

Supporting Information

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SI Methods

Models for Malaria

Terminology. $E(Y)$ is the expected monthly case count; NS indicates a natural cubic spline function; DMI_{3-4} , $NINO3_{1-2}$, and $rain_{2-3}$ represent average DMI, NINO3, and rainfall at lag 3–4, 1–2, and 2–3 months, respectively; $i.month$ represents indicator variables for the month; $i.year$ represents indicator variables for the year; and AR_1 represents a first-order autoregressive term. For example, $NS(DMI_{3-4}, 3df)$ indicates a linear term (raw data) and 2 spline terms of DMI at a lag of 3–4 months.

Models for malaria—DMI and NINO3:

$$(a) \log[E(Y)] = \alpha + NS(DMI_{3-4}, 3df) + NS(NINO3_{1-2}, 3df) + i.month + i.year + AR_1$$

Models for malaria—rainfall:

$$(b) \log[E(Y)] = \alpha + NS(rain_{2-3}, 3df) + i.month + i.year + AR_1$$

Models for DMI—Rainfall

Terminology. $E(Y)$ is the expected monthly rainfall, NS indicates a natural cubic spline function, DMI_1 represent DMI at a lag of 1 month, $i.month$ represents indicator variables for the month, $i.year$ represents indicator variables for the year, and AR_1 represents a first-order autoregressive term.

$$(c) \log[E(Y)] = \alpha + NS(DMI_1, 3df) + i.month + i.year + AR_1$$

Sensitivity Analyses

To investigate whether the results were sensitive to the levels of control for seasonal patterns, analyses were repeated using Fourier terms of month up to the fifth harmonic per year adding 1 harmonic at a time. Fourier terms (harmonic waves) can be used to recreate any periodic signal (such as a consistent seasonal pattern) using a linear combination of sine and cosine waves of varying wavelength [Stolwijk AM, Straatman H, Zielhuis GA (1999) Studying seasonality by using sine and cosine functions in regression analysis. *J Epidemiol Community Health* 53:235–238]. The number of harmonics defines the lowest wavelength reproduced (i.e., the level of seasonal adjustment), for example, with 5 harmonics corresponding to a wavelength of 10 weeks (one-fifth of a year).

