women have increased susceptibility to malaria and its associated complications such as maternal anaemia, stillbirth, low birth weight, and in worse scenarios, infant mortality and morbidity [5, 6]. MiP could be an impediment to the realization of targets 3.1 of the Sustainable Development Goals, thus reducing maternal mortality ratio to less than 70 deaths per 100,000 live births [7].

In order to shield women in moderate to high malaria transmission areas in Africa and their newborns from the adverse implications of MiP and its associated imminent problems, the WHO in 2012 revised its anti-malaria policy and recommended that all pregnant women within such regions should receive at least three doses of intermittent preventive treatment in pregnancy with antimalarial drug sulfadoxine-pyrimethamine (IPTp-SP) [8]. This recommendation was informed by the stagnated IPTp coverage rates and new evidence that reinforced the need for three doses or more [9]. Further, in 2016, the WHO developed new antenatal care (ANC) guidelines by endorsing an increase in the number of ANC to at least eight contacts between pregnant women and healthcare providers as a strategy to enhance prospects of IPTp-SP uptake [2].

IPTp-SP is to be taken by all pregnant women in moderate to high malaria transmission areas and should commence as early as possible within the second trimester. The doses are to be administered at least three times with at least one month interval until childbirth. Generally IPTp-SP declines episodes of MiP, neonatal mortality, low birth weight, and placental parasitaemia [2]. Empirical evidence indicate that IPTp contributes to 29%, 38% and 31% reduction in the incidence of low birth weight, severe malaria anaemia and neonatal mortality respectively [10, 11]. In 2018, out of the 36 African countries that recounted IPTp-SP coverage rates, about 31% of eligible women in the reproductive age received the recommended doses and this signified an increase relative to the rate reported in 2017 (22%) and 2010 (2%). In the case of Uganda, where malaria is endemic in 95% of the country [4], the 2019 World Malaria Report indicated that 30% or lower of the eligible women had three or more IPTp-SP doses [1]. Resistance of the parasite to SP has been noted, however, IPTp still remains a very cost-effective and a promising lifesaving intervention [12, 13].

In spite of the missed IPTp-SP opportunities in Uganda in the wake of MiP [1, 14, 15], scanty literature exist on MiP in Uganda. The few studies have either been limited to some regions of the country [16–20], used relatively old national data [21], assessed the impact of intermittent preventive treatment during pregnancy [22] and among others. To date, empirical national study utilizing the 2018–19 Uganda Malaria Indicator Survey that explore predictors of attaining three or more doses of IPTp-SP in the country is non-existent. With the aim of invigorating a critical evidence-based discussion on MiP prevention, and offering empirical evidence to guide MiP policies, this study investigated the rate of uptake and factors affecting uptake of three or more IPTp-SP doses as recommended by the WHO.

**Methods**

**Data description**

Data from the 2018–2019 Malaria Indicator Survey (2018–19 UMIS) of Uganda was analysed. This is a cross-sectional survey that is executed by the Uganda Bureau of Statistics (UBOS) and the National Malaria Control Division (NMCD), however, technical assistance was granted by the Inner City Fund (ICF) [23]. The survey sampled participants through a two-stage sampling design with the intent of achieving estimation of three essential indicators, thus rural-urban locations, all fifteen administrative regions and national coverage. The sampling commenced with selection of clusters from refugee and non-refugee sample frames [23] from the enumeration areas delineated for the 2014 National Population and Housing Census (NPHC). In all, 320 clusters were selected from non-refugee sample frame (236 and 84 from rural and urban settlements respectively). Urban settlements were oversampled to obtain unbiased estimations for rural and urban settlements. The same procedure was followed to select 22 clusters from the refugee frame. The next sampling phase involved the systematic selection of households and 28 households per cluster were selected resulting in a total of 8,878. Eligible women were those aged 15–49 and were either permanent residents or visitors who joined the household the night before the survey. In all, 8,231 women were successfully interviewed signifying 98% and 99% response rates for non-refugee and refugee settlements respectively. In the present study, however, 4,254 women were eligible for inclusion based on completeness of data.
Measurement of variables

Dependent variable
Adequate uptake of intermittent preventive therapy using IPTp-SP was the dependent variable for this study. During the 2018-19 UMIS, women were asked if they took IPTp-SP (Fansidar™), and the number of times this was taken during their last pregnancy. The current recommendation by the WHO endorses at least three doses for all pregnant women in locations that have moderate to high malaria transmission of which Africa and for that matter Uganda is inclusive [8, 24]. Following this recommendation, all women who revealed that they had at least three doses of IPTp-SP were categorized as having adequate IPTp-SP (coded 1) whilst those who had less than three were categorized otherwise (coded 0).

