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Net Values: Meaning, Motivation and Measurement in the Distribution, Use and Monitoring of Bed Nets for Malaria Control in Segou, Mali

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By

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Master of Health Sciences, Johns Hopkins Bloomberg School of Public Health, 2005

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An abstract of
A dissertation submitted to the Faculty of the James T. Laney School of Graduate Studies of Emory University in partial fulfillment of the requirements for the degree of
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Abstract

Net Values: Meaning, Motivation and Measurement in the Distribution, Use and Monitoring of Bed Nets for Malaria Control in Segou, Mali

Amy E. Patterson

Long-lasting insecticidal bed nets (LLINs) are a key tool for malaria control and elimination. Extensive resources have recently been devoted to scaling-up net coverage in Sub-Saharan Africa. To maximize the benefits of nets in the context of global elimination and eradication efforts, there is a need for better strategies for distributing and monitoring LLINs, and encouraging universal net use.

The primary objectives of this study were to describe practices of LLIN distribution, use and monitoring in a region with an existing net culture; to identify advantages and disadvantages of integrating LLIN delivery and monitoring with immunization services; to characterize factors that motivate or inhibit LLIN use among adults; and to understand the effects of social, linguistic and health systems factors on health worker performance and end-user uptake of malaria interventions.

Data were collected in Segou, Mali, from August 2008 to December 2009, in the context of a larger quasi-experimental evaluation of The Expanded Program for Immunizations (EPI) Contact Method, using a multi-phased mixed methods design. Qualitative methods included unstructured observations, participant observation, semi-structured interviews with health workers (N=89), semi-structured interviews (N=82) and focus groups (N=26) with parents of young children, and key informant interviews (N=16). Sources of quantitative data included systematic observations at EPI clinics (N=1,394), health facility records, and a household survey (N=3,283).

The findings are presented in three chapters, devoted separately to 1) routine integrated LLIN distribution, 2) potential determinants of universal LLIN use where ownership and use among children are already high and 3) health worker performance of the EPI Contact Method as a malaria monitoring and program management tool.

Together, the results highlight the influence of complex relationships between socio-cultural and health systems factors on the delivery, uptake and monitoring of malaria interventions, and draw attention to possible intended and unintended effects of current policies, performance targets and practices on the malaria control and EPI programs in Mali, while also illustrating challenges for measuring net ownership and use. Recommendations are made for preparing for the transition to a universal LLIN coverage strategy in Mali, for strengthening integrated approaches to LLIN distribution, and for improving measurement.

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CHAPTER 1

Introduction and Literature Review

> *"It's an...audacious goal—to reach a day when no human being has malaria, and no mosquito is carrying it. This is a long-term goal; it will not come soon. But to aspire to anything less is just far too timid a goal for the age we're in. It's a waste of the world's talent and intelligence, and it's wrong and unfair to the people who are suffering from this disease."* Melinda Gates, Gates Malaria Forum, Seattle, Washington, 2007

At the Gates Malaria Forum in Seattle in October 2007, Bill and Melinda Gates renewed the call for global malaria eradication, to the surprise of many in the audience, as well as in the larger malaria community. I was one of those surprised members of the malaria community when I first heard of the announcement several weeks later. My dissertation proposal was written in the context of a global malaria control effort but, by the time I reached my field site in Mali, the stakes had changed, the world was preparing for a second attempt at eradication and the focus and potential significance of my research questions had shifted. For that reason, I begin this introduction with an overview of the current global malaria elimination agenda and some of the major challenges to it, in order to establish the context, as well as the political, programmatic and research culture in which the work of this dissertation was conducted.

Soon after the declaration by the Bill and Melinda Gates Foundation (BMGF) the global community, led by the World Health Organization (WHO), embraced the goal and began to develop a research and programmatic agenda to achieve it. In 2008, a Global Malaria Action Plan (GMAP) was released by the Roll Back Malaria Partnership (RBM) to guide key

stakeholders in efforts to address the following ambitious goals (Roll Back Malaria Partnership, 2008):

- Achieving full coverage for all at-risk populations with locally appropriate interventions by 2010
- Cutting malaria cases worldwide in half, compared to 2000 levels, by 2010 and by 75% by 2015
- Reducing the number of global malaria deaths by 50% in 2010, compared to 2000 levels, and reaching near zero deaths from malaria by 2015
- Eliminating malaria in 8-10 countries by 2015 and afterwards in all countries in the pre-elimination phase
- Eradicating malaria worldwide by reducing the global incidence to zero, in the long term.

The GMAP strategy is a tripartite one involving 1) aggressive control in highly endemic countries in order to achieve low transmission and reduce morbidity and mortality, 2) progressive country-by-country elimination of malaria, and 3) research to support the development of new tools and approaches (e.g. vaccines, improved drugs, diagnostics, insecticides, innovative vector control strategies) to support global control and elimination (Roll Back Malaria Partnership, 2008).

After several decades of malaria control efforts that followed the suspension of the previous Global Malaria Eradication Program (Alonso, Brown, et al., 2011; Enayati & Hemingway, 2010; Greenwood, 2008; Litsios, 1996), the re-adoption of the goal of global eradication has led to a subsequent paradigm shift with important implications for research, routine monitoring and programmatic activities. Whereas the focus of malaria control programs is on reducing morbidity and mortality due to malaria, the focus of elimination and eradication efforts is instead on interrupting transmission (Doumbia et al., in press). Malaria control programs focus on the people most vulnerable to severe outcomes of malaria and on preventing and treating symptomatic cases. In contrast, in order to interrupt transmission, malaria elimination programs

must focus on vectors as much as on humans, on the asymptomatic and mildly symptomatic cases as much as on the severe, and on populations of all ages.

The feasibility of malaria elimination depends on a complex set of technical, operational and financial factors which can vary greatly from country-to-country, requiring tailored individual strategies for each. When assessing the feasibility of elimination and developing elimination plans, countries must consider factors such as transmission potential (the number of additional cases that arise from a single case under particular conditions), the rate of importation of new cases from other countries, national organization and infrastructure, total cost, available funding, and political commitment (Moonen, Cohen, Smith, et al., 2010; Moonen, Cohen, Snow, et al., 2010; Moonen, Cohen, Tatem, et al., 2010). And to achieve eradication, every malarious country must achieve elimination, permanently reducing the global incidence of new malaria cases to zero. As Melinda Gates recognized in her speech, eradication *is* an audacious goal due to a number of specific epidemiological, biological, technological, financial, political and historical challenges described in the following pages.

CHALLENGES FOR THE GLOBAL ERADICATION AGENDA

The Challenge of Scale and Scope: The Magnitude of the Global Malaria Burden

The magnitude of the global malaria burden makes it both particularly challenging and particularly imperative to address. Malaria remains one of the leading public health challenges in our world today, despite the existence of numerous potentially-effective tools for the prevention and treatment of this disease and the substantial increases in awareness of and funding for malaria in the past decade. There are currently 99 malaria-endemic countries, 67 of which are in the control phase and 32 of which are actively pursuing elimination (Feachem et al., 2010). These countries contain close to 50% of the world's population, with more than 3 billion people living in areas endemic for malaria (Roll Back Malaria Partnership, 2008). The 2008 GMAP estimated

the number of annual cases of malaria at between 350-500 million, the vast majority of them within Africa.

Recently published predictive models of global malaria mortality, based on all available data between 1980 and 2010, suggest that the burden may be much greater than previous estimates, particularly in the population of persons older than five years of age (Murray et al., 2011). These models indicate that global malaria deaths increased from 995,000 in 1980 (95% CI: 711000-1412-000) to a peak of 1,817,000 in 2004 (95% CI: 1430000-2366000), and then declined again to 1,238,000 in 2010 (929,000-1,685,000). In Africa, the number of malaria deaths increased from 493,000 in 1980 (95% CI: 290,000-747,000) to 1,613,000 in 2004 (95% CI: 1,243,000-2,145,000) and then declined rapidly to 1,133,000 in 2010 (95% CI 848,000-1,591,000). Outside of Africa, malaria mortality has decreased steadily since 1980. The numbers make the challenge of eradication seem daunting indeed but the magnitude and gravity of the consequences of malarial illness make it an important goal. Arguments variously present malaria eradication as a public health, economic social and moral imperative.

Public Health Burden. In addition to the large number of malaria-attributable deaths, morbidity due to malaria is considerable. Persons infected with simple malaria generally suffer from fevers, chills, vomiting, diarrhea and body aches, while those with severe forms of the disease have convulsions and may become comatose, with potential long-term neurological consequences. Certain forms of malaria are recurrent, with a single infection leading to numerous illness episodes. Malaria can also lead to morbidity associated with anemia, under-nutrition, HIV-infection due to contamination blood transfusions, and adverse effects of malaria treatments. There is a residual cognitive deficit in 10-15% of children who suffer from cerebral malaria (CM). Other neurological sequalae can include: hemiparesis, quadriparesis, hearing impairment, visual impairment, behavioral difficulties, language deficits, and epilepsy (Breman, Alilio, & Mills, 2004; Breman et al., 2006).

The enormous burden of malaria, particularly in African countries, may also exacerbate outcomes of other common infectious diseases. Co-infection with malaria and other infections can lead to increased morbidity and mortality and can modify immune responses (Cuadros, Branscum, & Crowley, 2011; Jaworowski et al., 2009; Moormann, Snider, & Chelimo, 2011; Perrault et al., 2009; Skinner-Adams, McCarthy, Gardiner, & Andrews, 2008; Yatich et al., 2010). In addition, years of presumptive treatment of fever in the absence of diagnostic tools has created a culture of medical practice in which other possible causes of fever, such as severe pneumonia, may be under-diagnosed and under-treated given the overlap of their symptoms with those of malaria (Kallander et al., 2006; Redd et al., 1992; Winch et al., 2005).

Economic Burden. In addition to the disease burden measured in mortality and morbidity, malaria also places heavy economic burdens on the inhabitants of malaria-prone regions. Health economists have described this burden in terms of both micro- and macro-level effects. The microlevel effects of malaria are measured in terms of the direct costs to both governments and households of preventing and treating malaria (e.g. insecticide-treated bed nets, medicines, doctors fees, transportation costs, insecticides and mosquito coils) and the indirect costs of malaria illness (e.g. productive days of work lost) (Arrow, Panosian, & Gelband, 2004; Chima, Goodman, & Mills, 2002; Desfontaine, Gelas, Goghomu, Kouka-Bemba, & Carnevale, 1989; Ettling, McFarland, Schultz, & Chisulo, 1994; Manzi et al., 2005; Russell, 2004). A 2004 review of published studies on the direct and indirect costs of malaria in the developing world illustrated direct monthly costs to households that ranged from $0.46 - $7.38 per capita (Russell, 2004). In countries where per capita income is often less than a dollar a day, these costs are significant, particularly when coupled with the costs for other household illnesses. A study conducted in Malawi found that, within very low income households, direct costs of malaria could be as high as 28% of household income (Ettling, et al., 1994). Annual indirect costs of malaria have been measured at between 2% - 6% of annual household income (Russell, 2004) and indirect costs per case of fever may account for as much as 79% of the total costs associated with

the illness episode (Sundewall et al., 2011). In Ethiopia, indirect costs have been measured at as high as US$23 per adult episode of malaria (Arrow, et al., 2004). While strategies for measuring the costs of malaria have been criticized for overestimating the burden of uncomplicated malaria, underestimating the costs of severe illness, failing to account for seasonal variations when measuring indirect costs, and failing to include the costs of coping mechanisms in response to perceived risk of disease (Arrow, et al., 2004; Chima, et al., 2002; Sachs & Malaney, 2002), there is little question that the micro-economic costs of malaria are significant.

When it comes to macrolevel effects, it has long been recognized that malarious regions tend to be impoverished regions. Economist Jeffrey Sachs has demonstrated that the average per-capita gross domestic product (GDP) in malaria-endemic countries in 1995 was approximately one-fifth the average across the non-malarious world, and annual economic growth in these countries between 1965 and 1990 was only 0.4% of per-capita GDP, compared to 2.3% in the rest of the world (Gallup & Sachs, 1998; Sachs & Malaney, 2002). Economists outline several possible routes by which malaria may prevent or slow the economic development of a country. These include demographic effects, effects on human capital, and effects on trade, tourism and foreign investment (Arrow, et al., 2004; Sachs & Malaney, 2002).

While there is a clear association between poverty and malaria, there is much debate over the direction of causality. Scholars take different positions when it comes to the question "does malaria block development or does development block malaria?" (Brown, 1986; Gallup & Sachs, 1998; Packard, 2001; Sachs & Malaney, 2002). Proponents of the "development blocks malaria" position highlight the fact that malaria control in the United States and Europe was achieved when housing conditions improved, and demonstrate cases in which malaria control has failed to lead to significant economic growth and development (Brown, 1986). Malaria economists are divided as to whether the ultimate financial savings justify the large costs and effort that would be required for total eradication, or even elimination, as opposed to a controlled low-endemicity state. Recently published models project that the cost savings over 50 years for elimination will

range from 0-42% depending on the country; these results led the authors to conclude that financial savings should not be the primary rational for elimination (Sabot et al., 2010).

Social Burden. The individuals who are the most socially and economically vulnerable are often also the ones most vulnerable to malaria. This is often the result of both higher biological susceptibility and lower access to treatments and preventive measures relative to other segments of the population. Children under-five years of age and pregnant women are disproportionally affected by malaria. Social factors such as socio-economic status, social organization, power relationships, cultural norms and beliefs can also have important impacts on the development and distribution of disease (Jones & Williams, 2004). Individuals who are socially vulnerable because of gender, age, ethnicity, political affiliations, class, or socio-economic status are likely to have less knowledge of appropriate treatment and are less likely to be able to access treatment in a timely fashion or to purchase preventive technologies (Jones & Williams, 2004). Families that are incapable of enacting socially or culturally efficacious practices (practices generally recognized within a culture as appropriate) and of protecting their children from disease may be further marginalized, leading to greater social vulnerability (Whyte, van der Geest, & Hardon, 2002). The social burden of malaria may also be measured through its effects on school attendance, educational achievement, demography and migration (Sachs & Malaney, 2002; Thuilliez, 2010; Thuilliez et al., 2010).

The Challenge of Biological Complexity: Vector and Parasite Biology

In addition to the scope and scale of the malaria problem, the complexities of malaria vector and parasite biology are similarly daunting. It is somewhat misleading to talk of malaria as a single disease: there are five different *Plasmodium* parasite species that can cause malaria in humans (*P. falciparum*, *P. vivax, P. ovale, P.malariae*, and *P. knowlesi*), and over 30 different species of *Anopheles* mosquitoes that can transmit them (Alonso, Brown, et al., 2011; Breman, et al., 2006). Different parasite and vector combinations are found in different regions. In most

African countries, multiple malaria parasites contribute to the burden of disease. The common African vectors, including *Anopheles gambiae,* are among some of the most efficient.

Characteristics of the parasite are also important to consider. For one, the parasite life cycle consists of multiple stages in both the human host and the mosquito vector. Not all stages in the human are associated with clinical manifestations, which presents challenges for case detection, surveillance and consequently for transmission interruption. The most effective vaccine will likely be one that targets multiple stages of the parasite within the human host. Individuals with low parasite densities or with innate immunity due to repeat exposures to malaria parasites may be infected without ever showing any clinical signs. Identifying these individuals is not a priority during control phases but is in the context of elimination efforts as they can still continue the transmission cycle (Laishram et al., 2012).

In addition, *P. vivax* can form hypnozoites, liver-stage forms of the parasite that can lie dormant in infected liver cells for months or years and allow the parasite to "hibernate" during less optimal transmission conditions. These hypnozoites explain the recurrent nature of *P. vivax* infections resulting from infection and introduce challenges for treatment. In order to fully prevent further transmission, treatments must produce a "radical cure," eliminating the hypnozoites as well as the other forms of the parasite. Primaquine is the current drug of choice for effecting a radical cure, but it is counter-indicated in regions with high rates of glucose-6-phosphate dehydrogenase (G6PD) deficiency because it can lead to hemolysis and subsequent hemolytic anemia in individuals with this genetic condition (Fernando, Rodrigo, & Rajapakse, 2011). This makes *P. vivax* a primary challenge for achieving elimination in countries with *P. vivax* infections (Feachem, et al., 2010).

Another important challenge is the fact that both parasite and vector have proven to be remarkably adaptive, quickly responding to selective pressure introduced by human efforts to prevent and treat infections. Malaria parasites have developed resistance to all current antimalarial drugs, and new potential treatments are only in the early stages of development

(Muller & Hyde, 2010). Additionally, most major malaria vectors have developed resistance to various forms of insecticides used for indoor residual spraying (IRS) and insecticide-treated bed nets (ITNs) (Ranson et al., 2011). There is already evidence of resurgence in malaria prevalence in areas where mosquitoes have developed resistance to deltamethrin, following the introduction of ITNs (Trape et al., 2011). In addition to genetic resistance, behavioral adaptations have emerged in some mosquito populations. There is some evidence that mosquito species that formally exhibited indoor-resting behaviors have begun to adopt outdoor resting behaviors, though ITNs do not seem to have yet resulted in changes to the timing of biting behaviors (Killeen et al., 2006; Pates & Curtis, 2005).

The fact that the malaria vectors and parasites are so adaptive and so quickly develop resistance to the tools and strategies that humans develop to attack them further supports arguments about the need to completely eliminate the malaria parasite. Failure to do so will result in an indefinite process of research and development to stay one step ahead of the constantly adapting parasites and vectors.

The Challenge of Inadequate Strategies, Tools and Technologies

There is widespread agreement among experts that the currently available tools and strategies are unlikely to be sufficient to eradicate malaria from all regions of the world, though they may be sufficient to eliminate the disease from certain areas with low malaria burden and the organizational and financial capacity required to achieve full coverage (Alonso, Besansky, et al., 2011; Alonso, Brown, et al., 2011; Greenwood, 2008). New tools and improved strategies will likely be needed to eliminate malaria from places with the highest transmission potential, high rates of infection caused by *P. vivax*, high levels of drug and insecticide resistance, and malaria vectors with outdoor biting and resting habits (Moonen, Cohen, Snow, et al., 2010). Among the needs identified as priorities for research and development are an effective vaccine, better drugs and insecticides (as well as strategies for preventing the emergence of resistance to them), and

safer treatments for the radical cure of *P.* vivax for all affected populations (Alonso, Atta, et al., 2011; Alonso, Ballou, et al., 2011; Alonso, Barnwell, et al., 2011; Alonso, Besansky, et al., 2011; Alonso, Djimde, et al., 2011; Enayati & Hemingway, 2010; Moonen, Cohen, Snow, et al., 2010). Some other proposed technologies currently at various stages of development include: insecticidal wall coverings, housing modifications, larviciding in urban areas, toxic sugar bait traps, and even radical strategies such as genetic modification of vectorial capacity (Alonso, Brown, et al., 2011; Enayati & Hemingway, 2010). Additional research is also required to inform decisions about the best ways to scale-up current interventions, the most effective combinations of various vector control strategies, and the best ways to integrate malaria activities with other health programs.

The Challenge of Weak Health Systems

Even if available technologies were sufficient to eliminate malaria, their effectiveness would depend on the ability of health systems to deliver them appropriately to the entire target population, as well as monitor intervention coverage and malaria incidence in a timely and accurate manner so as to be able to tailor interventions according to need and quickly respond to any outbreaks. The WHO conceptual framework for health systems includes six "building blocks": governance, health workforce, health financing, health technologies, health information and service delivery (WHO, 2007). People at all levels, from international partners to community members, are at the center of this framework (WHO, 2008). A breakdown at any point of this system can affect the performance of all others, with loss of program and intervention efficacy at each step of the way (Alonso, Bell, et al., 2011; Travis et al., 2004).

A stronger understanding of the dynamic relationships and interactions between the various people and processes that constitute the health system can help us to determine "what works, for whom, to what extent, and under what circumstances" (Alonso, Bell, et al., 2011) – all important questions as we try to find better ways to implement existing interventions and to

develop new ones. Systems thinking focuses on increasing attention to how new knowledge is created and disseminated; emphasizing relationship between individuals and organizations across different disciplines and fields; developing models to improve strategic decision-making; and systems organizing to improve organizational structure and function (Leischow et al., 2008; Leischow & Milstein, 2006). This kind of systems thinking can also highlight unintended positive or negative consequences of specific health programs, projects and delivery systems on other health activities or outcomes. For example, a systems thinking approach to studying integrated campaigns in Mali revealed disruptions in routine services provided for weeks at a time as the result of campaigns, and highlighted the fact that such campaigns can divert health workers' focus from non-campaign activities and place additional burden on already weak health systems (Cavalli et al., 2010).

The Challenge of Measuring, Monitoring and Evaluating Progress

Current measurement tools and monitoring systems are also inadequate for tracking incremental progress towards eradication and for providing nuanced information to direct and inform decision-making about programmatic strategies and priorities. As countries approach elimination, we will need much stronger and more reactive surveillance systems, as well as more sensitive tools for detecting malaria infections in asymptomatic cases to allow for active case detection and treatment (Alonso, Atta, et al., 2011; Bousema et al., 2004; Bousema & Drakeley, 2011; Laishram, et al., 2012; McMorrow, Aidoo, & Kachur, 2011; Moonen, Cohen, Snow, et al., 2010; Ouedraogo et al., 2009; Schneider et al., 2007; Shekalaghe et al., 2007). However, for countries that are still in the control phase, there is a need for much better tools to measure the coverage and equity of current interventions, and to assess intervention delivery systems for acceptability, feasibility, community engagement, efficiency, equity and cost-effectiveness (Alonso, Atta, et al., 2011).

Through the work of the RBM Partnership's Monitoring and Evaluation Reference Group (MERG), there is growing consensus about and standardization of the indicators and methods used to measure malaria outputs and outcomes. National malaria programs and their partners can access a large range of useful guidelines and examples for conducting malaria monitoring and evaluation on the MERG website (RBM Monitoring & Evaluation Reference Group, 2012).

Currently, large national surveys such as Demographic and Health Surveys (DHS) or Malaria Indicator Surveys (MIS) are the standard tools for measuring intervention coverage, treatment-seeking behaviors, and the prevalence of malaria and anemia. These surveys remain the gold-standard for measuring these indicators but they have a number of important limitations: they are costly and time-consuming; they are usually only powered to obtain national or regional-level estimates rather than the local or district level estimate necessary for microplanning activities; and they are generally conducted only every four to six years. A number of alternative strategies for malaria monitoring have been proposed, including lot quality assurance sampling (LQAS) (Biedron et al., 2010) , school-based surveys (Ashton et al., 2011; Brooker, Kolaczinski, Gitonga, Noor, & Snow, 2009), health facility-based surveys (Cibulskis, Pujari, & Otten, 2012; Rowe et al., 2009; Skarbinski, Winston, Massaga, Kachur, & Rowe, 2008) and integrated continuous surveys and quality management (Rowe, 2009). The EPI-Contact Method (EPI-CM), another proposed method, is the subject of one of the three papers included in this dissertation. There are still numerous debates about the validity, feasibility and appropriateness of each of these alternative methods.

In addition to the need for better monitoring methods, there are also still a number of important challenges to address regarding the definition and measurement of key malaria indicators. The first has to do with who we assess. Current coverage and prevalence indicators generally focus on children under-five and pregnant women. In order to develop and evaluate elimination programs, it will be necessary to measure coverage with malaria interventions and malaria prevalence among all age and gender groups (Smith, Hay, Noor, & Snow, 2009).

Additional challenges relate to how we collect and interpret verbally reported data. Terminology and translation present difficulties for asking questions about malaria incidence, knowledge and treatment, as well as for interpreting responses. In most parts of the world there are numerous local illnesses that correspond to the symptoms of the biomedical disease malaria, many of which are perceived to have etiologies and appropriate treatments that differ from those of "malaria" (Beiersmann et al., 2007; Heggenhougen, Hackethal, & Vivek, 2003a; Helitzer-Allen & Kendall, 1992; Makemba et al., 1996; Patterson, Winch, Gilroy, & Doumbia, 2006; Winch et al., 1996). While the terms for "fever" are likely more valid and reliable when translated, the use of fever as a proxy for malaria has low sensitivity and specificity (Bisoffi et al., 2010; Bisoffi et al., 2009; Mabunda, Aponte, Tiago, & Alonso, 2009; Smith, Hurt, Teuscher, & Tanner, 1995; Wang, Smith, & Lengeler, 2005).

The Challenges of Time and Money: Are we in it for the long haul?

Another reason that eradication is an audacious goal is that it is a long-term goal, and an expensive one. While it may be possible to eliminate malaria from a small subset of countries within the next 10-15 years, malaria eradication is likely to take at least fifty years, according to best estimates. This will require long-term political will and financial commitment. In order to sustain that commitment, donors and governments will need to see measurable signs of progress towards the ultimate goal. Without these smaller benchmarks to demonstrate forward moment, funders and health workers alike are likely to become frustrated and disillusioned, as was the case with the last attempt at global eradication. Experts estimate that the cost of funding elimination will be $3 billion per year or $4.02 per African (Teklehaimanot, McCord, & Sachs, 2007). Systematic analyses of funding for malaria control and elimination efforts suggest that current funding is inadequate, and that funding for certain high population malarious countries is disproportionately low (Snow, Guerra, Mutheu, & Hay, 2008). There is a need for more creative

and flexible funding structures, with longer funding cycles than the three-to-four year cycles that are currently the norm (Campbell, 2008).

