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Reduction in the Burden of Malarial Anemia in Benin: Confirmation of an Anti-Vector Approach at the National Level

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Abstract: To assess the association between mosquito net use and the burden of malaria as proxied by severe anemia. We also attempt to discern the comparative validity of two proposed cut-offs (Hb <8 and Hb <7 g dL^{-1}) for defining severe anemia. We use data from the nationally-representative Benin Demographic and Health Surveys (BDHS) conducted in 2001 and 2006 to assess the use of mosquito nets and severe anemia in children 6-23 months of age. We find that use of mosquito nets among all children in Beninois households is associated with a >40% reduction in the adjusted odds of being severely anemic for both survey years. The results of this analysis are equivocal on the question of whether <7 or <8 g dL^{-1} is the more valid cut-off point to define severe anemia in the context of malaria. There is a clear association between mosquito net use and reduced burden of severe anemia: not only is there a decrease in the national prevalence of severe anemia at the same time that an increase in mosquito net use was observed, but analyses of individual-level data also indicate a strong negative association between mosquito net use and severe anemia. These findings provide additional support for the continued promotion of mosquito nets as an important anti-vector strategy in the fight against malaria.

Key words: Malaria, anemia, malarial anemia, Benin, mosquito net, insecticide treated bed nets

INTRODUCTION

Malaria causes approximately one-fifth of all young child deaths in Africa (UNICEF, 2004) and Africa alone accounts for 90% of malaria mortality (WHO, 2008). Malaria is thought to be the primary cause of severe anemia (Hb <7 g dL^{-1}) in at least 50% of people living in malaria-endemic areas (Gillespie and Johnston, 1998). With increasing levels of chloroquine resistance (Trape, 2001), the Roll Back Malaria (RBM) partnership goal to halve the malaria burden by 2010 suggests the need for integrated approaches to combat malaria and reduce its consequences. One of the most important interventions for reducing the global burden of malaria is vector control by effective use of insecticide-impregnated nets. Various projects and controlled trials have found improvement in anemia levels with the use of mosquito nets, particularly Insecticide Treated Nets (ITNs). However, to the researcher's knowledge the efficacy of mosquito net use has not been evaluated with national survey data. In this study, we report on an analysis using the data from Benin Demographic and Health Surveys (BDHS) that seeks to determine the effectiveness of mosquito nets in reducing the transmission of malaria, as proxied by anemia status, net of competing risk factors for severe anemia. We also conduct a preliminary assessment of the comparative validity of two cut-offs for defining severe anemia (Hb <7 and Hb <8 g dL^{-1}).

Compared with other parasites, *Plasmodium falciparum* (*P. falciparum*) can invade a larger percentage of Red Blood Cells (RBC) leading to acute and chronic hemolysis and disordered red cell development resulting in severe anemia (Gillespie, 1998). It has therefore, been suggested that childhood anemia might be a suitable indicator of the burden of malaria in malaria-endemic parts of Africa (Korenromp *et al*., 2004). *P. falciparum* accounts for nearly all of the malarial infections in Benin. Morbidity due to malaria is very high among children under 5 years admitted in clinics and hospitals in Benin (Kinde-Gazard *et al*., 2004). Other West African countries, share similar risks of malaria; however, the percentage of children under 5 years, who slept under a mosquito net during the night preceding the survey is higher in Benin: in 34% of households with children under age 5, all children under age 5 slept under a net the previous night Benin, 2001; DHS (INSAE and ORC Macro, 2002). Benin also has a long history of programmatic activities around the use of mosquito nets: in 1992, the international

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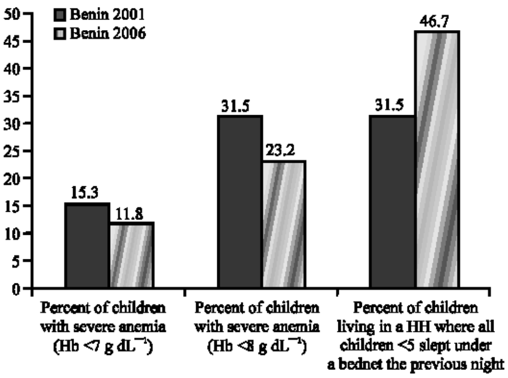