Independent variables
A total of ten (10) independent variables were included and were categorized under individual, community and region-level factors. This was possible due the hierarchical nature of the data set. The individual-level factors comprised age in completed years (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49) and education measured as highest level of educational attainment (no education, primary, secondary, higher). In addition were wealth quintile (poor, middle, rich), whether mosquito bite causes malaria (yes or no), if sleeping under ITN prevents malaria (yes or no) and if malaria can be prevented by destroying mosquito breeding site (yes or no). The community-level factors comprised residential status (urban, rural, refugee settlement), and socio-economic disadvantage at the community level. The sole region-level factor was socio-economic disadvantage at the region level. Several studies using the DHS dataset have followed the same categorization [21, 25, 26].

Statistical analyses
Stata version 13 was utilized for all the analyses. Weighted frequencies and percentages were used to present the proportion of women who had adequate IPTp-SP uptake or otherwise with respect to the independent variables (see Table 1). The association of significance between the explanatory variables and adequate IPTp-SP uptake was assessed with chi-square at 5% margin of error. Finally, a three-level multilevel logistic regression was fitted with five models. First of the five models was the empty model without any explanatory variable (Model I). The empty model is an unconditional model, which accounted for the magnitude of variance between community and region levels. This was followed by a model bearing all the individual-level variables (Model II) and subsequently Model III, which accounted for only community-level variables. Model IV featured region-level variables alone whilst the complete and ultimate model included variables of all the aforementioned levels/models (Model V). Output from the models comprised fixed and random effects. The fixed effects were reported as adjusted odds ratios (aORs) at 95% credible intervals (CrIs). However, the random effects reflected as intraclass correlation coefficient (ICC) and median odds ratio (MOR) [27]. With the ICC, it was possible to gauge the extent of variance in the possibility or tendency of adequate IPTp-SP uptake that is explained by community and region level factors. On the order hand, the MOR quantified the community and region variance as odds ratios and in addition estimated the likelihood of adequate IPTp-SP uptake that is influenced by community and region level issues. Groups having least observations were set as reference groups in the models.

Model fit and specifications
First, multicollinearity between the explanatory variables was assessed using the Variance Inflation Factor (VIF) [28] and the results showed that the variables were not highly correlated to warrant a concern (mean VIF=1.55, minimum VIF=1.19, maximum VIF=2.09). Second, the Bayesian Deviance Information Criterion (DIC) was used in determining the goodness of fit of all the models. Third, the Markov Chain Monte Carlo (MCMC) estimation was applied in modelling [29] and all models were specified using 3.05 version of MLwinN package in the Stata software.

Ethics approval
The 2018–2019 UMIS had approval from the Uganda National Council for Science and Technology (UNCST), the Ethics Committee of the School of Medicine Research and Ethics Committee (SOMREC) of the Makerere University as well as the institutional review board of the ICF. The author applied and was granted access to utilize the dataset for the purpose of this study.

Results
Descriptive findings
As shown in Table 1, less than half of the surveyed women had three or more IPTp-SP doses during their last pregnancies (45.3%). All the explanatory variables showed significant association at 95% level of significance. Nearly half of women aged 15–19 (49.9%) and the highly educated (47.1%) women received at least three doses. A greater section of rich women had at least three IPTp-SP doses (46.6%) and 50.1% of women who knew that mosquito bite causes malaria did the same. A
Table 1  Sample by IPTp-SP utilization during last pregnancy