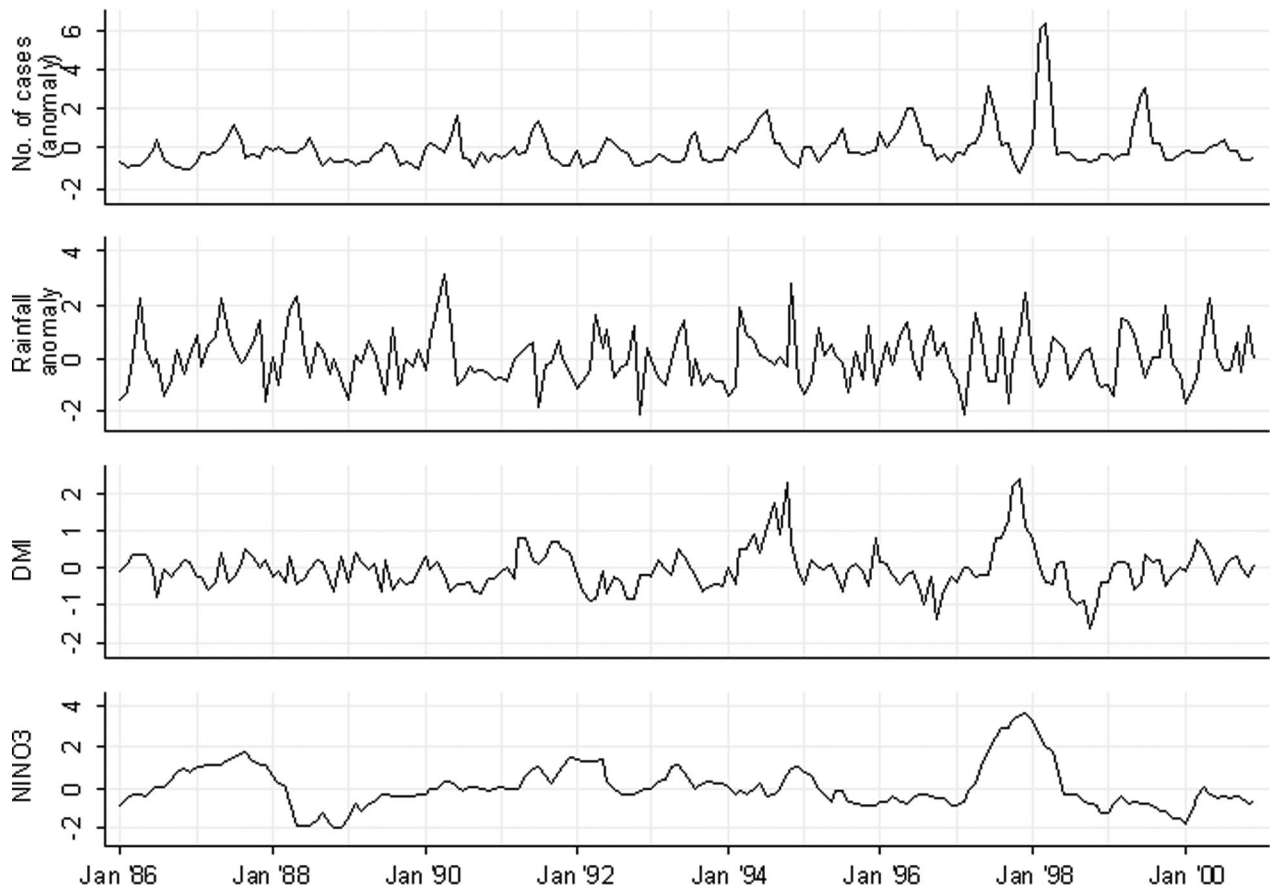


Fig. S1. Time series for the number of malaria inpatients each month in the Kisii district hospital, the rainfall in Kisii, the dipole mode index (DMI) and the NINO3 SST anomaly (NINO3), 1986–2000. The number of malaria inpatients each month and rainfall are represented by a standardized anomaly relative to the 1986–2000 mean for each variable.