The Challenge of Social and Political Human Factors: The Influence of "Human Ecology" on Malaria Epidemiology and the Feasibility of Elimination

Another challenge, and one often overshadowed by the emphasis on entomology, parasitology and the development of new technologies, is the fact that malaria transmission dynamics are greatly influenced by what medical historian Randall Packard refers to as the "human ecology of malaria." (Packard, 2007) While the effects of human, social and environmental factors on malaria transmission are sometimes mentioned in the global eradication and elimination discourse (Alonso, Brown, et al., 2011; Breman, et al., 2006), they are rarely discussed in detail or considered in the planning of interventions and elimination strategies. As Packard's history of malaria illustrates, human factors influence epidemiology by creating hospitable vector breeding sites, exposing new and vulnerable populations to infection and facilitating the spread of the malaria parasite to new areas. Social and political factors such as war, infrastructure development, agricultural activities, urbanization, and population movements all have the potential to dramatically change transmission dynamics and affect the feasibility of elimination for a given country (Heggenhougen, Hackethal, & Vivek, 2003b; Packard, 2007).

While some of these factors can be anticipated and addressed in the development and implementation of elimination strategies, others cannot. Elimination programs will need to be flexible and adaptive, and countries will need to be willing to modify both their plans and their goals if necessary. Until the economic and social conditions that create favorable environments for malaria transmission are addressed, it is likely to be difficult or impossible to achieve eradication (Packard, 2007). The extension of the arguments about the role of human ecology on malaria transmission is that malaria elimination programs must, by necessity, also be programs

that focus on sustainable economic development, peace building, human rights and environmental management.

Lessons and Warnings from the Past

Finally, this is an audacious goal because global eradication was attempted before, without success. There is concern among some in the malaria community that history will repeat itself, particularly if unrealistic goals and timelines again lead to donor fatigue (Das & Horton, 2010; Greenwood, 2008; Moonen, Cohen, Tatem, et al., 2010). Malaria was successfully eliminated from 79 countries from 1945 to 2010, with elimination in 37 countries between 1955 and 1978 (WHO, 2009), but since then only a few additional countries have achieved that target. Declines in funding for malaria after the end of the 1955 eradication campaign was suspended indefinitely led to dramatic resurgences of malaria, particularly in Sub-Saharan Africa (SSA) (Najera, Gonzalez-Silva, & Alonso, 2011; Snow, Trape, & Marsh, 2001) .

However the global community has learned much from the lessons of the past and is moving forward with realistic evidence-based targets, strong models for determining the feasibility of elimination, a detailed research agenda, a recognition of the fact that integration with other health programs and health systems strengthening are essential, and an awareness from the outset that this will be a long-term process. In order to avoid the pitfalls of the past, countries will need to be realistic about the feasibility of elimination within their borders, rather than pushing for an unreachable goal for political or nationalistic reasons (Feachem, et al., 2010). With a greater range of tools, new and innovative funding partners and structures and a dramatic increase in global commitment to and funding for malaria, there are reasons to be optimistic.

INSECTICIDE-TREATED NETS FOR MALARIA CONTROL AND ELIMINATION

Insecticide-treated nets (ITNS) are one of the best existing tools for malaria prevention, and they are the unifying focus of the three papers that constitute this dissertation. This work

contributes to a number of current dialogues and debates within the global malaria community about the best ways to distribute nets, encourage people to use them and monitor net ownership and use. I here present a brief overview of the role of mosquito nets in the history of malaria, and outline the key unresolved questions, debates and challenges related to the use of ITNs in the context of global malaria control and elimination efforts.

History of Mosquito Nets

For centuries, people have used a variety of different strategies to protect themselves from biting insects. These include burning cow dung or leaves to repel insects, as well as using heavy blankets or woven cotton tents (nets) as protective physical barriers. During the Second World War, armies began impregnating bed nets with insecticides to protect their troops from biting insects. A number of small-scale trials were conducted in the 1980s and 1990s to evaluate the potential of ITNs for disease control and, after these trials demonstrated that the technology was both safe and effective, the WHO recommended the use of ITNs as part of the global malaria control strategy (Lengeler & Snow, 1996). In 2007, the WHO officially recommended the use of long-lasting insecticidal nets (LLINs) which maintain effective insecticide levels for several years, compared to the previous ITNs which had to be re-treated every few months.

The Efficacy and Effectiveness of ITNs/LLINs

While there is general consensus in the malaria community that LLINs alone will be insufficient to completely interrupt malaria transmission and achieve elimination, they will continue to play an important role in malaria control and elimination efforts, at least until alternative technologies are developed. For countries that are still in the control phase, LLINs can prevent significant mortality and morbidity from malaria, and potentially also reduce levels of transmission to the point where other intervention strategies could be used to bring transmission to zero (Moonen, Cohen, Snow, et al., 2010). Because elimination and eradication are long-term

goals, malaria *control* strategies such as LLINs will need to be scaled-up and sustained even while research and development activities focus on the needs for superior alternative technologies. LLINs may also play an important role in preventing the re-introduction of malaria into countries or geographic regions that have achieved elimination.

The efficacy of ITNs and LLINs has been well-established, though their effectiveness in real-world conditions is often compromised by health systems and individual user-level factors (Lengeler & Snow, 1996). A Cochrane Review of ITNs and treated curtains for malaria control reported that ITNs can reduce malaria episodes for individual users in endemic areas by as much as 50% and provide 45% protection against anemia (Lengeler, 2004), while a more recent systematic review reported that ITNs have a 55% protective efficacy (range 49-61%) among children under-five in areas where the majority of malaria cases are due to *P. falciparum* (Eisele, Larsen, & Steketee, 2010). Models based on data from Malaria Indicator Surveys and Demographic and Health Surveys indicate that household ownership of at least one ITN is associated with a 20% reduction in parasitemia and a 23% reduction in mortality between the ages of 1 month and 5 years (Lim et al., 2011). An estimated 635 lives are saved for every additional 1,000,000 ITNs distributed (Akachi & Atun, 2011).

In addition to providing individual protection for those sleeping under insecticide treated nets, ITNs can also have community-level protective effects, protecting even those who don't sleep under nets by delaying mosquito feeding, diverting bites onto non-human hosts and, when coverage levels are high enough, even significantly reducing overall mosquito populations (Gimnig et al., 2003; Hawley et al., 2003; Hill, Lines, & Rowland, 2006; Howard et al., 2000; Killeen & Smith, 2007; Russell et al., 2010). A group-randomized controlled mortality trial conducted in Kenya found that the protective effects of ITNS on mortality, anemia and parasitemia extended to households without nets that were within 300 meters of household with nets (Hawley, et al., 2003). Bed nets have been associated with reductions of as much as 94% in entomological inoculation rate (Shaukat, Breman, & McKenzie, 2010).

Bed nets are a highly cost-effective strategy (White, Conteh, Cibulskis, & Ghani, 2011; Yukich et al., 2008; Yukich, Zerom, Ghebremeskel, Tediosi, & Lengeler, 2009). According to a recent systematic review, the median financial cost of protecting one person for one year with an ITN is $2.20 (range $0.88-$9.54), while the median incremental cost effectiveness ratio per disability adjusted life year averted was $27 (range $8.15-$110) (White, et al., 2011) . The reported costs per treated net year of protection for LLINs range from $1.38 to $1.90 (Yukich, et al., 2008). The cost of protecting a person with an ITN are much less than the combined costs of diagnosing and treating an episode of malaria: the median financial cost of diagnosing a case of malaria is estimated at $4.32 (range $0.34-$9.34), while the median financial cost of treating an episode of uncomplicated malaria is $5.84 (range $2.36-$23.65) and the median financial cost of treating an episode of severe malaria is $30.26 (range $15.64-$137.87) (White, et al., 2011) . These potential savings are compounded by the fact that, in many malarious countries, people experience multiple episodes of malaria a year. LLINs have been demonstrated to be more cost effective than other vector control strategies such as indoor residual spraying (IRS) (Yukich, et al., 2008)

Scaling Up LLIN Ownership and Use

There are a number of key research questions and operational challenges that must be addressed to increase the success of LLIN scale-up efforts and maximize the potential benefits of bed nets as countries gradually move through various phases of elimination. These challenges and questions relate to technology development and consumer demands, LLIN distribution strategies, achieving universal LLIN coverage and use, and measuring and monitoring LLIN indicators. These topics are all addressed in some way by the chapters that follow in this dissertation and thus I present below a brief summary of the current progress, knowledge, debates and questions pertaining to each one.

Best practices for bed net distribution. There have been rapid increases in bed net ownership and use in the past few years, primarily as the result of large-scale mass distribution campaigns. Of 20 countries with available data, 16 have at least tripled ITN coverage since 2000 (UNICEF & Roll Back Malaria Partnership, 2007). Household ownership of at least one net in Africa was reported to be 2.2% in 1999 while 2008 reports estimated ownership at 32.8% (Flaxman et al., 2010). However, net ownership and use still remain well below the ambitious full-coverage targets, and additional work is needed to evaluate and understand the variety of factors that contribute to the effectiveness of different types of delivery systems at all steps of the process (Webster, Chandramohan, & Hanson, 2010; Webster, Hill, Lines, & Hanson, 2007). This would help to resolve continued debates about the best delivery system or combination of systems in terms of equity, cost and sustainability (Cohen & Dupas, 2010; Kolaczinski & Hanson, 2006; Muller et al., 2008; Sexton, 2011; Stevens, 2005). It could also improve the efficiency and effectiveness of current delivery approaches for use in particular contexts and for a given target population.

There is growing consensus that different delivery strategies should be considered complementary rather than competitive, and that the gains of combining multiple systems are additive (Lengeler & deSavigny, 2007). Taking a lesson from global immunization programs, the Scale-up for Impact (SUFI) in most countries consists of “Catch-up” phases, during which large numbers of LLINs are delivered rapidly through mass campaigns, and “Keep-up” phases during which LLINs are distributed to those born after the campaign through routine health system mechanisms, including the Expanded Program for Immunizations (EPI) and antenatal care clinics (ANC) (Grabowsky, Nobiya, & Selanikio, 2007). “Mop-up” activities are conducted to make sure that nets are distributed to people who were missed during the mass campaign. Most countries plan for large-scale LLIN replacement campaigns to be conducted 3-4 years after the initial campaign to replace nets after the insecticide is projected to fall below effective levels.

While retail market and social marketing have a number of potential benefits, particularly when it comes to considerations of sustainability, these strategies will likely need to be accompanied by free or subsidized net distribution systems for years to come. The cost of an unsubsidized or even partially subsidized net is still prohibitive for many households in malaria endemic countries and people may be unwilling or unable to prioritize the purchase of bed nets over other essential purchases due to financial constraints (Heggenhougen, et al., 2003a; Makemba et al., 1995; Ziba, Slutsker, Chitsulo, & Steketee, 1994). Given the fact that the highest malaria transmission season coincides with a period in the agricultural cycle during which people have the least access to cash, people may prefer to make a number of small expenditures related to mosquito control, purchasing less effective items such as mosquito coils, spray insecticides or natural repellants instead of paying for the purchase or re-treatment of ITNs (Aikins et al., 1993; Aikins, Pickering, & Greenwood, 1994; Heggenhougen, et al., 2003a; Remme, 2001; Winch et al., 1997). During the post-harvest period, when people have access to larger sums of cash, mosquito densities are lower and ITNs may not be seen as a priority (Heggenhougen, et al., 2003a; Remme, 2001).

Integrating bed net distribution with routine services such as the Expanded Program for Immunizations (EPI) or antenatal care (ANC) clinics has proven to be a cost-effective way to increase net ownership and use among pregnant women and children under-five in many malarious countries, and has increased net ownership equity between different socio-economic strata and between rural and urban populations (Cohen & Dupas, 2010; Grabowsky et al., 2005; Kulkarni et al., 2010; Noor, Amin, Akhwale, & Snow, 2007; Noor, Mutheu, Tatem, Hay, & Snow, 2009; Thwing et al., 2008). However, this kind of targeted distribution to vulnerable groups is insufficient to achieve the high coverage rates necessary to produce protective community-level effects (Flaxman, et al., 2010), and it leaves certain subpopulations unprotected by mosquito nets (Larsen et al., 2010).

The transition to universal coverage. In the past few decades, the majority of bed net distribution programs have targeted those groups at most risk of morbidity and mortality due to malaria: children under-five years of age and pregnant women. However, national malaria programs are gradually beginning to adopt "universal coverage" net distribution strategies. These strategies generally allocate 2-3 bed nets per household, depending on the number of people who usually sleep there, and assume that 2-3 people share a net.

There are a number of reasons for this shift. One is that higher rates of coverage are necessary to achieve the community benefits of LLIN distribution, as mentioned above. Protecting adults also seems to provide additional benefits in terms of protecting children (Killeen et al., 2007). Preliminary data from a study conducted by The Carter Center in Southeast Nigeria suggest that full coverage strategies may actually lead to increased net use among vulnerable groups, compared to distribution strategies that target only those groups (The Carter Center, 2010). The recently published revised estimates of death due to malaria elevate the urgency of moving to universal coverage since it appears that far more individuals older than the age of five are dying from malaria than previously thought (Murray, et al., 2011). This means that even when countries are still in the control phase, universal coverage will be important for reducing morbidity and mortality. These new mortality estimates also mean there are strong economic, moral and rights-based arguments in favor of distributing bed nets to adults. Finally, for countries targeting elimination, universal coverage will be important to help reduce transmission.

Achieving universal LLIN use. Accompanying the goal of universal net ownership is the related goal of universal net use. Universal use means that all individuals sleep under an insecticide-treated bed net, every night, during all seasons of the year. While countries are still working to reach a state of low-endemicity malaria control, universal use will help to reduce morbidity and mortality, and reduce transmission by limiting opportunities for transmission between vectors and human hosts and reducing overall mosquito populations. As the malaria burden in a given geographic area is reduced, universal use will remain important given the

increased risk of severe outcomes of malaria infection associated with reductions in innate immunity. However, as transmission is reduced it may be possible to limit the emphasis on LLINs to certain seasons or certain geographic areas.

Many questions remain about the barriers to and motivations of consistent LLIN use. Access to a net remains the strongest predictor of net use (Eisele, Keating, Littrell, Larsen, & Macintyre, 2009), but net use continues to lag behind net ownership even following mass distribution and communication campaigns (Eisele, et al., 2009; Korenromp et al., 2003; Miller, Korenromp, Nahlen, & Steketee, 2007). Previous studies have identified a number of potential determinants of LLIN use and maintenance. Large-scale national surveys such as the DHS and MIS tend to focus primarily on individual-level factors such as knowledge, local illness beliefs, attitudes (e.g. perceived risk, physical discomfort), and technical difficulties associated with using nets, though smaller-scale qualitative and quantitative studies have begun to highlight the importance of factors at the household, community and environmental levels, as well as a number of characteristics of the nets themselves that influence use. The following paragraphs provide a brief overview of some of the identified determinants of net use.

Socio-demographic determinants of use. Socio-demographic characteristics are often associated with net use behaviors, though the strength and direction of the relationships between these factors and net use often vary according to context. Age and gender can be important factors (Alaii, Hawley, et al., 2003; Baume & Marin, 2007; Graves et al., 2011; Ng'ang'a et al., 2009). For example an analysis of data from Mali, Senegal, Ethiopia, Ghana, Nigeria and Zambia found children younger than five years of age and pregnant women to be the most likely to use nets (Baume & Marin, 2007), while a study conducted in Western Kenya found that adults were more likely than children to sleep under a net (Alaii, Hawley, et al., 2003). More and more studies are beginning to show that children between the ages of 5 and 15 are the least likely to sleep under bed nets (Eisele, et al., 2009; Iwashita et al., 2010; The Carter Center, 2012b), and that young males may be the least likely to be protected by a net (Baume & Marin, 2007; Eisele,

et al., 2009). Educational attainment and socio-economic status (SES) have also been associated with net use (Alaii, Hawley, et al., 2003; Edelu, Ikefuna, Emodi, & Adimora, 2010), and ethnic group has also been associated with net use (Thomson et al., 1996).

Knowledge as an essential but insufficient determinant of net use. Most studies of the determinants of net use focus on knowledge, indicative of underlying assumptions that rational people who are aware that malaria is transmitted by mosquitoes, and thus that bed nets can protect you from malaria, will sleep inside a bed net as long as they have access to one. For example, in Ethiopia, following a mass LLIN distribution campaign in 2007, mother's knowledge of malaria causes, symptoms, danger signs and preventive measures was associated with the use of bed nets by children under-five (Hwang et al., 2010).

Biomedical knowledge about malaria, however, does not always replace local beliefs about the etiologies of febrile illness (Hausmann-Muela, Muela Ribera, Mushi, & Tanner, 2002). While mosquitoes are frequently recognized as a cause of local illnesses compatible with biomedical classification of malaria, other commonly-perceived causes include: fatty or oily foods, unripe or overripe fruits, spoiled food, dirty water, spending time in the hot sun, sleeping outside, breastfeeding, malevolent spirits and witchcraft (Patterson, 2005; Patterson, et al., 2006). When mosquitoes are considered only one of many causes of malaria or febrile illness, people may doubt the potential effectiveness of nets for malaria protection (Alaii, Van den Borne, Kachur, Shelley, et al., 2003). Because febrile diseases with different perceived causes are associated with different seasons, bed nets are often perceived to be more effective during some seasons than others (Makemba, et al., 1996; Winch et al., 1996b). Additionally, local beliefs about alternative causes of malaria and associated preventive practices may cause people to feel that they are already sufficiently protected and don't need to use a net. For example, men in the Kilombero Valley of Tanzania have reported that drinking beer makes their blood stronger and makes them more resistant to diseases such as malaria (Hausmann-Muela, et al., 2002).

Attitudes towards LLINs. Attitudes towards LLINs have also been the focus of much study, as knowledge is generally hypothesized to indirectly lead to behavior change by changing attitudes. Perceived advantages of net use are not always associated with mosquitoes but can also include benefits such as protection from falling debris, privacy, decoration, as was found in a study of communities in five West African countries (Aikins, et al., 1994). Other perceived advantages include protection from bed bugs and other insects (Alaii, Van den Borne, Kachur, Mwenesi, et al., 2003). Sometimes the advantages of bed nets have to do with their potential to be used for other purposes, such as door coverings, fishing nets and wedding veils which can lead to decreased use for their intended purpose (Lover, Sutton, Asy, & Wilder-Smith, 2011; Minakawa, Dida, Sonye, Futami, & Kaneko, 2008). LLINs are also reportedly used to protect food and animals from insects (Lover, et al., 2011).

Negative attitudes towards nets have been linked to physical discomfort associated with excessive heat (Alaii, Hawley, et al., 2003; Cohee et al., 2009), allergic reactions to insecticides or feelings of being confined while sleeping. The inconvenience and hassle associated with hanging bed nets is another reported reason for non-use (Rickard et al., 2011; Toé et al., 2009). There are some reports of negative attitudes associated with distrust in free distribution (Chuma, Okungu, Ntwiga, & Molyneux, 2010) or rumors, such as those reported in Western Kenya that bed nets were designed to limit fertility (Alaii, Van den Borne, Kachur, Shelley, et al., 2003).

Ptactical knowledge and skills. Knowledge and skills related to the proper use and maintenance of bed nets are also essential if people are to extend the lives of their nets and thus benefit from continuous protection. Awareness of the need to use nets during all seasons, the need to repair holes in nets, and the duration of insecticide is often lacking (Widmar, Nagel, Ho, Benziger, & Hennig, 2009), as is knowledge of the appropriate height at which one must hang a bed net to be adequately protected (The Carter Center, 2012a, 2012b). If a net is not maintained or used properly, its effectiveness at protecting people from malaria will be reduced. This could

potentially lead to dissatisfaction with the results of net use and subsequent abandonment of the practice.

The importance of household and community-level factors in determining net use. However, a growing body of research highlights additional constraints that may prevent people from acting upon their knowledge and illustrates the ways that net use is influenced by a complex interplay of social, cultural, structural and environmental factors. These studies present challenges for the idea that there is a direct linear relationship between knowledge, attitudes and practices (Agyepong & Manderson, 1999). For example, disruptions to normal sleeping arrangements as the result of visitors, house construction or social events and gatherings can interrupt net use (Alaii, Hawley, et al., 2003). Livelihood demands that require a person to sleep away from home may also interrupt net use (Dunn, Le Mare, & Makungu, 2011). People may not always take bed nets with them when they spend the night away from their homes, either because of the value they place upon the net and the fear that something would happen to it (Alaii, Hawley, et al., 2003), because they had been intending to return home (Dunn, et al., 2011), or possibly because of the hassle associated with transporting a net. Environmental factors such as climate and temperature (Alaii, Hawley, et al., 2003; Ng'ang'a, et al., 2009), mosquito density (Baume, Reithinger, & Woldehanna, 2009), and the availability and proximity of land for farming and grazing livestock (Dunn, et al., 2011) can also influence net use. Socio-cultural practices and norms are also important. For example, in Tanzania, the use of bed nets is considered inappropriate when women sleep outside during funerals because mosquito bites are symbolically associated with mourning (Dunn, et al., 2011; Marsland, 2006).

There is also increasing recognition of the way that factors associated with household size, structure and composition play a large role in determining both whether a given net is used and whether a given household member sleeps under a net (Alaii, Hawley, et al., 2003; Baume & Marin, 2007; Iwashita, et al., 2010; Keating, Macintyre, Mbogo, Githure, & Beier, 2005; Ng'ang'a, et al., 2009; Toé, et al., 2009). It may be difficult to hang a net, particularly a

rectangular one, in a small house (Alaii, Hawley, et al., 2003). Addition difficulties are introduced when the same space is used for sleeping at night and for multiple other purposes during the day (Toé, et al., 2009).

Net-level factors. Characteristics of the nets themselves, such as cost, size, shape, color, size of holes, type of insecticide used and physical durability have also been shown to influence net use (Alaii, Hawley, et al., 2003; Baume, et al., 2009; Chuma, et al., 2010; MacCormack & Snow, 1986; Ng'ang'a, et al., 2009). The development of LLINs was a great step-forward as it eliminated the need for people to re-treat their nets every six months and thus reduced user burden and increased the likelihood that people would be protected by nets with effective insecticide levels for longer periods of time. However, there are still needs for a wider variety of forms and shapes of protective barriers that will reduce the amount of hassle and inconvenience associated with the use of bed nets, are appropriate for a wider range of housing structures and sizes, can be used over all types of sleeping spaces, and will address the specific preferences and desires of consumers. For example, evidence from Peru demonstrates that in places where there is an existing practice of using non-impregnated muslin nets people sometimes rejected ITNs because they did not provide the same advantages of warmth, privacy security for young children as the traditional nets (Harvey et al., 2008).

Importantly, initial evidence from the field suggests that LLINs physically deteriorate long before insecticide levels fall below effective levels, with implications for the timing of net replacement campaigns and for cost-effectiveness estimates as well as for net effectiveness and use (The Carter Center, 2010). There is a linear reduction in effectiveness corresponding to increased numbers of holes in bed nets to the point that, after a certain number of holes develop a net offers little or no protection (Rehman et al., 2011). In Ethiopia, some of the most commonly cited reasons for net non-use are associated with the age, physical condition and perceived loss of insecticidal effect of the nets (Baume, et al., 2009; The Carter Center, 2012a).

Limits to existing understandings of determinants of net use. However, much of the variability in net use behaviors remains unexplained. A recent review of the literature concluded that there is a dearth of well-designed studies to inform interventions designed to increase net use among individuals who own nets (Pulford, Hetzel, Bryant, Siba, & Mueller, 2011). Additionally, there is a need for a much more nuanced understanding of the interactions and potential mediating and moderating relationships between different determinants of net use, as well as the seasonal variability in factors that encourage or inhibit net use. As countries strive to achieve universal net use, it will also be important to develop a stronger understanding of the determinants of use among net-owning individuals older the age of five, and of the ways that the determinants for this population differ from those influencing net use among the previously targeted "vulnerable groups."

Effective communication messages and strategies for encouraging net use. With a better understanding of the factors that motivate and inhibit net use, it will be possible to develop more effective tailored interventions for encouraging behavior change, including but not limited to improved behavior change communication messages and methods. In addition to developing new and more effective behavior change messages, it is important to study the ways that people understand, interpret and act upon these messages rather than assuming that messages are always received in exactly the same way they were intended, as has often historically been the case with health education programs.

Health education strategies for malaria often seem to be based on an implicit underlying premise that messages are discrete, transparent, objective and immutable entities directly transmitted from source to audience. However, studies of discourse and socio-linguistics have repeatedly demonstrated the reciprocal relationships between talk and the social and cultural context of talk; talk does more than reflect social conditions and transmit existing knowledge; it also creates and reinforces them. Research on audience reception has challenged the assumption of a straightforward process of cause and effect leading from the production to the reception of a

message; while there is some disagreement regarding the extent to which individual audience members actively respond to or resist media messages, most scholars agree that reception is somehow influenced by aspects of lived experience, be it those associated with individual needs, characteristics and experiences (Brooker & Jermyn, 2003; Radway, 2003), or with membership in a larger community that shares a set of cultural assumptions (Fish, 1980) and codes (Hall, 1980) that determine the meaning of a text (interpretive communities). Effective communication depends on the extent to which assumptions and encoded meanings are shared by message producers and receivers (Hall, 1980; Pigg, 2001). Given linguistic, socio-economic and cultural differences between the personnel of government and non-governmental organizations, health providers and lay persons in most African settings, processes of encoding and decoding health messages are likely to differ (Hall, 1980), producing ample opportunities for miscommunication about malaria and LLINs.