Fig. 1: Percent of children 6-23 months with severe anemia and children <5, who slept under the bednet a night before the survey in 2001 and 2006

Development Research Center (IDRC) initiated a community-based ITN program in the country; Benin is also the recipient of grants for the Malaria Control Booster Project, which will support the country's Roll Back Malaria (RBM) Strategic Plan from 2006-2010. Given the history of programmatic activity around mosquito nets, the relatively high levels of use of mosquito nets in the population and the intense and perennial nature of malaria transmission, it is of interest to assess the association between use of bednets and malaria as proxied by severe anemia in Benin.

Defining severe anemia: Because it has been argued that severe anemia should be used to estimate the prevalence of malaria at the national level and because prevalence of severe anemia is more than double at Hb <8 g dL^{-1} what it is at Hb <7 g dL^{-1} (Fig. 1), any decision about defining the cut-off for severe anemia in the presence of malaria be empirically-based. Thus in addition to assessing the association between mosquito net use and severe anemia, we also attempt to discern the comparative validity of the two cut-offs for defining severe anemia.

MATERIALS AND METHODS

Nationally representative data from the Benin DHS in 2001 and 2006 were used for this analysis. Funded by the US Agency for International Development (USAID), both surveys were implemented by Benin's Institute National de la Statistque et de l'Analyse Économique with technical assistance from MEASURE DHS, a Macro International project. In addition to questions on health and reproduction, the DHS questionnaire includes a small number of questions on malaria. These include questions on Intermittent Preventive Treatment (IPT) during pregnancy among women with a birth in the 5 years preceding the survey, prompt and effective treatment of fever among children under age 5 and mosquito net/ITN use among household members. In this analysis, no distinction is made between the use of treated or untreated nets, because data on type of net used in the household were not collected for the 2001 survey.

In the 2001, Benin DHS, 97% of the selected households responded to the survey, resulting in completed questionnaires for 5,769 households in the 2006 Benin DHS, 97% of selected households responded, yielding completed questionnaires for 17,511 households.

The selection of the age range of the study sample was informed by a number of considerations. Children born in malaria-endemic areas are usually protected from severe anemia in the first 6 months of life due to maternal Immunoglobulin (Ig) and by expression of fetal hemoglobin (Weatherall *et al*., 2002; Riley *et al*., 2001) and thus do not have the same risk of anemia as experienced by older children. Use of ITNs is associated with greater reductions in the severity of anemia in children age 6-23 months compared with older children. In addition, seasonal fluctuation in anemia prevalence is greatest in the age group 6-23 months (Korenromp *et al*., 2004). Also, high levels of anemia (<8 g dL^{-1}) in children occur between the ages of 6 and 17 months indicating a vulnerable age group exposed to high malaria transmission levels (Eliades *et al*., 2006). Given these considerations, the study sample for this analysis consists of all last-born children age 6-23 months, who were tested for anemia. This selection strategy results in the inclusion into the study sample of one child per household, thus, precluding any intra household correlations among children. The number of cases was 706 in the 2001 dataset and 1,359 in the 2006 dataset. The number of cases included in the 2006 analysis is small relative to the number of households included in the survey because anemia testing took place in a one-third subsample of households. Data collection for both surveys was carried out from August to November during the malaria transmission season; thus, any seasonal variations in malaria-related behaviors that could hypothetically affect our analysis, such as use of mosquito nets are in effect held constant over the two surveys.

We construct two dichotomous dependent variables: one variable where severe anemia is defined as having a hemoglobin concentration of <7 g dL^{-1} per the conventions of the nutrition community and one where severe anemia is defined as having a hemoglobin concentration of <8 g dL^{-1} per the conventions of the RBM partnership (Korenromp *et al*., 2004). Anemia status was assessed by measuring children's hemoglobin levels using the hemoglobinometer by HemoCue System (HemoCue Sweden).