| Variable                              | At least 3 doses of IPTp-SP in last Pregnancy | X²; p-value |
|---------------------------------------|-----------------------------------------------|-------------|
|                                       | No n (%)                                      | Yes n (%)   | Total n (%) |
| Individual level                      |                                               |             |             |
| Age                                   |                                               |             |             |
| 15–19                                 | 143(50.1)                                     | 142(49.9)   | 286(100)    |
| 20–24                                 | 553(52.0)                                     | 510(48.0)   | 1063(100)   |
| 25–29                                 | 606(55.8)                                     | 479(44.2)   | 1085(100)   |
| 30–34                                 | 497(56.4)                                     | 385(43.6)   | 882(100)    |
| 35–39                                 | 318(54.8)                                     | 262(45.2)   | 580(100)    |
| 40–44                                 | 163(59.6)                                     | 110(40.4)   | 273(100)    |
| 45–49                                 | 49(58.2)                                      | 35(41.8)    | 84(100)     |
| Education                             |                                               |             |             |
| No education                          | 379(55.1)                                     | 309(44.9)   | 689(100)    |
| Primary                               | 1294(55.0)                                    | 1060(45.0)  | 2354(100)   |
| Secondary                             | 537(54.4)                                     | 450(45.6)   | 987(100)    |
| Higher                                | 118(52.9)                                     | 105(47.1)   | 224(100)    |
| Wealth quintile                       |                                               |             |             |
| Poor                                  | 572(53.8)                                     | 491(46.2)   | 1063(100)   |
| Middle                                | 863(56.9)                                     | 654(43.1)   | 1517(100)   |
| Rich                                  | 894(53.4)                                     | 780(46.6)   | 1675(100)   |
| Mosquito bite causes malaria           |                                               |             |             |
| No                                    | 1573(57.4)                                    | 1166(42.6)  | 2739(100)   |
| Yes                                   | 755(49.9)                                     | 759(50.1)   | 1515(100)   |
| Sleeping under ITN prevents malaria   |                                               |             |             |
| No                                    | 553(60.0)                                     | 368(40.0)   | 920(100)    |
| Yes                                   | 1776(53.3)                                    | 1557(46.7)  | 3333(100)   |
| Destroying mosquito breeding site prevents malaria |   |             |             |
| No                                    | 1909(54.0)                                    | 1624(46.0)  | 3533(100)   |
| Yes                                   | 420(58.3)                                     | 301(41.7)   | 720(100)    |
| Community level factors               |                                               |             |             |
| Residential status                    |                                               |             |             |
| Urban                                 | 493(52.4)                                     | 448(47.6)   | 940(100)    |
| Rural                                 | 1664(56.2)                                    | 1298(43.8)  | 2962(100)   |
| Refugee settlement                    | 172(49.1)                                     | 179(50.9)   | 351(100)    |
| Zone                                  |                                               |             |             |
| Southern                              | 719(56.0)                                     | 565(44.0)   | 1284(100)   |
| Eastern                               | 617(55.6)                                     | 493(44.4)   | 1110(100)   |
| Northern                              | 465(54.2)                                     | 392(45.8)   | 858(100)    |
| Western                               | 528(52.7)                                     | 474(47.3)   | 1002(100)   |
| Socio-economic disadvantage           |                                               |             |             |
| Tertile 1(least disadvantaged)        | 935(53.2)                                     | 822(46.8)   | 1757(100)   |
| Tertile 2                             | 855(58.1)                                     | 615(41.9)   | 1470(100)   |
| Tertile 3(most disadvantaged)         | 539(52.5)                                     | 487(47.5)   | 1026(100)   |
| Region level factor                   |                                               |             |             |
| Socio-economic disadvantage           |                                               |             |             |
| Tertile 1(least disadvantaged)        | 1048(55.2)                                    | 851(44.8)   | 1899(100)   |
| Tertile 2                             | 860(54.2)                                     | 725(45.8)   | 1585(100)   |
| Tertile 3(most disadvantaged)         | 421(54.7)                                     | 349(45.3)   | 770(100)    |
| Total                                 | 2329(54.7)                                    | 1925(45.3)  | 4254(100)   |

Source: 2018-19 Uganda Malaria Indicator Survey
significant proportion of women who knew that sleeping under ITN prevents malaria (46.7%) and those who did not know that destroying mosquito breeding sites prevents malaria (46.0%) received at three or more doses of IPTp-SP. Receiving at least three doses of IPTp-SP was profound in refugee settlements (50.9%), Western zone (47.3%), most disadvantaged communities (47.5%) and moderately disadvantaged regions (45.8%).

Fixed effects
Table 2 presents the findings of the fixed effects. The complete and final model (Model V) indicates that women aged 15–19 had less odds of receiving at least three IPTp-SP doses compared to those aged 45–49 [aOR = 0.42, CI = 0.33–0.98]. Those who had no formal education were less likely to achieve the minimum recommended doses [aOR = 0.51, CI = 0.35–0.81]. Similarly, poor women [aOR = 0.80, CI = 0.78–0.91] and women who knew that mosquito bite can cause malaria [aOR = 0.84, CI = 0.73–0.96] were less likely to have three or more doses of IPTp-SP relative to the rich women and women who did not know that mosquito bite can cause malaria respectively. Women who reported that sleeping under ITN prevents malaria had higher odds of three or more IPTp-SP doses [aOR = 1.22, CI = 1.04–1.43] relative to those who reported otherwise. The findings further revealed that urban residents were less probable to have at least three doses [aOR = 0.60, CI = 0.46–0.82] as well as most disadvantaged communities [aOR = 0.67, CI = 0.50–0.86] relative to rural residents and least disadvantaged communities correspondingly. Similarly, most disadvantaged regions were aligned with less likelihood of three or more IPTp-SP uptake [aOR = 0.59, CI = 0.48–0.78] compared to the least disadvantaged regions.

Random effects
Outcome of the random effects were also reported in Table 2. The empty model (Model I), revealed that the discrepancy in uptake of three or more IPTp-SP doses was substantial at the community level [σ² = 1.86; CrI = 11.12–2.18] than regional level [σ² = 1.13; CrI = 1.06–1.20]. Also, the ICC of Model I indicated that 18% and 47% disparity in IPTp-SP uptake are linked to region and community level factors respectively. According to the final model (Model V), the MORs indicate that when a woman changes her community to a community with higher likelihood of three or more doses of IPTp-SP, she has 3.83 higher chances of achieving the recommended doses (i.e. three or more). Similarly, moving to a region with high likelihood of three or more IPTp-SP doses is associated with 2.74-fold increase in having three or more IPTp-SP doses.