Patients' willingness to comply with medical advice and behavioral recommendations has been shown to be associated with attitudes towards health facilities and health care providers (Abdel-Tawab & Roter, 2002; Bertakis, Roter, & Putnam, 1991; Brody, Miller, Lerman, Smith, & Caputo, 1989; Brody et al., 1989; Roter, 1983; Roter & Hall, 1991, 1994; Roter, Hall, & Katz, 1987; Roter et al., 1998). Positive attitudes towards a health care provider are influenced both by interpersonal interactions and by institutional level factors (Gilson, Alilio, & Heggenhougen, 1994; Russell, 2005), and are directly related to a patient's perception of the quality of care provided. Among the factors determining a patient's perceptions of trust and quality of care are judgments about the provider's competence, the provider's attitudes and behaviors towards the patient, and the provider's listening skills (Gilson, et al., 1994; Russell, 2005; Tibandebage & Mackintosh, 2005). Patients also consider the extent to which procedures and prescriptions are explained, demands for bribes, and the extent to which physicians provide the expected or desired treatments when evaluating the quality of a medical encounter, and therefore the degree of trustworthiness of the provider or facility (Gilson, et al., 1994; Russell, 2005; Tibandebage & Mackintosh, 2005). Facility-level characteristics such as the availability of drugs and equipment,

cleanliness and comfort, and policies directly affecting patients may also determine attitudes towards health care providers and health facilities (Gilson, et al., 1994).

The nature of the communication between health care provider and client may be as important as the specific content communicated when it comes to determining behavioral change and adherence to recommendations (Abdel-Tawab & Roter, 2002; Bertakis, et al., 1991; Brody, Miller, Lerman, Smith, Lazaro, et al., 1989; Montgomery, Mwengee, Kong'ong'o, & Pool, 2006; Roter, 1983; Roter & Hall, 1991, 1994; Roter, et al., 1987; Roter, et al., 1998). There is a danger that negative experiences at a health facility may in fact lead patients to avoid or delay seeking care from that source in the future (Gilson, et al., 1994). In contexts where LLINs are primarily distributed through routine services provided by health facilities, this could potentially have negative effects on bed net coverage. If clients are sufficiently dissatisfied with the treatment they receive at health facilities, they may avoid them altogether, choosing to obtain services from alternative sources in the community or within the private sector. As the result of this, they risk bypassing LLIN distribution activities altogether. Increasingly, researchers are beginning to recognize the importance of the related concepts of trust (Eriksen et al., 2005; Gilson, et al., 1994; Goudge & Gilson, 2005; Russell, 2005; Tibandebage & Mackintosh, 2005) and perceived quality of care (Gilson, et al., 1994; Tibandebage & Mackintosh, 2005) in determining health seeking behaviors in the developing world.

The pedagogical approaches adopted by providers in their interactions with patients may also play an important role in determining health seeking behavior. For example, while providers interviewed in the context of a study conducted in Tanzania see themselves as “teachers,” the pedagogical strategies they employ may actually discourage appropriate treatment seeking, particularly given the way that they reinforce hierarchies of gender, power and social class and may leave mothers feeling disempowered (Montgomery, et al., 2006). These factors may also influence the likelihood that an individual will comply with provider’s recommendations related

to preventive behaviors, such as net use (de Hoop & van Kempen, 2010), though few studies on that particular topic have been published.

Measuring Progress towards the Targets of Universal LLIN Coverage and Use

In conjunction with the development of more efficient and effective strategies for delivering nets and encouraging people to use them, it is important to measure bed net coverage and use, as well as their impacts on malaria morbidity and mortality. As mentioned above, there is a general need for less costly assessment strategies that produce timely, locally-relevant data for key malaria indicators that can be used for both program planning and evaluation purposes. However, there are also a number of more specific ongoing debates and discussions about the best way to measure LLIN ownership and use.

Bed net coverage is generally reported in terms of three key indicators: the percentage of households owning at least one net, the percentage of individuals who slept inside a net the previous night, and the percentage of nets that were used the previous night. Net ownership is generally confirmed by direct observation of the net, which also provides an opportunity to assess net characteristics such as brand and condition (holes). Individual net use and nets used last night are almost always assessed by self-report, though the percentage of nets hanging at the time of data collection is often used as a directly-observed proxy for the percentage of nets used the previous night (Krezanoski, Comfort, & Hamer, 2010). Self-report data are vulnerable to respondent bias, particularly as exposure to health education messages increases, since people may be reluctant to admit that they are not complying with public health recommendations. However, using nets that are hanging during the day as a proxy for nighttime net use is also problematic as it doesn't allow for the possibility that people take down their nets during the day for reasons including space constraints, the need to wash nets or a desire to protect the nets from additional wear and tear. To address these limitations, there have been a few studies in which net use by individuals has been directly observed by during unannounced nighttime visits to

households (Frey, Traore, De Allegri, Kouyate, & Muller, 2006), but this is both logistically difficult and ethically sensitive given the discomfort that many would potentially feel about being observed while sleeping.

Differences in the percentage of households owning more than one net and the percentage of individuals who slept under a net the previous night are often described as "gaps" or "lags" between ownership and use. However, direct comparisons are problematic given the fact that the two indicators have different denominators (number of households verses number of individuals). Thus it is not possible to unequivocally determine that the differences reflect a failure to use nets and not a continued gap between the number of nets distributed and the number needed to cover all sleeping spaces in the household. Considering these indicators side-by-side with the percentage of nets that were used last night is one way that people have tried to determine whether the differences in coverage and use primarily reflect a problem with ownership (access) or a problem with use (behavior). If most of the nets distributed are in use, then low use can be viewed as a sign of insufficient access to nets, whereas large numbers of nets remaining unused in their packaging indicate a greater need to address other barriers to use. In addition, analyses of net use data are often restricted to households owning nets in order to isolate factors other than ownership that are associated with use (Eisele, et al., 2009; Macintyre et al., 2006).

As described above, there are a wide range of potential barriers to net use, but currently there are no standardized universal indicators for characterizing reasons for net non-use – at least in-part because reasons for non-use can vary quite dramatically from context to context. A recent publication by a team of authors with extensive experience conducting and monitoring large-scale national LLIN distribution campaigns proposes a framework of categories of non-use which can be applied to data commonly collected in MIS and DHS (vanden Eng et al., 2010). Individual (net use), household (net ownership) and net (hanging) variables are combined into one indicator which has as its denominator the number of people. According to this framework, net non-users

are classified as belonging to one of three groups: non-users in households with no nets, non-users in household that own but are not hanging an ITN, and non-users in households with a net hanging who are not sleeping under it. The authors demonstrate the potential of the framework using data from surveys conducted in the context of integrated campaigns in five African countries. While this framework is useful, it still has its limitations as it fails to address the fact that access to nets *within* a given household may differ between household members (Baume & Marin, 2007). The fact that a person's household owns a net, or even hangs a net, does not necessarily mean that the person is able to use that net. This issue of *intrahousehold access to nets* is one that will be explored further in this dissertation.

Current assessments of the adequacy of net coverage generally classify a household as a net-owning or non-owning household, without considering the number of individuals or, more importantly, the number of sleeping spaces in the household to categorize households further into those with adequate numbers of nets or inadequate numbers of nets. This was less of an issue in the days of targeted net distribution campaigns aiming to reduce morbidity and mortality among pregnant women and children because one or two nets could potentially cover all of these vulnerable individuals within a household. Now, in the days of universal coverage for transmission reduction, there is a need for more nuanced ways to measure net coverage and to understand the relationships between household ownership, intrahousehold access to net, and net use.

Additionally, there is a growing recognition of the need to differentiate between reported use, defined as the use of any net last night, and 'effective use,' defined as the use of a net that is actually providing sufficient protection from mosquito bites (Moonen, Cohen, Tatem, et al., 2010). In order for a net to offer effective coverage, it must be intact and well-maintained, have sufficient levels of insecticide, and be tucked in correctly. While data pertaining to net age, retreatment (in the case of ITNs), condition (holes) , hanging and use are sometimes collected,

analyses of net use rarely use these variables to stratify net use according to effective and ineffective use.

RESEARCH CONTEXT: THE MAALRIA SITUATION IN MALI, WEST AFRICA

The research presented in this dissertation was conducted in the West African country of Mali. Malaria is endemic to the central and southern regions of the country (where about 90% of Mali's population lives), and considered epidemic in the north based upon limited viability of *Anopheles* species in the desert climate. Malaria transmission varies in the five geo-climatic zones. It occurs year-round in the Sudano-Guinean zone in the south, as well as in the Niger River Delta and in areas with large-scale irrigation projects to support rice cultivation. In endemic areas, peak malaria incidence generally occurs shortly after the end of the rainy season. While the timing of this peak varies somewhat from year to year and region to region, a study conducted in central Mali using health facility data from 1996 to 2004 found that the highest numbers of malaria cases were consistently treated in December of each year (Findley et al., 2005; Findley, Medina, Sogoba, Guindo, & Doumbia, 2010). The transmission season is shorter in the northern Sahelian Zone, lasting approximately three to four months (July/August to October). Epidemics have been known to occur in the north (Tombouctou, Gao, and Kidal Regions) and in northern districts of Kayes, Koulikoro, Segou and Mopti Regions. However, the last identified epidemic was in September 2003 in Tombouctou (President's Malaria Initiative, 2012).

Malaria remains the leading cause of morbidity and mortality in Mali, despite impressive progress in the scale-up of malaria interventions in recent years. Data from the national health information system (*Système Local d'Information Sanitaire* or SLIS) indicate that there were 2.1 million clinical cases of malaria in health facilities (528,962 severe and 1,627,618 uncomplicated) in 2010, accounting for 44% of all outpatient visits (President's Malaria Initiative, 2012).

However, only 10% of these cases were confirmed by either RDT or microscopy, meaning that actual numbers of malaria cases are likely considerably lower. A study conducted in the Mopti Region of Mali found that between 22.3% and 33.6% of fever cases were attributable to malaria, depending on the season (Dicko et al., 2005). However, even when this is taken into account, the burden of malaria morbidity still represents a considerable public health problem, and there has been little evidence of reduction in malaria cases since 2000 (WHO, 2010).

Recently published predictive models developed using all available mortality data from 1980-2010 indicate that all-age malaria mortality in Mali has continued to increase steadily despite the rapid scale-up of LLIN distribution and other interventions. The total number of deaths estimated for 2010 was 39,283 (95% CI: 19774-77017). Mortality has declined among children under-five since 2000 (from 31,745 to 28,859) but has increased in individuals older than five from 6,416 (95% CI: 4,086-9,662) in 2000 to 10,424 in 2010 (95% CI: 6,034-19,981) (Murray, et al., 2011). Prevalence of parasitemia by microscopy among children 6 to 59 months of age as measured during a 2010 national survey ranged from 2.2% in the capital of Bamako to 59.2% in the Southern-most region of the country, with a national average of 37.5% (Programme National de Lutte contre le Paludisme (PNLP), INFO-STAT, & ICF Macro, 2010). The predicted mean annual entomological inoculation rates ranged from 80-100 between 1965-1998 (Gemperli, Vounatsou, Sogoba, & Smith, 2006).

Given the current malaria profile, experts believe that elimination in Mali is not likely to be achievable with existing tools (Tatem et al., 2010).

The Malian National Strategic Plan for Malaria Control

Mali's 2007-2011 strategic plan for malaria control sets forth the following objectives: a) reduce malaria mortality by at least 50% compared to 2000 levels; b) reduce malaria case-fatality rates reported in health facilities by at least 80%, compared to levels in 2005; and c) reduce malaria morbidity by at least 50% as compared to levels in 2000.

To achieve these objectives, the PNLP has defined four major malaria control and prevention strategies: 1) improved case management, 2) intermittent preventive therapy in pregnancy (IPTp), 3) vector control (distribution and use of ITNs, larviciding to destroy breeding sites, and targeted indoor residual spraying (IRS)), and 4) malaria epidemic preparedness. Cross-cutting approaches to support these major strategies include: community mobilization and behavior change communication (BCC), operational research, and monitoring and evaluation. In 2006, Mali declared that ITNs should be provided free of charge to pregnant women and children under-five at CSCom, and that artemisinin-based combination therapies (ACT) should be provided free of charge for children under-five.

LLIN distribution in Mali. In 2007, 2.2 million LLINs were distributed to households in Mali as part of a mass integrated campaign. This was the first ever integrated campaign comprised of five interventions: LLIN distribution, Vitamin A, and albendazole for de-worming, in addition to polio and measles vaccinations. Since then LLINs have been distributed to targeted vulnerable groups in the context of routine immunization and antenatal services. According to the national strategic plan, women are to receive an LLIN at their first ANC visit at government hospitals and health centers, and children are given an LLIN when they complete their vaccination series with the measles vaccination at approximately 9 months of age. In 2010, the government of Mali adopted a policy of universal bed net coverage and began planning for another mass distribution campaigns. However, at the time of the study described here, the policy of universal coverage had not yet been implemented.

Rates of bed net ownership and use among children under-five in Mali are some of the highest within Sub-Saharan Africa. According to data from an anemia and malaria prevalence survey conducted in Mali in 2010, 93% of households own at least 1 net of any kind, and 84.7% own at least one LLIN (Programme National de Lutte contre le Paludisme (PNLP), et al., 2010). The same survey found that 80.2% of children under-five slept under a bed net the previous night and that 70.2% slept under an LLIN. Mali had the highest percentage of households with at least

one net out of all African countries with available nationally representative survey data reported in the 2010 World Malaria Report, as well as the highest percentage of children under-five sleeping under an ITN (WHO, 2010).

This makes Mali a particularly interesting case study for a number of reasons. The high rates of net ownership mean that examinations of distribution practices could provide useful lessons and instructive examples for other countries. The fact that access to nets is already high makes Mali an ideal setting to study the influence of factors *other than net ownership* on net use. Also, the fact that net use is already high among children under-five suggests that knowledge and positive attitudes are already fairly widespread and creates an ideal context for identifying other less commonly recognized determinants of net use and for learning how behavior change communications messages may need to be modified to encourage use among adult populations in the context of the transition to universal coverage.

The Malian Health System

Malaria interventions, including LLINs, are primarily delivered within the public health sector in Mali. The national health system has four levels: national, regional, district and health zone. In 2008-2009, when this study was conducted, there were four national reference hospitals, six regional hospitals, fifty-nine district health centers (*Centres de Santé de Référence* or CSREF), and more than 800 community health centers (*Centres de Santé Communautaire* or CSCOM). The coverage area of each CSCom is referred to as the health zone.

In addition to providing consultative and treatment services, the CSCom are points of delivery for LLINs and malaria health education, and are the source of most routine malaria surveillance data. Each CSCom is managed by a trained nurse or doctor, the *Chef de poste médical* (CPM), who is assisted by some combination of maternity nurses, vaccination technicians, interns/volunteers, pharmacists and guards – though many facilities have no more than three employees on staff. In addition to routine services, the staff assists with health

campaigns, including polio campaigns or mass drug administration (MDA) for parasitic infections such as onchocerciasis or trachoma.

CSCom are established when communities fulfill the following criteria: a minimum of 10% contribution to the construction or renovation of the health facility; the hiring and support of health personnel; and the establishment of a community health association (associations de santé communautaire - ASACO). Once the CSCom is officially approved, the Ministry of Health (MOH) provides an initial stock of medicines, supplies and equipment. According to Mali's strong policy of cost recovery, which is based on the controversial Bamako Initiative (Garner, 1989; Hanson & McPake, 1993; Jarrett & Ofosuamaah, 1992; Ridde, 2011), CSCom must then replenish their stock from either government stores or private pharmacies, using money generated from the sale of essential drugs. CSCom are responsible for financing the transportation of drugs, supplies and LLINs from the district to the health zone level. Costs such as fuel, generators, motorcycles and motorcycle repairs, facility maintenance and some staff salaries are covered by charging user fees for services and, in some places, membership fees that allow for reduced service charges. The ASACO is responsible for the financial management of the CSCom. In theory, communes are also supposed to provide support for the CSCom, often including staff salaries. Salaries may also be paid by other partners in the case of CSCom that receive additional funding associated with a particular project or initiative.

Partnerships and Funding for Malaria Control in Mali

Malaria control activities, including bed net distribution and health education activities, are coordinated by the national malaria control program (PNLP) and its partner organizations. In 2008 and 2009, the years in which this study was conducted, the government of Mali contributed $6.7 and over $9 million respectively to fund the activities of the PNLP (President's Malaria Initiative, 2012), though its contributions have decreased since then. Mali was selected as a President's Malaria Initiative (PMI) country in 2006 and has received significant financial and

technical support from USAID and the Centers for Disease Control and Prevention (CDC) since that time. Other key partners who support the work of the PNLP include the Global Fund[1], WHO, UNICEF, the World Bank and the Dutch Cooperative, Population Services International (PSI), CARE, Save the Children, and a strong network of other local and international non-profit organizations (NGOs) and private voluntary organizations (PVOs).

THE STUDY SITE: SEGOU, MALI

This project was conducted in two districts of the Segou Region of Mali. The Segou Region is located in the center of the country, and its capital city (also named Segou), is approximately 235 km north-east of the capital city of Bamako. Two main rivers, the Niger and the Bani, traverse the region, and irrigation projects have been introduced in certain zones to facilitate rice farming. There are three main seasons in Segou: the rainy season, the cold dry season and the hot dry season. Malaria is endemic, with a peak immediately following the end of the rainy season. The region is predominantly agricultural, and the primary occupations are agri-business, fishing and animal husbandry.

Most people in this region belong to the Bambara ethnic group, though the towns along the rivers are heavily populated by Bozo fishermen. Other common ethnic groups include the Peuhl and Sarakole. Over 40% of women in Segou Region are in polygamous marriages (Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS), Direction Nationale de la Statistique et de l'Informatique du Ministère de l'Économie de l'Industrie et du Commerce (DNSI/MEIC), & International, 2007).

Net Ownership in Segou

The percentage of households owning any kind of mosquito net in the Segou Region was 85% in 2006, *prior to mass distribution campaigns*, according to the National Demographic and Health Survey, while 52.8% of children under-five slept under any bed net. These rates were

much higher than in any other region of the country, though the gap diminishes somewhat when comparisons are limited to insecticide treated nets and even more so when limited to long-lasting insecticidal nets (Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS), et al., 2007). In this region, approximately 70% of pregnant women seek care from a trained medical professional and close to 80% of children are vaccinated against measles and thus have the potential to receive an LLIN through routine distribution channels (Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS), et al., 2007).

STUDY OVERVIEW

The scope of the overall research project was broad, examining the topics of bed net distribution and use, malaria diagnosis and treatment, the integrated delivery of malaria interventions with other routine services, innovative approaches to monitoring key malaria indicators, health systems constraints on the effective delivery of malaria interventions, and audience reception of malaria behavior change communications - all in the context of the rapid scale-up for impact of malaria control strategies. A detailed overview of the study objectives and mixed methods research design is presented in Chapter 2.

This dissertation presents a subset of the data collected in the context of the larger project. The three papers included herein each address a different topic related specifically to long-lasting insecticidal bed nets (LLINs) as a strategy for decreasing transmission and reducing malaria-specific morbidity and mortality: LLIN distribution through routine Expanded Program for Immunization (EPI) services, the determinants of LLIN use among individuals of all ages where net use is already high among children under-five, and LLIN monitoring.

Collectively, these papers highlight a number of important health systems factors likely to influence the success of a wide range of malaria activities and apply health systems thinking (de Savigny, 2009) to understand the complex relationships between malaria control programs, other health programs and all of the key elements of the health system, including people at all

levels. They also address the influence of socio-culture beliefs, practices and norms, and communication on LLIN distribution and use. The implications of the findings presented here are cross-cutting and have broader implications for malaria control and elimination activities in addition to LLIN distribution, as well as for other child health services provided at community health centers (CSCom).

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Chapter 1 Notes

[1] Mali's Round 6 Phase 2 grant from the Global Fund was suspended in 2010 due to the results of an investigation by the Global Fund Inspector General which revealed that approximately $5.3 million from the tuberculosis and malaria grants had been misused ((GFATM, 2011) The government of Mali has responded by replacing the Minister of Health and has already begun to pay back the amount of misappropriated funds. The types of inappropriate uses of funds identified during this investigation were ongoing throughout the period of my field work in Mali, though they had not yet been internationally recognized. These include false procurements, fabricating documentation of travel and meeting attendance to justify per diem payments and overcharging for purchases, among other things.

CHAPTER 2

Overview of Mixed Methods Research Design

The data presented in this dissertation represent a subset of the findings of an 18-month-long project conducted in Segou, Mali. The primary objectives of the study were to evaluate the implementation, validity and effects of the EPI (Expanded Program for Immunizations) Contact Method, a novel health facility-based tool designed to both monitor and improve rates of bed net use and appropriate treatment of childhood illnesses, and it was these objectives that drove most of the study design and sampling decisions. However, the research also explored a broad range of other topics related to the delivery, uptake and evaluation of malaria control interventions in Mali. These topics included practices of bed net distribution and use, malaria case management in the context of a new policy to provide ACTs and RDTs for children under-five free of charge, and malaria communication between all key players within the health system. The research questions related to each of these topics are presented in Table 2.1.

To address the primary research questions regarding the EPI contact method, two adjacent districts in Segou Region with comparable demographics and malaria epidemiology, according to the 2006 DHS, were selected for inclusion in the study. The EPI-CM was introduced in one district (Segou) in September of 2008. The other district (Baraoueli) served as a comparison district. Baseline and follow-up household surveys were conducted in both districts. The data from the two time-points were compared to determine whether the EPI-CM resulted in improved LLIN use and treatment-seeking for childhood illnesses among children aged 12-23 months (the ages that would have had the potential to be exposed to the EPI contact method during the period between baseline and follow-up). To assess the validity of the EPI-CM data compared to the gold standard of the household survey, point estimates for key EPI-CM indicators obtained using the EPI-CM were compared to those obtained using survey data for children 0-11 months of age (the age groups assessed using the EPI-CM).

In addition to these household surveys, the research involved a number of additional quantitative and qualitative data collection activities integrated in a complex mixed methods research design. These additional data collection activities were conducted in six health zones of the intervention district (Segou) and three health zones in the comparison district (Baraoueli). Data collection in Segou District was more intensive, as these additional activities were primarily included to examine the processes of implementation of the EPI-CM. A smaller number of data collection activities were conducted in three health zones of Baraoueli for comparative purposes.

MIXED METHODS RESEARCH DESIGNS

Mixed methods research designs constitute a third type of research approach distinct from both quantitative and qualitative designs. Mixed methods designs differ from studies that include parallel but separate quantitative and qualitative components in that the two types of data are integrated at various phases of the research process. One form of data might inform the sampling design and data collection tools used for the other. Alternatively it might help to explain or validate the findings generated by the other method. Some researchers merge qualitative and quantitative into a single dataset during the analysis phase, looking at the qualitative data generated by individuals who all gave a certain response to a specific survey question or who share some other characteristics. The mixing of different types of data has the potential to generate better quality data and a stronger understanding of a research problem than the use of a single method. However, mixed methods research often requires more time and is more logistically complicated to conduct than research involving a single method (Creswell, 2007a).

Mixed methods research designs are generally classified according to 1) the sequence of qualitative and quantitative methods, 2) the relative priority of the quantitative and qualitative data, 3) the point at which the data are integrated ("mixed") and 4) the theoretical perspective of the project (if appropriate) (Creswell, 2003; Creswell, 2007a; Creswell, 2007b).

As exemplified by Creswell's typology of mixed methods designs, different designs are appropriate for different purposes (Creswell, 2007b). For example, if one wants to be able to explain or contextualize quantitative results, one would use a sequential mixed methods design that consists of a primary quantitative data collection phase followed by a qualitative phase (sequential explanatory design). If one wants to assess the generalizability of qualitative data or use qualitative data to inform the development of quantitative data collection instruments and measures, one would use a sequential design in which the quantitative phase follows the qualitative phase (sequential exploratory design).

Concurrent designs in which qualitative and quantitative data are collected and analyzed simultaneously are best when one wants to strengthen the validity of one's conclusions by comparing data collected using qualitative and quantitative approaches (concurrent triangulation design). This kind of triangulation of methods helps to compensate for the specific inherent limitations of each type of method.

Finally, embedded designs are those in which a smaller sub-study, either qualitative or quantitative, is embedded within a larger design of the other type. These most often embed smaller qualitative studies within larger quantitative designs. For example, a qualitative sub-study embedded within an experimental or quasi-experimental design can help to explain the mechanisms, unintended consequences or challenges of an intervention (embedded experimental design). Alternatively, qualitative data can be used to explain and interpret correlations observed in cross-sectional quantitative data (embedded correlational design).

OVERVIEW OF THE RESEARCH DESIGN: A FOUR-PHASE MIXED METHODS STUDY

The mixed methods design used for this study had four phases and combined elements of sequential exploratory, sequential explanatory, concurrent triangulation and embedded experimental designs. The design is depicted in Figures 2.1 and 2.2. On this diagram of the

study design, “qual” indicates “qualitative”, “quant” represents “quantitative” and the capital and lowercase letters are used to indicate greater and lesser priority respectively. Descriptions of each of the four phases are presented below.

Phase One

Phase One consisted of baseline qualitative observations and interviews at community health facilities in order to inform the development of data collection tools for subsequent phases, as well as the training materials for the pilot study of the EPI-CM. The EPI-CM was introduced in all health facilities of Segou District between Phases One and Two, in September 2008, and continued through the end of December 2009.