The independent variable of interest reflects use of mosquito nets by children under age 5 in the household and has the following three categories: no mosquito nets exist in the household or no children slept under any mosquito net the previous night; some but not all children in the household slept under mosquito nets the previous night and all children in the household slept under mosquito nets the previous night. It is expected that complete mosquito net coverage of all children in a household will afford the best protection from infection by *P. falciparum*, thus, reducing the risk for severe anemia.

Another key, independent variable included in the model is height-for-age (stunting). The two main forms of malnutrition among children worldwide are anemia and stunting (height for age ≤2 SD below the NCHS/WHO international growth reference (Branca and Ferrari, 2002)). In an effort to isolate the effects of malarial contributions to anemia we controlled for stunting, which indicates chronic malnutrition. The length of the child was measured using a height Board (Shorr Inc.) for all children 6-23 months in the household regardless of whether, the mother was co-resident. Stunting was entered into the model as a continuous variable. Two other nutrition variables were added to the model to control for the child's acute nutritional environment: the child's consumption of meat in the past week and the child's breastfeeding status.

Previous research indicates that sex-linked genetic mutations may enhance male resistance to the progression of malaria and severe anemia (Guindo *et al*., 2007) thus, we include sex of the child in the models. Ownership of mosquito nets varies by household economic status in Benin, as does the quality of housing materials (Gwatkin *et al*., 2007). When in good condition, both of these serve to protect against bites from Anopheles mosquitos. Further in Benin, household wealth is strongly associated with severe anemia. We therefore, control for wealth using asset-based wealth index quintiles (Rutstein and Johnson, 2004).

Other independent variables included in the model are child's age in months (grouped) and residence (urban or rural).

Chi-square (χ^2) tests of independence and one-way ANOVAs were used in bivariate analyses, while, logistic regression was chosen for multivariate analysis. All statistical analysis was conducted with SPSS version 15 (SPSS Inc. Chicago).

RESULTS

Descriptive statistics: In 2001, 32% of children ages 6-23 months were living in a household where, all children under 5 years of age slept under a mosquito net the night before the survey; this figure increased to 47% in 2006. At the same time that mosquito net use increased, severe anemia in children age 6-23 months, defined respectively as Hb <7 and <8 g dL^{-1}, decreased over time from 15 and 32% in 2001 to 12 and 23% in 2006 (Fig. 1). The survival of children also improved in Benin from 2001-2006; the under-five mortality rate declined from 160-125 during the same time period (INSAE and Macro, 2007). Several plausible factors could have contributed to the observed reduction in morbidity and mortality including malaria control programs with widespread distribution and use of ITNs.

Table 1 shows that while severe anemia was consistently higher for males than for females, the difference was not statistically significant except in 2006 at the Hb <8 g dL^{-1} cut-off, where the relationship bordered on significance (p = 0.053). While, the age variable was not significant in the bivariate analysis, the oldest age group, 21-23 months, was consistently least likely to be severely anemic. As expected, the association between severe anemia according to either cut-off definition and wealth quintile was significant, with children in the two wealthiest quintiles being less likely than the others to experience severe anemia. Use of mosquito nets was significantly and negatively associated with severe anemia and children who lived in households where, all children under 5 slept under a mosquito net were the least likely to be severely anemic. Rural children were consistently more likely to demonstrate severe anemia; however, this relationship was not always statistically significant. Children, who were currently breastfeeding were consistently more likely to be severely anemic; however, the relationship only attained statistical significance at $p<0.05$ in 2006. Children who had consumed meat in the week before the survey were less likely to be severely anemic; the relationship was highly statistically significant except in 2001 under the Hb <7 g dL^{-1} cut-off definition. Similarly, children with severe anemia had a significantly lower height-for-age than children without severe anemia in all instances except for children who had Hb <7 g dL^{-1} in the 2001.