Discussion
The aim of this study was to investigate the predictors of three or more IPTp-SP doses in Uganda as recommended by the WHO [8, 24]. Less than half of the women met the recommended dosage. This is far below the prevalence in other sub-Saharan African countries such as Ghana (63%) [30] but higher than the proportion of women who obtain at least three doses in Mali (36.7%) [31] and Senegal (37.51%) [32]. The prevalence, however, denotes an appreciation from 16% to 18% as reported by earlier studies based on the 2016 Uganda Demographic and Health Survey dataset [21, 33]. The relative increase in optimal IPTp-SP uptake since 2016 is suggestive that the recent anti-malaria and IPTp-SP initiatives are useful. Yet, for Uganda alone to account for 5% of the global malaria burden [1] is not good enough and more public health sensitization, and behavioural change communication interventions should be intensified. Hitherto, IPTp-SP administration has been dependent on ANC attendance, meanwhile, even where ANC attendance is high, as in the case of Malawi (84.0%) sometimes optimal uptake of IPTp-SP is low (24.8%) [34]. Thus, varied interventions such as adopting technological approaches and mobile phone alerts/reminders could prompt pregnant women to achieve the recommended dosage as a way of augmenting the traditional approach of administering the drug during ANC.

The study revealed that women aged 15–19 had less odds of receiving at least three IPTp-SP doses compared to those aged 45–49. Due to stigmatization, cultural and traditional connotations of adolescent pregnancy in Uganda [35], adolescent pregnant women may be less motivated to frequent health facilities, and thereby have an increased likelihood of missing or having lower IPTp-SP uptake. Recent synthesis of evidence on maternal healthcare utilization also noted that adolescents generally have lower maternal healthcare utilization [36]. Perhaps, having a secluded and special care for adolescent pregnant women may motivate their likelihood of visiting the health facility for the doses. In the event that the healthcare provider forgets to administer IPTp-SP, it is common knowledge that not all adolescents will feel comfortable and confident to query the healthcare provider for the drug whilst she is in a queue with her mothers’ age mates and possibly feels apprehended.

Those who had no formal education and poor women were less likely to achieve the minimum recommended doses. Being poor and/or uneducated denotes disempowerment [26] and there is congruence in the literature about the positive impact of empowerment on maternal healthcare utilization [37, 38] and taking charge of one's holistic wellbeing [39]. This observation points to
Table 2  Individual, community and region-level predictors of IPTp-SP utilization