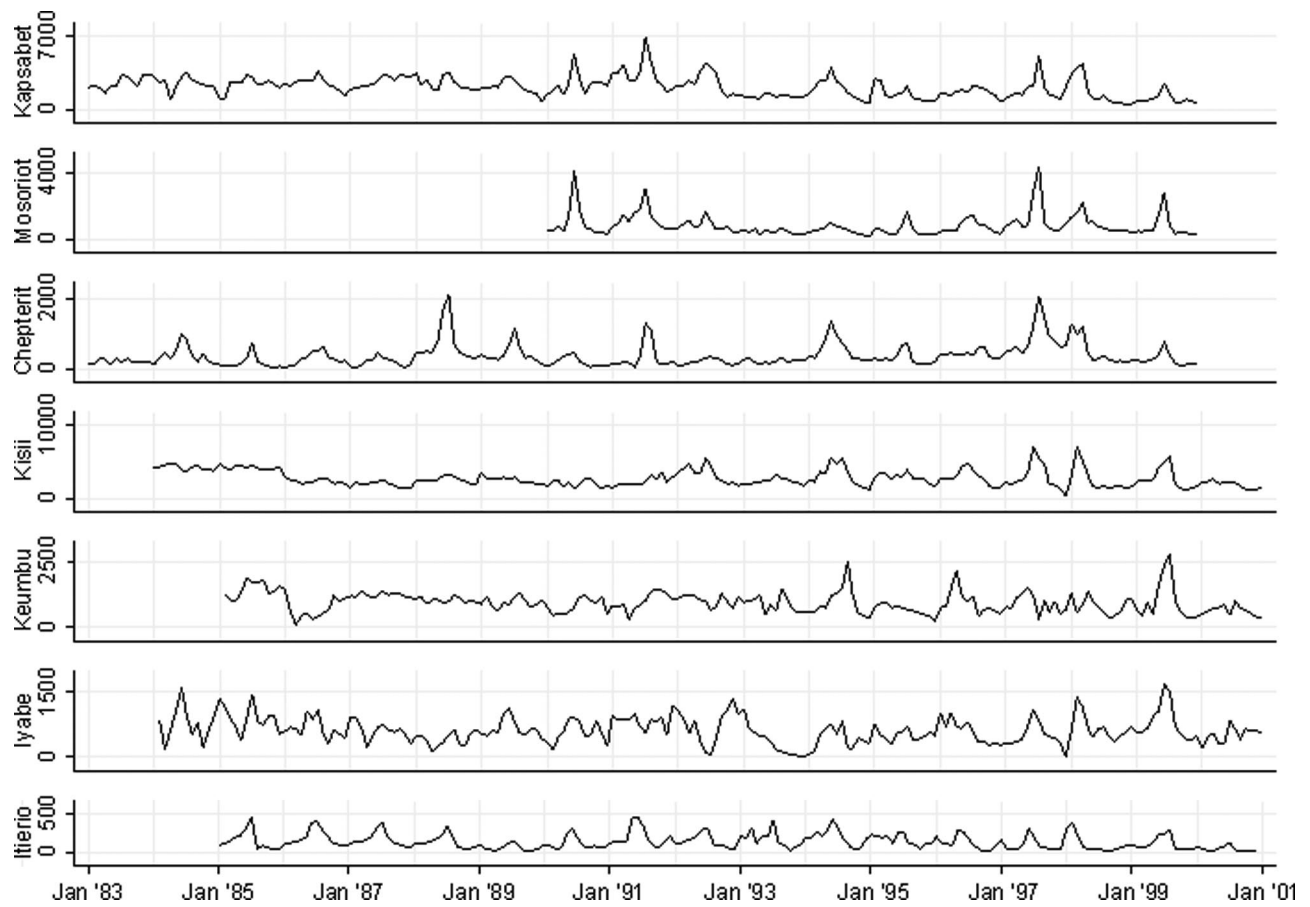


Fig. 52. Time series of the number of malaria outpatients of 7 hospitals per month in Nandi and Kisii districts, 1983–2000.