In both data sets, stunting was negatively associated with use of mosquito nets, i.e., children living in households where all children under five slept under mosquito nets were taller than children who lived in households where no children or only some children slept under the nets. However, the relationship was not statistically significant.

Multivariate results: Table 2 shows the results of the multivariate models. Model 1 shows the results when severe anemia is defined as Hb <7 g dL^{-1} and mosquito

Table 1: Percent of last-born children age 6-23 months with Hemoglobin (Hb) levels <7 and <8 g dL^{-1}, with p-values for chi- square test, according to selected characteristics, 2001 and 2006 Benin DHS

	Benin 2001			Benin 2006		
Selected covariates	Percent Hb <7 g dL^{-1}	Percent Hb <8 g dL^{-1}	n	Percent Hb <7 g dL^{-1}	Percent Hb <8 g dL^{-1}	n
Sex of child	p = 0.359	p = 0.114		p = 0.115	p = 0.053	
Male	16.5	34.2	357	13.2	25.5	659
Female	14.0	28.7	349	10.4	21.0	699
Child's age (months)	p = 0.258	p = 0.254		p = 0.248	p = 0.062	
6-8	14.4	30.7	139	13.7	24.4	270
9-11	17.2	30.8	116	14.9	24.7	255
12-14	16.2	36.8	117	10.9	23.6	238
15-17	17.9	36.6	123	10.3	22.0	223
18-20	18.7	29.0	107	11.6	27.1	225
21-23	7.8	23.3	103	7.4	13.5	148
Wealth quintiles	p = 0.002	p = 0.000		p = 0.000	p = 0.000	
Poorest	19.3	41.0	166	11.3	27.1	284
Second	22.2	38.2	153	18.1	29.4	299
Middle	15.5	29.3	148	12.5	28.3	271
Fourth	9.4	24.6	138	10.8	20.1	269
Wealthiest	6.9	18.6	102	5.1	8.9	236
Use of bednets	p = 0.025	p = 0.000		p = 0.000	p = 0.000	
No children	18.1	37.2	441	15.2	29.1	572
Some children	11.9	34.9	42	16.0	27.8	150
All children	10.3	19.7	223	7.7	16.7	635
Residence	p = 0.005	p = 0.110		p = 0.078	p = 0.005	
Rural	17.9	33.5	474	12.9	25.5	904
Urban	9.9	27.6	232	9.7	18.7	455
Child currently breastfeeding	p = 0.205	p = 0.070		p = 0.001	p = 0.000	
No	10.4	22.4	77	3.3	11.8	152
Yes	15.9	32.6	629	12.9	24.6	1206
Child ate meat in past week	p = 0.174	p = 0.001		p = 0.000	p = 0.000	
No	17.0	37.0	376	15.2	28.1	730
Yes	13.3	25.2	330	7.8	17.5	628
Height for age SD	p = 0.297	p = 0.052		p = 0.007	p = 0.033	
Mean SD no severe anemia	-120.19	-115.07	547 (440)	-157.45	-156.48	1070 (929)
Mean SD, severe anemia	-138.72	-140.00	99 (207)	-196.51	179.98	138 (279)
Total	15.5	31.6	706	11.8	23.2	1359

SD: Standard Deviation z-score

net use is not included in the model; model 2 adds the mosquito net use variable. Model 3 shows the results when severe anemia is defined as Hb <8 g dL^{-1} and mosquito net use is not included in the model and Model 4 adds the mosquito net use variable.

Adjusted results of the Benin, 2001 multivariate analysis indicate that use of mosquito nets by all children under age 5 in the household results in a 42% reduction in the odds that a child will have severe anemia as defined at the Hb <7 g dL^{-1} cut-off (p = 0.057); a 56% reduction in the odds of severe anemia as defined at Hb <8 g dL^{-1} was also observed (p = 0.000). The adjusted results of the Benin, 2006 multivariate analysis are similar: the odds of severe anemia are reduced by 49% with the use of mosquito nets among all children under age 5 in the household where severe anemia is defined at Hb <7 g dL^{-1} and by 41% where, severe anemia is defined at Hb <8 g dL^{-1} (p<0.005 for both models).

