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1.

Malaria is a major problem in Ethiopia, being the leading cause of outpatient visits, admissions (excluding those for normal deliveries) and deaths in the country in 2005—2006, and accounting for over 20% of deaths at all ages.[1] There are estimated to be 5—6 million malaria cases per year. However, exposure to malaria varies markedly by location and season.

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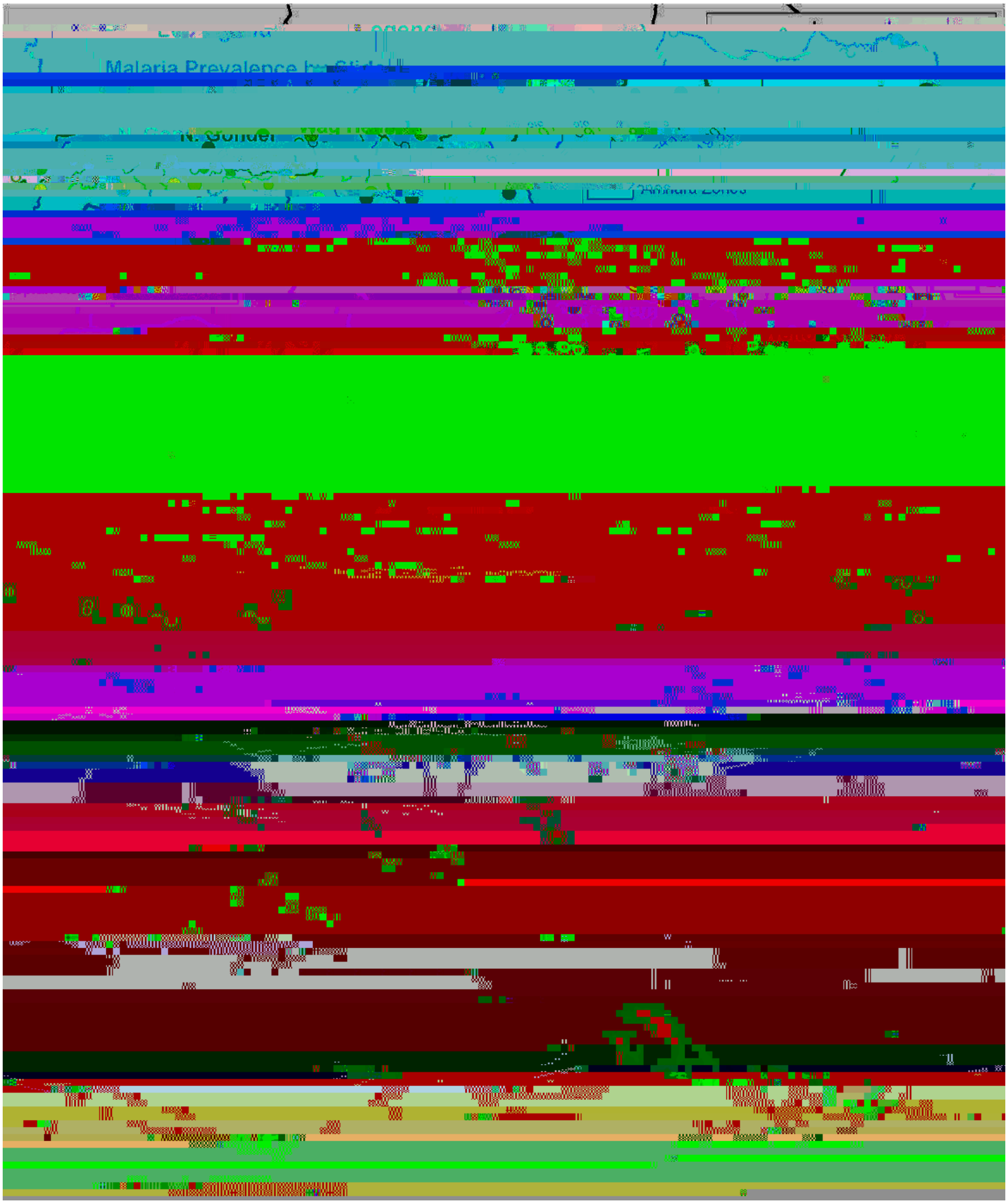

Figure 1 Map of the survey sites and malaria prevalence estimates by cluster.

basis of altitude. Overall, the percentage of the population excluded due to residing in non-malarious areas was 27% of the total.