Phase Two

Phase Two of the research was a cluster-randomized household survey, based on the questionnaire used for standard Malaria Indicator Surveys (MIS). The survey data influenced the development of qualitative interview and group discussion guides used in Phase Three. Questions were added to these Phase Three guides for the purpose of further exploring and explaining trends observed in the Phase Two survey data.

Phase Three

Phase Three consisted of a wide variety of qualitative and quantitative methods conducted concurrently over a 15-month period. The included methods were: a) unstructured observations at health facilities; b) participant observation during trainings, workshops and meetings at the district and national levels; c) in-depth interviews with CSCom staff; d) review of health facility records, reports and registers containing any data related to the EPI-CM or malaria control; e) systematic observations of vaccination clinics and medical consultations; f) follow-up interviews with the health workers and parents who participated in observed vaccination clinics

and medical consultations; vaccination clinic exit interviews; g) group discussions with mothers, father and grandmothers; and h) review of malaria health communications media (television, radio and print). The sampling strategies employed for the qualitative data collection activities reflect a desire to capture the perspectives of a wide variety of people involved with the planning, delivery, uptake, supervision and evaluation of malaria control interventions, as well as to examine any seasonal differences in these activities.

While data were collected from health facility records and registers in all CSCom of the Segou district (the EPI-CM district) during Phase Three, six facilities in Segou District and three facilities in Baraoueli (comparison district) were selected for a thorough process evaluation of the EPI-CM, as well as an intensive study of the social, cultural and health systems factors influencing LLIN distribution and use, communication about malaria and the diagnosis and treatment of febrile illnesses. These facilities were selected, with input from the district medical administrator, to reflect variability in CSCom functionality, distance from the district capital, and gender and training of the director of the CSCom (CPM).

The data collected during Phase Three were examined and discussed by the research team as they were collected and thus informed sampling decisions and data collection tools for subsequent activities in a continuous iterative process inspired by methods of grounded theory (Charmaz, 2006; Glaser & Strauss, 1967; Strauss & Corbin, 1990). The triangulation of different methods and data sources served to strengthen the validity of findings. When seemingly contradictory data were identified (either from different people or by different methods), efforts were made to collect additional information in real time so as to resolve or explain the contradiction. When Phase Three data suggested potentially important determinants of LLIN ownership, LLIN use or malaria case management, additional questions and response options were added to the survey questionnaire to be used in Phase Four. During the final analysis, the data collected during Phase Three were used to contextualize and explain the findings of household surveys conducted in both Phase Two and Phase Four.

Phase Four

Phase Four was a follow-up cluster-randomized household survey primarily designed to evaluate both the effects of the EPI-CM on health behaviors (through comparison with baseline) and the validity of the data collected using the method (through comparison of EPI-CM and "gold standard" survey data). However, it also was used to assess key malaria prevention and treatment behaviors and their potential determinants. The baseline questionnaire was modified for use in Phase Four to determine the generalizability of key themes identified during qualitative data collection activities in Phase Three.

TRIANGULATION: A STRATEGY FOR STRENGTHENING THE VALIDITY OF CONCLUSIONS

A variety of qualitative and quantitative data collection activities was used to explore each of the four nested research topics and associated research questions, in various combinations (See Table 2.2). The approach to the research involved the triangulation of methods, data and investigators in order to strengthen the validity of the final conclusions (Patton, 2002; Thurmond, 2001).

Triangulation of Methods

Multiple methods were used to collect data pertaining to each topic so as to maximize the benefits of each method and compensate for its weaknesses (triangulation of methods). For example, systematic observations of EPI clinics were conducted to learn whether health workers were implementing the EPI-CM correctly, and what information they provided to parents in the form of tailored counseling as a function of responses to EPI-CM questions. However, to account for the possibility that health workers behave differently when being observed, parents were asked to describe the questions asked and the information provided to them by the vaccination

technician in EPI clinic exit interviews conducted at the entrance of the health facility on days when vaccinations were not directly observed. Data from daily EPI-tally notebooks and monthly reports were examined to see whether health workers consistently conducted the EPI-CM on days when no member of the research team was in attendance, and if they used the method during both facility-based and outreach vaccination clinics. To understand why health workers performed in a particular way when implementing the EPI-CM, and how parents responded to and understood this new activity, follow-up qualitative interviews were conducted with parents and health workers who had been observed.

Triangulation of Data Sources

Data were collected from key stakeholders at each level of the health system to ensure that a wide range of perspectives on malaria control activities were represented and to identify and compensate for the potential biases inherent in data from any one source. For example, to better understand the strengths and weaknesses of current LLIN distribution systems, interviews were conducted with employees of the NGOs responsible for coordinating bed net distribution activities, with MOH staff at the regional level who were in charge of managing the LLIN stock at the regional warehouse, with district-level health administrators who supervised the community health facilities and managed the periodic allocation of LLINs to them, with staff at community health facilities who directly distributed LLINs to pregnant women and children who completed their vaccination series, and with rural women who were the intended beneficiaries of the free distribution of LLINs. By comparing their perspectives, it was possible not only to get a more complete picture of the process of LLIN distribution but also to identify points of miscommunication and misunderstanding which led to breakdowns in the system and to some potentially detrimental unintended consequences of LLIN distribution for routine health facility activities.

As another form of triangulation of data sources, data concerning vaccination clinics and the communication between vaccination technicians and parents were collected from three health zones in the comparison district and six zones in the intervention district. The purpose of this was to facilitate the explanation of any differences between zones identified in the comparison of baseline and follow-up survey data, or the lack thereof. Because the zones were not expected to differ greatly in terms of socio-cultural beliefs and practices, health seeking behaviors, malaria communication or LLIN use, no in-depth interviews with parents were conducted in Baraoueli. However, these topics were explored in group discussions conducted in both districts to check the validity of this assumption.

Triangulation of Data Collection Time Points

Data were also collected throughout the year to account for the possibility of seasonal trends in behaviors, health service activities and their determinants. This is particularly important not only because malaria is seasonal in nature but also because of the seasonal rhythms of agricultural activities which are likely to influence health facility attendance due to related fluctuations in work load, available time, and available financial resources. Of equal importance is the fact that community health facility activities vary somewhat throughout the year. Though the standard package of child survival interventions is supposed to be provided throughout the year, routine health facility activities are sometimes interrupted by mass campaigns, such as the numerous polio campaigns that were conducted during the period of this study. Tables 2.3 and 2.4 present information on the triangulation of data collection activities by source and season, where applicable. While the intention had been to evenly distribute systematic observations and follow-up interviews (for both EPI clinics and fever consultations) throughout the year and between health zones, this was not possible given extended interruptions in EPI services due to mass campaigns, stock-outs of vaccines, weather or other factors, and the fact that rates of

treatment seeking for febrile illness were extremely low during periods other than the rainy season.

Triangulation of Investigators

The research team included men and women, Malians and Americans and individuals with different programmatic experiences and academic backgrounds. This diversity of perspectives helped the members of the team to identify moments when their own beliefs, backgrounds and experiences had the potential to bias either the collection or interpretation of data (reflexivity) (Barry, Britten, Barber, Bradley, & Stevenson, 1999; Finlay, 2002; Patton, 2002).

DATA COLLECTION METHODS

The subset of specific methods relevant to each of the subsequent chapters is described in detail within the given chapter.

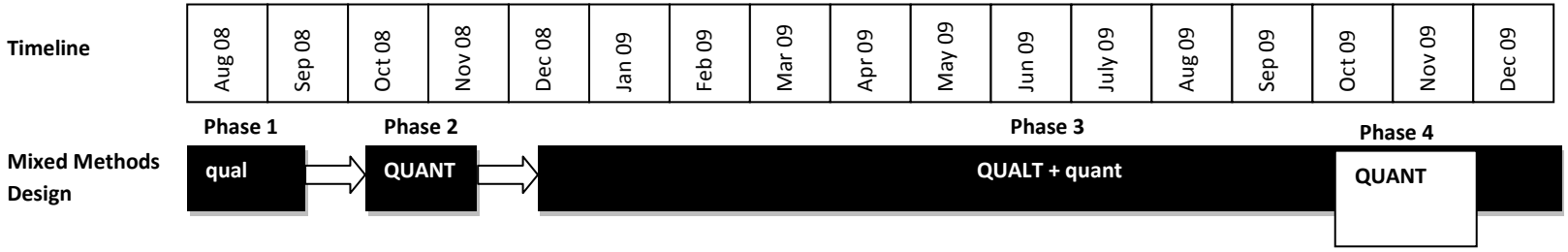
Table 2.1 : Research Topics and Associated Research Questions

The EPI Contact Method (EPI-CM) as a Tool for Monitoring Key Child Health Indicators	• Does the EPI-CM produce valid estimates of key child health indicators (i.e. statistically equivalent to gold-standard household survey data)? • Does the EPI-CM lead to improvements in health behaviors related to LLIN use and the treatment of childhood illnesses? • How do health workers implement the EPI-CM? • What are the factors that influence health workers' performance of the EPI-CM?
Bed Net Distribution and Use	• What are the strengths and weaknesses of delivering long-lasting insecticidal bed nets (LLIN) through routine EPI and antenatal care (ANC) services? • What are the factors that determine bed net use among all segments of the population? • What are people's preferences regarding LLINs? • What types of arguments are likely to persuade people to use bed nets?
Malaria Case Management (Diagnosis and Treatment)	• What do parent and health workers know about the new policy mandating free malaria treatments for children under-five? What are their attitudes towards this policy? • How are health workers using RDTs and ACTs? What factors influence their decision to use or not use RDTs? • What are the perceived effects of the free treatment policy on health facility performance and financial sustainability?
Malaria Health Education and Behavior Change Communication	• How is information about malaria control produced, disseminated, received, and re-interpreted as it circulates between different levels of the health system? • Are the messages received the same as the ones intended, and if not, how do they differ and what are the possible explanations for this? • What are the effects of these communications (intended and unintended)? • What are the emic models/theories of behavior change in rural Malian communities? (i.e. How do local people describe and conceptualize the processes and determinants of behavior change?) o What are the strategies used within these communities to encourage behavior change? o How could local understandings of behavior change be used to develop better communication and education to increase bed net use and appropriate treatment of fever in children?

Table 2.2: Relationships between Research Methods and Research Topics

METHODS	Phase	Type of Method	RESEARCH TOPICS ADDRESSED				
			EPI-CM (process, impact, validity)	LLIN [illegible]	LLIN Use	Malaria Case Management	Malaria Communication
Baseline and follow-up household surveys	2, 4	QUANT	●	●	●	●	●
EPI-CM tally notebooks	3	QUANT	●				
EPI-CM monthly reports	3	QUANT	●				
EPI clinic exit interviews with parents	3	QUANT	●	●	●	●	●
Systematic observations of EPI clinics	3	QUANT	●	●			●
Post-observation interviews with parents who participated in EPI clinics	3	QUAL	●	●	●	●	●
Post-observation interviews with health workers who conducted the EPI-CM	3	QUAL	●	●			●
In-depth interviews with health workers	1, 3	QUAL	●	●		●	●
Anonymous health worker questionnaires	3	QUANT	●				●
Unstructured observations	1, 3	QUAL	●	●		●	●
Participant observation during meetings, workshops and trainings	3	QUAL	●	●		●	●
Key informant interviews	3	QUAL	●	●		●	●
Review of CSCom health education logs	3	QUAL		●	●		●
Media Review: television, radio & posters	3	QUAL		●	●	●	●
Group Discussions	3	QUAL		●	●	●	●
Systematic observations of fever consultations	3	QUANT				●	●
Post-observation interviews with parents whose children were treated for fever	3	QUAL		●	●	●	●
Post-observation interviews with health workers who treated sick children	3	QUAL		●	●	●	●
Review of health facility treatment & LLIN distribution registers	3	QUANT				●	

Figure 2.1 **MIXED METHODS DESIGN 1: DATA COLLECTION**



Data Collection Procedures

Observations of EPI clinics (N=7 clinics)

Informal interviews with health workers (N=16)

Household Survey (N=2,332)

Quantitative Methods

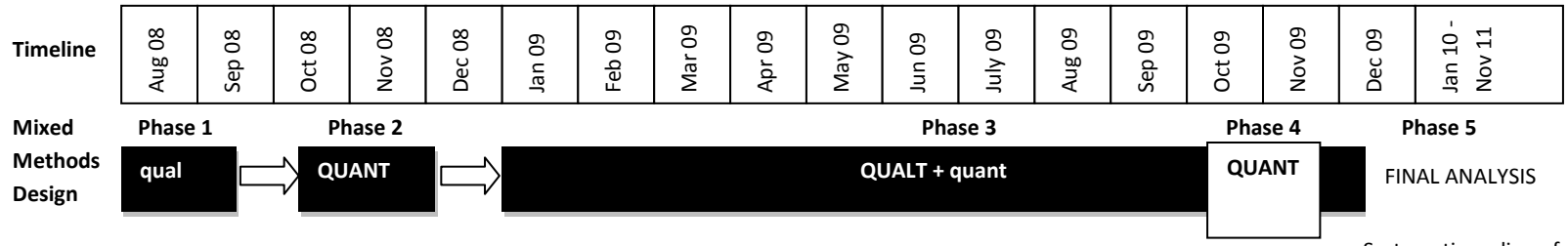
- Structured observations of parent-provider interactions during EPI clinics (N=1,394 interactions in 42 EPI clinic sessions)
- Exit Interviews with parents attending EPI clinics (N= 482)
- Review of health facility records, registers and reports
- HW anonymous questionnaire at end of study period

Qualitative Methods:

- Unstructured Observations of EPI clinics
- Participant Observation (HW meetings and trainings)
- Key informant interviews with community leaders (N=4), MOH staff (N=8), representatives of NGOs and bilaterals (N=8), other (N=1))
- In-depth Interviews with health workers (N=30)
- Post-observation interviews with parents (N=50) and health workers (N= 31) who participated in observed EPI clinics
- Post-observation interviews with parents (N=30) and health workers (N=23) who participated in observed medical consultations
- Group discussions with mothers (N=15), fathers (N=6) and grandmothers (N=6)
- Review of malaria communications materials (posters, radio, television)

Household Survey (N=3,283)

Figure 2.2 MIXED METHODS DESIGN 2: ANALYSIS AND "MIXING"



Analysis

Descriptive summary of EPI clinic processes

Descriptive statistics for survey data (key malaria, EPI and communication indicators)

Preliminary theories and list of key themes from qualitative data developed concurrently with ongoing data collection

Percentages of health facilities collecting EPI-CM data and submitting EPI-CM reports each month

Monthly values for EPI-CM indicators, by health facility and aggregate

Systematic coding of qualitative data

Adjusted frequencies, percentages and confidence limits: surveys, EPI-CM tallies & reports, systematic observations

Rao-Scott chi-square

"Mixing"

Baseline qualitative data used to inform development of EPI-CM training materials and data collection instruments for subsequent phases of study

Baseline survey data used to inform development of data collection instruments for subsequent phases of study

Ongoing examination of qualitative data used to modify data collection instruments for subsequent data collection activities in a continuous iterative process

Calculations of percentages related to EPI-CM data collection, reporting and results used to identify potential problems with the implementation of the EPI-CM which were explored in subsequent qualitative interviews and observations

Preliminary qualitative and quantitative data compared to identify potential biases in either kind of data, and to identify differences in what health workers said (qualitative) and what they did

Comparison of qualitative and quantitative data to:

- Assess generalizability of qualitative findings
- Compare groups
- Identify potential biases in data
- Explain and contextualize results of EPI-CM experiment

Table 2.3: Seasonal Distribution of Days of Systematic Observations of EPI Clinics & Fever Consultations

		Number of Days of Systematic Observations (All clients attending health facility each day were observed.)						TOTAL DAYS	
		Rainy Season		Cold Season		Hot Season			
	Zone	EPI Clinics	Fever Consultations	EPI Clinics	Fever Consultations	EPI Clinics	Fever Consultations	EPI Clinics	Fever Consultations
EPI-CM District	**A**	2	4	2	0	1	0	5	4
	B	2	4	3	0	1	0	6	4
	C	3	1	2	0	0	0	5	1
	D	2	1	2	1	0	0	4	2
	E	3	5	3	0	1	0	7	5
	F	5	1	2	1	0	0	7	2
Comparison District	**G**	3		0		3		6	
	H	3		0		3		6	
	I	1		0		1		1	

** Totals do not include numerous days when qualitative staff spent the day at health facilities but no clients came for immunizations or fever treatments.*

*** The protocol called for 12 days of observations of EPI clinics per health facility but, due to extended disruptions of vaccination services as the result of polio campaigns, vaccine shortages and weather, it was not possible to attain the desired sample.*

Table 2.4: Seasonal Distribution of Qualitative Interviews with Parents and Health Workers, by Gender and Category

		Rainy Season (June-Oct)			Cold Season (Nov- Feb)			Hot Season (March-May)			All Seasons		
		Female	**Male**	**Total**	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**	Female	Male	**Total**
In-depth Interviews with Health Workers	Chef du post	0	3	**3**	2	4	**6**	0	3	**3**	2	10	**12**
	Vaccination Technician	0	3	**3**	1	3	**4**	0	3	**3**	1	9	**10**
	Maternity Nurse	3	0	**3**	1	0	**1**	2	0	**2**	6	0	**6**
	Other	1	1	**2**							1	1	**2**
Post-observation interviews with health workers	After EPI clinics	2	13	**15**	1	9	**10**	4	2	**6**	7	22	**31**
	After fever consultations	4	17	**21**	0	2	**2**	0	0	**0**	4	19	**23**
Post-observation interviews with parents	After EPI clinics	18	0	**18**	22	0	**22**	10	0	**10**	50	0	**50**
	After fever consultations	22	2	**24**	3	0	**3**	3	0	**3**	28	2	**30**

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CHAPTER 3

Intended and Unintended Synergies and Cascade Effects: Applying a Systems Thinking Approach to Integrated LLIN Distribution and Expanded Program for Immunizations Services in Segou, Mali

ABSTRACT

Background: Integration is one of the four key strategic areas of the 2006-2015 Global Immunization and Vision Strategy (GIVS) framework. Long-lasting insecticidal bed net (LLIN) distribution is commonly added to Expanded Program for Immunizations (EPI) as part of the scale-up of LLIN coverage for malaria control. There are a number of important potential benefits associated with the integration of these interventions, but there are also concerns about the potential unintended negative consequences. This study examined integrated LLIN distribution and EPI services in the West African country of Mali.

Methods: This mixed methods examination of LLIN distribution in Segou, Mali was conducted in the context of a larger evaluation of a health facility-based monitoring and program management tool called the EPI Contact Method (EPI-CM) between August 2008 and December 2009. Data collection methods included unstructured observations at community health facilities; participant observation during meetings, trainings and workshops at the national and district levels; semi-structured interviews with health workers (N=31); follow-up interviews with health workers after systematic activities observations of CSCom activities (N=52); semi-structured interviews with parents of children receiving immunizations or treatment for fever at community health facilities (N=80); key informant interviews with community leaders (N=4), representatives of government and non-governmental organizations (N=9), supervisors and trainers of CSCom staff (N=8), and community leaders (N=4); focus groups with mothers (N=15 groups), fathers (N=5 groups) and grandmothers (N= 6 groups) in rural communities; health facility records on malaria and immunization activities; and a representative household survey (N=3,283).

Results: In the two study districts, 96.1% (95% CI: 95.3, 96.9) of households owned at least one net, while 66% owned more than one (95% CI: 63.8, 69.0). Antenatal care services (ANC) were reported as the source of 12.9% of nets (95% CI: 10.8, 5.1), while 22.1% (95% CI: 19.8, 24.5) and 10% (95% CI: 8.0, 12.0) were received during fixed vaccination clinics and vaccination outreach activities respectively. Of the households without a net, 31% (95% CI: 22.7, 39.8) indicated that the reason they did not own a net was that they had not participated in ANC or EPI clinics. Among individuals who did attend EPI and ANC clinics, 32.7% (CI 30.6%-34.7%) had experienced a stock-out of nets. These stock-outs led to the widespread understanding that "one gets a bed net only by chance," and fostered beliefs that health workers were engaged in discriminatory or corrupt practices. The inconsistencies and irregularities in LLIN distribution were reported to result from challenges associated with the procurement and management of stock in the context of integration, and from efforts to avoid stock-outs and wastage at all costs, even if it meant that certain groups of children would be excluded from EPI and LLIN interventions. Stock-outs of LLINs also had the potential to alter EPI clinic attendance patterns, introducing challenges for managing vaccine stock in the context of integration. EPI activities were prioritized over LLIN distribution during service delivery, health education, monitoring and evaluation and supervision. Health workers tended to value LLINs more for their potential to increase vaccination clinic attendance than for their ability to reduce malaria prevalence.

Conclusions: The results of this study highlight a number of synergies and potential positive and negative cascade effects of linking LLIN distribution to EPI services, and illustrate the importance of examining integrated interventions from a health systems perspective. Observed challenges for integration seemed to result more from weaknesses in the overall health system than from particular innate characteristics the linked interventions. Recommendations for improving the consistency and equity of LLIN distribution include modifications to procedures for estimating stock needs and reporting unused doses of vaccines, as well as the introduction of standard procedures for distributing LLINs to individuals who attended routine EPI and ANC

clinics during a stock-out. The global discourse about vaccine "wastage" must be transformed to maximize the number of eligible children who benefit from these linked interventions. There is a need for more systematic efforts to ensure that both LLIN distribution and EPI interventions are equally emphasized in health worker training, supervision and evaluation to increase the likelihood that all eligible persons will receive an LLIN and improve the quality of health education provided on the topics of LLIN use and proper maintenance.

BACKGROUND AND INTRODUCTION

There has been growing interest in integrating immunization programs with other child health interventions since WHO and the United Nations Children's Fund listed integration as one of the four key strategic areas of the 2006-2015 Global Immunization and Vision Strategy (GIVS) framework (WHO, 2005). The possibility of linking multiple interventions to the Expanded Program for Immunizations (EPI) is particularly appealing in the Sub-Saharan African context, where routine immunization clinics often serve as the only point of contact between health workers and the children who live in the coverage areas they serve.

Integration can take different forms, including "linked referral" (providing information about other services available at the same health facility), "integrated routine delivery" (delivering other services during routine vaccination clinic encounters), and "integrated campaign delivery" (delivering other services during mass immunization campaign) (Wallace, Dietz, & Cairns, 2009). Among the interventions that have been integrated with immunization activities to date, in various forms, are family planning services, intermittent prevention treatment for malaria, vitamin A supplementation, cooking demonstrations, the distribution of nutritional supplements, breast-feeding promotion, mass drug administration for parasitic infections and helminthes, and mass distribution of insecticide-treated nets (ITNs) (Jakobsen, Sodemann, Molbak, Alvarenga, & Aaby, 1999; Wallace, et al., 2009).

Integration can facilitate the rapid scale-up and uptake of the intervention linked to EPI and antenatal services. Other potential benefits include decreased competition for resources between health programs (Bahl et al., 2002; Clements, Nshimirimanda, & Gasasira, 2008; Grabowsky et al., 2005; Grabowsky et al., 2005; Wallace, et al., 2009), increased client satisfaction (Grabowsky, et al., 2005) and increased attendance at vaccination clinics (Guyatt, Gotink, Ochola, & Snow, 2002; Wallace, et al., 2009).

However, integration also has potential costs, including increased burden on health facility staff, logistical challenges, and decreased attention to other non-linked interventions for the same health problems (Cavalli et al., 2010; Clements, et al., 2008; Wallace, et al., 2009). An additional concern is that health workers will have insufficient time and focus during busy vaccination clinics to provide adequate education about the linked interventions, particularly when attendance at vaccination clinics is high (Wallace, et al., 2009; Wolkon, 2005).

There is a need for additional research to determine the extent to which these potential benefits and costs of implementation are realized in actual field settings, as well as to develop a better sense of the limits to the number and type of interventions that can be linked to EPI clinics. A 2009 literature review failed to find clear evidence that integration increases the efficiency of resource use, and few of the identified studies presented quantitative data to demonstrate benefits or limitations (Wallace, et al., 2009).

Bed net distribution has a number of features that make it a particularly strong candidate for integration (Wallace, et al., 2009). The intervention requires few, if any, additional specialized skills and theoretically demands little additional time during vaccination clinics. Bed nets provide protection from diseases for which there are currently no existing vaccinations, including both lymphatic filariasis and malaria, and thus net distribution complements vaccination services to provide more complete protection from infectious diseases. Moreover, the populations targeted by immunization and antenatal clinics have historically been the same

priority populations targeted for bed net distribution by malaria control programs because they are the most vulnerable to severe consequences of malaria infections.