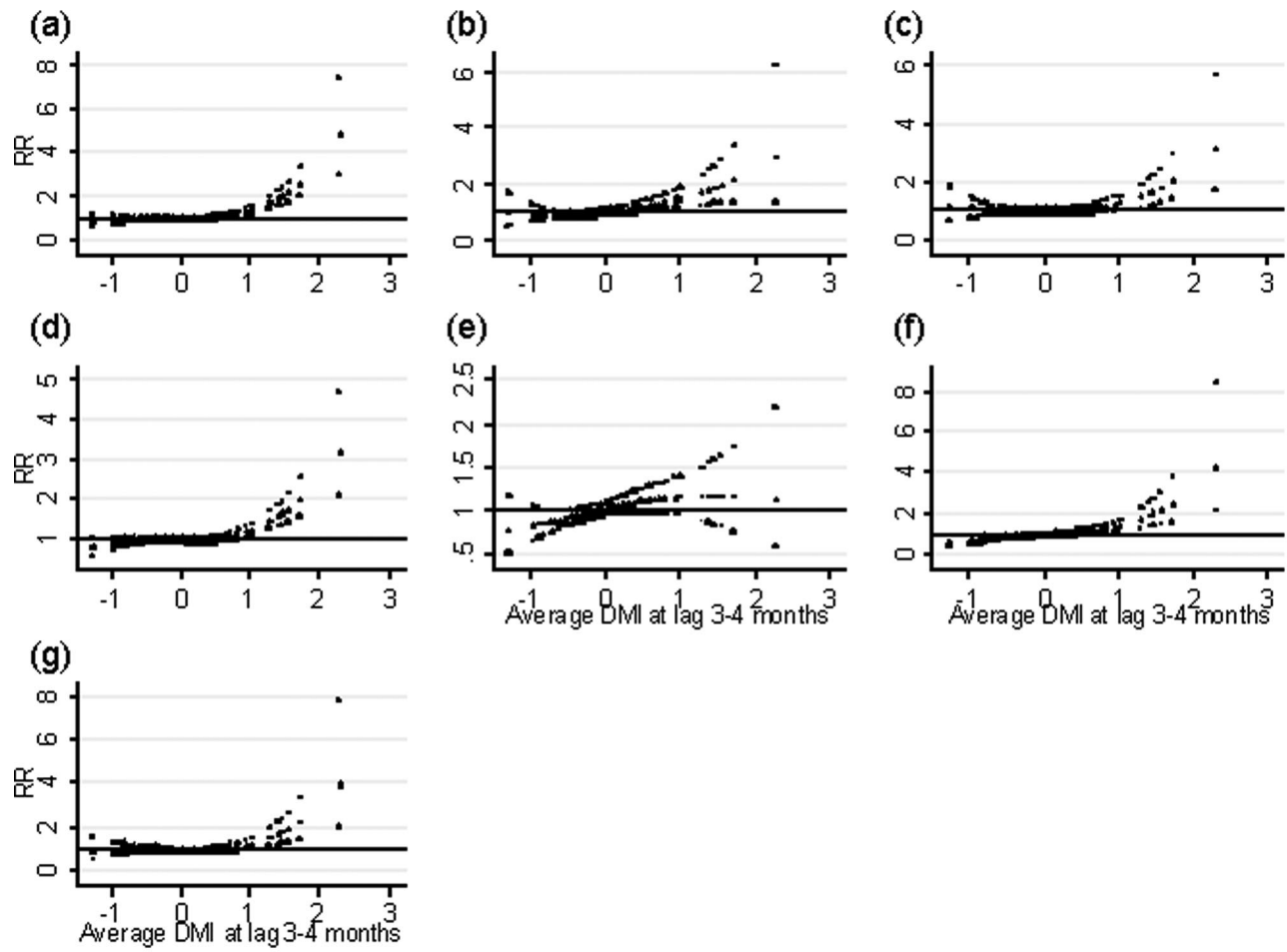


Fig. S3. Relationship between the relative risk (RR) of malaria scaled to the mean number of outpatients per month and the dipole mode index (DMI) (lag 3–4 months). The center line in each graph shows the estimated spline curve, and the upper and lower lines represent 95% confidence limits: (a) Kapsabet, (b) Mosoriot, (c) Chepterit, (d) Kisii, (e) Keumbu, (f) Iyabe, and (g) Itierio.

