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Increasing certainty of seasonal malaria chemoprevention impact: A mathematical model using routine data in Burkina Faso

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Age-related variations in routine data can be attributed to other interventions, non-malarial fevers and treatment-seeking, which mask the impact of seasonal malaria chemoprevention

Introduction

Evidence from randomised controlled trials has demonstrated that seasonal malaria chemoprevention (SMC) can prevent approximately 75 percent of malaria cases. However, data from the Health Management Information System (HMIS) in Burkina Faso indicate an increase in cases among children under five since SMC was implemented.[1] This could indicate changes in treatment-seeking or reporting, or that SMC is not achieving the desired effect. We developed a framework utilising a mathematical model to assess whether SMC impact is consistent over time, across different metrics and among various population subgroups.

Methods

- We calibrated a malaria transmission model, developed at Imperial College London,[2] to fit to microscopy-confirmed prevalence in 65 districts of Burkina Faso based on data from the Demographic Health Survey Programme (DHS) from 2010–2018. Calibration was conducted using the maximum likelihood by varying mosquito density. Factors included in the model were rainfall, mosquito net use (sourced from the Malaria Atlas Project) and treatment (based on DHS data).
- We simulated SMC with 70 percent coverage in children 3–59 months and compared the modelled predictions of clinical cases to HMIS data showing the proportion of children under five with malaria that was confirmed by a rapid diagnostic test. We also compared modelled detectable cases to DHS data showing the prevalence of children 6–59 months with malaria that was confirmed by microscopy.
- We accounted for changes in treatment-seeking over time using the consultation rate for all illness in the dry season, when there are few malaria cases.
- We included non-malarial fevers (NMFs) that might be counted as cases at health facilities due to incidental asymptomatic *parasitaemia*. This inclusion was based on data regarding the background rate of NMFs[3] and the prevalence of asymptomatic patent infection by age.

Results

- Over time, the number of cases reported in the HMIS increased but the proportion of cases in children under five who received SMC decreased compared to 5–14-year-olds, who did not. The decrease in the proportion of cases in under-fives coincided with the introduction of SMC in varying years by district (2014–2019) (Figure 1).
- Evidence of seasonal variation was found in the proportion of cases in under-fives prior to SMC introduction. This occurred without any age-targeted seasonal prevention measures or other age-specific seasonal changes, masking the impact of SMC in HMIS data. We replicated these patterns by including non-malarial fevers presenting at the health facility and accounting for changes in treatment-seeking. These findings correlate with modelled predictions (r=0.60, p>0.001) (Figure 2).
- Modelled estimates of prevalence in children 6–59 months by district aligned with DHS prevalence data, indicating the anticipated impact of SMC (Spearman correlation coefficient: r=0.66, p>0.001; r=0.76, p>0.001; r=0.60, p>0.001; in 2010, 2014 and 2017, respectively) (Figure 3).

Figure 1. HMIS data showing the proportion of cases in children five and under among all children 14 and under by month and year of SMC introduction (district-level and median)

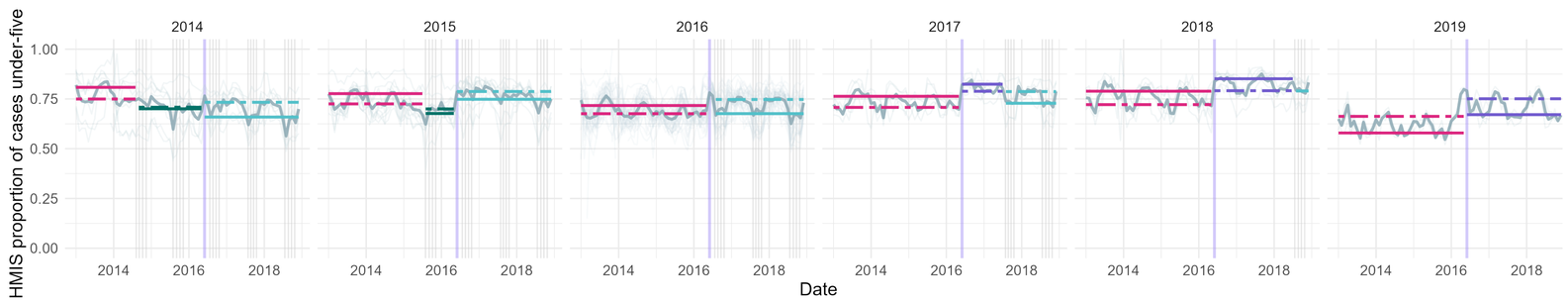


Figure 2. Model predictions of the proportion of cases in children five and under among all children 15 and under compared to estimates from HMIS data by district and year (2013–2018) in dry and rainy season

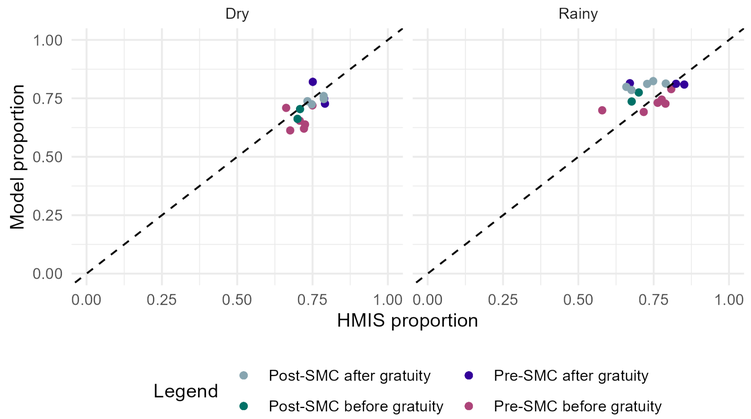
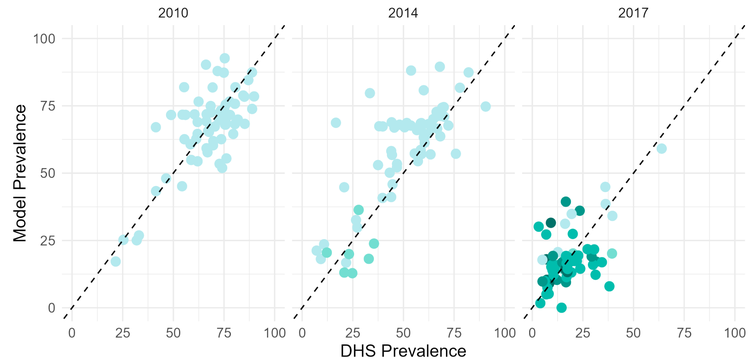


Figure 3. Model predictions of the prevalence of infection in children 6–59 months compared to estimates from DHS survey data by district and year (2010, 2014, 2017)



Conclusion

The impact of SMC in routine data can be obscured by various factors, including changes in policy, seasonality, treatment-seeking behaviour and other interventions. A mathematical model can be used to triangulate relevant data sources to account for these factors and allow for a more accurate estimation of the impact of SMC.

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References

1. de Cola MA et al. Impact of seasonal malaria chemoprevention on prevalence of malaria infection in malaria indicator surveys in Burkina Faso and Nigeria. BMJ global health, 2022.
2. Griffin JT et al. Estimates of the changing age-burden of *Plasmodium Falciparum* malaria disease in sub-Saharan Africa. Nature Communications, 2014.
3. Watson OJ et al. Modelling the drivers of the spread of *Plasmodium Falciparum* hrp2 gene deletions in sub-Saharan Africa. eLife, 2017.