| Fixed effects                        | Individual level |                     | Community level factors |                     |
|--------------------------------------|------------------|---------------------|-------------------------|---------------------|
|                                     | Model I          | Model II            | Model III               | Model IV            | Model V             |
| aOR [95% Crl]                        | aOR [95% Crl]    | aOR [95% Crl]       | aOR [95% Crl]           | aOR [95% Crl]       |
| Individual level                     |                  |                     |                         |                     |
| Age                                  |                  |                     |                         |                     |
| 15–19                                | 0.22**[0.11–0.81]| 0.42*[0.33–0.98]    |                         |                     |
| 20–24                                | 0.43*[0.24–0.98] | 0.38*[0.25–0.79]    |                         |                     |
| 25–29                                | 0.99[0.62–1.62]  | 0.81[0.53–1.22]     |                         |                     |
| 30–34                                | 1.01[0.62–1.64]  | 0.81[0.53–1.24]     |                         |                     |
| 35–39                                | 0.94[0.56–1.55]  | 0.76[0.48–1.18]     |                         |                     |
| 40–44                                | 0.99[0.58–1.71]  | 0.81[0.50–1.30]     |                         |                     |
| 45–49                                | 1[1]             | 1[1]                |                         |                     |
| Education                            |                  |                     |                         |                     |
| No education                         | 0.33*[0.17–0.77] | 0.51**[0.35–0.81]   |                         |                     |
| Primary                              | 0.53*[0.44–0.82] | 0.62*[0.51–0.91]    |                         |                     |
| Secondary                            | 1.09[0.74–1.60]  | 1.06[0.75–1.50]     |                         |                     |
| Higher                               | 1[1]             | 1[1]                |                         |                     |
| Wealth quintile                      |                  |                     |                         |                     |
| Poor                                 | 0.81*[0.79–0.94] | 0.80*[0.78–0.91]    |                         |                     |
| Middle                               | 0.89[0.75–1.06]  | 0.88[0.74–1.05]     |                         |                     |
| Rich                                 | 1[1]             | 1[1]                |                         |                     |
| mosquito bite causes malaria         |                  |                     |                         |                     |
| No                                   | 0.85*[0.74–0.97] | 0.84*[0.73–0.96]    |                         |                     |
| Yes                                  | 1[1]             | 1[1]                |                         |                     |
| Sleeping under ITN prevents malaria  |                  |                     |                         |                     |
| No                                   | 1[1]             | 1[1]                |                         |                     |
| Yes                                  | 1.23*[1.06–1.43] | 1.22*[1.04–1.43]    |                         |                     |
| Destroying mosquito breeding site prevents malaria |                  |                     |                         |                     |
| No                                   | 1.16[0.97–1.39]  | 1.165[0.96–1.41]    |                         |                     |
| Yes                                  | 1[1]             | 1[1]                |                         |                     |
| Community level factors              |                  |                     |                         |                     |
| Residential status                   |                  |                     |                         |                     |
| Urban                                | 0.69**[0.31–0.88]| 0.60**[0.46–0.82]   |                         |                     |
| Rural                                | 0.78*[0.68–0.96] | 0.80[0.61–1.05]     |                         |                     |
| Refugee settlement                   | 1[1]             | 1[1]                |                         |                     |
| Zone                                 |                  |                     |                         |                     |
| Southern                             | 1[1]             | 1[1]                |                         |                     |
| Eastern                              | 1.05[0.74–1.49]  | 1.07[0.71–1.61]     |                         |                     |
| Northern                             | 1.08[0.73–1.61]  | 1.12[0.68–1.83]     |                         |                     |
| Western                              | 1.19[0.84–1.68]  | 1.22[0.81–1.84]     |                         |                     |
the need for the Uganda Government and its partner organizations to appreciate that optimising IPTp-SP utilization transcends beyond provision of funds to secure the drugs. Thus, enhancing education opportunities for women and widening their wealth status such that every woman in the reproductive age will be competitive in finding a decent occupation could facilitate uptake of IPTp-SP in the country. Whilst education offers the knowledge for women to appreciate the need for achieving the recommended dosage, enhanced wealth status will offer the financial or economic power required to

| Table 2 (continued) |
|---------------------|
|                     | Model I | Model II | Model III | Model IV | Model V |
| Socio-economic       |         |          |           |          |
| disadvantage         |         |          |           |          |
| Tertile 1 (least     |         |          |           |          |
| disadvantaged)       |         |          |           |          |
| Tertile 2            |         |          |           |          |
| Tertile 3 (most       |         |          |           |          |
| disadvantaged)       | 0.87 [0.72–1.05] | 0.91 [0.73–1.12] |          |          |
| Region level factor  |         |          |           |          |
| Socio-economic       |         |          |           |          |
| disadvantage         |         |          |           |          |
| Tertile 1 (least     |         |          |           |          |
| disadvantaged)       |         |          |           |          |
| Tertile 2            |         |          |           |          |
| Tertile 3 (most       |         |          |           |          |
| disadvantaged)       | 0.71* [0.65–0.92] | 0.67** [0.50–0.86] |          |          |
| Random effects       |         |          |           |          |
| Region level         |         |          |           |          |
| Variance (SE)        | 1.13 [1.06–1.20] | 1.14 [1.04–1.21] | 1.12 [1.05–1.20] | 1.15 [1.07–1.21] | 1.14 [1.06–1.20] |
| ICC (%)              | 18.00 [15.01–22.90] | 17.72 [15.20–19.08] | 16.33 [15.21–18.00] | 17.10 [16.91–18.70] | 18.22 [17.90–19.02] |
| MOR                  | 2.76 [2.03–3.42] | 2.77 [2.65–2.86] | 2.74 [2.66–2.84] | 2.78 [2.68–2.86] | 2.89 [2.33–3.51] |
| Explained            | 35.72 [29.06–41.20] | 31.03 [27.61–37.31] | 33.20 [27.31–37.28] | 30.82 [26.97–37.91] |          |
| variation            | [1]      | [1]      | [1]       | [1]       | [1]       |
| Community level      |         |          |           |          |
| Variance (SE)        | 1.86 [1.12–2.18] | 2.00 [1.71–2.31] | 1.98 [1.14–2.20] | 1.59 [1.22–1.98] | 1.99 [1.42–2.36] |
| ICC (%)              | 47.60 [39.8–50.7] | 49.80 [37.98–53.70] | 48.50 [36.90–59.08] | 48.40 [37.00–51.20] | 49.22 [38.99–52.51] |
| MOR                  | 3.67 [2.74–4.09] | 3.85 [3.48–4.26] | 3.83 [2.77–4.12] | 3.33 [2.87–3.83] | 3.84 [3.12–4.33] |
| Explained            | 52.00 [46.30–59.80] | 48.99 [41.40–55.81] | 47.89 [38.21–52.55] | 48.70 [43.00–52.00] |          |
| variation            | [1]      | [1]      | [1]       | [1]       | [1]       |
| Model fit statistics |         |          |           |          |
| Bayesian DIC         | 5839     | 6002     | 5998      | 6010     | 6012     |
| N                    | 15       | 15       | 15        | 15       | 15       |
| Region level         | 340      | 340      | 340       | 340      | 340      |
| Community level      |          |          |           |          |
| Individual           | 4254     | 4254     | 4254      | 4254     | 4254     |