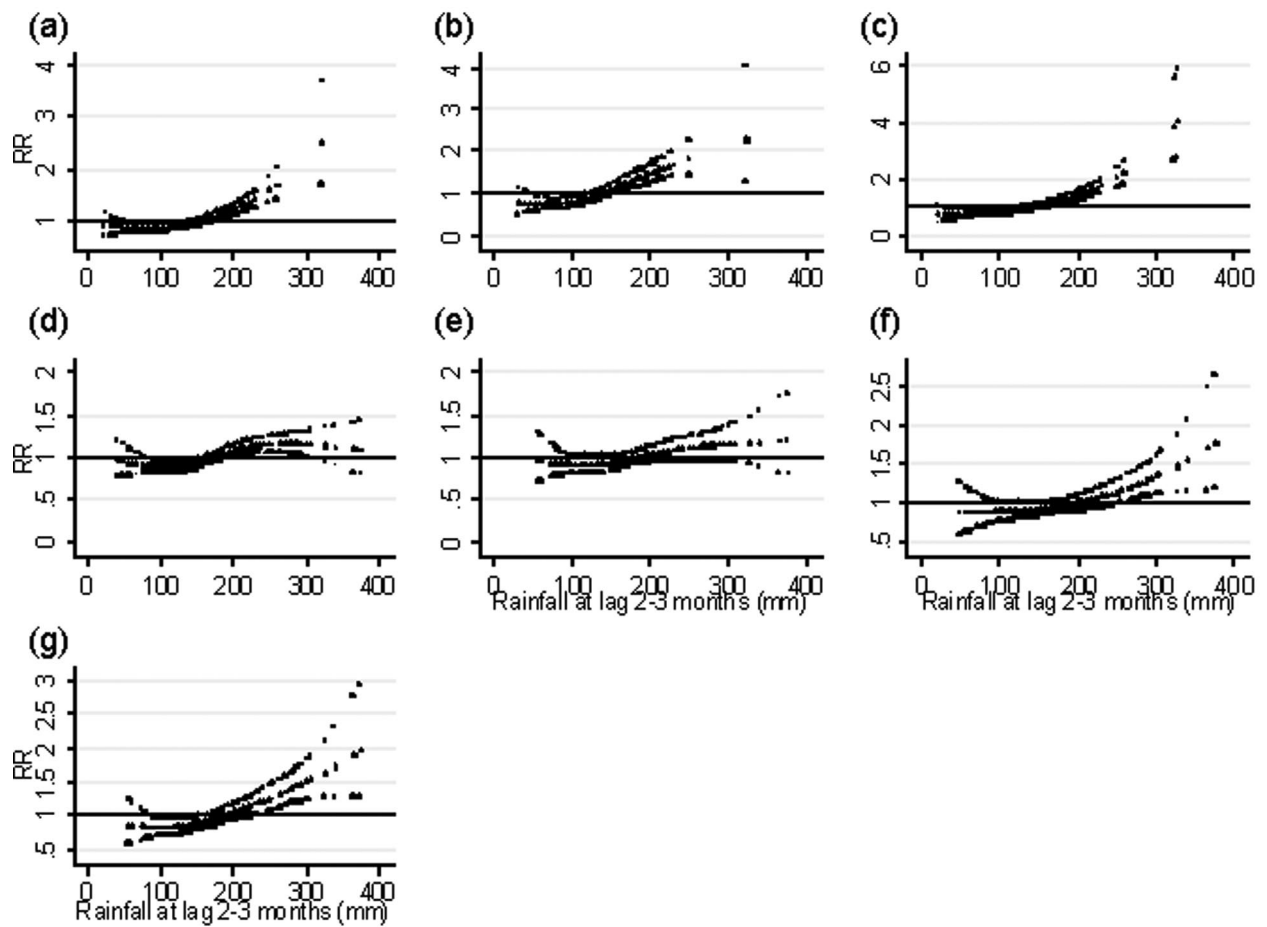


Fig. S4. Relationship between the relative risk (RR) of malaria scaled to the mean number of outpatients per month and the rainfall (lag 2–3 months). The center line in each graph shows the estimated spline curve, and the upper and lower lines represent 95% confidence limits: (a) Kapsabet, (b) Mosoriot, (c) Chepterit, (d) Kisii, (e) Keumbu, (f) Iyabe, and (g) Itierio.

