Socioeconomic status and malaria-related outcomes in Mvomero District, Tanzania

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ABSTRACT

While policies often target malaria prevention and treatment – proximal causes of malaria and related health outcomes – too little attention has been given to the role of household- and individual-level socioeconomic status (SES) as a fundamental cause of disease risk in developing countries. This paper presents a conceptual model outlining ways in which SES may influence malaria-related outcomes. Building on this conceptual model, we use household data from rural Mvomero, Tanzania, to examine empirical relationships among multiple measures of household and individual SES and demographics, on the one hand, and malaria prevention, illness, and diagnosis and treatment behaviours, on the other. We find that access to prevention and treatment is significantly associated with indicators of households' wealth; education-based disparities do not emerge in this context. Meanwhile, reported malaria illness shows a stronger association with demographic variables than with SES (controlling for prevention). Greater understanding of the mechanisms through which SES and malaria policies interact to influence disease risk can help to reduce health disparities and reduce the malaria burden in an equitable manner.

I. Introduction

While much work has been done on socioeconomic disparities in health outcomes in developed countries (e.g., Adler and Rehkopf 2008), less attention has been given to health inequities in the context of infectious disease in developing countries (Schellenberg et al. 2003). Since malaria presents one of the greatest health challenges facing the developing world, resulting in over 300 million acute illnesses each year and killing an African child every 30 seconds (World Health Organization 2002), disparities in malaria outcomes are of particular interest. The global burden of malaria is highly unequally distributed, with a striking overlap between malaria and poverty rates at a national level (Sachs and Malaney 2002). Within countries, evidence for a socioeconomic gradient in malaria illness is more mixed (Worrall et al. 2005), but several studies suggest that low socioeconomic status (SES) is associated with higher malaria rates (Who/Unicef 2005; Hustache et al. 2007; Somi et al. 2007; Bernard et al. 2009).

This paper addresses the relationships between socioeconomic status and malaria both conceptually and empirically. Our conceptual framework builds on Stratton et al.'s discussion of the *fundamental* and *proximal* causes of malaria (Stratton et al. 2008). *Proximal* causes of malaria are the usual targets of malaria control policies, and include access to and use of prevention measures to reduce exposure to malaria-transmitting mosquitoes, and treatment measures to improve outcomes once someone falls sick. Meanwhile, the *fundamental* causes of malaria illness include a range of 'upstream' factors

including socioeconomic context, environmental conditions, global inequality, systems of health care provision, and global health care research. Complex interactions between fundamental and proximal causes ultimately shape the distribution of malaria illness and related morbidity and mortality.

In light of this framework, our empirical study uses a household-level dataset from ten rural villages in Mvomero District, Tanzania, to examine the relationships between household socioeconomic and demographic indicators, on the one hand, and malaria prevention, illness, and diagnosis and treatment indicators, on the other. By examining how various aspects of SES, including wealth, education, occupation, religion, age, and gender, are associated with malaria-related outcomes, we are able to discern patterns that may provide insight into the SES-malaria relationship.

II. Conceptual Framework

Our conceptual framework aims to shed light on some of the ways in which individual- and household-level socioeconomic and demographic conditions can shape malaria-related outcomes. To address this question, we first need a working definition of socioeconomic status. For our purposes, we are concerned with the range of factors that indicate or determine positioning within a social hierarchy, including income or wealth, education, occupation, and ethnicity, as well as demographic factors like household size, age, and gender.

A second point of clarification is that our primary concern in this paper is with *individual-* and *household*-level status as they relate to malaria outcomes. As the Stratton

et al. framework highlights, several fundamental causes of malaria operate at the level of community-, regional-, national-, or even international-level phenomena, from local environmental conditions to global inequalities. Addressing the linkages between each of these factors and households' malaria outcomes is beyond the scope of this paper. Instead, we are primarily concerned with assessing more micro-scale relationships between SES and malaria, while recognizing that these relationships occur within broader contexts.

From this perspective, Figure 1 outlines several pathways that may potentially link individual and household SES to malaria and subsequent health status (e.g., mortality).

Pathway 1: SES affects access to malaria prevention

Several aspects of SES may influence behaviours that prevent malaria. For example, ownership and use of mosquito nets may increase with wealth and education (Noor et al. 2006; Bernard et al. 2009; McElroy et al. 2009).

Pathway 2: SES as a fundamental cause of malaria

SES may affect the probability that individuals get malaria *via* its influence on malaria prevention; however, some SES indicators may also affect malaria illness directly. For example, housing quality may influence exposure to mosquitoes (e.g., Ye et al. 2006). Recent research linking psychological stress (higher among lower SES groups) to immune functioning, including susceptibility to infectious disease (Glaser et al. 1999), suggests another potential pathway.

Pathway 3: SES affects access to accurate diagnosis and effective malaria treatment, affecting subsequent health outcomes

Even if probability of illness is constant across the population, malaria-related morbidity and mortality may be worse among lower SES groups if these groups are not diagnosed correctly and/or do not receive prompt and effective treatment for their illness (e.g., Schellenberg et al. 2003; Njau et al. 2006).