Integrated vaccination campaigns, routine immunization clinics and antenatal care (ANC) services have proven to be effective mechanisms for distributing ITNs and long-lasting insecticidal nets (LLINs) to pregnant women and infants in Sub-Saharan African (SSA) countries (de Oliveira et al., 2010; Grabowsky, et al., 2005; Grabowsky, et al., 2005; Grabowsky, Nobiya, & Selanikio, 2007; Kulkarni et al., 2010; Muller et al., 2008; Thwing et al., 2008), particularly in areas with strong existing immunization programs and where vaccination coverage is at least as high as the targets for net coverage. When LLIN distribution was integrated with routine immunization services in Malawi, reported net use among children 12-23 months of age approximately doubled compared to the comparison group (Mathanga, Luman, Campbell, Silwimba, & Malenga, 2009). In Mozambique, where ITN vouchers were distributed as part of a mass immunization campaign, household net ownership increased by over 25% (de Oliveira, et al., 2010). An integrated measles vaccination and net distribution campaign conducted in Zambia in 2003 had even more dramatic results: only 16.7% of rural households containing children had at least one ITN prior to the campaign, but 81.1% had an ITN post-campaign (Grabowsky, et al., 2005). An integrated campaign in Niger, in 2005, increased net ownership from 6.3% to 65.1% (Thwing, et al., 2008). Integrated distribution campaigns have also been shown to be cost effective (De Allegri et al., 2010; Mueller et al., 2008) and to increase equity between the richest and poorest when it comes to net ownership (Guyatt, et al., 2002; Thwing, et al., 2008).

Examinations of linked interventions often focus primarily on discrete outcomes pertaining to each of the specific interventions. Less attention has been paid to the ways that integrated interventions interact with and influence each other as interrelated components of complex systems. An in-depth examination of the relationships between integrated interventions using a “systems thinking” approach can lead to a better understanding of the effects of

integration on individual program outcomes as well as on the strength and performance of the overall health system and can help to identify and characterize both intended and unintended consequences of integration.

A systems thinking approach has been described as one that considers the relationships and synergies between all components of a health system, recognizing that health systems are dynamic, self-organizing, highly connective, non-linear, and governed by feedback loops, and that, as a result, systems are often resistant to change, short term effects of interventions may differ greatly from long-term effects, and the results of interventions within systems can often be unexpected and counter-intuitive (de Savigny, 2009). The WHO Health Systems Framework includes systems includes six interrelated "building blocks" that should be considered when applying a systems approach to understanding the process and effects of specific interventions: governance, health workforce, health financing, health technologies, health information and service delivery (WHO, 2007). People are at the center of this health systems framework, driving all of the other elements.

The focus of this paper is on the process of the integrated delivery of EPI services and LLINs, and on the potential positive and negative synergies between the two linked interventions in the context of a complex health system. Data collected in Segou, Mali between October 2008 and December 2009 are presented to demonstrate the complex relationships between vaccination services, net distribution and the persons who deliver and receive these interventions. The potential intended and unintended cascading effects of integration on key malaria and EPI outcomes are discussed, and potential problems are considered from a systems thinking perspective, with attention to the interrelated influences of various health systems components.

Integrated LLIN Distribution and EPI Services in Mali, West Africa

In 2007, 2.2 million LLINs were distributed to households in Mali as part of an integrated mass campaign. This was the first ever integrated campaign including five interventions: LLIN

distribution, Vitamin A, and albendazole (for de-worming), in addition to polio and measles vaccinations. Since then LLINs have been distributed to targeted vulnerable groups in the context of routine EPI and antenatal services. According to the national strategic plan, women are to receive an LLIN at their first ANC visit at government hospitals and health centers, and children are given an LLIN when they receive the measles vaccine and thus complete their vaccination cycle at approximately 9 months of age. This study focused primarily on the integration of LLIN distribution with EPI services, though many of the findings are equally applicable to the distribution of LLINs through ANC clinics.

The majority of LLIN distribution and EPI services in Mali are delivered through a network of Community Health Centers (Centre de santé communautaire – CSCom), located at the level of the health zone. Each CSCom is managed by a trained nurse or doctor, the Chef de poste médical (CPM), who is assisted by some combination of maternity nurses, vaccination technicians, interns/volunteers, pharmacists and guards – though many facilities have no more than three employees on staff. The majority of services provided by the CSCom are based on strict policies of cost recovery, though both vaccinations and LLINs are provided free of charge. CSCom are responsible for financing the transportation of vaccines, supplies and LLINs from the district to the health zone level. Costs such as fuel, generators, motorcycles and motorcycle repairs, facility maintenance and some staff salaries are covered by charging user fees for services. Mali has a decentralized health system in which the financial management of the CSCom is the responsibility of community health associations (ASACO).

The EPI program in Mali consists of a combination of three strategies: fixed vaccination clinics[1] conducted on a weekly basis at the CSCom, outreach activities conducted in rural villages on a rotating basis, and mass vaccination campaigns. In some parts of Mali, where funding and staffing allow, districts offer an additional "mobile strategy" in which staff from the district reference hospital (Centre de Santé de Référence - CSRef) visit communities not reached by standard outreach activities in order to provide immunization services. Five different vaccines

are administered as part of the EPI schedule in Mali: Bacillus Calmette-Guérin (BCG), oral polio vaccine (OPV), Diphtheria-Tetanus-acellular pertussis-Hepatitis B-Haemophilus influenza Type B (PENTA), Measles, and Yellow Fever.

The research presented here was conducted in two districts of the Segou Region of central Mali. Vaccine coverage in this region was considerably higher than the national average in 2006, prior to the start of LLIN distribution through routine EPI clinics (Demographic and Health Surveys, 2006). According to results from the 2006 national Demographic and Health Survey, the percentage of children 12-23 months completely vaccinated was 57.5% (Demographic and Health Surveys, 2006). Only 9.2% of children 12-23 months of age in Segou region were completely unvaccinated (Demographic and Health Surveys, 2006). Routine health systems data indicate that there have been nationwide increases in measles coverage rates since 2006 (The Government of Mali, 2009, 2011), and therefore increases in the number of children who are eligible to receive LLINs through routine EPI distribution channels.

METHODS

Study Design

The integration of EPI services and LLIN distribution was examined in the context of a larger multi-phase mixed methods study conducted from August 2008 to December 2009 in two adjacent districts of the Segou Region of Central Mali. The parent study, which has been described in detail elsewhere (Wei et al., 2012a; Wei et al., 2012b), was a non-randomized controlled evaluation of the validity and effectiveness of a proposed health facility-based tool, the EPI Contact Method (EPI-CM), which was designed to both monitor and improve child health behaviors.

The study design included a wide range of qualitative and quantitative methods (See Chapter Two). The particular order and combination of methods were selected to capitalize on the complementary strengths of multiple methods, while compensating for the inherent

limitations of each. Qualitative data helped to explain quantitative results, while quantitative data provided a way to assess the representativeness of qualitative findings. During all data collection activities, particular attention was paid to health systems factors with the potential to influence the delivery of both LLINs and EPI services (Alonso et al., 2011; Cavalli, et al., 2010; de Savigny, 2009), including a wide range of previously identified determinants of health worker performance (Rowe, de Savigny, Lanata, & Victora, 2005).

Data Collection Methods

The data presented in this paper were collected using the following methods: unstructured observations, extended semi-structured interviews with health workers, brief follow-up interviews with health workers who participated in observed EPI clinics and medical consultations, follow-up interviews with parents[2] who participated in observed EPI clinics and medical consultations, group discussions, key informant interviews and a representative household survey. Each of the specific data collection methods is described in greater detail below.

Unstructured observations. Much of the data presented in this paper was collected through participant observation. The members of the research team spent several days a week at nine community health facilities (CSCom) selected for intensive study (See Chapter 2). Whenever they visited these facilities to conduct other data collection activities (including systematic observations of patient-provider interactions, vaccination clinic exit interviews, and interviews with health workers), they conducted unstructured observations of routine health facility activities and communications between health workers and clients. They paid particular attention to determinants of health worker performance, departures from recommended practices for service delivery, and the strengths and weaknesses of integrating malaria control interventions with EPI. They also engaged in informal conversations with health facility staff, during which they asked questions about the events and activities observed, often using concrete data recorded in health facility registers and reports to stimulate conversation.

At the end of each day of observations, the members of the research team wrote detailed field notes using a standard format with designated sections for: 1) detailed descriptions of observed events, 2) key similarities and differences between the events observed that day and those observed on other days or in other health facilities, 3) questions to be followed up on in subsequent interviews with the key actors in the observed activities to better understand why certain actions were taken and how they were understood by the various people involved, 4) comments about how the presence of the observer may have influenced the behaviors of health workers and clients at the health facility (reflexivity) (Barry, Britten, Barber, Bradley, & Stevenson, 1999; Finlay, 2002) and 5) a list of key themes and topics relevant to the observations (for example, "vaccine stock outage," "communication about bed nets" or "LLIN distribution"). These field observations were discussed during weekly team meetings. Semi-structured interview guides were periodically modified to include additional questions designed to increase understanding of observed phenomena.

Semi-structured qualitative interviews with health workers. Semi-structured qualitative interviews were conducted with health workers who were involved in EPI and malaria control activities at nine CSCom selected for intensive study. Multiple interviews were conducted with CSCom directors at three CSCom and the vaccination technician at one CSCom in order to obtain additional information about topics not thoroughly addressed in the first interview. In all, 12 interviews were conducted with CSCom directors, 10 with vaccination technicians, six with maternity nurses and one with a medical intern.

The relevant topics addressed in the semi-structured interview guide included the roles and responsibilities of each category of staff at the CSCom, the major challenges and rewards associated with work at the CSCom, ways to improve health worker performance and job satisfaction, bed net distribution procedures, responses to and explanations of LLIN stock outages, health communications, net monitoring and evaluation activities, and sources and applications of data pertaining to key malaria indicators. The interviewers were trained to ask

follow-up questions based on participants' responses in order to obtain rich descriptive detail, and they were encouraged to depart from the interview guide to ask questions about unanticipated topics raised by participants, as long as they were relevant to the larger research questions and objectives of the overall project. Interviews were conducted either at the health facility or at the home of the health worker and generally were one to two hours in duration. The interviews were conducted in either French or Bambara (depending on the preferences of the participants), recorded using digital audio recorders, and subsequently translated into French (if necessary) and transcribed.

Follow-up interviews with health workers who participated in observed EPI clinics and medical consultations. Systematic observations of EPI clinics and medical consultations were conducted to learn about the processes of EPI service delivery, the implementation of the EPI-CM, LLIN distribution and the nature and content of communication between health workers and the parents of young children (Data presented in Chapter 5). In order to better understand the motivations, logic and constraints driving observed health worker actions, brief follow-up interviews were conducted with health workers at the end of each day of observations.

Interviewers asked questions about specific actions observed or specific aspects of communication between health workers and parents during the day of observation. For example, if no LLINs were distributed during an EPI clinic, or if information on the importance of bed nets was provided to some participants but not others, the interviewer would ask why. The interviewers also used these conversations as an opportunity to obtain clarification and additional detail regarding information obtained during previous data collection activities at the same health facility, and to ask additional questions arising from ongoing preliminary analyses and initial theory development. No structured interview guide was used for these interviews, given the inability to predict in advance what would happen during a given day of observations.

A total of 52 short follow-up interviews were conducted with health workers at the nine CSCom selected for observations (31 following observed vaccination clinics and 23 following

observed medical consultations). These interviews generally lasted between 15-20 minutes, and were conducted either at the community health center (CSCom) or at the health worker's home, depending on his or her preference. Interviews were conducted in either French or Bambara, were recorded using digital audio recorders, and were subsequently translated into French (if necessary) and transcribed.

Follow-up interviews with parents who participated in observed EPI clinics and medical consultations. Semi-structured interviews were also conducted with 50 randomly selected parents whose children were vaccinated during observed immunization clinics, and with 30 parents whose children were treated during observed medical consultations. During each day of vaccination clinic observations, three parents whose children were vaccinated were randomly selected. On the days when medical consultations were observed, all parents who brought their children for the treatment of febrile illness were asked if they would be willing to participate in an interview. For logistical reasons, parents were excluded from participation in interviews if they lived outside of the health zone where they were seeking care.

Parents were asked to describe their recent experiences at the health center (on the day when observations were conducted) in order to facilitate comparisons of health worker, parent and observer interpretations of the same events. Follow-up questions were asked to elucidate what parents understood about malaria and vaccinations based on their communications with health workers, to learn about parent perceptions of the quality of care and to assess parent satisfaction with the treatment provided at the CSCom. In addition to these questions, all participants in these interviews were asked about their experiences with LLIN distribution activities, their exposure to communications about malaria and LLINs, their general knowledge and attitudes regarding LLINs, and their malaria treatment seeking and net use behaviors.

Interviews with parents were conducted two to seven days after the observed vaccination clinic or consultation for fever treatment, at a time and place selected by the participant, and generally lasted one to two hours. Interviews were conducted in Bambara (depending on the

preferences of the participant), were recorded using digital audio recorders, and were subsequently translated into French and transcribed.

Group discussions. Group discussions (N=9) were organized with female caretakers of young children in each of the nine health zones in order to learn about their net use practices, their attitudes towards LLINs, their experiences with LLIN distribution systems, and their treatment seeking behaviors when their children have a fever. For each discussion, six to ten women were recruited with the assistance of community leaders, community health workers or staff at the community health center who had been asked to purposively select women who represented a range of different life experiences and perspectives on child health. The people who assisted with the recruitment were explicitly instructed to select women from different households, and to avoid the disproportionate representation of friends and family members of the village chief or the community health workers. Many of the group discussions were conducted during routine EPI clinics while women were waiting for vaccinations to begin because this was a time when the group discussion would not interrupt women's daily work in the household or the family fields. The discussions generally lasted approximately one hour.

An additional 17 group discussions were conducted with fathers (N=5), mothers (N=6) and grandmothers (N=6) to learn about their exposure to radio, television, print and interpersonal communications about malaria and LLINs, and the ways that they understood the content and messages of these communications in the context of their lived experiences. Six to ten people participated in each discussion. During these group discussions, the facilitators played television and radio public service announcements about malaria that were in circulation at the time of the study, and displayed posters and other print materials about malaria. They then asked the participants what they understood from these communications, whether the materials and messages seemed relevant to their lives and if they thought they could apply these messages. During these discussions, participants often spontaneously introduced the topic of LLIN

distribution mechanisms, despite the fact that this topic was not specifically addressed in the group discussion guide.

Participants were recruited from villages in the selected six health zones in Segou District where other data collection activities (in-depth interviews or observations) were already scheduled. Community leaders and community health workers assisted with the recruitment, recommending individuals who represented a range of knowledge and experience about malaria. These group discussions were generally held at the community health center or at the home of the village leader, and lasted between one and two hours.

All discussion groups were conducted in Bambara and recorded using digital recorders. A designated member of the research team took notes during the discussions to assist in the process of differentiating between speakers during the subsequent transcription and translation of the conversation.

Key informant interviews. Key informant interviews were conducted with individuals expected to have specialized knowledge of the topics explored in the context of this research. To learn more about the procedures of policy development, planning, implementation and management of malaria control activities in Mali, extended detailed conversations were carried out with representatives of each of the major non-governmental organizations involved in malaria education and net distribution activities in Segou District (N=2), as well as with representatives of the National Malaria Control Program (N=1) and five Bamako-based organizations involved in the production and dissemination of malaria communications materials and the coordination of net distribution activities in Mali (N=6). Additional interviews were conducted with district reference hospital personnel involved in the supervision and training of community health center staff in Segou District (N=7), and with the director of a health worker training institute (N=1). The interviews were conducted in French or English, depending on the participant and lasted one to two hours. They generally took the form of informal conversations directed by a general list of topics rather than a structured interview guide and were not always recorded. Recorded

interviews were transcribed verbatim. Detailed notes on the content of unrecorded interviews were written up as field notes to be included in subsequent analyses.

Representative household survey. A cross-sectional household survey was conducted in October 2009 in households containing children aged 0-23 months (the age group with the potential to have been exposed to the EPI-CM). The questionnaire was based on those used for standard Malaria Indicator Surveys (MIS), and included questions pertaining to bed net ownership, bed net condition and maintenance behaviors, bed net use, malaria knowledge (transmission, severity, susceptibility), and the incidence and treatment of fever among children in the household within the past two weeks. However, the survey differed from the standard MIS in that additional questions were added to explore key themes identified during earlier qualitative data collection activities and no blood tests were conducted.

Global-positioning-system (GPS)-enabled Dell Axim X50 (Dell, Round Rock, TX) handheld computers running Visual CE Version 11 (Syware, Cambridge, MA) were used for both household selection and data entry in a manner previously described (vanden Eng et al., 2007). 60 villages in each district were selected by probability proportional to size. With a local guide, trained enumerators visited all households in selected villages and mapped by GPS those containing children aged 0-23 months. From those households, 30 households in each village were selected by simple random sample, and interviews were conducted with caretakers of children aged 0-23 months. If no caretaker was present, enumerators made two additional attempts before using a randomly preselected alterative household. No replacements were made for household refusals.

Sample size calculations were driven by the primary objectives of the parent study: a) to evaluate the validity of EPI-CM data for children 0-11 months of age compared to household survey data, and b) to assess the effects of the EPI-CM on child health behaviors among children 12-23 months who were potentially exposed to the method during vaccination clinics. These calculations have been described in detail elsewhere (Wei, et al., 2012a; Wei, et al., 2012b).

Study Staff and Training

The qualitative research team was comprised of Malian social scientists who spoke Bambara fluently. Prior to the start of data collection, they participated in over two months of intensive training, conducted by the PI, which covered the research design and research questions, social science theory and qualitative research methods, with ample opportunities for practice with detailed feedback. All qualitative interviews and group discussions were conducted either by members of this team, or by the PI with the assistance of a Bambara-speaking translator native to Segou District.

Survey enumerators were fluent in Bambara and participated in a week-long training on PDA-based surveys, the survey instrument for the study and research ethics. This training was coordinated by the University of Bamako Malaria Research and Training Institute (MRTC), a National Institute of Health (NIH) International Center of Excellence in Research (ICER), and was jointly facilitated by the PI on the project and collaborators from the US Center for Disease Control and Prevention and MRTC.

Analysis

Qualitative interview and group discussion data. The study team members who collected and transcribed the qualitative data made an initial list of key themes after reviewing each transcribed document. The themes relevant to each data collection activity were checked off on a matrix with a row for each interview/group discussion, and a column for each theme in order to identify salient themes. Team members met several times a month to discuss the growing list of themes and to develop and refine a list of codes and associated definitions for subsequent systematic analysis. The resulting initial codebook was further developed and modified during final analysis to reflect additional themes identified through a close reading of the documents, as well as developing theories.

Qualitative data were analyzed using the qualitative management software package MaxQDA (version 10): codes were linked to relevant segments of text, text retrieval functions were used to examine all text segments related to a particular code, and patterns of co-occurrence of codes were examined to develop a stronger understanding of the relationships between themes.

As an additional measure to assess and strengthen the validity of the analysis of the qualitative data, two French-speaking individuals, one a native Malian with extensive experience in both qualitative research and child health projects in Mali and the other an American with training in behavioral sciences, were recruited to read through the transcripts and actively search for "negative cases" (examples that challenged, complicated or negated the initial theories and conclusions). They read preliminary drafts of the papers and then collectively reviewed 22% of the transcripts, writing memos about the ways that the data supported or challenged the conclusions in these drafts, and applying codes from the project codebook. The final conclusions were modified to account for and incorporate the negative cases identified.

Household survey data. Descriptive statistics for variables related to net ownership, net distribution, net use and vaccination coverage were generated using the Proc SurveyFreq command in the statistical software package SAS (version 9.2). Analyses of household survey data were not weighted due to the self-weighted probability-proportional-to-size sampling method. However, to account for the survey design, the Strata and Cluster options for the Proc SurveyFreq command in SAS were used to stratify by district and account for clustering by village, the primary sampling unit. Aggregate data from both study districts are presented here.

Institutional Review and Ethical Clearance

The study was reviewed and approved by Institutional Review Boards at the Emory Rollins School of Public Health, the University of Bamako and the US Centers for Disease Control and Prevention. Written informed consent was obtained from all health workers, while

oral consent was obtained from community leaders, parents and grandmothers, many of whom were illiterate.

RESULTS

Evaluations of integrated LLIN and EPI service delivery activities generally focus on three sets of outcomes: LLIN ownership, LLIN use and vaccination coverage rates. Following a brief description of the processes of integrated service delivery, as observed in Segou, Mali, quantitative and qualitative results pertaining to each of these main categories of outcomes are presented. Data are presented to illustrate the pathways by which various interrelated health systems components can influence key EPI and malaria outcomes, with particular attention to the potential positive and negative synergies associated with the integration of EPI and LLIN distribution activities.

Processes of Integrated EPI and LLIN Service Delivery in Segou, Mali

Service delivery schedule. Each community health center in Segou has an official weekly vaccination clinic schedule, generally consisting of one to two days of "fixed strategy" clinics (at the health facility) and one to two days of outreach in communities served by the health facility. In practice, however, it is difficult to know when vaccinations will take place since both fixed clinics and outreach activities are commonly cancelled due to conflicting demands on health worker time (for example, trainings, meetings, child health campaigns, personal obligations), weather, motorcycle breakdowns, lack of sufficient fuel, or vaccine shortages. During the period of this study, fixed clinics were held more regularly than outreach.

In many health zones in Segou, certain vaccinations are only administered on certain days in an effort to avoid waste. While the polio and PENTA vaccines were usually provided during all EPI clinics, BCG, measles and yellow fever vaccines were often only administered one day a week or, in the case of some of the smaller health zones, one day per month. This is because

these particular antigens come in vials containing multiple doses and have a limited period of activity once opened. Any excess doses must be discarded at the end of the day. While these multi-dose vials have advantages over single-dose formulations in terms of costs and logistics related to production, shipping and storing, they introduce substantial challenges for stock management and service provision. If there are insufficient numbers of children to use up all or most of the doses of a particular vaccine on a given day, health workers have been instructed to inform parents to return another day rather than open the vial and risk wasting numerous doses.[3] In order to maximize the number of children eligible for these vaccines on a given day, community health centers limit the number of days when these vaccinations are provided.

This practice is in stark contrast with the official WHO position which states that all eligible children should be able to receive vaccinations at any time, even if there is no scheduled vaccination clinic that day, and even if it means opening an entire vial of vaccine to immunize a single child. While all EPI training materials emphasize the importance of minimizing waste, they also stress the fact that increasing immunization coverage is more important, even if some doses of vaccine must be sacrificed in order to accomplish immunization. The following words appear in a text box in WHO training materials designed for use with health workers: "The opportunity to immunize may be more valuable than a dose of vaccine" (World Health Organization, 2004a). However, in Segou, avoiding waste seemed to be a much higher priority for health workers at all levels than avoiding missed opportunities to immunize.

When asked direct questions about the reasons for this departure from standard WHO recommended practice (during interviews, meetings and trainings), health workers at both the district and CSCom level in Segou indicated that these practices of restricted vaccination service delivery were been mandated by the National Center for Immunizations. They explained this in terms of limits to the supply of vaccines procured each year. Interviewers were told on multiple occasions that WHO could insist that vaccines be administered to every child on any day only "if WHO pays for the vaccines." When this topic was discussed during a meeting with key partners

at the national level, individuals with historical knowledge of EPI in Mali said that they initially followed the WHO guidelines but experienced frequent stock-outs as the result of high levels of vaccine wastage. Thus they moved to the more restricted schedule for immunization delivery.

Sequence of activities during EPI clinics. The events and activities observed during vaccination clinic in Segou can be broken down into the following categories: data entry procedures, health education, vaccinations, and LLIN distribution. During observations conducted in the context of this study, they were generally conducted in that order, with some variations.

Data entry procedures. During observed fixed and outreach vaccination clinics, health workers collected the WHO vaccination cards from parents as they arrived, and simultaneously filled out the cards, the vaccination registers and the vaccination tally sheets while they were waiting for others to arrive. They waited until they felt that the vast majority of women likely to attend the clinic had arrived, and until all of the requisite paperwork had been completed for all children present, before starting actual service delivery activities. This process could take as long as four hours, and was never observed to last less than an hour.

This reflects another variation from recommended practice. WHO training materials instruct health workers to enter basic demographic information in the EPI register when parents first arrive at the health facility, but to wait until the vaccines are actually administered to enter the information about which doses the child received (World Health Organization, 2004a). They are also to wait until the time that vaccines are actually administered to complete immunization tally sheets and enter information on the WHO immunization cards. This is to account for the possibility that vaccines may run out or parents may leave before a given child is actually immunized.

Interview and observation data from this study suggest that the divergent practice observed in Segou evolved primarily for reasons having to do with time management and the organization of different activities during the day. It seems to have been, at least in part, a

cascade effect of linking health education to EPI clinics as part of the "EPI-plus" program in Mali. In order to maximize the exposure to health education, health workers wait until they think that the vast majority of vaccination clinic attendees have arrived before beginning a mass information and education session. Women may begin arriving as early as seven in the morning and continue to trickle in until almost noon, and thus several hours often pass between the arrival of the first client and the beginning of health education. In order to make most efficient use of their time, and reduce the amount of time required to complete the post health education activities, health workers take advantage of these otherwise unoccupied hours to fill out registers, tally sheets and WHO immunization cards.

When asked where they learned to organize EPI clinics in this way, some health workers reported that they learned from older health worker mentors at the CSCom level while others indicated that they had been instructed to proceed in this way during training and supervision activities conducted by staff of the CSRef. This seems to be a well-established practice in Segou, one that is inherited by new health workers from their mentors. Health workers at the CSCom level did not seem to be aware that this practice differed from WHO recommendations.

During this data entry process, the WHO cards for children receiving measles vaccines were often removed from the general pile of cards and set aside so that these children could be vaccinated all at once. This seemed to facilitate the logistics of LLIN distribution since LLINs were generally distributed from the pharmacy, rather than at the same place where vaccines were administered. In some health facilities, health workers were observed to count up the number of children eligible for BCG and measles/yellow fever vaccines as they collected the WHO cards, and to dismiss those parents early if it looked like there would not be enough children to justify opening a vial. However, in most facilities, these clients were kept waiting until the end of the day, with the hope that enough additional eligible children would arrive later so as to allow for them all to be vaccinated.