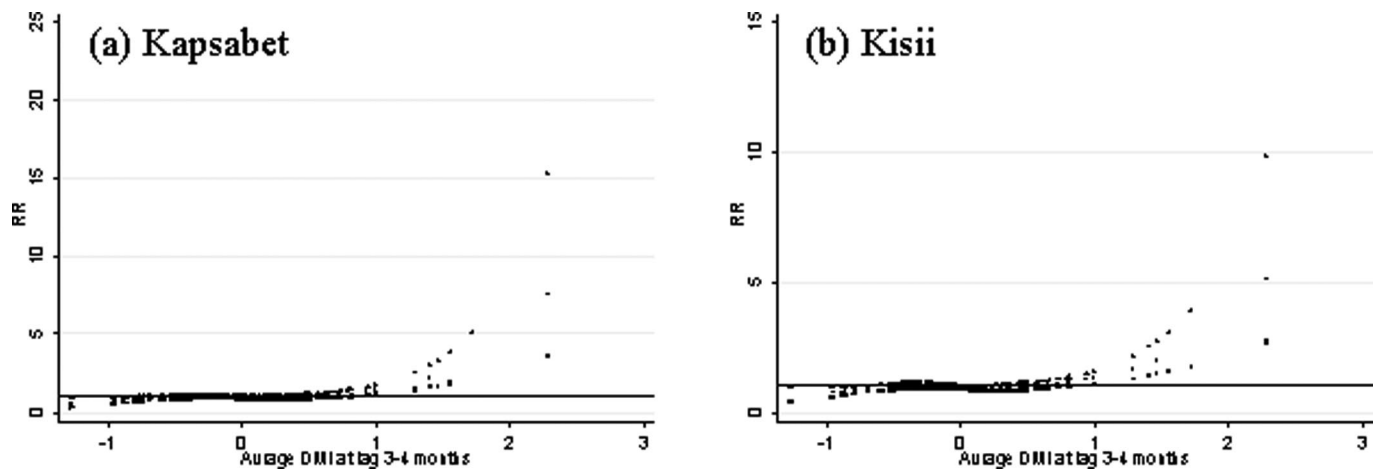


Fig. S5. Relationships between the relative risk (RR) of malaria scaled to the mean number of inpatients per month in Kapsabet (a) and Kisii (b) district hospitals and the dipole mode index (DMI) (lag 3–4 months) adjusted for rainfall (lag 2–3 months). The middle line in each graph shows the estimated spline curve, and the top and bottom lines represent 95% confidence limits.

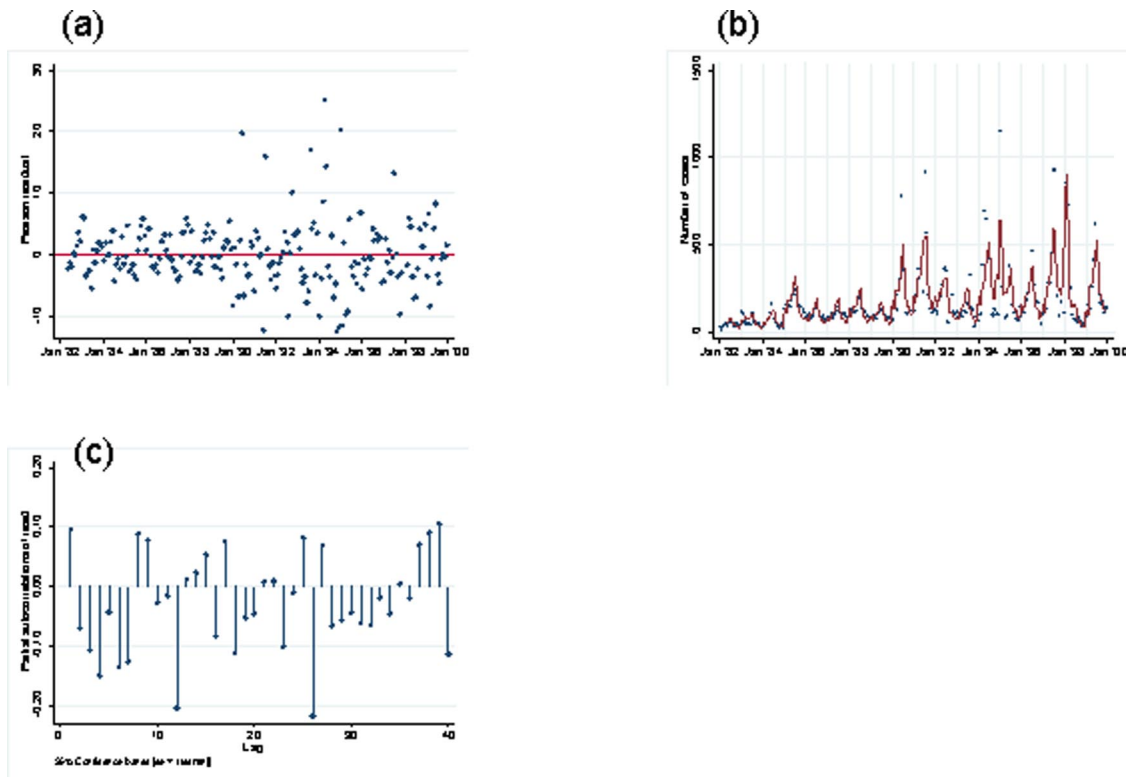


Fig. S6. Diagnostics of malaria-DMI models; inpatients of Kapsabet district hospital: (a) plots of model residuals, (b) predicted and observed time series plots, and (c) partial autocorrelation function of the residuals.