To summarize these three pathways, SES may affect access to malaria prevention and treatment, and may also affect malaria illness more directly. However, we are careful to note that observed association between SES and malaria may be due to other causal pathways. Household-level SES interacts with other fundamental causes of poor health outcomes, from community-level social resources to environmental conditions. Causality may also run in the opposite direction – i.e., from health status to SES. At an international level, Gallup & Sachs (2001) estimate that countries with intense malaria have income levels that are only 33% of non-malarial countries, and Somi et al. (2007) also find evidence for a dual causality between malaria and SES within Tanzania.

Given the multitude of pathways potentially linking SES and malaria, our goal is not to provide definitive evidence supporting one causal mechanism over another. Instead, we use a cross-sectional household-level dataset to explore associations between SES indicators, on the one hand, and malaria-related outcomes, on the other, in one specific context. Patterns of association that emerge shed light on the plausibility of different pathways in this location, identifying priority areas for future study. Our results also

highlight disparities in both health outcomes and access to health-promoting resources, potentially informing policies to promote greater health equity in this context.

III. Empirical Methods

In June of 2007, we conducted a study of malaria behaviours and outcomes in Tanzania's Mvomero District (6.139-6.463°S, 37.53-37.64°E), a rural area located in the northern section of Morogoro Region about 200 km west of Dar es Salaam. The total population of Mvomero is about 280,000, and it covers an area of 7,325 km^2 (Ngasongwa 2007). Primary economic activities include crop farming and, to a lesser extent, livestock rearing. Malaria is the leading cause of morbidity and mortality among both adults and children in Mvomero (Ngasongwa 2007); transmission occurs throughout the year and is expected to peak during the long rainy season (March-May). Prior work indicates that the overall prevalence of *P. falciparum* in our study area is about 35% (Mboera et al. 2007). Mvomero has a total of three hospitals (one public, two private), 43 dispensaries (35 public, 8 private), and four health centres for an overall ratio of 1.8 health facilities per 10,000 people.

Of the 101 villages in the district, we purposively selected 10 villages to represent a range of agricultural and ecological conditions (see Figure 2). We systematically randomly sampled 408 households from lists maintained in each village, with population weighting used to determine the number of surveys conducted in each village. Five experienced male Tanzanian interviewers administered the surveys in Tanzania's national language, Kiswahili, which is spoken throughout the study area. To ensure gender balance

in our sample, enumerators alternately administered surveys to male heads of household and female primary caregivers.

The study protocol, including the final survey instrument and its statement of informed consent, were reviewed by Duke University's Institutional Review Board and the National Institute for Medical Research in Tanzania. Research clearance and permits were obtained from the Tanzanian Commission for Science and Technology.

SES and Demographic Indicators

We use a variety of indicators to measure different components of households' SES, including wealth, education, occupation, religion, and household composition. Descriptive statistics for these indicators are presented in Table 1. While most of these variables are self-explanatory, our choice of wealth measures requires further discussion. Our study faces the common challenge of accurately measuring this fundamental component of SES in a rural agricultural setting. In particular, since reliable measures of income or expenditure are difficult to collect, we draw on a variety of asset and infrastructure indicators including ownership of consumer durables, housing characteristics, home and land ownership, and ownership of large livestock.[1] In addition to being easier to measure, asset-based measures are closely correlated with expenditure across a variety of contexts (Filmer and Pritchett 2001).

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[1]Other variables that have been shown to be significantly correlated with wealth in similar contexts include drinking water and latrine access (Njau et al. 2006; Vyas and Kumaranayake 2006). Regrettably, this data was not collected in our survey.

Among studies that have adopted asset-based wealth measurement, there have been two broad approaches. The first involves aggregating different indicators into a single wealth index using principal components analysis (Schellenberg et al. 2003; McKenzie 2005; Vyas and Kumaranayake 2006). While this approach is useful in drawing broad conclusions about how outcomes vary by wealth, it can obscure which dimensions or measures of wealth are related to the outcome of interest. Thus, the second approach is to include various asset measures directly in order to explore a wider set of relationships (e.g., does ownership of durables have a different relationship with the outcome of interest compared to livestock ownership?).

Our approach here is hybrid. We use principal components analysis to create a single *durables* index using eight locally-available items selected based on prior work in Mvomero (see Table 1). However, rather than including our other assets (house size, house quality, home ownership, land ownership, and livestock) in this index, we include them separately in subsequent analyses. This choice is based in part on an examination of the pairwise correlation coefficients (Table 2) among these different indicators, which suggest that these six variables are capturing different aspects of wealth. For example, livestock ownership is only significantly (and weakly: $\rho=0.10$) correlated with durables and land ownership, and we think it is likely that livestock ownership captures cultural, lifestyle, and occupational differences in addition to economic prosperity more narrowly. Including these measures separately also allows a more detailed view into multiple potential pathways (e.g., direct effects of livestock ownership or housing quality on malaria infection).