With regard to the other covariates, we find that compared with boys, girls consistently have lower odds of severe anemia; this relationship is significant at the 10% level only in 2006. As expected, we find in most models that children in the wealthiest quintile are significantly less likely to be severely anemic than children in the poorest quintile. Residence is not significantly associated with severe anemia in any model; the lack of significance is not explained by the presence of the wealth variable, which is sometimes correlated with urban residence. Nutritional status is only significant for the 2006 model of Hb <7 g dL^{-1}; severe anemia is associated with a small decrease in height-for-age. While, the breastfeeding variable is not significant when analyzing the data from 2001, it is highly significant in 2006 and is associated with a three-fold increase in the odds of severe anemia defined as Hb <7 g dL^{-1} and a 90% increase in the odds of severe anemia defined as <8 g dL^{-1}. In 2001, the child's consumption of meat in the week prior to the survey was significantly associated with a reduction of about 35% in severe malaria defined at Hb <8 g dL^{-1}, but not defined at Hb<7 g dL^{-1}, suggesting the greater importance of dietary contribution to severe anemia defined as Hb<8 g dL^{-1}. In 2006, however, consumption of meat was significantly associated with severe anemia at both cut-off definitions, with meat

Table 2: Logistic regression results: likelihood of being severely anemic (using two sets of definitional cut-offs: Hb <7 and Hb <8 g dL^{-1}), among last-born children age 6-23 months, 2001 and 2006 Benin DHS

	Model 1 Severe anemia (<7 g dL^{-1})		Model 2 Severe anemia (<7 g dL^{-1})		Model 3 Severe anemia (<8 g dL^{-1})		Model 4 Severe anemia (<8 g dL^{-1})	
Selected covariates	Sig.	Exp (β)	Sig.	Exp (β)	Sig.	Exp (β)	Sig.	Exp (β)
Benin 2001								
Sex (ref: male)	0.150	0.719	0.131	0.706	0.166	0.783	0.137	0.766
Child's age in months (ref: 6-8 m)								
9-11	0.547	1.241	0.629	1.189	0.844	1.058	0.993	0.997
12-14	0.871	1.064	0.956	1.021	0.300	1.361	0.388	1.298
15-17	0.463	1.327	0.508	1.291	0.165	1.523	0.205	1.477
18-20	0.604	1.238	0.765	1.132	0.946	0.979	0.678	0.870
21-23	0.060	0.341	0.041	0.311	0.193	0.604	0.110	0.535
Wealth (ref: Poorest quintile)								
Second	0.492	1.226	0.420	1.272	0.775	0.932	0.950	0.984
Middle	0.479	0.798	0.532	0.819	0.083	0.643	0.113	0.665
Fourth	0.032	0.436	0.056	0.475	0.004	0.451	0.016	0.506
Wealthiest	0.039	0.343	0.096	0.414	0.002	0.324	0.018	0.420
Use of bednets (ref: No children used)								
Some children	-	-	0.422	0.662	-	-	0.642	0.842
All children	-	-	0.057	0.584	-	-	0.000	0.441
Residence (ref: rural)	0.282	0.722	0.303	0.730	0.920	1.023	0.938	1.018
Height for age (continuous)	0.355	0.999	0.370	0.999	0.147	0.999	0.167	0.999
Currently breastfeeding (ref: no)	0.749	0.852	0.675	0.810	0.828	0.924	0.620	0.832
Child given meat in past week (ref: no)	0.700	0.910	0.712	0.913	0.026	0.654	0.033	0.661
Constant	0.000	0.130	0.000	0.116	0.000	0.381	0.000	0.367
-2 LL	-	521.700	-	517.600	-	765.200	-	750.100
Benin 2006								
Sex (ref: male)	0.065	0.708	0.093	0.728	0.068	0.772	0.097	0.790
Child's age in months (ref: 6-8 m)								
9-11	0.231	1.392	0.198	1.430	0.149	1.381	0.122	1.416
12-14	0.581	0.845	0.573	0.841	0.578	1.138	0.570	1.142
15-17	0.940	0.976	0.935	1.026	0.247	1.322	0.185	1.380
18-20	0.932	0.973	0.994	1.002	0.065	1.568	0.050	1.617
21-23	0.675	0.840	0.665	0.834	0.532	0.820	0.535	0.820
Wealth (ref: Poorest quintile)								
Second	0.063	1.604	0.061	1.612	0.678	1.085	0.673	1.087
Middle	0.616	1.150	0.400	1.269	0.692	1.084	0.420	1.182
Fourth	0.980	1.008	0.645	1.149	0.249	0.776	0.532	0.869
Wealthiest	0.022	0.365	0.106	0.483	0.000	0.247	0.000	0.309
Use of bednets (ref: No children used)								
Some children	-	-	0.951	0.983	-	-	0.684	0.912
All children	-	-	0.002	0.518	-	-	0.001	0.591
Residence (ref: rural)	0.442	1.182	0.415	1.195	0.142	1.279	0.128	1.292
Height for age (continuous)	0.023	0.999	0.026	0.999	0.102	0.999	0.110	0.999
Currently breastfeeding (ref: no)	0.021	3.488	0.024	3.422	0.026	1.992	0.028	1.978
Child given meat in past week (ref: no)	0.016	0.603	0.023	0.618	0.003	0.630	0.004	0.641
Constant	0.000	0.051	0.000	0.055	0.000	0.181	0.000	0.190
-2 LL	-	809.500	-	799.100	-	1238.500	-	1226.900