Screening for vaccine eligibility. When they collected WHO cards and entered vaccination data in the registers and tally sheets, health workers also actively screened for children who were ineligible for vaccinations either because they had not yet reached the age at which their next immunization was due or because the particular vaccines they required were not being administered that day (due to stock-outs or systematic scheduling). Despite the fact that community health workers and traditional communicators (griots) were often mobilized to walk from door-to-door on the days leading up to vaccination clinics, informing mothers that all children of certain ages should be brought to the health center for vaccinations, there were almost always some women who attended observed vaccination clinics before their children were eligible for their next dose. Health workers attributed this to the fact that most women in the communities they serve are illiterate, and often women just go to vaccination clinics whenever their friends are going, regardless of differences in their children's ages. When ineligible children were identified, health workers informed the mothers that they had come too early and provided them with information about the appropriate date to return.

When health workers identified children who were older than 11 months of age, they took one of three courses of action. They sent the mother away because the child had aged-out of the target age group for vaccinations; they set the card aside so that they could vaccinate the child at the end of the day if there were leftover doses that would otherwise go to waste; or they left the card in the pile with the others and vaccinated the child regardless of age.

This variability in practice reflects a number of mixed messages identified during this study. WHO materials state that infants above one year of age who are not fully vaccinated should still receive the missing doses but that these doses should be tallied separately so as not to include in the numerator children who are not part of the denominator for calculating vaccination coverage (World Health Organization, 2004a). The EPI tally notebooks and reporting forms used by health workers in Segou included separate columns for children older than 11 months in order to facilitate this practice. However, vaccines administered to children older than 11 months are

classified as “wastage” in WHO calculations for estimating stock needs and managing vaccine stock.

In Segou, the message that doses administered to children older than 11 months are to be considered wastage seemed much more salient than messages that it is acceptable to “sacrifice” some doses in order to ensure that the maximum numbers of children are protected. Some health workers in Segou reported that they had been explicitly instructed by their trainers and supervisors not to vaccinate children older than 11 months. Others said that they had been told to vaccinate children older than 11 months of age only if there were doses left over at the end of the clinic that would go to waste otherwise. Different doctors were heard to give different messages about this during observed meetings and trainings at the district level.

At the district and national levels, some key informants expressed discomfort with the fact that children older than 11 months were excluded from the protection of vaccines through no fault of their own, but indicated that this practice was necessitated by the fact that stock procurements estimates were based only on the population of children 0-11 months of age (despite the fact that children older than 12 months are technically included in procurement estimates as part of the buffer calculated for “wastage”).

Health workers expressed anxiety that they would get in trouble for vaccinating children older than 11 months, even if they did so at the end of the vaccination clinic. Even those who did ever vaccinate children older than 11 months were seen to record the doses administered in the reporting columns designated for younger children rather than in the column designated for children 12-23 months of age, thus artificially inflating estimated coverage rates but concealing the fact that children outside of the target age group had been vaccinated and thus that vaccine doses had been “wasted.”

Health education. After they completed filling out the registers and tally sheets, the CSCom staff convened the clinic attendees for mass education sessions. These were generally conducted as question and answer sessions, with the health worker asking the questions and

calling on women to respond. Health workers reported that they could choose from a variety of different topics during these sessions, but they almost always chose to focus on vaccine-preventable diseases during observed EPI clinics. Examination of health education logs in nine CSCom selected for intensive study confirmed that this was the topic addressed during most health education sessions. A few exceptions were observed when representatives of NGOs visited the CSCom for the express purpose of giving a talk on another topic such as HIV/AIDS or family planning, or when a shipment of soon-to-expire nutritional supplements was provided to one CSCom to be distributed for free during EPI clinics. When LLINs were discussed during education sessions, it generally seemed to be in response to specific questions raised by participants, rather than as a pre-selected topic of discussion.

Vaccinations. The actual administration of vaccinations only began after the health education sessions, sometimes as many as four hours after the first mother arrived at the health facility. Health workers did not always call children in the order of arrival so the very first child to arrive was sometimes the very last to be vaccinated. The entire process of administering vaccines was rarely observed to take more than 30 minutes, even when health workers had close to 100 children to vaccinate. However, during clinics where health workers consistently implemented the Expanded Program for Immunizations Contact Method (See Chapter 5), this process could take considerably longer. Measles vaccinations were generally provided at the end of the session, allowing health workers to determine the number of vials of vaccine they could open while still minimizing waste.

LLIN Distribution. LLINs were usually distributed at the very end of vaccination sessions, especially at the smaller CSCom observed. This was because, at these facilities, the same health worker was generally responsible for administering immunizations and distributing LLINs (and sometimes also for examining and treating patients). Because LLINs were generally distributed directly from the CSCom pharmacy where the LLIN stock notebooks were kept rather

than at the same site where vaccines were administered, conducting vaccinations and LLIN distribution sequentially, rather than simultaneously, seemed to be logistically simpler to manage.

At the larger peri-urban CSCom included in this study, which had larger staffs, vaccinations and LLIN distribution were more likely to be conducted in tandem as the two tasks could be delegated to separate health workers. As soon as the child was vaccinated, the mother was instructed to show the completed WHO immunization card to the pharmacy manager in order to obtain a net.

During outreach activities, vaccination technicians had the sole responsibility for conducting all immunization and net distribution activities, while the maternity nurse provided antenatal care services. Both the vaccination technician and the maternity nurse usually traveled on the same motorcycle for outreach activities, carrying all vaccines and EPI supplies with them. This made it difficult to transport sufficient numbers of LLINs.

Implications of Integration for LLIN Ownership and Equitable Access to LLINs

Household survey data suggest that integrated routine services have played a large role in achieving high rates of LLIN ownership in Segou and Baraoueli Districts. In Segou and Baraoueli Districts, 96.1% (95% CI: 95.3, 96.9) of households owned at least one net, while 66% owned more than one (95% CI: 63.8, 69.0). Of the observed nets, 85.5% were LLINs (95% CI: 83.2, 87.8). Over 45% of these nets had been received during routine integrated services. Antenatal care services (ANC) were reported as the source of 12.9% of nets (95% CI: 10.8, 5.1), while 22.1% (95% CI: 19.8, 24.5) and 10% (95% CI: 8.0, 12.0) were received during fixed vaccination clinics and vaccination outreach activities respectively. Of the remaining nets, 48.1% (95% CI: 44.9, 51.3) were received during the 2007 integrated mass distribution campaign.

These results indicate that campaigns and routine services have reached the vast majority of households in Segou. However, qualitative data collected during the study raise some concerns about the possibility that LLIN distributions services linked to vaccination and ANC

clinics may consistently exclude certain particularly vulnerable households. While fewer than 10% of households included in the 2009 household survey reported having no nets, 31% (95% CI: 22.7, 39.8) of those households indicated that the reason they did not own a net was that they had not participated in ANC or EPI clinics. The qualitative data suggest a number of different reasons for clinic non-attendance.

Community level barriers to EPI clinic attendance. People who live in certain villages may be less likely to attend vaccination clinics than others, and thus may be systematically excluded from net distribution through routine services. People who live furthest away from health facilities, or in villages with less accessible roads, may be less likely to attend EPI clinics, and also less likely to receive outreach services, particularly during the rainy season. In the past these communities were reached by "mobile EPI clinics" during which staff from the district CSRef visited them by car to conducted outreach but those activities had been discontinued at the time of this study due to funding and fuel shortages.

In Segou, there were also reports of communities that were excluded from vaccination and LLIN distribution services due to conflicts between community leaders and ministry of health or local government officials. According to health workers at the CSCom, the leaders of one such community were angered when their request to have the community health center constructed in their village was denied. They subsequently refused to have anything to do with the CSCom when it was constructed in a nearby village, prohibiting women from participating in CSCom health service activities and banning health workers from conducting outreach activities or advertising the dates of fixed vaccination clinics within the village. According to the health workers, who are admittedly likely to be somewhat biased, community leaders wanted the CSCom to be constructed in their villages in order to increase their likelihood of personal gain (either in terms of financial or social capital).

Household-level barriers to EPI clinic attendance. Women whose heads of household refuse permission to attend EPI clinics are also excluded from LLIN distribution activities. While

health workers often attributed this to ignorance or stubbornness on the part of these household heads, the data suggest a number of health systems factors that are likely to contribute to these refusals, including aspects of CSCom financing and management mechanisms, governance, information and communication systems, technologies and human resources.

The possible influences of health financing systems on household EPI clinic attendance. CSCom financing and management mechanisms may introduce barriers to EPI clinic attendance through practices of charging for WHO immunization cards. One potential reason that household heads deny or delay women permission to attend vaccination clinics is that they do not have the cash required to purchase one of these cards. According to the Bamako Initiative (1987), which still strongly influences policy regarding health services management and funding in Mali, immunization services are to be provided free of charge but can be subsidized by user fees charged for medical consultations or revenue generated from medicine sales. Theoretically, these free services should include the provision of the WHO immunization card that households maintain as a record of the child's vaccination history. However, the observed health facilities in Segou all charged a small fee for the purchase of these cards.

According to health workers at the CSCom level, the income generated by the sale of these cards played an important role in covering routine health facility costs, including fuel and motorcycle repairs, generator fuel and sometimes even staff salaries. The cost for the WHO immunization cards varied quite widely from health zone to health zone as the prices were independently set by the community health associations (ASACO). Some mothers were aware of these inconsistencies between CSCom, though they did not understand them, and asked members of the study team to explain and justify the differences.

The possible influences of service delivery procedures and health facility staffing on household EPI clinic attendance. Household heads may also be reluctant to give women permission to absent themselves from the fields or home in order to attend a vaccination clinic, particularly because vaccination clinics often take all day, despite the fact that the injections

themselves can be done in a matter of seconds. When there were long delays during vaccination clinics, women who were observed in the context of this study frequently expressed concern that their husbands would be angry and would not believe that they had been at the health facility for all that time. Women occasionally vocalized their frustration with delays during observed EPI clinics, informing health workers that they had to get home to prepare the midday meal or were late to get to the fields to help with planting or harvest activities. Given the extreme deference generally paid to health workers by rural mothers in this context, these behaviors suggest the extremity of the situation.

A number of factors contributed to the long wait times experienced during EPI clinics. The integration of additional interventions during EPI clinics is certainly one. LLIN distribution does not seem to greatly increase the time burden associated with EPI clinics. However, the same cannot be said for health education sessions. If it were not for the need to wait until a large mass has assembled for these sessions, health workers could vaccinate children as they arrived and mothers would be able to return home immediately thereafter. The additional intervention piloted in the context of this study, the EPI Contact Method, also incrementally extended wait times by increasing the amount of time that health workers spent with each mother and child pair when administering vaccinations.

Staffing shortages also contributed to wait times. When a sole health worker is responsible for all aspects of the vaccination clinic, and must also examine and treat patients, service delivery procedures are likely slower than if there are multiple personnel who can divide up the tasks of data entry, vaccine preparation, vaccine administration, LLIN distribution and the treatment of patients.

Qualitative interview data suggest that women's experiences with long wait times at the CSCom have initiated a cycle that ultimately may lead to even longer delays before the start of vaccinations. Women who arrived early for their first vaccination clinic, only to find that they had to wait several hours, quickly learned to complete their cooking and other household tasks

before going to the CSCom for the EPI clinic. Given this, these women may arrive very late in the day, thus further extending the wait times for others.

The possible influences of health communication and health information on household EPI clinic attendance. Failures to collect and effectively communicate health information may also contribute to non-attendance at EPI clinics. Some people actively choose not to have their children vaccinated, due to general concerns about side effects or possible long-term adverse effects or as the result of specific rumors. For example, during the period of this study, there was a marked decline in attendance at EPI clinics in one particular health zone. When health workers were asked about this they responded that this was due to rumors that children were being infected with malaria at the health facility itself, and specifically during vaccination clinics. The widespread nature of this rumor and its likely association with decreasing clinic attendance rates were later confirmed through conversations with community health workers and village leaders. While people did not necessarily believe that health workers were intentionally infecting children or that the infections were the direct result of injections, they did see the health center as the source of contagion and thus stayed away, with the result that children in these villages who reached the age of nine months during the time when this rumor was circulating were unlikely to benefit from linked net distribution activities. While health workers at the CSCom in this health zone believed that the increases in febrile illness were due to an outbreak of some other contagious disease, and not malaria, in the absence of strong diagnostic technologies, a robust health information system and the capacity to effectively communicate with community members, they were unable to assuage the fears of local residents and convince them to attend vaccination clinics.

"One Gets a Net only by Chance": Inconsistencies and Interruptions in LLIN Distribution for those who do attend EPI Clinics.

Linking LLIN distribution to EPI clinics and making the completion of the childhood vaccination series a prerequisite for receiving a net also introduces a number of particular situations in which otherwise eligible people who *do* participate in EPI clinics are unable to obtain an LLIN. Even if they themselves had been able to successfully acquire an LLIN through routine EPI or ANC services, almost all women who participated in qualitative interviews and group discussions seemed to know of others who had not been able to get a net. While participants in these qualitative data collection activities often had little to say about net use, they became very animated when discussing perceived inconsistencies and inequities in LLIN distribution practices.

Client understandings of perceived inconsistencies in LLIN distribution practices. Mothers in Segou explained and interpreted the unpredictability and inconsistency of net distribution activities during EPI clinics in a number of ways. Among the mothers who participated in qualitative interviews and group discussions, there were several commonly shared understandings of the reasons that some people receive nets while others don't. The most frequent explanation offered by the women in our sample was that one "gets a net only by chance," or that it is "God's will" (Inchallah) that some people receive nets while others don't. This is a neutral explanation which avoids the assignment of blame to any party. According to this explanation, there are a limited number of LLINs available in the country and some women and children have the luck to seek routine services at the health clinic while nets are available, while others don't.

However, some of the other explanations offered by women were less neutral and demonstrated mistrust and resentment of health workers at the CSCom level. Some women expressed a belief that the inconsistency in distribution was due to the fact that health workers were actively discriminating against rural, illiterate women, refusing to give them LLINs even

when they did have available stock. During in-depth interviews, several women reported that health workers told them they were "too dirty" to receive an LLIN and that they didn't deserve one. This type of behavior was usually attributed to young (and predominantly female) medical interns assigned to rural health clinics for a short period during their training.

Other forms of discriminatory or preferential treatment on the part of doctors and medical technicians were also cited as possible explanations for the fact that one is not always able to get a net at the CSCom. There was a belief that health workers gave precedence to their own friends and family members, regardless of whether or not those people met the criteria for receiving an LLIN. People also saw the nets available for sale in markets or from ambulatory vendors as evidence that health workers were selling nets for their own personal gain.

Health worker explanations of inconsistencies and interruptions in LLIN distribution. After it became apparent that perceived inequity in net distribution was a particularly salient topic for rural mothers, research staff explored the topic in all subsequent interviews with health workers. Specifically, health workers were asked to explain why some people do not receive nets during routine services and why parents may perceive LLIN distribution to be governed entirely by chance or God. Responses provided by health workers, coupled with observation data, suggested a number of specific situations in which an otherwise eligible person would not receive an LLIN at an EPI clinic.

Situation 1: Outreach activities. Participants in outreach activities may not consistently receive LLINs. In order to conduct vaccination outreach clinics, as mentioned above, vaccination technicians often have to ride long distances on motorcycles, along poorly maintained roads, with a maternity nurse perched on the back clutching a cooler full of vaccines. While they may be able to find a way to secure a few LLINs to the motorcycle, they are not always able to transport sufficient numbers of LLINs to meet the needs, and thus children who receive their measles vaccination during outreach may be less likely to receive a net.

Some health facilities have overcome this obstacle by enlisting community health workers to transport LLINs to the villages for distribution at the time of outreach activities. In villages where there is a strong cadre of literate and highly-motivated community health workers, CSCom staff may write down the names of the children immunized against measles during outreach and then have the community health workers deliver LLINs to them at a later date. Theoretically, the CPM or vaccination technician could make a second trip to the village for the sole purpose of retroactively distributing LLINs, but time constraints and limits on the amount of fuel provided by the community health association for the CSCom motorcycle likely limit the feasibility of this option.

Situation 2: Seeking Care "Hors Airs." Children who are vaccinated at EPI Clinics "Hors Aire" (Outside of Zone) may not receive an LLIN. While health workers may be willing to vaccinate children from another health zone if there are additional doses of measles vaccine left in the vial, many are reluctant to give a LLIN to a child who is not part of the denominator used to determine the CSCom's allocation of LLINs. If a child's vaccination card is marked to show that the child has received the measles antigen, it will be difficult for the mother to claim an LLIN in her own health zone at a later date given that health workers have no way of knowing whether the mother is lying in an attempt to manipulate the system and obtain a second net.

Situation 3: LLIN Stock-outs. Periodic shortages of LLINs at the CSCom level are likely the primary reason that some otherwise eligible women and children do not receive an LLIN. At the time of this study, data pertaining to the frequency and duration of LLIN stock-outs were not routinely reported in CSCom monthly or trimester reports, though the national malaria control program was in the process of introducing a new monthly malaria report format that would include this information. However, CPMs and vaccination technicians reported in qualitative interviews that stock-outs at the end of the month were a fairly common occurrence. When mothers participating in the 2009 household survey were asked if they had ever experienced a stock-out of LLINs during EPI clinics, 32.7% (CI 30.6%-34.7%) said yes.

Health workers at the CSCom and district levels, as well as representatives of NGOs involved in implementation and management of routine LLIN distribution provided a number of different explanations for the stock-outs.

Discrepancies between vaccination coverage rates and the target LLIN coverage rates used for procurement calculations. An explanation for LLIN stock-outs commonly cited by health workers at all levels, as well as by employees of NGOs responsible for the coordination of routine LLIN distribution activities in Segou, was that LLIN shortages were systematically produced as the result of the way that annual stock needs were calculated. According to these arguments, LLIN procurement needs were calculated based on a target of 80% coverage of both the birth cohort and the number of women who become pregnant in a year. In health zones with measles vaccine coverage rates higher than 80%, LLIN stock-outs would thus be inevitable. While measles coverage in Segou Region was 78.6% in 2006, according to the DHS, individual health zones within the region often reported coverage rates of over 100% in monthly, trimester and annual reports submitted to the district level.

Participants in interviews did not seem aware that LLIN procurement calculations generally also provide for a "buffer stock" of nets. The spoke of the 80% target as the maximum limit, not as a goal that could be exceeded. With the belief that it would be impossible to distribute nets to more than 80% of the clinic attendees due to limited stock of LLINs, there was little incentive to try to exceed targets.

Inaccurate census data. At the time of this study, the population projections used to calculate both vaccine and LLIN stock needs were based on census data that was approximately 10 years old. In addition, population projections produced by the National Directorate of Statistics were based on administrative units that did not always correspond perfectly to the geographic boundaries of health zones. Both of these facts were cited by study participants as reasons for a gap between the estimates of the number of people in the target population for LLIN

distribution and the actual number of people attending EPI and ANC clinics. Inaccurate denominators could potentially explain systemic shortages of LLINs.

Poor management by CPM at the CSCom level. When asked to explain shortages of LLINs and vaccines at the community health facility level, health administrators at the district, regional and national levels located the responsibility with the directors of community health facilities (CPMs). According to them, it was poor management at the health facility level that led to shortages at the end of a month because, as they explained, CPMs should anticipate stock-outs and request additional supplies from the district level in advance. However, the CSCom directors reported that, while they were sometimes able to obtain additional supplies in this manner, their requests for LLINs were often refused and they were told to wait until the next month's shipment of nets was available for them to transport to their facility. Health workers at the CSCom-level understood and explained this in terms of favoritism (the district level reserving surplus LLINs for the future needs of some health zones while refusing to send them to others with existing needs), in terms of corruption at higher levels (higher level officials selling LLINs on the open market for personal gain), or in terms of stock shortages extending all the way to the national level.

Variability in vaccination clinic attendance patterns. Monthly allocations of LLINs for each CSCom are determined by dividing the total estimated annual LLIN need into twelve equal portions, rather than by calculating estimated monthly need based on previous years' attendance rates for the given month. This system thus does not account for the fact that attendance at EPI clinics tends to fluctuate according to seasonal patterns in weather, agricultural activity and holidays. Additionally, it does not account for the fact that people sometimes seek routine services from health facilities in health zones adjacent to the one where they live. This attendance "hors aire" (outside the zone) may not always be randomly and equally distributed between health zones and seems to be influenced both by local perceptions of the quality of care provided at specific CSCom and by the location of weekly markets. People may travel extra

distances to avoid health facilities where they (or their friends and family members) have had negative experiences, and often profit from trips to larger towns for weekly market days to attend vaccination clinics on the same day rather than miss an additional day of work in their fields to attend vaccination clinics in their own health zone.

As a result of these fluctuating attendance patterns, both within and between health zones, the allocated monthly supply of nets may be insufficient to meet demand during certain months, and more than sufficient during others. Due to limited storage capacity at health facilities, as well as concerns about the possibility that "corrupt" health workers will sell LLINs on the free market for personal gain, organizations involved in the planning and coordination of routine LLIN distribution are reluctant to provide CSCom with much of a buffer stock of nets to accommodate these fluctuations.

Limited retroactive LLIN distribution to those who attended EPI or ANC clinics during a stock-out. Women and children who seek routine EPI or ANC services during LLIN stock-outs are very unlikely to receive a LLIN when the health facility stock is replenished. Of the 1072 household survey participants who reported experiencing stock-outs of nets during EPI clinics, only 314 (29.3%) said that they were able to obtain a net at a later date. When asked to explain this, health workers' responses generally fell into three main categories.

Fear of stock-outs: "She is not part of this month's target population." The first type of response focused on health workers' understandings of the way that LLIN stock needs are estimated, and on their fears of being sanctioned for stock-outs resulting from a failure to adhere to distribution guidelines. Health workers explained that they were unable to take a net from the current month's supply to give to a woman who had not received a net during the previous month because that woman "was not part of the current month's target population." CSCom staff did not feel that they were authorized to distribute nets to these women. They also were reluctant to do so because they worried that it would result in another stock outage. Health workers at the CSCom level expressed anxiety about the possibility of sanctions from higher levels if they

experienced multiple consecutive LLIN stock-outs. Others indicated concern for their reputations given the possibility that residents of the health zone would interpret a stock-out as a sign that the health worker was stealing LLINs for personal profit. Some health workers reported that they had had been specifically instructed by supervisors and trainers not to retroactively distribute LLINs to women who had attended routine services during a stock-out – a fact which was independently confirmed by staff at the district level and at the regional office of one NGO involved in LLIN distribution.

At the time of this study, health facility performance with respect to malaria control was primarily assessed on a trimester basis in terms of the number of cases treated and the absence of LLIN stock-outs. The focus of monthly meetings of CPM at the CSCom level was primarily on CSCom performance of EPI activities, but LLIN stock management and stock-outs were also frequently addressed. The discourse of health administrators and supervisors focused more on chastising health facility directors for running out of LLINs than on praising them for high distribution rates.

LLINs seen primarily as incentives to increase EPI coverage. The second type of common response offered by CSCom staff to explain the fact that women who experienced stock-outs were not provided with other opportunities to claim an LLIN at a later date stemmed from the belief that LLINs were distributed during vaccinations and antenatal visits primarily as an incentive to get people to seek those services, and thus to improve progress towards national and international targets for vaccination and maternal health indicators. As one vaccination technician explained when asked about the primary objectives of LLIN distribution activities, the main purpose of LLIN distribution is to "achieve the 95%," a reference to the target for vaccination coverage. Health workers who expressed this belief stated that there was no need to retroactively distribute LLINs to those women who had already received antenatal care or whose children had received all of their vaccinations. According to their logic, giving women a net

after they had already complied with EPI and ANC recommendations would serve no further purpose in terms of improving vaccination and antenatal care coverage.

The absence of standardized process for retroactive distribution. The third explanation provided by health workers was simply that there was no system in place to facilitate LLIN distribution to women who had already received antenatal or vaccination clinic services but had not received a net at that time. These women do not regularly return to the CSCom for other services, and weak telecommunications infrastructure and long distances to villages served by the CSCom present challenges for communicating with them when a new shipment of nets arrives. Perhaps most importantly, in light of the extremely hierarchical nature of decision-making within the Malian health system, CSCom staff had not received any clear directives from above instructing them to retroactively distribute nets to those whose attendance at EPI or ANC clinics coincided with a stock-out.

In most cases, health workers kept records of the women who had received LLINs, rather than those who had <u>not</u>, which means there was no way to actively locate them for distribution of LLINs at their homes at a later date. In addition, there was no standard practice (either within or between zones) of marking vaccination cards to indicate that a net was received. This made it essentially impossible for health workers to verify if a woman who claimed not to have received a net was telling the truth.

A vaccination card essentially functions as a voucher guaranteeing the card holder to a free LLIN at the time that the measles vaccine is administered. Because there is no designated space to record whether or not an LLIN was received, the card loses all value as a voucher the moment the date for the measles vaccination is entered, regardless of whether the child actually obtained a net.