Other SES indicators include years of **education** and primary **occupation** of the head of household. Table 1 shows that a third of household heads had no formal education, while about 58% had only a primary education and 8% had a secondary or higher education. Surveyed households are overwhelmingly agricultural, with less than 3% of households listing business as their occupation while more than 97% of household heads are employed in crop farming, livestock rearing, or mixed farming (crops + livestock).

Turning to households' **religion**, 35% of respondents self-identified as Christian while 65% were Muslim. **Household composition** was also included in the analysis, as these demographic characteristics may be related to a household's status. Households consisted of an average of 4.6 individuals, including 0.59 children under five, and were male-headed in 82% of cases. Household heads ranged in age from 18 to 105 years (mean = 45). Interviewers achieved a roughly equal gender balance for survey respondents (49% male vs. 51% female). To examine potential reporting differences between men and women, respondents' gender is included as an explanatory variable in subsequent analyses.

Malaria Prevention, Illness, and Treatment Indicators

Malaria-related indicators include malaria prevention, illness, and diagnosis and treatment. Descriptive statistics for these indicators are presented in Table 3. Turning first to prevention, we focus on ownership of insecticide treated mosquito nets (ITNs). Tanzania has been a leader in implementing policies to promote and distribute ITNs throughout the country, initiating a program of voucher subsidies for pregnant women in

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2004 and subsequently extending these to children under five (Magesa et al. 2005; Khatib et al. 2008). Our interviewers asked survey respondents whether or not they owned any nets; 93% of survey respondents responded affirmatively. Interviewers then asked to enter the how and directly observe nets, and were permitted to do so in 83% of surveyed households. For each net, interviewers asked whether or not it had been treated with an insecticide. As our primary indicator of a household's malaria prevention behaviour, we measured the ratio of recently-treated ITNs to household members – i.e., ITNs per capita. Among households with available data (i.e., excluding households that claimed to have nets but did not allow interviewers to observe nets directly), the average ratio of ITNs per capita was 0.27, or roughly one ITN for every four individuals.[2]

Turning to malaria illness, respondents were asked whether or not each household member had suffered from malaria in the past three months. Since our survey was conducted in June, the three-month recall period used to measure reported malaria overlaps with the peak prevalence season (March-May). Budget limitations precluded the collection of parasitological data from blood tests, and we acknowledge the potential limitations of using self-reported malaria data (although there is some evidence that misreporting is less of an issue for children in high transmission areas (Reyburn et al. 2004)). To be cautious, however, our data should more accurately be interpreted as measuring the incidence of malaria-like symptoms (e.g., fever), rather than malaria *per se*. Moreover, because we are also interested in diagnosis and treatment behaviours, *perceived* malaria illness is an

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[2] Condition of nets is also an important factor to consider. In practice, most (93%) of the nets that were observed by interviewers were either "intact" or had only "small holes." Because we do not observe a lot of variation in nets' condition, and because nets with small holes can still be effective if they are treated with insecticides, we believe ITNs per capita is a more useful measure of prevention access in this context.

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interesting indicator in its own right. We thus report results based purely on respondents'

reports of illness (i.e., "Did [household member] have malaria in the past three months?").

The self-reported malaria prevalence among individuals in our sample was 52.8% over the

three months prior to the survey. Reported prevalence was higher among children under

five (69.2%) compared to all other individuals (50.5%).

For each reported malaria case, interviewers collected information about how the

case was diagnosed ("How did you know it was malaria?"). Our key diagnosis and

treatment indicator records whether or not the reported malaria case was diagnosed at a

health facility using a blood test. In addition to being the most accurate form of diagnosis,

this indicator may reflect access to a 'high-quality' health facility. Respondents reported

that individuals received blood test diagnoses in 37% of reported cases (Table 3). In an

additional 42% of cases, individuals went to a health facility for diagnosis but did not

receive a blood test, while individuals were self-diagnosed in 21% of cases. Interestingly,

out of a total of 957 reported malaria cases, only one was reportedly diagnosed by a

traditional healer.

Data Analysis

Survey data were analyzed using Stata 11/SE software (StataCorp 2009). We

examined relationships between SES and malaria indicators using regressions of the

general form:

$$Y_{ijk} = f(n_{ijk}, X_{jk}, Z_k) + \varepsilon_{ijk}$$

where Y is the outcome of interest, i denotes individuals, j denotes households, k denotes villages, n_{ijk} are individual variables (for outcomes measured at the individual level) and X_{jk} are household characteristics. In addition, Z_k are village variables: there are potentially multiple contextual factors that will be associated with variation in behaviours and health outcomes across the study villages. Because we are primarily interested in examining the relationship between *household-level* SES and malaria indicators, our approach here is to include a full set of village dummy variables or fixed effects. This approach essentially differences out unobserved heterogeneity *across* villages and allows us to isolate the association between household characteristics and malaria-related outcomes *within* villages.[3]

We use a linear regression model for ITNs per capita. For the binary malaria illness and diagnosis indicators, we report marginal effects calculated from multivariate probit models. For our household-level prevention measure (ITNs per capita) we use village-clustered standard errors to account for interdependence of outcomes within villages, while our analyses of individual-level outcomes (reported illness and blood test diagnosis) cluster at the household level.