Sig.: Significance, Exp(B): Exponentiated Beta/odds ratio

consumption associated with an approximately, 40% reduction in severe anemia for the models of Hb <7 g dL^{-1} and by about 35% for the models of Hb <8 g dL^{-1}.

DISCUSSION

Results of the Benin 2001 and 2006 multivariate analysis indicate that, controlling for a variety of confounding and background variables, use of mosquito nets by all children in the household results in a 42 and 48% reduction, respectively in the likelihood that a child will have severe anemia defined as Hb <7 g dL^{-1}. Use of mosquito nets is also associated with a 56 and a 41% reduction in severe anemia defined as Hb <8 g dL^{-1}, in 2001 and 2006, respectively.

A myriad of smaller studies have found similar results with the use of mosquito nets in the households. A community-based, group randomized, controlled trial of ITNs in western Kenya followed infants from birth to 24 months. The study observed that the ITNs reduced the malaria attack rates by 74% in infants. The incidence of clinical malaria and moderate-to-severe anemia was reduced by 60% (Ter Kuile *et al*., 2003). In Malawi, Holtz *et al*. (2002) observed that 15% of children in households that had no mosquito nets were anemic (<8 g dL^{-1}), compared with 7% of children who lived in a household with one or more mosquito nets-a >50% reduction in severe anemia in children <5 years of age. In Tanzania, Njagi *et al*. (2003) observed the protective efficacy of ITNs on anemia was 42% in pregnant women. Marchant *et al*. (2002) also observed that use of ITNs reduced the risk of severe anemia by 38% in pregnancy.

Low socio-economic status remains a significant risk factor for severe anemia. Poverty and malaria are intimately associated. Malaria-endemic countries are not only poorer than non-malarious countries, but they also have lower rates of economic growth (Sachs and Malaney, 2002). In addition, malaria has economic consequences including direct costs (medical consultations, hospitalizations, laboratory tests and medications) and indirect costs (work days lost) for households that are already socioeconomically disadvantaged (Rashed *et al*., 2000). Socio-economic disparities in the use of mosquito nets are evident from various studies. About 92% of women in Tanzania reported lack of money as the main reason for not using ITNs (Marchant *et al*., 2002). In another study in Malawi (Holtz *et al*., 2002), among households that did not own a mosquito net, 85% reported not having a mosquito net due to lack of money. Qualitative research also finds that the cost of mosquito nets can prohibit ownership even when household members recognize their importance and effectiveness (Okrah *et al*., 2002).