*p < 0.05, **p < 0.01, ***p < 0.001; aOR = adjusted Odds Ratio; CrI = Credible Interval; ICC = Intra-cluster correlation; MOR = Median Odds Ratio; 1 = reference
offset cost which could have hindered them from accessing the recommended dosage.

Women who knew that mosquito bite can cause malaria were less likely to have three or more doses of IPTp-SP, however, those who knew that sleeping under ITN can prevent malaria had higher odds of three or more IPTp-SP doses. All things being equal, women who are knowledgeable about possible routes and preventive strategies of malaria are expected to utilize all available opportunities to protect themselves and their newborns [40]. Arguably, a greater section of the women may be unsure of the information they possess about the causative and preventive routes. The content of ANC messages delivered throughout the trimesters could reflect issues pertaining to malaria causation and preventive strategies in order for women to be conscious and be appreciative of the need to achieve the full dosage. This is very critical on the account that malaria is endemic in the over 95% of the country [4].

The findings further revealed that urban residents were less probable to have at least three doses. Unlike rural settings, urban centres are usually clean with less hideouts for mosquitoes or limited conducive breeding sites for mosquitoes. Consequently, there is a high temptation for urban residents to feel that they are less susceptible to malaria even during pregnancy. However, a rural resident may be concerned about being at increased risk of malaria and hence utilize all means possible to achieve the recommended doses. This finding further indicates that availability of health facilities does not necessarily imply healthcare utilization. Thus, several other factors interrelate to determine utilization. This is because health facilities and health personnel are prevalent in urban settings of Uganda relative to the rural locations [41, 42] and all things being equal, urban residents were expected to have increased chances of achieving the recommended IPTp-SP dosage. Health education among urban women through the mass media may be useful to boost IPTp-SP uptake among them.

Most disadvantaged communities and regions were aligned with less likelihood of three or more IPTp-SP uptake. Being a resident of most disadvantaged communities may be indicative of limited access to IPTp-SP outlets such as health facilities and mobile clinics [42]. As a result, these finding was anticipated. This points to the need for urgent appraisal of existing IPTp-SP administration/interventions and prioritization of the possibilities of increasing access among women in most disadvantaged regions and communities. It is by such approaches that malaria burden in Uganda can be reduced and thereby increase the country's prospects of achieving SDG target 3.1 [7].

**Strengths and limitations**

This study emerged from the most recent national malaria survey of Uganda. Due to the sampling procedure and large sample, it is representative of all women aged 15–49 in Uganda. In spite of this strength, the study has some noteworthy limitations. The study adopted a cross-sectional design and as such causal inference is not permissible. Second, since the outcome variable was self-reported, under-reporting or over-reporting of optimal IPTp-SP uptake is plausible. Also, since the study was based on pre-existing data without information on health system factors, I was unable to interrogate health system factors.

**Conclusion**

The study revealed that less than half of Ugandan women achieved the recommended IPTp-SP dosage at their last pregnancy preceding the 2018-19 UMIS. Community and region level factors are significant predictors of optimal IPTp-SP uptake. All existing IPTp-SP interventions that focus on individual level factors alone need to be reviewed to reflect broader community and region level factors in order to wane the high malaria prevalence in the country. More especially, augmenting IPTp-SP uptake in most disadvantaged communities would require much scrutiny into suitable approaches to ensure access by obviating all barriers. Also, contextually responsive behavioural change communication interventions could invoke women’s passion to achieve the recommended dosage.

**Abbreviations**

ANC: Antenatal care; aOR: Adjusted Odds Ratio; CI: Credible Interval; DIC: Deviance Information Criterion; ICC: Intra-cluster correlation coefficient; ITN: Insecticide-treated net; IPTp-SP: intermittent preventive treatment in pregnancy; MOR: Median odds ratio; NMCD: National Malaria Control Division; NPHC: National Population and Housing Census; SOMREC: School of Medicine Research and Ethics Committee; UMIS: Uganda Malaria Indicator Survey of Uganda; UN CST: Uganda National Council for Science and Technology; VIF: Variance inflation factor; WHO: World Health Organization.

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**Author contributions**

EKA conceptualized and designed the study, analysed the data and drafted the manuscript.