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[3] It is also possible that the relationship between SES and malaria is heterogeneous *within* villages. For example, education may have larger effects for very poor households. Our sample size precludes a more thorough examination of these interactions, and the effects we identify should be viewed as *average* effects within villages.

IV. Results

Table 4 presents results from multivariate regressions assessing the relationships among SES and malaria-related indicators.[4] Turning first to prevention, we find that three wealth indicators (living in a large house, owning more land, and owning large livestock) are positively and statistically significantly associated with ITN ownership. Households with more children under five actually tend to have fewer ITNs per capita, as do larger households more generally. We do not observe differences in ITN ownership based on education, religion, occupation, gender, or age of the household head.

To separate the relationship between SES and prevention, on the one hand (i.e., Pathway 1 in Figure 1), from a more direct relationship between SES and malaria illness (Pathway 2), we included ownership of ITNs as an explanatory variable in the malaria illness regressions. Results indicate that the probability of a reported malaria cases is lower in households with more ITNs per capita. Turning to SES indicators, both the consumer durables index and house quality are positively associated with an individual's probability of having a reported malaria case. Individuals are somewhat less likely to have a reported case if their household owns large livestock, and if their household head is employed in business. Overall, having more individuals in the household is associated with a *lower* likelihood of reported malaria, but having more children under five in the household increases the likelihood that an individual had a reported case. Not surprisingly, children under five are themselves more likely to have had a reported malaria case. We also observe that male-headed households had a higher incidence of reported malaria.

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[4] Bivariate relationships were also examined. Results available from the authors upon request.

Finally, we examine use of blood tests for malaria diagnosis for all individuals who had a reported malaria case. Durables and home ownership are positively associated with this outcome. Education, occupation, and religion are not significantly associated with receiving a blood test. Individuals are less likely to receive a blood test diagnosis in larger households, and males were marginally less likely than females to be diagnosed in this way. Use of blood tests was higher for children under five.[5]

V. Discussion

Referring to the conceptual model, what do our results suggest about the way SES relates to both proximal and fundamental causes of malaria burden in Mvomero? Which pathways seem most plausible, and where do we observe disparities in malaria-related outcomes? To answer these questions, we organize our discussion around the three SES-malaria pathways highlighted in Figure 1.

Pathway 1: SES affects access to malaria prevention

Our data from Mvomero offer some support for the hypothesis that households with more resources are better able to purchase and correctly use malaria prevention methods. As in several other studies (Macintyre et al. 2002; Noor et al. 2006; McElroy et al. 2009), we find that that certain asset-based wealth indicators are significantly associated with ownership of ITNs. However, in contrast with some of these studies, we do not find an association between formal education and net ownership (Macintyre et al. 2002; Noor et

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[5] As an alternative health-seeking indicator, we also looked at whether or not each case was diagnosed at a health facility, regardless of whether a blood test was used. Housing size and quality and individual's age were associated with health care access using this measure.

al. 2006) or between occupation and net ownership (Goesch et al. 2008). Thus, for the malaria prevention indicator we examined here, wealth-based disparities seem to be the greatest concern in Mvomero.

This finding has important implications for Tanzania's net distribution policies. As mentioned above, Tanzania has promoted net use among vulnerable groups (pregnant women and children under five) through a system of vouchers. However, our data suggest that only 17% of households in Mvomero had actually used a voucher to purchase their nets; instead, most nets were apparently purchased at full price (see Table 3). Under these circumstances, it makes sense that we observe that households with more resources are able to afford more nets. Furthermore, the fact that we find a *lower* ratio of ITNs per capita in households with more children under five suggests that existing policies may not be effectively targeting this vulnerable group in Mvomero.

Meanwhile, the absence of a clear education effect may be testament to the pervasive public health messages in this area. Signs promoting net use can be seen throughout the district, and most survey respondents (92%) listed nets as the most effective malaria prevention method. Thus, awareness of nets' benefits does not appear to be a major barrier to their use in this area; access and cost issues deserve further attention.

Pathway 2: SES as a fundamental cause of malaria

Overall, we do not see large disparities in self-reported malaria illness related to the household-level SES measures included here. Two wealth measures, durables and house quality, are actually *positively* associated with reported illness, in contrast with other

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studies (Hustache et al. 2007; Somi et al. 2007; Bernard et al. 2009) that find a negative

relationship between ownership of durables and malaria illness. Our findings are more

closely in line with Schellenberg et al. (2003) who find that there is little variation across

socioeconomic groups in the probability of a self-reported fever. We do see a substantially

lower incidence of malaria illness among individuals whose household heads are employed

in business; however, given the small number of non-agricultural households in our sample

(9 out of 408), we are cautious about over-interpreting this finding and note that further

investigation of occupational differences in malaria exposure would be informative.