The study also indicates that being a female child reduces the risk of having severe anemia in both the 2001 and 2006 surveys by about 30%, although, about the same number of male and female children slept under mosquito nets the night before the survey.

Several nutritional indicators exerted more significant effects on the dependent variable in 2006 than in 2001. Stunting was significant in the 2006 model of Hb <7 g dL^{-1}, but not in either 2001 model. The current breastfeeding status of the child had no significant association in 2001 in either the bivariate or the multivariate analysis and yet in 2006, it was highly significantly associated with severe anemia with large effects. In 2001, consumption of meat was significantly associated with severe anemia status only when modeling severe anemia defined at Hb <8 g dL^{-1}; by 2006, consumption of meat was statistically significantly associated with severe anemia at both cut-off levels. These results in conjunction with the overall increase in moderate to severe stunting in Benin between 2001 and 2006 (from 31-43%; INSAE and Macro, 2007), suggest that a problem of insufficient dietary intake increased in magnitude between the two survey periods. Though the under-five mortality decreased from 2001-2006, it is still plausible to find a positive association between child survival and undernutrition as greater numbers of children survive in a setting that is more resource-constrained than usual.

Finally, we find that the goodness of the model fit, as reflected by the -2 Log Likelihood (-2 LL) value, is better then the dependent variable is defined as Hb <7 g dL^{-1} as compared to being defined as Hb <8 g dL^{-1}. For the 2001 models that include the mosquito net variable, the -2 LL value for the model of Hb <7 g dL^{-1} is 518; this compares favorably with the -2 LL value for the model of Hb <8 g dL^{-1}, which is 750. The 2006 data produce even starker differences in goodness of fit, with the model of Hb <7 g dL^{-1} having a -2 LL of 799, as compared to 1227 for the model of Hb <8 g dL^{-1}. The coefficients for the meat consumption variable in the 2001 models also suggest that nutrition is more important in determining hemoglobin levels among those with Hb <8 g dL^{-1} as compared to those with <7 g dL^{-1}; however, given the increase in malnutrition from 2001-2006 survey, interpretation of the food-consumption variables for 2006 is unclear. The results of this analysis are equivocal on the question of whether <7 or <8 g dL^{-1} is the more valid cut-off point to define severe anemia in the context of malaria. However, while more data points are required to assess the performance of the two definitional cut-offs for severe anemia as they relate to the performance of malaria control activities, these results and those presented elsewhere (Johnson and Sangha, 2008) suggest that the cut-off of <7 g dL^{-1} may be more specific to malaria than that of <8 g dL^{-1}.

CONCLUSION

The findings show that mosquito net use is associated with reduced odds of severe anemia in children in Benin, net of competing factors, at the national level. Several other smaller studies have shown the impact of mosquito nets, specifically ITNs, on maternal anemia and parasitemia in high transmission areas. Malaria in pregnancy increases the risk of abortion, stillbirth, pre-maturity, intrauterine growth retardation and low birth weight in infants. Since, low birth weight children in turn are predisposed to malaria, ITN coverage for pregnant women and their newborns is equally important as for young children.

These results also support the suggestion that severe anemia reflects the prevalence of malaria to some unquantified (and perhaps unquantifiable) degree. Because severe anemia increases the probability of death, it is likely that malaria control interventions such as mosquito net use not only reduce severe anemia at the national level, but also reduce the mortality of children at the national level as well. However, coverage is poor for children under five and even worse for children in rural areas. In addition, even when people know that having a mosquito net is beneficial, poverty may prevent them from acquiring one. Therefore, not only encouraging the use of mosquito nets but also making them available to the households that cannot afford them is a critical element required to reap broad-based health benefits from this low-cost intervention.

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