Strategies for making sure every child receives a net. Health facility employees in some health zones have found ways to respond to and overcome these problems in order to ensure that all children in the target age group receive a net in a timely fashion. One CPM told us that

he distributed LLINs to any age-eligible children who attended EPI clinics during measles vaccine stock-outs, even though they had not yet completed their vaccination cycle because he believed that "children shouldn't be penalized for something that isn't their fault." In this same health zone, the vaccination technician kept careful records of children who had been vaccinated during LLIN stock-outs and enlisted community health workers to deliver nets from the next shipment directly to the children's homes, usually by bicycle. A few women in other health zones reported, during qualitative interviews, that they had returned to the health facility at the end of a stock-out to request a net and had received one, but these cases seem to be the exception.

Implications of Integrated Interventions for LLIN Use

The linking of LLIN distribution services to EPI clinics also has potential implications for LLIN use, with regards to both decisions about the particular household members who will use the nets and the likelihood that the distributed nets will be used and maintained appropriately.

Prioritization of vulnerable groups. Integrated distribution may increase the likelihood that pregnant women and children will be given priority for net use within households. The linking of LLIN distribution to EPI activities seems to have strengthened associations between LLINs and the targeted vulnerable groups, creating widespread understanding and acceptance of the fact that pregnant women and children under-five are to be given priority when it comes to net use. Likely due in part to the fact that LLINs are distributed to individuals, and are presented as "rewards" for attending ANC and EPI clinics, LLINs are seen as individually-owned goods rather than household belongings, though this is also likely due the sensitive and personal nature of bedclothes because of their associations with sex. Individual nets are commonly distinguished by using the names of the women or children who received them at the CSCom (for example, "Kadia's net" or "Moussa's net"). The specific woman who received the net from the CSCom is generally the one who decides which household members will sleep under it, and contrary to

common perception, male heads of household do not seem to claim LLINs distributed to their children for their own use.

Storing nets for the future. Inconsistencies and interruptions in LLIN distribution encourage women to keep excess nets in storage rather than sharing them with other household members who don't own a net. Given the perceived inconsistency in LLIN distribution practices, women are hesitant to assume that they will be able to receive free nets in the future. They do not know if the government will continue to provide free nets. If it does, they do not know if they will have additional children. If they do have additional children, they cannot be confident that LLINs will be available on the day that they attend an EPI clinic. Participants in the qualitative study suggested that, for this reason, women sometimes put their new LLINs in storage and continue using their older nets or their traditional nets until they are too worn to serve as an effective barrier against nuisance mosquitoes.[4] If the unpredictability of net distribution leads women to put excess nets in storage, rather than sharing them with household members who do not own an LLIN, fewer people will be protected by LLINs than expected according to the procurement need calculations underlying LLIN distribution planning and coordination. This practice presents challenges for net need calculations that assume that a certain number of people will sleep under each net, that all nets in the household will be equally available to all household members, and that all nets owned by a household will be in use.

Insufficient attention to LLINs during health education. Minimal information is provided about appropriate LLIN maintenance and use in the context of linked intervention activities. As mentioned previously, despite the fact that health workers were free to choose from a number of different child health topics when conducting health education in the context of EPI clinics, they almost always focused on vaccine-preventable diseases and rarely discussed LLINs.

Household survey data suggest that health education in Segou is not sufficiently addressing needs for improved education about LLINs. While knowledge that sleeping under a mosquito net can protect you from malaria was common, there was little awareness of the

differences between LLINs and the ITNs previously distributed in Mali (prior to 2007). Only 18.8% (95% CI: 16.8, 21.8) of household survey respondents knew that LLINs did not have to be retreated with insecticide. During qualitative interviews, some mothers indicated a belief that their nets no longer had effective levels of insecticide because they had not been retreated recently, explaining that they were no longer able to find re-treatment kits at the CSCom or in the market. Survey respondents also lacked knowledge about appropriate net washing behaviors: 62.9% (95%CI: 59.7, 66.0) said that they were not sure how often they should wash their nets.

Implications of Integrated Interventions for EPI Coverage Rates

This study was not designed to permit a statistical analysis of the effects of LLIN distribution activities on EPI and ANC clinic attendance. However, health workers and community leaders reported that LLIN distribution greatly increased attendance at ANC and vaccination clinics, and that many women "only come for the mosquito nets and don't come if there's a stock-out of nets." With increased attendance comes increased revenue for the community health center through the purchase of additional immunization cards. This added revenue could potentially lead to increased vaccination outreach activities if the money is used to cover motorcycle repairs or to purchase fuel for use during outreach visits to communities.

Parent attitudes suggest that LLINs are an effective incentive to encourage attendance at EPI clinics. During follow-up interviews with mothers who participated in observed EPI clinics, participants were asked to describe the thing they were most satisfied with during their recent visit to the CSCom. In response, parents commonly mentioned the distribution of LLINs, even if their child had not yet completed the vaccination series and thus had not yet received a net.

Implications of Integrated Interventions for Vaccine Stock Management

When LLIN distribution and EPI services are integrated, the effects of LLIN stock-outs extend to the immunization program as well. In group discussions and in-depth interviews, rural

women revealed a number of possible ways that LLIN stock shortages could influence EPI and ANC clinic attendance, with potential implications for the adequacy of vaccine stock and immunization supplies to meet needs. Despite a weak telecommunications network in this region, news travels fast by word-of-mouth. According to health workers in Segou, when women learn that there are no LLINs at the CSCom in their health zone, they decide to do one of three things: 1) attend the vaccination or ANC clinic as scheduled, despite the fact that they know that they will not receive an LLIN, 2) attend a different CSCom in a nearby health zone or in the district capital, or 3) delay going for immunizations or antenatal care until they hear that LLINs are again available.

The first option is unlikely to have any impact on vaccination and ANC coverage rates, but women who make this choice, as well as their children, are not likely to obtain a net from another source and thus could be at increased risk for malaria. The second choice, however, could potentially result in shortages of vaccines and immunization supplies at nearby CSCom, in addition to LLINs, given the unplanned increases in clinic attendance. This then could initiate a cascade effect, with women from the second health zone going to a third when there are no longer sufficient LLINs or vaccines at their own CSCom. The third choice introduces similar potential problems for estimating supply needs, given unexpected surges in attendance as soon as LLINs become available again.

DISCUSSION

Positive and Negative Interactions and the Cascade Effects of Integration

The results of this study suggest that linking LLIN distribution and EPI services in Segou has resulted in many of the expected positive effects of integration (Briggs & Garner, 2006; Clements, et al., 2008; Wallace, et al., 2009). These include increases in vaccination coverage and exposure to health education as the result of increased vaccination clinic attendance. In the context of malaria control programs that focus on the groups most at risk to morbidity and

mortality, distribution of LLINs during EPI clinics may reinforce the message that pregnant women and young children should be given priority for net use, though this is less of an advantage in the context of malaria elimination programs and the related shift towards universal net use.

However, the findings also demonstrate the potential cascading negative effects and challenges that can result from integration (Wallace, et al., 2009). Many of these are related to the challenges of coordinating stock management for linked interventions. The linking of LLIN distribution to EPI services in Segou appears to have led to some irregularity and inequity in access to nets. These inconsistencies have the potential to encourage people to store LLINs for the future rather than putting the maximum number of nets possible into use, and may foster distrust and negative attitudes towards health workers and community health centers. Evidence from other similar contexts suggests that distrust and negative attitudes may limit the effectiveness health education activities. Higher levels of trust have been associated with greater effectiveness of malaria health education specifically (de Hoop & van Kempen, 2010), while attitudes towards health workers and facilities have been identified as determinants of treatment seeking and adherence to health behaviors (Das & Ravindran, 2010; Mwisongo, Gilson, Konradsen, & Bygbjerg, 2005; Russell, 2005). Stock-outs of LLINs may also introduce changes in vaccination clinic attendance patterns, which then can lead to additional challenges for managing both LLIN and vaccine stock, introducing the potential for future stock-outs of both and the repetition of the cycle.

Health workers in Segou seem to attach much more importance to the delivery of vaccines than to the distribution of LLINs in the context of EPI clinics. Much less time is devoted to providing health education about LLINs. Additionally, the perception that the true value of LLIN distribution is in its ability to encourage health facility attendance seems to act as a disincentive to retroactively distribute LLINs to children who were vaccinated during an LLIN stock-out. The prioritization of EPI activities is likely linked to the fact that EPI outcomes are

reported more frequently and in a more standard fashion, are given more attention in monthly meetings and are heavily emphasized in assessments of health worker performance. Evaluations of health worker performance related to LLIN distribution seem to focus much more on the avoidance of stock-outs than on the number of LLINs distributed.

The processes and outcomes of integrated LLIN distribution and EPI clinics are influenced by a wide number of health systems components (de Savigny, 2009; WHO, 2007). Key among those influencing EPI and LLIN activities in Segou are health facility financing (cost-recovery, role of ASACO), governance at all levels (decentralization, transparency), the health workforce (staffing, motivation, empowerment), and information (data collection and reporting forms, communication with communities and communication between health workers and clients).

Recommendations for Addressing Identified Problems for Integrated LLIN Distribution

A number of the challenges and potential negative outcomes associated with stock-outs in the context of integration could be reduced or eliminated if CSCom were to be provided with a buffer stock of nets to accommodate fluctuations in monthly EPI clinic attendance.[5] If concerns that health workers will sell the LLINs for personal profit make policy-makers reluctant to approve that strategy, an alternative would be to institute a formal standardized system for retroactively delivering LLINs to clinic attendees who experienced an LLIN stock-out at the time of vaccination service delivery. This would require the addition of a designated LLIN checkbox on the vaccination cards distributed to parents so that health workers would have a way of identifying individuals who had not received nets.

Adding spaces to record LLIN distribution and stock management information on monthly EPI reports would facilitate better microplanning of LLIN stock needs, and also potentially elevate the importance of LLIN distribution in the minds of CSCom staff by including it in the report most commonly used to assess overall health facility performance. Integrated

reporting formats would also reduce the burden on health workers compared to parallel reporting systems, and thus could make it easier for CSCom to submit complete and timely reports.

Providing a set rotating schedule of topics for health education sessions could be one way to increase the amount of attention paid to other interventions, including LLIN distribution, and to improve health communication about the related health problems and recommended health behaviors. In general, health workers should be actively encouraged to give equal priority to all linked interventions, recognizing the importance of each in its own right rather than simply as a means to increase immunization coverage.

These recommended changes will all require increased coordination and integration of planning and policy-making activities at the highest levels, necessitating increased collaboration between the National Center for Immunizations and the National Malaria Control Program. At the time of this study, "integration" seemed to be something that happened primarily at the CSCom level. Planning, procurement, supervision and data management related to each of the linked interventions were conducted largely in isolation, often by different teams of people, at the district, regional and national levels. While each team was generally informed of the activities of the others and, at the national level, provided an opportunity to give feedback, the two programs still functioned primarily as independent vertical programs with some intersecting activities, rather than as a truly integrated health system. Additional fragmentation was introduced by the fact that LLIN distribution activities were coordinated by different NGO partners in different regions of the country, often using somewhat different strategies.

A call for a change in the discourse about "wastage" and stock-outs

Anxieties about wastage and stock-outs were identified as strong potential determinants of health worker behaviors related to both EPI and LLIN distribution, and were linked to observed vaccination practices that differ from those in WHO guidelines and training materials. While limiting waste is important in the context of resource-poor settings, the disproportionate

emphasis on avoiding waste compared to the delivery of interventions in Segou may prevent people from receiving essential free services. A major transformation of the discourse about "wastage," as well as modifications to the procedures for calculating vaccine stock needs, will likely be required before health workers at all levels begin to focus more on the importance of immunizing every infant, and by extension distributing as many nets as possible, than on minimizing waste.

Current calculations of vaccine wastage conflate multiple types of unused doses, concealing differences between doses lost to negligence or poor stock management and doses necessarily sacrificed as the result of efforts to make sure that every child is protected against vaccine-preventable diseases. "Wasted doses" are those doses in unopened vials that are lost for various reasons such as broken bottles or the disruption of the cold chain before they could be administered. "Sacrificed doses," by comparison, are those that are unavoidably lost in order to immunize as many people as possible. These include doses remaining unused at the end of a vaccination clinic, or those lost when a vial is opened to vaccinate a single child outside of the context of routine EPI clinics. Doses administered to children outside of the target group (children older than 11 months or those residing outside of the coverage area) are counted as "wasted" doses. All the different reasons for lost doses are combined in monthly reporting of wastage and are treated as indistinguishable when it comes to evaluating health facility performance.

WHO health worker training materials do indicate that maximizing immunization coverage should be prioritized over minimizing waste, and therefore suggest that certain types of waste are not only acceptable but desirable. However, the use of the term "wastage" makes this a somewhat paradoxical statement. The negative connotations of the term imply mismanagement on the part of health facility staff and discourage health workers from vaccinating any categories of children included in calculations of vaccine waste.

Restricting the use of the term "wastage" to those doses lost prior to the point at which they could have been administered and creating a separate reporting category for doses administered to individuals outside of the target population would be important steps towards transforming health worker attitudes towards unused doses and creating an administrative environment that encourages health workers to capitalize on every possible opportunity to immunize eligible infants and pregnant women.

In order to change the attitudes of administrators and supervisors at the district, regional and national levels toward unused doses of vaccine, it may be necessary to modify the way that vaccine stock needs are calculated for procurement purposes. Until administrators and supervisors at *all levels* are convinced that stock need calculations (and subsequently actual procurements) allow for specific acceptable losses of vaccine doses, they will likely continue to discourage health workers from doing anything that increases the total number of unused doses, regardless of the structure and content of reporting forms. Current methods for calculating stock needs in most countries employ a standard wastage factor (usually between 5-15%, depending on the number of doses in the standard vial for the specific vaccine).[6] While this should theoretically be sufficient to cover all acceptable reasons for vaccine loss, it does not allow health workers at various levels to identify the number of doses procured for the purposes of vaccinating children outside of the target population or in contexts other than routinely scheduled clinics. Introducing separate multipliers for different types of vaccine non-use in the calculations for estimating vaccine stock need would make visible the different types of non-use and could help convey the message that types of non-use which enable health workers to vaccine the maximum number of people should not be discouraged. It also could help countries determine if their current standard wastage factor is sufficient. Adding a target percentage of children over the age 11 months (potentially equivalent to the gap between the previous year's target and actual coverage rates) should also be considered to ensure that these children are protected.

Strengths and Limitations

One of the greatest strengths of this research was that it focused on the processes of integrated service delivery, and not only the outcomes, leading to a much more nuanced understanding of the potential advantages and disadvantages of integration and facilitating the development of concrete recommendations for improving the outcomes of each of the linked interventions. The triangulation of the perspectives of administrators, health workers and the intended recipients of integrated services served as a validity check and helped to illuminate potential biases and points of failed communication between the various groups. The triangulation of methods was another strength. The qualitative data helped to explain quantitative findings regarding the percentage of households that cited EPI clinic non-attendance as the reason they did not own a net. In addition, it provided much more detail about the meanings and values that health workers and potential net recipients attach to LLIN distribution procedures than has been previously published.

However, there were a number of limitations to the study design when it came to the investigation of this topic of LLIN distribution within the larger parent study. LLIN stock-outs and distribution procedures were not a primary focus of the study as initial conceptualized. When qualitative interview and focus group data revealed this as one of the most salient topics for rural women, and when potential problems with the integrated service delivery were identified through direct observation, the study team decided that this was an important topic to examine in greater detail. As a result, additional questions about LLIN distribution were added to qualitative data collection guides partway through the study. However, the quantitative tools employed during the study did not sufficiently allow for comprehensive assessments of the validity and representativeness of all qualitative findings.

The study design did not include rigorous methods for systematically assessing the frequency and duration of LLIN stock-outs, or the relative frequency of health education sessions focused on LLINs and vaccine preventable diseases. This was due to inaccurate assumptions that this information would be consistently recorded at the CSCom level and included in monthly and

trimester reports submitted to the district level. While cells for reporting whether or not a stock-out was experienced in the past month were included in the EPI-CM monthly reports introduced as part of the project, this data was frequently missing from submitted reports.

The qualitative data suggested a number of topics that should be more systematically assessed in future standard evaluations of LLIN distribution activities, including stock-outs encountered, perceived discrimination and the impacts of LLIN stock-outs on EPI clinic attendance patterns and stock management. While questions pertaining to some of these topics were added to questionnaire for the household survey conducted at the end of the project, these were based on a very preliminary analysis of the qualitative data and did not address all of the important topics eventually identified in the final analysis. Additional measures should be developed to statistically test the various hypothesized interactions between EPI and LLIN distribution activities, as well as the influence of health systems factors on the outcomes related to each of these interventions.

CONCLUSIONS

This research on LLIN distribution practices in the context of EPI clinics in Segou, Mali contributes to ongoing debates about the best strategies for delivering LLINs and about the relative advantages and disadvantages of integrated intervention delivery systems. The case study presented here highlights the ways that the discrete outcomes of each intervention in an integrated service delivery package are influenced by the processes of integration within a particular health systems context. While LLIN distribution and EPI services generally satisfy criteria for the compatibility of linked interventions (Wallace, et al., 2009), the extent to which the potential benefits of integration are realized and the particular challenges experienced are likely to vary greatly between settings given differences in key health systems factors.

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Chapter 3 Notes

[1] Throughout this paper the term "vaccination clinic" refers to a specific activity during which vaccinations are provided either at the health facility (fixed) or in one of the surrounding villages (outreach), and not to a location or physical structure.

[2] The term "parent" is used in the Malian sense to refer to any adult with the responsibility of caring for a child. While this is often a mother or father, it also could refer to an aunt, uncle, grandparent or even a close family friend. Here the term "parent" usually refers to a mother, as mothers are generally the ones to take children to EPI clinics. Male parents, however, were often the ones to take sick children to the health center for treatment.

[3] The study team encountered one mother who was directly observed to return to the health facility three times before her child was finally vaccinated and she received an LLIN.

[4] Few participants admitted to storing nets for future use *themselves* but they reported that other people are likely to do so. Less than 1% of nets observed during the 2009 household survey were reported to be in unopened packages or replaced in their packaging for storage. However, the wording of the question did not account for nets that were not in active use but were not stored in their original packaging. Given that health workers commonly remove the packaging before giving out the nets to discourage the practices of placing new nets in storage or reselling them, few people will have the original packaging, and thus this indicator is likely to underestimate the number of nets in storage. During the 2009 survey, 100% of nets were reported to have been hung the previous night, but only 72.7% (95% CI: 69.0, 76.4) of nets were actually observed to be hanging. These nets that were not hanging represent the maximum number of nets that were potentially in storage at the time of the survey.

[5] Eliminating stock-outs of LLINs during routine EPI clinics has added importance due the potential implications of reactions to stock-outs for general health seeking and health promotion behaviors, and not only for immunization and LLIN coverage. If people interpret inconsistencies in LLIN distribution as signs of discrimination, favoritism or corruption this may foster resentment and negative attitudes towards the health center and health workers. Because trust and attitudes towards health facilities and health workers are associated with treatment-seeking behaviors and compliance with medical recommendations, frustration with LLIN distribution practices may have broader implications for malaria and other health outcomes.

[6] There are currently three possible ways to calculate vaccine stock needs (World Health Organization, 2004b). The first multiplies the estimated number of children in the birth cohort, the number of doses of vaccine in the country's vaccination schedule, the desired coverage rate and an estimated "wastage factor" (usually between 5-15%, depending on the number of doses in the standard vial for the specific vaccine). The second is based on previous consumption: the sum of the remaining doses at the end of the year and the quantity of doses lost during the year is subtracted from the sum of the number of doses in the initial stock remaining at the beginning of the year and the number of new doses received throughout the year. The third method uses information about the frequency and size of immunization sessions to calculate vaccine needs. The number of immunization posts is multiplied by the number of weeks during which vaccination sessions are conducted, the number of sessions per week, the number of vials used in a session and the number of doses per vial for a given vaccine. The first method is used in Mali. Current target coverage rates are 97% or higher for all infant vaccines (The Government of Mali, 2009, 2011). Wastage rates are 15% for measles and yellow fever vaccines and 5% for BGC, OPV, DPT and pneumococcal vaccines.

CHAPTER 4

Preparing for the Transition to Universal LLIN Coverage: Factors that Motivate, Inhibit and Interrupt LLIN Use among Persons of all Ages in Segou, Mali

ABSTRACT

Background: Insecticide-treated nets (ITNs) are one of the most effective existing tools for reducing morbidity and mortality due to malaria. ITN ownership in malaria-affected countries has increased dramatically in the past decade, mainly as the result of large-scale mass distribution campaigns. However, in most places, rates of reported net use remain well below rates of net ownership. There is a need for additional research on the determinants of net use, and the relationships between them, in order to develop better social behavior change interventions and address any modifiable structural, social and environmental barriers to net use. As more and more countries adopt policies of universal coverage with long-lasting insecticidal nets (LLINs), it is important to understand the determinants of net use among men and women of all ages as they are likely to different somewhat from the factors influencing net use among previously targeted vulnerable groups (pregnant women and children under-five), with possible implications for intervention strategies.

Methods: Potential determinants of LLIN use among individuals of all ages were examined using a multi-phased mixed methods research design from August 2008 to December 2009 in two districts of the Segou Region of Central Mali. Data collected during an initial exploratory phase informed the development of the questionnaire for a subsequent household survey, strengthening the validity of qualitative findings and facilitating an assessment of their generalizability. Methods included unstructured observations at the community and household levels; semi-structured interviews with parents of children under-five recruited at community health facilities (N=80); key informant interviews with community leaders (N=4); focus groups with mothers

(N=15 groups), fathers (N=5 groups) and grandmothers (N= 6 groups) in rural communities; and a representative household survey (N=3,283).

Results: There is a strong existing culture of net use in Segou, Mali, evidenced by high reported net use among children (>91% for children 0-23 months of age), and reflected in perceived norms and social expectations that everyone who owns a net will use it. Among survey participants, 89.3% (95% CI: 87.7-91.0) were of the opinion that LLINs have no disadvantages. The barriers to net use commonly reported in other contexts (heat, allergies, and insufficient knowledge) were very rarely mentioned as potential barriers to net use. Instead, the factors identified as potential determinants of net use among people who have access to a net in this context were intermittent, recurrent, conditional factors such as fatigue, disruptions to usual sleeping spaces or travel. The effects of fatigue are likely influenced by the type and location of a person's sleeping space as well as the amount of social support for net use provided by other household members. Many of these factors vary seasonally. While people in Segou reported that they use nets during all times of the year, the factors that motivate net use appear to differ from season to season. There was a strong preference for traditional heavy cotton nets during the cold season, while LLINs were preferred during the rainy and hot seasons. Though net ownership in the study district was very high (> 96%), the qualitative data highlighted the fact that nets owned by the household are not equally available to all members of the household.

Conclusions: While net use in this context is high among young children, there are no available population estimates of net use among adults. Qualitative data from this study suggest that limited access to nets is still a significant barrier to net use for adults in this population and that universal coverage net distribution strategies are thus likely to be well-received in this region. However, even with increased access to nets as the result of new universal coverage policies in

Mali, there are a number of interrelated factors that are likely to interrupt or inhibit net use among adult populations in Segou, making them vulnerable to malaria morbidity and mortality and providing opportunities for continued transmission. Interventions designed to increase social support and decrease the perceived time burden and hassle associated with preparing nets for sleeping could help to encourage more consistent nightly net use among adult women and, by extension, the men and children whose nets the women are primarily responsible for hanging. The data suggest a need for more systematic considerations of variations in intrahousehold access to nets when determining net distribution policies and delivery strategies, as well as when monitoring net ownership and use. In contexts like Segou, where nets are considered individual property, rather than household goods, measuring net ownership at the individual level rather than the household level will likely facilitate better understandings of the apparent gaps between net ownership and net use. Many of the identified influences on net use are likely to be difficult or impossible to change, raising questions about how much net use is enough and about the amount of additional resources that should be devoted to interventions targeting individual net users once a certain threshold of knowledge has been achieved and positive attitudes have been established. These resources may be better directed towards the development of improved housing and other insecticide treated materials that require less individual effort and have the added advantage of protecting multiple household members, reducing intrahousehold variability in protection against malaria.

BACKGROUND AND INTRODUCTION

Insecticide treated bed nets (ITNs) are one of the most effective existing tools for reducing malaria morbidity and mortality. An estimated 6.35 lives are saved for every additional 10,00,0 ITNs distributed (Akachi & Atun, 2011). Data presented in a 2004 Cochrane Review of the effectiveness of ITNs indicate that for every 1,000 children sleeping under and ITN, 5.5 lives will be saved, assuming 70% usage of distributed nets. A recent systematic literature review

reported that ITNs have a 55% (range 49-61%) protective efficacy among children under-five in areas where the majority of malaria cases are due to *P. falciparum*, and that the pooled protective efficacy of ITNs and intermittent preventive therapy for pregnant women (IPTp) is 35% (95% CI: 23-45%) (Eisele, Larsen, & Steketee, 2010).

The past decade has seen dramatic increases net ownership in Sub-Saharan Africa, largely as the result of increased funding for nets provided by partners such as The Global Fund for AIDS, Tuberculosis and Malaria (GFATM), The World Bank (WB), The Bill and Melinda Gates Foundation (BMGF) and USAID. As part of the scale-up for impact (SUFI) of malaria control interventions, the majority of these nets have been distributed free-of-cost or at highly subsidized rates to pregnant women and children under-five in the context of mass campaigns, supplemented by distribution through antenatal care (ANC) services and the Expanded Program for Immunizations (EPI). The decision to target these particular populations was based on the fact that pregnant women and children are the ones most vulnerable to severe outcomes and mortality from malaria. However, in 2007, the World Health Organization (WHO) recommended universal coverage with long-lasting insecticidal bet nets (LLINs) for all people at risk of malaria, regardless of age or gender (WHO, 2007). Universal coverage is generally operationally defined as one net for every two people, though recent estimates suggest that a ratio of one net for every 1.60 persons is necessary to avoid stock-outs during distribution campaigns (Kilian, Boulay, Koenker, & Lynch, 2010).