Perhaps more intriguing are the observed relationships between various

sociodemographic factors and reported malaria illness. Hustache et al. (2007) find a

positive association between the number of individuals in the home and likelihood of

malaria illness in French Guiana. In contrast, when we include both total household size

and number of children under five, we find that total household size is *negatively*

correlated with reported illness, while the number of young children is *positively*

associated with this outcome. It is well established that children under five are themselves

more susceptible to malaria, and our data reflect this. However, it is unclear if and how

this could translate into an increased malaria risk for other individuals in the household, or

why a greater total household size might be "protective." Also meriting further

examination is the finding that reported malaria cases are more prevalent in male-headed

households. Of course, these associations may not be causal, and we acknowledge the

potential problems involved with self-reported malaria illness. Examining which of these

relationships persist in datasets better suited to addressing these issues is thus a key priority for future research.

Pathway 3: SES affects access to accurate diagnosis and effective malaria treatment, affecting subsequent health outcomes

The third pathway we examine concerns the steps that occur after an individual gets sick: specifically, do individuals seek accurate diagnosis and treatment at health facilities? As noted earlier, Schellenberg et al.'s (2003) Tanzania study finds that there is little variation across socioeconomic groups in the probability of a self-reported fever; however, they also find that higher SES groups are more likely to receive appropriate treatment, leading to disparities in ultimate health outcomes. Similarly, we find some evidence of SES disparities in malaria diagnosis, with ownership of consumer durables being positively correlated with the likelihood that an individual was diagnosed at a health facility using a blood test. Once again, some interesting results emerge regarding household composition: individuals are less likely to be diagnosed using a blood test in larger households, and females are somewhat more likely to be diagnosed in this manner compared to males. It is encouraging that blood tests appear to be used more often for children under five, as this indicates that these particularly susceptible individuals are more likely to be brought into health facilities when they show symptoms of malaria.

Synthesizing across these different pathways, our results seem to provide stronger evidence for the relationships between SES indicators and the proximal causes of malaria (prevention and treatment) in Mvomero, and less evidence that household- and individual-

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level SES is a fundamental cause of malaria *independent* of these proximal pathways. For

access to prevention and treatment, we find that wealth-based disparities are more

prevalent that education-based differences in malaria-related outcomes in Mvomero. In

light of this finding, malaria control programs that reduce financial barriers to prevention

and treatment should be examined. For example, promoting distribution of and use of ITN

vouchers among poorer households could be a relatively low-cost way of reducing

disparities in malaria prevention.

We also note that while "wealth" appears to matter for all three of the malaria-

related indicators we examined here, there is variation in the specific wealth indicators that

are associated with each outcome. For example, households that own large livestock tend

to own more ITNs per capita and have fewer reported malaria cases compared with non-

livestock owners, while we do not observe a significant relationship between livestock

ownership and malaria diagnosis behaviour. Meanwhile, our durables index is positively

correlated with illness and diagnosis indicators, but not with ITN ownership. As we noted

earlier, the different indicators we include are likely to be capturing various dimensions of

wealth and social status more broadly, and our results suggest that these dimensions affect

malaria prevention, diagnosis, and treatment in somewhat different ways. As one purely

hypothetical scenario, it is possible that livestock owners in Mvomero have a particular

lifestyle that makes them more likely to own nets and also decreases their malaria risk

independently of ITN use (e.g., through a zooprophylaxis effect as in Mutero et al. 2004.)

While a full exploration of this and other hypotheses regarding the patterns of wealth-

malaria relationships we observe is beyond the scope of this paper, our findings do suggest

that using a single wealth measure may obscure complex and multifaceted relationships. These results also highlight the difficulties in reliably measuring wealth and understanding its relationships with health outcomes.

We acknowledge several additional limitations in our empirical study. First, while our conceptual model addresses the proximal and fundamental *causes* of malaria, our cross-sectional data do not allow us to make definitive statements about causal relationships. Second, while our detailed, malaria-focused household survey provides a rich set of indicators that we can use to probe for SES-malaria linkages in Mvomero, our results may not generalize to different settings. For example, the Mvomero context is one in which nearly all households have at least one mosquito net. Variation across households and efforts to improve access to ITNs are thus concentrated at the *intensive* margin: i.e., increasing the number of nets a household owns, or improving insecticide retreatment rates. In a context where nets were less prevalent – i.e., where expansions were occurring along the *extensive* margin – we would expect to see different relationships between SES and net use.