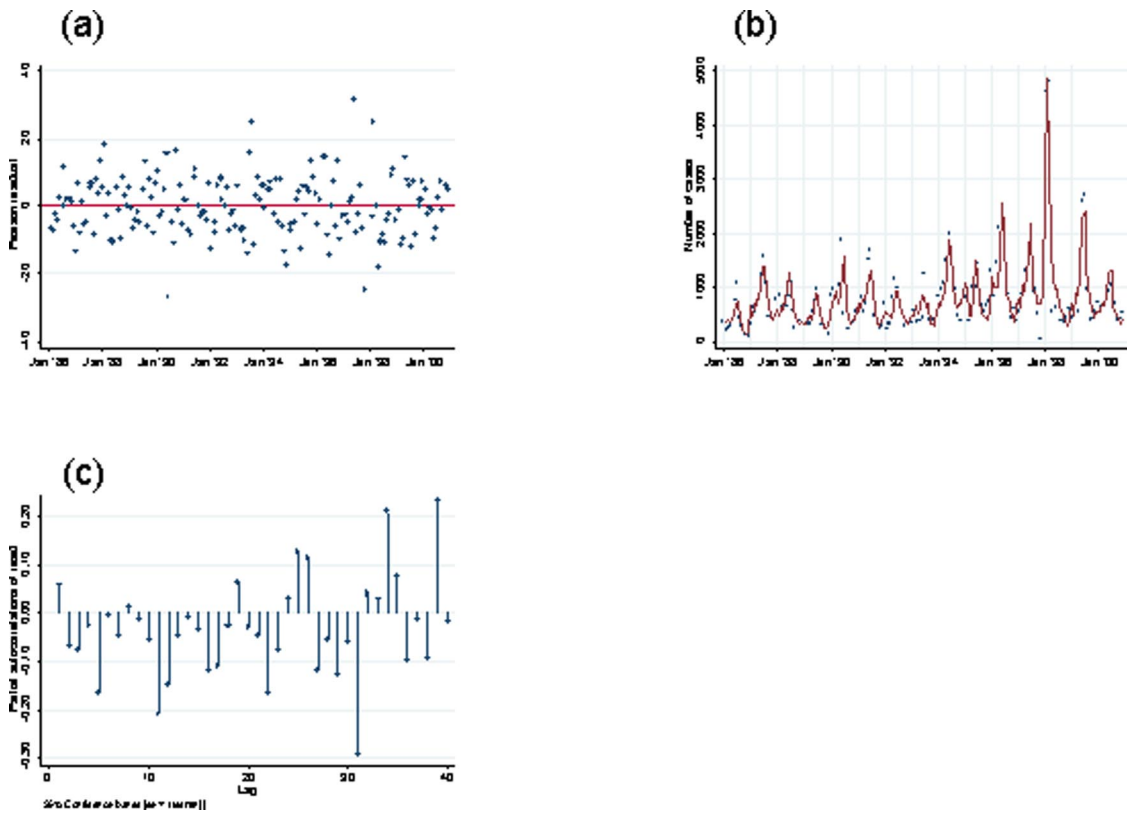


Fig. S7. Diagnostics of malaria-DMI models; inpatients of Kisii district hospital: (a) plots of model residuals, (b) predicted and observed time-series plots, and (c) partial autocorrelation function of the residuals.

Table S1. Comparison of Akaike's information criterion (AIC) for models of malaria with different climate factors

Climate factor	Kapsabet	Kisii
DMI	34.1	90.1
NINO3	43.8	104.9
RAIN	39.6	102.8
DMI + RAIN	31.5	83.7
NINO3 + RAIN	34.2	90.2
DMI + NINO3	33.6	87.4
DMI + RAIN + NINO3	30.3	81.1

The outcomes are the number of malaria inpatients per month in Kapsabet and Kisii district hospitals. Models include a linear term and natural cubic splines of each climate factor indicated, indicator variables of months, and indicator variables of years. DMI, NINO3, and RAIN represent average DMI, NINO3, and rainfall at a lag of 3–4, 1–2, and 2–3 months, respectively.

Table S2. Diagnostics of malaria–DMI models for inpatients of Kapsabet and Kisii district hospitals

	Deviance	Res. df	AIC
Kapsabet	5572.6	174	33.6
Kisii	13932.9	144	87.4

Res. df, residual degrees of freedom. Models include a linear term and natural cubic splines of DMI and NINO3, indicator variables of months, and indicator variables of years.