Clusters were defined as *kebeles*. The multistage cluster random sampling design used zones and *woredas* in Amhara and 'quadrants' (groups of *woredas*) in Oromia/SNNPR as preliminary sampling stages. The strategy was designed to select 160 clusters (16 per zone) in Amhara and 64 clusters (8 per quadrant) in Oromia/SNNPR, giving 224 clusters in total, each targeted to include 25 households. Clusters were randomly selected from among the malarious *kebeles* in each *woreda* or quadrant. After selection, one cluster in Borena Zone of Oromia Region was replaced due to security concerns. Within clusters, five state teams (divisions of a *kebele*) were randomly selected, and within each state team, five households were selected by the random walk method. Households within a cluster were assigned sequential numbers as they were sampled. All eligible participants (all age groups and both sexes) in even-numbered households were invited to participate in testing for malaria parasites. Locations of the selected clusters are shown in Figure 1. Verbal informed consent to participate in interviews was sought from the heads of the household. Signed informed consent for blood testing was sought from each individual and parents of children aged 17 years and younger. Personal identifiers were removed from the data set before analyses were undertaken.

2.2. [illegible]

The survey questionnaire was based on the Malaria Indicator Survey Household Questionnaire, modified for the local conditions as previously described.[22,23,26] A wealth index was constructed for each household using principal components

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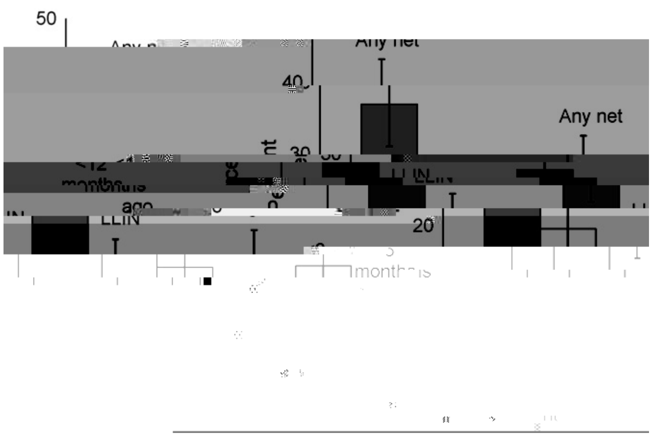


[illegible] 2 Household net possession and use by people of all ages, and proportion of houses sprayed. LLIN: long-lasting insecticidal net; bars represent 95% CI.

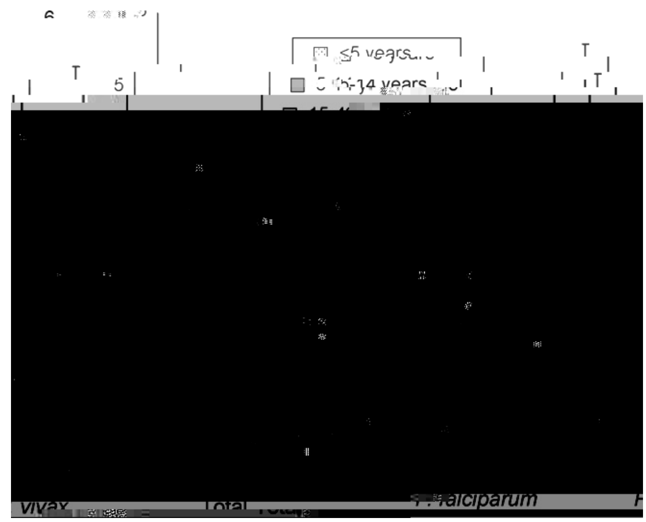
The design effect in this survey ranged from 1.6 for the variable representing age group to 4.1 for altitude.

3.2. [illegible]