Finally, our focus in this paper has been on the relationship between household- and individual-level SES and malaria-related outcomes. As we mentioned at the outset, however, many of the fundamental causes of malaria operate at larger scales, from community-level environmental conditions to national malaria control policies and the decisions of international donors. While our goal here was to examine one particular set of relationships, it is clear even from our results that a deeper understanding of the factors influencing malaria outcomes will require analyses that are broader in scope. In each of

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the multivariate regressions we conducted, the village dummy variables were highly significant (see last row in Table 5), indicating substantial heterogeneity in all three malaria-related outcomes across the 10 study villages even controlling for observable household and individual characteristics. Future studies could take a multilevel approach to examining this cross-village variation in more detail, as well as assessing how household-level characteristics like wealth and status interact with larger scale phenomena like community environmental conditions and social capital.

Despite these limitations, this paper takes the important step of broadening the discussion of malaria's causes from purely proximal factors (prevention and treatment) to one set of fundamental causes (household and individual SES) and examining how these causes might interact to produce health outcomes in Mvomero and similar contexts. By placing our empirical findings in this broader context, our study helps to clarify (or at least produce hypotheses about) mechanisms and pathways. To the extent that policies can correct, counterbalance, or operate through these pathways, this type of research can help to inform more equitable malaria control policies.

Acknowledgements

VII. References

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Figure 1: Conceptual Model of Key Pathways Linking Socioeconomic Status and Malaria-Related Outcomes
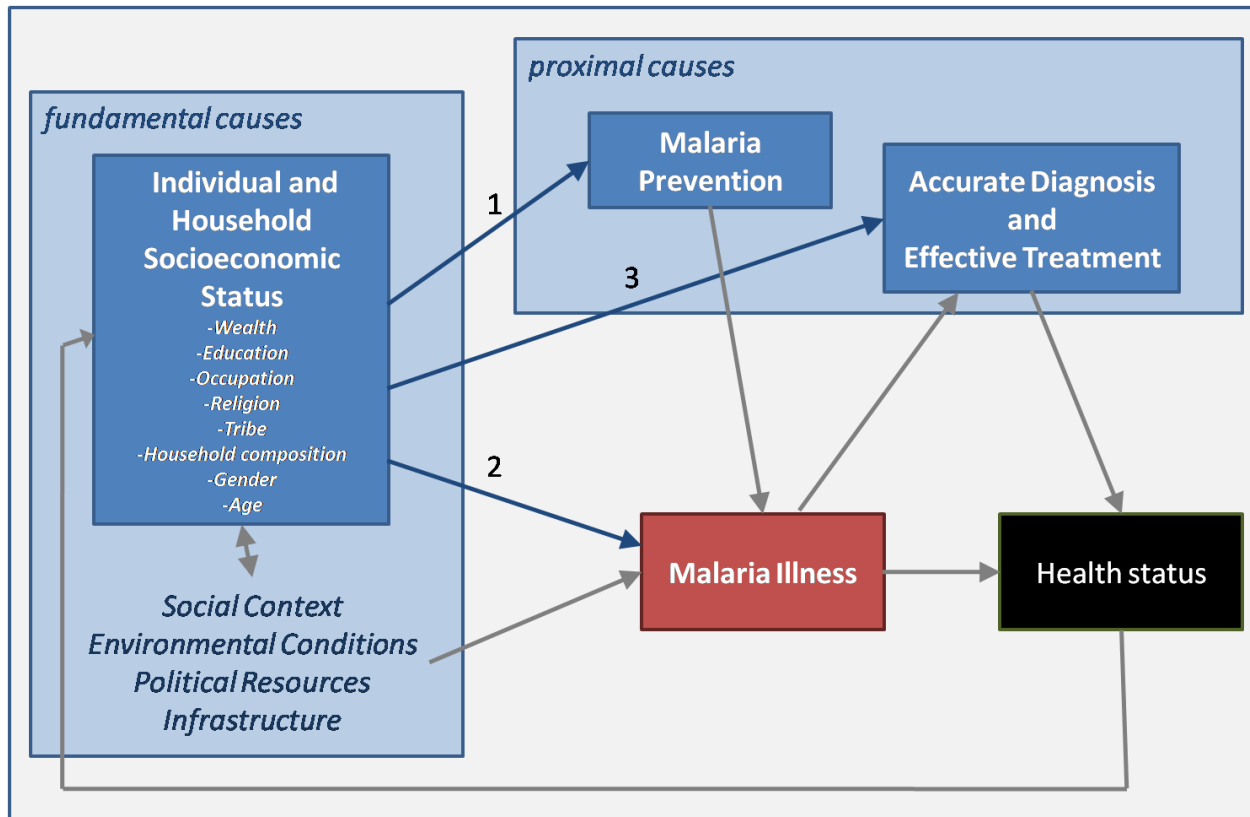
Figure 2: Location of Mvomero District, Tanzania, and 10 Study Villages
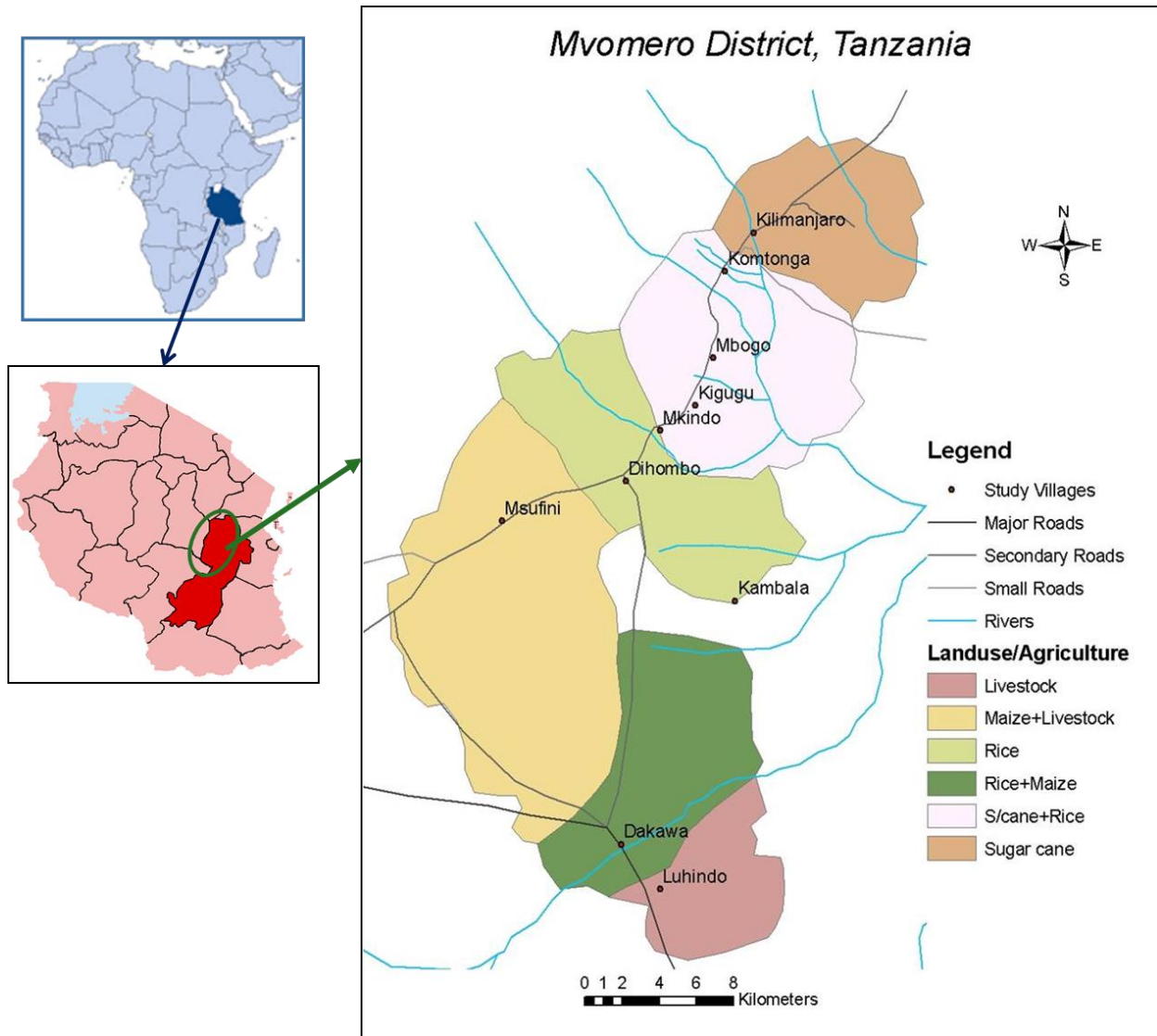
Table 1: Descriptive Statistics for SES indicators in the Mvomero Sample