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**Availability of data and materials**

The dataset supporting the conclusions of this article is available in the Measure DHS repository, [https://www.malarisurveys.org](https://www.malarisurveys.org).

**Declarations**

**Ethics approval and consent to participate**

Not applicable.
References
1. WHO. World Malaria Report. Geneva: World Health Organization; 2019.
2. WHO. Intermittent preventive treatment in pregnancy (IPTp). Geneva, World Health Organization, 2019. [Available from: https://www.who.int/malaria/areas/preventive_therapies/pregnancy/en/]
3. Roman E, Andrejko K, Wolf K, Henry M, Yousl S, Florey L, et al. Determinants of uptake of intermittent preventive treatment during pregnancy: a review. Malar J. 2019;18:372.
4. Government of Uganda. President’s Malaria Initiative: Malaria Operational Plan FY. Kampala, 2019.
5. Pell C, Straus L, Andrew EV, Meñaca A, Pool R. Social and cultural factors affecting uptake of interventions for malaria in pregnancy in Africa: a systematic review of the qualitative research. PLoS ONE. 2011;6:e22452.
6. Jacobs B, Ir P, Bigdeli M, Annear PL, Van Damme W. Addressing access barriers to health services: an analytical framework for selecting appropriate interventions in low-income Asian countries. Health Policy Plan. 2012;27:288–300.
7. United Nations. Transforming our World: The 2030 Agenda for Sustainable Development. Geneva, 2015.
8. WHO. Policy brief for the implementation of intermittent preventive treatment of malaria in pregnancy using sulfadoxine-pyrimethamine (IPTp-SP). Geneva: World Health Organization, 2013.
9. Kayento K, Garner P, van Eijk AM, Diarra SS, Konaté D, Tall M, et al. Intermitent preventive therapy for malaria during pregnancy using 2 vs 3 or more doses of sulfadoxine-pyrimethamine and risk of low birth weight in Africa: systematic review and meta-analysis. JAMA. 2013;309:594–604.
10. Garner P, Gulmezoglu A. Drugs for preventing malaria in pregnant women. Cochrane Database Syst Rev. 2006;4:CD000169.
11. Bhutta ZA, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? Lancet. 2014;384:347–70.
12. Sicuri E, Bardaji A, Nhampossa T, Maixenchs M, Nhacolo A, Nhalungo D, et al. Cost-effectiveness of intermittent preventive treatment of malaria in pregnancy in southern Mozambique. PLoS ONE. 2010;5:e13407.
13. Flegg JA, Patil AP, Venkatesan M, Roper C, Naidoo I, Hay SI, et al. Spatiotemporal mathematical modelling of mutations of the dhps gene in African Plasmodium falciparum. Malar J. 2013;12:249.
14. Uganda Bureau of Statistics, ICF International Inc. Demographic and Health Survey 2011. Uganda: Kampala, Uganda, and Calverton, Maryland, USA, 2012.
15. Rassi C, Siduda GS, Graham K, Meier J, Sielkoleiko J, Drile LV, et al. Assessing and addressing barriers to IPT2 uptake in Uganda. Uganda: Malala Consortium.
16. Rassi C, Graham K, Mufubenga P, King R, Meier J, Gudo SSJM. Assessing supply-side barriers to uptake of intermittent preventive treatment for malaria in pregnancy: a qualitative study and document and record review in two regions of Uganda. Malar J. 2016;15:341.
17. Braun V, Remps E, Schnack A, Decker S, Rubaihayo J, Turneswiggme NM, et al. Lack of effect of intermittent preventive treatment for malaria in pregnancy and intense drug resistance in western Uganda. Malar J. 2015;14:372.
18. Sangaré LR, Stegachis A, Brenchlinger PE, Richardson BA, Staudige SK, Kiwuwa MS, et al. Determinants of use of intermittent preventive treatment of malaria in pregnancy: Jinja, Uganda. PLoS ONE. 2010;5:e15066.
19. Nydownegyenyi R, Clarke SE, Hutcheson CL, Hansen KS, Magnussen P. Efficacy of malaria prevention during pregnancy in an area of low and unstable transmission: an individually-randomised placebo-controlled trial using intermittent preventive treatment and insecticide-treated nets in the Kabale Highlands, southwestern Uganda. Trans R Soc Trop Med Hyg. 2011;105:607–16.
20. Crawford Z, Howe J, Pisani F. Reducing malaria in pregnancy in North-eastern Uganda: a three-pronged approach for enhancing IPTp uptake amongst Karamojong women. The Pardee Periodical Journal of Global Affairs. 2018;3:21–38.
21. Okeowo D, Opiyo J, Atwoli S, Kizza CT, Nabatanzi M, Biribava C, et al. Factors associated with uptake of optimal doses of intermittent preventive treatment for malaria among pregnant women in Uganda: analysis of data from the Uganda Demographic and Health Survey, 2016. Malar J. 2019;18:250.