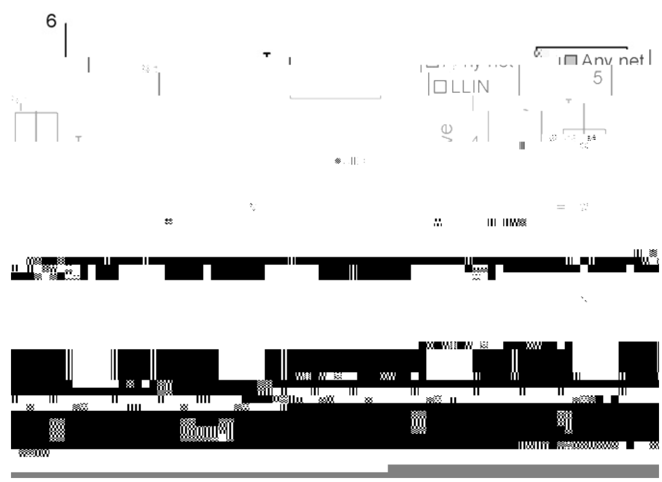
The mean number of nets or LLINs owned per house was 0.6 (95% CI 0.4—0.7) and 0.3 (95% CI 0.2—0.4), respectively. We estimated that 37.0% (95%CI 31.1—43.3) of households had at least one net of any type and 19.6% (95%CI 15.5—24.5) had at least one LLIN (Figure 2). Overall, 27.8% (95% CI 23.5—32.7) of people reported sleeping under a net the previous night, while 15.3% (95% CI 12.0—19.2) slept under an LLIN (Table 1 and Figure 2). The proportions were only slightly higher for under-fives (31.8% net and 17.4% LLIN) and for pregnant women (35.9% net and 18.9% LLIN) (Table 1). Within the last 12 months and 6 months, respectively, 15.5% (95% CI 11.2—20.9) and 5.7% (95% CI 3.7—8.9) of houses had been sprayed (Figure 2). The type of insecticide used is unknown, but DDT is the most commonly used chemical.

3.3. [illegible]

The locations and proportions of people positive for malaria in the sampled clusters are shown in Figure 1. Malaria prevalence was 4.1% (95% CI 3.4—4.9) overall. There were 1.3 times as many people infected with *P. falciparum* (2.5%) as *P. vivax* (1.9%) infections, with 0.3% of infections being mixed. There was no difference in parasite prevalence by gender.



[illegible] 3 Malaria prevalence (slide positivity) by species and age group. LLIN: long-lasting insecticidal net; bars represent 95% CI.



[illegible] 4 Malaria prevalence (slide positivity) by number of nets (any type) and long-lasting insecticidal nets (LLIN) per household. Bars represent 95% CI.

There was no difference in prevalence by age group (Figure 3): the apparent declining trend of *P. falciparum* prevalence by age was not statistically significant. However, there was a declining trend of prevalence (both species combined) with increasing numbers of LLINs in the house (Figure 4).

There was a decline in prevalence with altitude (Table 2), although people infected with malaria were found in all

[illegible] 1 Percentage of sampled individuals sleeping under mosquito nets on the night prior to the survey.

	n	Any net % (95% CI)	LLIN % (95% CI)
All age groups	27 884	27.8 (23.5—32.7)	15.3 (12.0—19.2)
Children aged <5 years	4387	31.8 (26.8—37.4)	17.4 (13.6—22.0)
Women aged 15—49 years	6510	29.0 (24.4—34.0)	16.0 (12.6—20.1)
Self-reported pregnant women	489	35.9 (28.8—43.7)	18.9 (14.0—25.0)

LLIN: long-lasting insecticidal net.

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Table 2 Malaria (species-specific) prevalence by slide, by altitude, all regions combined.

Altitude class (m)	*n*	Any positive slide		*Pf*	*Pv*	*Pf+Pv*	*Pf*:*Pv* ratio
		n (%)	(95% CI)	*n* (%)	*n* (%)	*n* (%)	
≤1000	125	11 (7.3)	(1.9—23.8)	5 (4.1)	4 (2.2)	2 (1.1)	1.6
1000—1500	1529	67 (4.7)	(3.1—7.2)	42 (2.7)	17 (1.5)	8 (0.6)	1.6
1500—2000	5640	232 (4.2)	(3.3—5.4)	122 (2.4)	102 (1.7)	8 (0.2)	1.4

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the question regarding net use the single night before the survey did not accurately capture the net use over a longer period. It may also be that the mere presence of an LLIN in the house gives protection. In multivariate analysis, use of an LLIN the previous night was in fact associated with increased malaria prevalence, suggesting that net use is influenced by the householder's estimation of the risk (i.e. nets tend to be used more in areas of greater exposure to malaria).

There may be additional risk factors that we did not address in this study. A study in Tigray region by Gebreyesus et al.[16] is very relevant, although it estimated incidence of malaria in children under 10 rather than prevalence. In multivariate regression there were seven significant risk factors for malaria incidence (earth roof, open eaves, windows, single sleeping rooms, no separate kitchen, animals sleeping in the house and use of irrigated land). Deressa et al.[31]

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