	N		
Wealth indicators			
Consumer durables: *Households owning at least one…*			
Motorcycle	408	7	1.7%
Bicycle	408	215	52.7%
Sewing machine	408	25	6.1%
Radio	408	237	58.1%
Television	408	12	2.9%
Cassette player	408	57	14.0%
Sofa	408	25	6.1%
Cell phone	408	88	21.6%
Total durables owned	408	Mean: 1.6	Range: 0-5
Households living in SMALL house (1 room)	404	68	16.8%
Households living in MEDIUM house (2-3 rooms)	404	260	64.4%
Households living in LARGE house (4+ rooms)	404	76	18.9%
House quality is "low" (0-1 point on 3-pt quality index)	404	227	56.2%
Household owns home	403	356	88.3%
Land area owned (Ha)	408	Mean: 4.12	Range: 0-66
Household owns large livestock	408	46	11.3%
Education/Knowledge			
Head has no formal education	408	137	33.6%
Head has primary education	408	238	58.3%
Head has secondary or higher education	408	33	8.1%
Religion			
Christian (Muslim)	408	144 (264)	35.3% (64.7%)
Occupation			
Head employed in business vs. agriculture	408	9	2.2%
Household composition			
Household size	408	Mean: 4.6	Range: 1-12
Total children <5	408	Mean: 0.59	Range: 0-4
Gender			
Respondent is male	408	199	48.8%
Household head is male	408	333	81.6%
Age			
Age of household head	401	Mean: 45.4	Range: 18-105
Age of respondent	400	Mean: 42.7	Range: 17-95