22. Conrad MD, Mota D, Foster M, Tukwasibwe S, Legac J, Turneswiggme P, et al. Impact of intermittent preventive treatment during pregnancy on Plasmodium falciparum drug resistance—mediating polymorphisms in Uganda. J Infect Dis. 2017;216:1008–17.
23. Uganda National Malaria Control Division (NMCD). Uganda Bureau of Statistics (UBOS), ICF: Uganda Malaria Indicator Survey 2018–19. Kampala, Uganda, and Rockville, Maryland, USA. NMCD, UBOS, and ICF; 2020.
24. WHO. Parasitological confirmation of malaria diagnosis: report of a WHO technical consultation. Geneva, World Health Organization; 2010.
25. Ameyaw EK, Tetteh JK, Arman-AnsaK AH, Aduo-Adjei K, Sena-Iddrisu A. Female genital mutilation/cutting in Sierra Leone: are educated women intending to circumcise their daughters? BMC Int Health Human Rights. 2020;20:19.
26. Yaya S, Uthman OA, Ekholuenetale M, Bishwajit G. Women empowerment as an enabling factor of contraceptive use in sub-Saharan Africa: a multilevel analysis of cross-sectional surveys of 32 countries. Reprod Health. 2018;15:214.
27. Larsen K, Merlo J. Appropriate assessment of neighborhood effects on individual health: integrating random and fixed effects in multilevel logistic regression. Ann J Epidemiol. 2005;161:81–8.
28. Akinwande MO, Dikko HG, Samson A. Variance inflation factor: as a condition for the inclusion of suppressor variable (s) in regression analysis. Open J Stat. 2015;5:754.
29. Goldstein H. Multilevel statistical models. London: Hodder Arnold, 2003.
30. Darteh EKM, Buabeng J, Akuamoah-Boateng C. Uptake of intermittent preventive treatment in pregnancy for malaria in Ghana: further analysis of the 2016 Malaria Indicator Survey. DHS Working Paper No. 158. Rockville, Maryland, USA: ICF; 2019.
31. Diarra SS, Konaté D, Diawara SI, Tall M, Diakité M, Doumbia S. Factors associated with intermittent preventive treatment of malaria during pregnancy in Mali. J Parasil. 2019;105:299–302.
32. Mbengue MAS, Bei AK, Mboup A, Ahoudi A, Sarr M, Mboup S, et al. Factors influencing the use of malaria prevention strategies by women in Senegal: a cross-sectional study. Malar J. 2017;16:470.
33. Asimwe G. Determinants of optimal uptake of intermittent preventive treatment of malaria during pregnancy in Uganda. MSc Dissertation, Makerere University, 2019.
34. Mafuleka T, Chumchit M. Factors influencing utilization of intermittent preventive treatment of malaria during pregnancy among mothers of under-one children in rural Lilingwe, Malawi. J Health Res. 2018;32:62–75.
35. Namuli V, Chinkomonono GS, Atuhare C, Christensen BN, Pemuntu V, Cumber SN. Maternal health services for pregnant adolescent girls in Uganda: barriers and opportunities. 2020. http://ir.must.ac.ug/xmlui/handle/123456789/1468.
36. Mekonnen T, Dune T, Perz J. Maternal health service utilisation of adolescent women in sub-Saharan Africa: a systematic scoping review. BMC Pregnancy Childbirth. 2019;19:566.
37. Tiruneh FN, Chuang Y-Y, Chuang Y-C. Women's autonomy and maternal healthcare service utilization in Ethiopia. BMC Health Serv Res. 2017;17:718.
38. Chol C, Negin J, Agbo KE, Cumming RG. Women's autonomy and utilisation of maternal healthcare services in 31 Sub-Saharan African countries: results from the demographic and health surveys, 2010–2016. BMJ Open. 2019;9:e023128.
39. Ameyaw EK, Appiah F, Agbeshi CS, Kannon P. Contraceptive use in Ghana: what about women empowerment? Adv Sex Med. 2017;7:44–54.
40. Strecher VJ, Rosenstock IM. The health belief model. In: Baum A, Newman S, Weinman J, West R, McManus C, editors. Cambridge handbook of psychology, health and medicine. 113: Cambridge University Press; 1997. p. 117.
41. Rutebemberwa E, Buregyeya E, Lal S, Clarke SE, Hansen KS, Magnussen P, et al. Assessing the potential of rural and urban private facilities in implementing child health interventions in Mukono district, central Uganda—a cross sectional study. BMC Health Serv Res. 2016;16:268.
42. Mwesigwa CL, Okumu BA, Kirabo-Nageme C, Ejeeu E, Kruge E, Tennant M. Mapping the geographic availability of public dental services in Uganda relative to ruralization and poverty of the population. J Glob Oral Health. 2020;2:86–92.

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