Table 2: Pairwise Correlations between Different Wealth Indicators

	Durables index	House size	House quality	Own house	Land area	Total lg. livestock
Durables index	1.00					
House size	0.19*** (0.000)	1.00				
House quality	0.38*** (0.000)	0.36*** (0.000)	1.00			
Own house	-0.19*** (0.000)	0.04 (0.428)	-0.16*** (0.001)	1.00		
Land area	0.29*** (0.000)	0.17*** (0.001)	0.14*** (0.004)	0.12** (0.014)	1.00	
Total lg. livestock	0.10** 0.041	0.04 (0.404)	-0.04 (0.436)	0.035 (0.482)	0.10* (0.050)	1.00

p-values in parentheses.
*=significant at 10% level; **=significant at 5% level; ***=significant at <1% level

Table 3: Descriptive Statistics on Malaria Prevention, Illness, and Diagnosis/Treatment

	N		
Malaria Prevention: Nets			
Respondent said household owned mosquito net(s)	408	379	92.9%
Nets observed in household by interviewer	408	340	83.3%
Household used voucher to purchase a net	366[†]	63	17.2%
Average number of nets observed per household	366[†]	Mean: 1.99	Range: 0-8
Average ratio of ITNs per capita	**366**[†]	**Mean: 0.27**	**Range: 0-1.5**
Malaria Illness (Self-reports)			
Individual reportedly had malaria in past 3 months	**1833**	**968**	**52.8%**
Child under 5 reportedly had malaria in past 3 months	227	157	69.2%
Malaria Diagnosis and Treatment			
Individual was diagnosed at health facility using blood test	**957**	**353**	**36.9%**
Individual was diagnosed at health facility without blood test	957	399	41.7%
Individual was diagnosed at home	957	204	21.3%
Individual was diagnosed by traditional healer	957	1	0.1%

Variables in bold are dependent variables in Tables 4 and 5.

† Data missing for 42 households who said they had nets but did not allow interviewer to enter the home to observe nets.

Table 4: Multivariate Analyses of the Assocations between SES and Malaria-related Indicators

		ITNs per capita at household level			Individual reported to have malaria in past 3 months			Individual's reported malaria case diagnosed using blood test		
		n=356, R^2=.168			n=1604, Pseudo R^2=.074			n=923, Pseudo R^2=.138		
		Coefficient	95% CI		Coefficient	95% CI		Coefficient	95% CI	
Wealth	Durables index	.009	-.034	.052	.022*	-.003	.047	.041**	.001	.081
	Small house vs. medium house	-.085	-.210	.040	-.009	-.115	.098	-.012	-.153	.129
	Large house vs. medium house	.081**	.017	.144	-.006	-.099	.087	.023	-.119	.164
	High house quality vs. low	.0002	-.065	.065	.078**	.001	.156	.087	-.032	.206
	Own house vs. rent	.051	-.062	.165	-.006	-.129	.117	.171**	.008	.334
	Land area	.009**	.002	.015	-.002	-.007	.003	.003	-.006	.011
	Total livestock	.001***	.0005	.002	-.001**	-.002	-.0001	.0002	-.002	.002
Education	Head educ.: Primary+ vs. none	.042	-.065	.151	.014	-.068	.096	-.023	-.144	.097
Occupation	Head employed in bus. vs. ag.	-.007	-.189	.174	-.213**	-.408	-.019	-.162	-.485	.160
Religion	Christian vs. Muslim	.003	-.047	.054	.002	-.075	.078	-.075	-.197	.047
HH composition	Household size	-.019*	-.041	.004	-.026**	-.051	-.002	-.037**	-.069	-.005
	Total children <5	-.047*	-.100	.007	.104***	.047	.161	-.007	-.091	.076
Gender	Male respondent vs. female	-.030	-.094	.035	.003	-.072	.079	.042	-.070	.154
	Male HH head vs. female	.018	-.037	.073	.115**	.015	.214	.020	-.130	.169
	Male individual vs. female				-.038	-.085	.008	-.051**	-.101	-.001
Age	Age of HH head	-.002	-.006	.001	.002*	-.0004	.005	.002	-.002	.007
	Age of individual				.001	-.0003	.003	-.0008	-.003	.001
	Individual is under 5				.179***	.098	.260	.088**	.017	.159
Net use	ITNs per capita				-.126**	-.249	-.004			
F-stat for joint significance of village dummies		688.0***			50.4***			23.9***		

For ITNs, table reports results from linear (OLS) regressions. For reported malaria illness and blood test diagnosis, results are average marginal effects calculated from probit regressions. All models also include village dummy variables (fixed effects). For ITNs per capita, standard errors are clustered at the village level. For illness and diagnosis, standard errors are clustered at the household level.

*=significant at 10% level; **=significant at 5% level; ***=significant at <1% level