There are a number of reasons for the shift to universal coverage. High levels of net ownership and use are required to maximize the community-level benefits of ITNs and high rates of use among adults have been shown to provide protection for children (Gimnig et al., 2003; Hawley et al., 2003; Hill, Lines, & Rowland, 2006; Howard et al., 2000; Killeen & Smith, 2007; Russell et al., 2010). Results from a comparative study conducted in Southeast Nigeria suggest that universal coverage distribution strategies can result not only in higher rates net ownership and overall net use than targeted distribution strategies, but also in higher rates of net use among

pregnant women and children under-five years of age (The Carter Center, 2010). Modeling exercises suggest that universal coverage strategies will be necessary to achieve large reductions of the malaria burden in Africa (Killeen et al., 2007). Recent models suggest that past mortality statistics have dramatically underestimated malaria-attributable mortality in persons older than the age of five (Murray et al., 2011), suggesting that even stronger arguments may be made about the public health, moral and human rights significance of providing nets to all persons in malarious areas.

Additionally, in the context of a renewed commitment to the goal of malaria elimination and eradication, the focus has shifted from reducing morbidity and mortality to transmission interruption. In order to interrupt transmission, it is necessary to prevent mosquitoes from biting any infected individuals, regardless of their age, sex or risk or severe complications. While older individuals often have acquired immunity, and may be completely asymptomatic when infected with malaria parasites, they still can act as reservoirs of infection and thus play an important role in perpetuating the cycle of transmission. While experts generally agree that ITNS alone will be insufficient to achieve malaria elimination in areas with high transmission and large populations of outdoor-biting vectors, high coverage with ITNs can reduce malaria prevalence to levels where other strategies can be more effectively used to bring transmission to zero (Moonen et al., 2010).

While increasing LLIN ownership is an essential first step, the benefits of universal net coverage can only be fully realized with universal net *use*. The factors that motivate, inhibit, or interrupt net use among groups other than pregnant women and children under-five are likely to differ somewhat from the key determinants of net use within those groups, and it will be important to proactively anticipate and address these differences in tandem with the shift to universal coverage distribution models. Past studies of the barriers to net use have tended to focus primary on individual-level factors such as knowledge and attitudes, but these variables leave much of the variability in net use unexplained (Pulford, Hetzel, Bryant, Siba, & Mueller, 2011). There is a need to develop a much stronger understanding of the various social, cultural,

structural and environmental determinants of net use, as well as the complex relationships between them.

This paper presents the results of an exploratory study of the factors that influence net use among people of all ages, during all seasons of the year, in a region of the West African country of Mali with a strong existing culture of net use. The data were collected using a variety of quantitative and qualitative methods in the context of Segou, Mali, a region that already has high net ownership and high rates of net use among children under-five. The results described here highlight factors that motivate, inhibit and interrupt net use among men and women of all ages in Segou, in anticipation of the planned transition to universal coverage in Mali. Potential relationships between these factors, as well as seasonal variations likely to influence the relative magnitude and directionality of their effects, are discussed. Recommendations for future research, as well as possible strategies to encourage the universal uptake of net use following universal distribution campaigns are also proposed.

The Malaria Situation in Segou, Mali

The Segou Region is located in the center of Mali, and its capital city (also named Segou), is approximately 235 km north-east of the capital city of Bamako. Two main rivers, the Niger and the Bani, traverse the region, and irrigation projects have been introduced in certain zones to facilitate rice farming. There are three main seasons in Segou: the rainy season, the cold dry season and the hot dry season. Malaria is endemic, with a peak immediately following the end of the rainy season. The region is predominantly agricultural, and the primary occupations are agri-business, fishing and animal husbandry. Most people in this region belong to the Bambara ethnic group, though the towns along the rivers are heavily populated by Bozo fishermen. Other common ethnic groups include the Peuhl and Sarakole. Over 40% of women in Segou Region are in polygamous marriages (Cellule de Planification et de Statistique du

Ministère de la Santé (CPS/MS), Direction Nationale de la Statistique et de l'Informatique du Ministère de l'Économie de l'Industrie et du Commerce (DNSI/MEIC), & International, 2007).

LLINs were distributed in this region as part of a mass integrated campaign in 2007, and since then have been distributed to pregnant women and children under-five in the context of routine immunization and antenatal services. The percentage of households owning any kind of mosquito net in the Segou Region was 85% in 2006, *prior to mass distribution campaigns*, according to the National Demographic and Health Survey, while 52.8% of children under-five slept under any bed net the previous night. These rates were much higher than in any other region of the country, though the gap diminishes somewhat when comparisons are limited to insecticide treated nets and even more so when limited to long-lasting insecticidal net (Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS), et al., 2007). Given that all nets distributed via free distribution mechanisms are LLINs, the relatively higher ownership of untreated nets in this region compared to others suggests the importance of traditional cotton nets (and other untreated nets) in Segou, and indicates that people are willing to pay for additional nets to supplement those freely distributed through mass campaigns and vaccination clinics.

In Segou, as in other parts of Mali, people have historically used traditional blankets and nets for protection from mosquito bites. Traditional woven blankets and heavy cotton bed nets were used to protect people from nuisance mosquitoes in Mali long before people knew that mosquitoes transmit malaria (Dupuis-Yakouba, 1921). These traditional nets are also a central part of traditional marriage ceremonies as the bride and groom spend the first week of their married life ensconced in one of these nets inside the "konyo so" (marriage house or room). The bride's family provides her with one of these nets as part of her wedding trousseau and, as a result of this practice, almost all married or previously-married women in the Segou region have owned at least one bed net in their lives, even if not an insecticide-treated net. Women are generally quite familiar with bed nets, the way to hang them, and the potential advantages of net use. These

nets are extremely durable and thus women keep and use them for years after their wedding ceremonies.

METHODS

Overview of Study Design

The data analyzed and presented here were collected in the context of a larger mixed methods study designed to evaluate a proposed health-facility-based tool for malaria monitoring and program management called the Expanded Program for Immunizations (EPI) Contact Method (EPI-CM). Detailed descriptions of the EPI-CM and the design of the parent study are presented in Chapters Five and Two respectively.

The data presented here were collected between August 2008 and December 2009, from a number of different sources, using a combination of qualitative and quantitative methods. The particular order and combination of methods were selected to capitalize on the complementary strengths of multiple methods, while compensating for the inherent limitations of each. Qualitative data provided rich, descriptive, explanatory detail, while quantitative data provided a check on the validity and representativeness of qualitative findings. Data were collected from different sources, and during all seasons of the year, in order to represent a wide range of perspectives and to account for the likelihood that people's net use practices and attitudes towards nets vary as a function of temperature, rainfall and mosquito densities.

Data Collection Methods

The specific data presented here were obtained using the following methods, each of which is described in more detail below: semi-structured interviews with rural mothers; group discussions with mothers, fathers and grandmothers; key informant interviews with community leaders; unstructured observations; and a representative household cluster survey. Interviews and group discussions were conducted in nine health zones of two districts of Segou Region (Segou

and Baraoueli) that had been selected for inclusion in an intensive process evaluation carried out as part of the larger parent study (See Chapter 2). These facilities were selected, with input from the district medical administrator, to reflect variability in CSCom functionality, distance from the district capital, and gender and training of the director of the CSCom (CPM). Representative household survey data were collected in all health zones of these two districts.

Previously published baseline comparisons of the two districts revealed no significant differences in net ownership, mother's education, children's vaccination histories, or reported incidence of common childhood illnesses (fever, respiratory infection and diarrhea) (Wei et al., 2012b). ITN ownership and ITN use among children under-five were significantly higher in Baraoueli District than in Segou District. However, the rates for ITN ownership exceeded the national target of 80% in both districts (92.4% in Baraoueli versus 88.1% in Segou, $p=0.04$) and ITN use among children under-five was relatively high in both districts (86.2% in Baraoueli versus 76.9% in Segou. $p<0.01$) (Wei, et al., 2012b).

Semi-structured interviews with rural parents. Semi-structured interviews were conducted with parents recruited during systematic observations conducted at health facilities as part of the larger study (See Chapter Two). The sample included 50 randomly selected women whose children were vaccinated during observed immunization clinics, and with 30 parents (28 mothers and two fathers) whose children were treated during observed medical consultations. During each day of vaccination clinic observations, three parents whose children were vaccinated were randomly selected. On the days when medical consultations were observed, all parents who brought their children for the treatment of febrile illness were asked if they would be willing to participate in an interview. For logistical reasons, parents were excluded from participation in interviews if they lived outside of the health zone where they were seeking care.

In addition to questions about their recent experiences at the health facility, their general knowledge about malaria and their treatment seeking behaviors for fever, all participants in these interviews were asked about their experiences with LLIN distribution activities, their exposure to

communications about malaria and LLINs, their general knowledge and attitudes regarding LLINs, and their net use behaviors. To elucidate details regarding net hanging and use practices, participants were asked to list all of the members of their household who did and did not sleep under a net the previous night and to explain where the net was hung, how it was suspended, who hung it and how many people slept under it. Questions explicitly addressed seasonal variations in net use practices. To better understand the barriers to net use, respondents were asked to describe the conditions of the *last time* they slept without a bed net, even when they stated that they always slept under a net. To learn more about the relative perceived advantages and disadvantages of different types of nets, people were asked to compare the pros and cons of traditional nets and LLINs.

Interviews with parents were conducted two to seven days after the observed vaccination clinic or consultation for fever treatment, at a time and place selected by the participant, and generally lasted one to two hours. Participants were given locally-appropriate gifts of sugar and soap to thank them for their contributions to the research. Interviews were conducted in Bambara, were recorded using digital audio recorders, and were subsequently translated into French and transcribed.

Group discussions. Group discussions (N=9) were organized with 10-12 female caretakers of young children in each of the nine health zones in order to learn about their net use practices, their attitudes towards LLINs, their experiences with LLIN distribution systems, and their treatment seeking behaviors when their children have a fever. Participants were recruited with the assistance of community leaders, community health workers or staff at the community health center who had been asked to purposively select women who represented a range of different life experiences and perspectives on child health. The people who assisted with the recruitment were explicitly instructed to select women from different households, and to avoid disproportionate representation of the friends and family members of the village chief or the community health workers. Many of these group discussions were conducted during routine EPI

clinics, while women were waiting for vaccinations to begin, because this was a time when the group discussion would not interrupt their daily work in the household or the family fields. The discussions generally lasted approximately one hour.

An additional 17 group discussions were conducted with fathers (five groups of six to ten), mothers (six groups of six to ten) and grandmothers (six groups of six to ten) to learn about their exposure to radio, television, print and interpersonal communications about malaria and LLINs, and the ways that they understood the content and messages of these communications in the context of their lived experiences. During these group discussions, the facilitators played television and radio public service announcements about malaria that were in circulation at the time of the study, and displayed posters and other print materials about malaria. They then asked the participants what they understood from these communications, whether the materials and messages seemed relevant to their lives and if they thought they could apply these messages. Participants were recruited from villages in the selected six health zones in Segou District where other data collection activities (in-depth interviews or observations) were already scheduled. Community leaders and community health workers assisted with the recruitment, again recommending individuals who represented a range of knowledge and experience about malaria. These group discussions were generally held at the community health center or at the home of the village leader, and lasted between one and two hours.

All discussion groups were conducted in Bambara and recorded using digital recorders. A designated member of the research team took notes during the discussions to assist in the process of differentiating between speakers during the subsequent transcription and translation of the conversation. Participants received locally-appropriate gifts of sugar and soap to thank them for their time.

Key informant interviews. Key informant interviews were conducted with community leaders (N=4) in four of the six health zones selected for intensive qualitative data collection. The primary objectives of these interviews were to learn about the role of communities in the

delivery and uptake of malaria control interventions, and to learn about traditional strategies for communicating information and encouraging behavior change. These interviews were conducted by the principle investigator on the project (PI), with the assistance of a Bambara translator. These interviews were conducted at the homes of the community leaders and lasted one to two hours. The translator transcribed the interviews, translating the Bambara dialogue into French.

Unstructured observations. Unstructured observations were conducted in households of rural villages when the research team visited to conduct interviews or group discussions. These observations focused on aspects of net use and care including the location of sleeping spaces, the ways that nets were hung over sleeping spaces, and the condition and type of nets. At the end of each day of data collection activities the research assistants to describe these observations, including descriptive notes, comparisons with observations conducted at other households, questions to be explored in subsequent data collection activities, reflexive notes and a list of key themes and topics relevant to the observations.

Representative household survey. A cross-sectional household survey was conducted in October 2009 in households containing children aged 0-23 months (the age groups with the potential to have been exposed to the EPI-CM over the course of the study). The questionnaire was based on those used for standard Malaria Indicator Surveys (MIS), including questions pertaining to bed net ownership, bed net condition and maintenance behaviors, bed net use, malaria knowledge (transmission, severity, susceptibility), and the incidence and treatment of fever among children in the household within the past two weeks. However, the survey differed from most MIS in that no blood tests were conducted. The survey was conducted after preliminary analyses of the interview, group discussion and observational data, and questions were added to the modified MIS questionnaire to explicitly assess the representativeness of qualitative data pertaining to the factors that motivate, interrupt or inhibit net use in Segou Region.

Global-positioning-system (GPS)-enabled Dell Axim X50 (Dell, Round Rock, TX) handheld computers running Visual CE Version 11 (Syware, Cambridge, MA) were used for both household selection and data entry in a manner previously described (vanden Eng et al., 2007). Sixty villages in each district were selected by probability proportional to size. With a local guide, trained enumerators visited all households in selected villages and mapped by GPS those containing children aged 0-23 months. From those households, 30 households in each village were selected by simple random sample, and interviews were conducted with caretakers of children aged 0-23 months. If no caretaker was present, enumerators made two additional attempts before using a randomly preselected alterative household. No replacements were made for household refusals.

Sample size calculations were driven by the primary objectives of the parent study: a) to evaluate the validity of EPI-CM data for children 0-11 months of age compared to household survey data, and b) to assess the effects of the EPI-CM on child health behaviors among children 12-23 months who were potentially exposed to the method during vaccination clinics. These calculations have been described in detail elsewhere (Wei et al., 2012a; Wei, et al., 2012b).

Study Staff and Training

The qualitative research team was composed of seven Malian research assistants, in addition to the principle investigator (PI) for the project. All research assistants spoke Bambara fluently, had training in the social sciences, and had experience working in rural settings on projects related to health. Prior to the start of data collection, they participated in over two months of intensive training, conducted by the PI, which covered the research design and research questions, social science theory and qualitative research methods, with ample opportunities for practice with detailed feedback. All qualitative interviews and group discussions were conducted either by members of this team, or by the PI with the assistance of a Bambara-speaking translator native to Segou District.

Survey enumerators were fluent in Bambara and participated in a week-long training on PDA-based surveys, the survey instrument for the study and research ethics. This training was coordinated by the University of Bamako Malaria Research and Training Institute and was jointly facilitated by the lead author and a collaborator from the US Center for Disease Control and Prevention.

Analysis

Qualitative interview and group discussion data. The study team members who collected and transcribed the qualitative data made an initial list of key themes after reviewing each transcribed document. The themes relevant to each data collection activity were checked off on a matrix with a row for each interview/group discussion, and a column for each theme in order to identify salient themes. Team members met several times a month and, during these meetings, discussed the growing list of themes and worked to develop and refine a list of codes and associated definitions for subsequent systematic analysis. The resulting codebook was further developed and modified during final analysis to reflect additional themes and developing theories. Qualitative data were analyzed using the qualitative management software package MaxQDA (version 10): codes were linked to relevant segments of text, text retrieval functions were used to examine all text segments related to a particular code, and patterns of co-occurrence of codes were examined to develop a stronger understanding of the relationships between themes. For example, the codes for "shame/embarrassment" and "behavior change strategies" were frequently applied to the same passages, suggesting that negative reinforcement is often intentionally employed as a means of encouraging desirable behaviors. Preliminary review of the data suggested that there were no strong differences between districts with respect to the qualitative data on net use, and thus the qualitative data are presented in aggregate here.

As an additional measure to assess and strengthen the validity of the analysis of the qualitative data, two French-speaking individuals, one a native Malian with extensive experience

with both qualitative research and child health projects in Mali and the other an American with training in behavioral sciences, were recruited to read through the transcripts and actively search for "negative cases" (examples that challenged, complicated or negated the initial theories and conclusions). They read preliminary drafts of the dissertation and then collectively reviewed 22% of the transcripts, writing memos about the ways that the data supported or challenged the conclusions in these drafts, and applying codes from the project codebook. The final conclusions were modified to account for and incorporate the negative cases identified.

Observation data. Data from unstructured observations were discussed in regular team meetings and informed the continuous iterative process of modifying and revising the qualitative interview and group discussion guides to reflect new findings and preliminary theories.

Household survey data. Descriptive statistics for variables related to demographic characteristics, net ownership, net use and maintenance, net condition, net preferences, malaria knowledge and other potential determinants of net use behaviors were generated using the Proc SurveyFreq command in the statistical software package SAS (version 9.2). Analysis of household survey data was not weighted due to the self-weighted probability-proportional-to-size sampling method. However, to account for the survey design, the Strata and Cluster options for the Proc SurveyFreq command in SAS were used to stratify by district and account for clustering by village, the primary sampling unit. Rao-Scott chi-square tests were conducted to determine if there were any statistically significant differences between districts. For the majority of variables relevant to this sub-study, there were no significant differences and thus aggregate results are presented here. Where there were significant differences, these are noted.

Institutional Review and Ethical Clearance

The study was reviewed and approved by Institutional Review Boards at the Emory Rollins School of Public Health, the University of Bamako and the US Centers for Disease Control and Prevention. Written informed consent was obtained from all health care providers,

government officials and NGO employees, while oral consent was obtained from community leaders, parents and grandmothers, many of whom were illiterate.

RESULTS

Presented below are the results of this exploration of the factors that influence LLIN use among people of all ages in Segou, Mali. The identified factors are divided into four main categories: cultural context, determinants of access to LLINs, factors with the potential to inhibit or interrupt LLIN use among adults who have access to one, and factors with the potential to overcome or outweigh barriers to net use among adults who have access to one. Quantitative data from the 2009 household survey are presented throughout to illustrate the prevalence of these potential determinants within a larger, representative sample. Relationships between the various factors are discussed, as are likely seasonal variations in their influence.

A Strong Bed Net Culture

Decisions about net use in Segou, Mali are situated in a strong bed net culture. Awareness of bed nets is widespread and attitudes towards bed nets in general and LLINs in particular are positive. When asked to list the disadvantages of LLINs, 89.3% (95% CI: 87.7-91.0) of survey participants spontaneously responded that LLINs have no disadvantages. Additional details about specific perceived advantages and disadvantages will be presented in subsequent sections of this paper.

Participants in qualitative data collection activities expressed beliefs that net use is common and frequent in their communities, and that others expect them to use bed nets. When asked to explain the reasons that someone who owns a bed net might not use it, rural mothers struggled to understand the question, unable even to conceive of such a scenario. Women generally responded by rejecting the validity of the question entirely, insisting that anyone who

owns a net would use it. As one woman put it, “A mother who owns a bed net but does not use it? That woman must not be normal.”

The qualitative data collected during this study indicate that people in Segou use nets throughout the year, rather than mainly using them during periods with the greatest mosquito density or highest malaria prevalence. During interviews and group discussions, some participants reported that they had become so habituated to sleeping under a net that they were unable to sleep without one, regardless of the season.

Access to Nets

Data collected during baseline and follow-up surveys suggest that overall net ownership has increased since the 2006 DHS, likely as the result of the 2007 mass distribution campaign and continued routine LLIN distribution activities since then. Among households included in the household survey, 96.1% (N=3283, 95% CI 95.3-96.9) owned at least one bed net of any kind, surpassing the national target of 80%. Of the households owning any nets, 66.4% owned more than one (95% CI: 63.8--69.0%). The vast majority of participants in the qualitative study had access to some sort of net, even if not an LLIN.

The majority of observed nets were LLINs and, among these, Permanet brand nets were the most common. There were some statistically significant differences in the proportions of different types of nets owned by households in the two study districts (See Table 4.1). Of the 2,985 nets observed in 2009, 85.5% were LLINs (95% CI: 83.6-87.5%). In Segou, 78.9% of nets were LLINs (95% CI: 75.3-87.6) while LLINs accounted for 91.8% of nets in Baraoueli (95% CI: 90.1-93.5). Traditional cotton nets were significantly more common in Segou District than in Baraoueli: traditional and locally fabricated nets accounted for 17.0% of observed nets in Segou (95% CI: 13.5-20.5) and 2.5% of observed nets in Baraoueli (95% CI: 1.38-3.58).

Only 61 of the total of 3,283 households included in the 2009 survey reported that they did not own any bed nets. When members of these households were asked why they didn’t have

any bed nets, the most common responses were that they didn't attend routine vaccination clinics (31.3%, 95% CI: 22.7-39.8%) or that there were no nets available when they brought their child to be vaccinated (24.2%, 95% CI: 16.2-32.3%)). Only one person said that the household had received a net but didn't like it and no one reported not wanting an LLIN.

The demand for bed nets is high enough in Segou that some people reported willingness to purchase nets if they failed to receive one during routine distribution activities or were not eligible to receive one under the current policy. Examples from qualitative interviews included men who purchased fabric to have their tailors sew them a bed net, people who purchased ITNs or untreated locally-made nets in the market, and women whose husbands or children purchased LLINs for them as gifts. The vast majority of nets purchased by individuals, however, were traditional cotton nets purchased by a bride's family as part of her wedding trousseau. Essentially all of the women interviewed had owned one of these nets at one time, and most still possessed them. The nets that people purchased were generally untreated nets. Some people expressed awareness that these traditional or tailor-made nets could be treated with insecticides, and indicated that they had treated these types of nets in the past but stopped because re-treatment kits were no longer available at community health facilities and they didn't know where else to obtain them.

However, it is important to note that high household net ownership is not necessarily correlated with high access to nets among all household members, particularly when it comes to adolescent boys, unmarried women and the elderly. The qualitative data demonstrated the success of Mali's efforts to prioritize pregnant women and children when it comes to LLIN use. Men and women alike recognized that LLINs were "for women and children" and women often reported that their husbands slept under their older "marriage nets" while the children slept under the new LLIN. The widespread prioritization of children was underscored by the results of the household survey: 91% of children 0-23 months of age were reported to have slept under a bed net the previous night in 2009 (95% CI: 89.7-92.1%). Among survey participants, 58.7% (95%

CI: 55-62.6%) listed children under-five among those most vulnerable to malaria and 36.9% (95% CI: 33.9-40%) recognized the particular vulnerability of pregnant women. 551 individuals (16.8%, 95% CI: 15.1-18.4%) responded that "everyone" is vulnerable to malaria.[1] When women were asked, during qualitative interviews, to list the household members who did not sleep under a net the previous night, most households reported that everyone slept under a net, even if that meant that there were three to four children under the same net, or meant that infants slept with both parents under one net. However, in the few households where some people were not protected by nets, it was generally older male children and young, unmarried men and women who did not use nets. A common complaint among grandmothers who participated in discussion groups was that the government "does not value old persons" enough to provide them with bed nets.

Intrahousehold access to nets among segments of the population other than mothers and children is limited not only by the absolute number of nets in a household and the prioritization of pregnant women and children, but also by proprietary notions reinforced by LLIN distribution strategies. Nets are very much viewed as individually-owned possessions, rather than commonly-owned household goods. A net is owned by the specific woman who received it from the hands of a health worker, and it is generally she who determines when, and by whom, it will be used. When a woman owns only one or two nets, these nets are generally used by herself and by her biological children. However, women who own additional nets do not necessarily lend the extras to other family members without nets.

It was commonly reported in qualitative data that women use one net while keeping others in storage.[2] This was particularly the case when women owned both a traditional cotton net and an LLIN. They explained that, during the cold seasons, they kept the LLIN in storage and used their traditional marriage nets. During the other seasons, they used the LLIN and put the marriage net in storage. Additionally participants reported that women often store new LLINs until the nets they are currently using are too worn out to provide protection, given uncertainty

about whether they will be able to receive additional free nets from the government. Some women also save unused LLINs to give to their daughters as part of a wedding trousseau. The sharing of bed nets within a household, particularly traditional "marriage nets," is likely limited by cultural taboos linked to the association between bed nets and beds, and therefore, by extension, between bed nets and sex.

Factors that Inhibit or Interrupt Consistent Net Use among Adults with Access to Nets

Initially, most participants in qualitative research asserted that they used bed nets every night, in all seasons, and indicated that it was impossible to imagine a scenario in which a person would own a bed net and not use it. They would often report that all members of *their* village used nets but that it was possible that people in other villages might not use them. Rarely, people acknowledged that allergic reactions to insecticides or difficulty breathing under nets could prevent someone from ever using an LLIN, and there were a few reports of people who just "don't like nets." None of the household survey participants, however, listed respiratory problems as a disadvantage of sleeping under an LLIN, and fewer than 2% mentioned skin reactions to the chemicals (1.76%, 95% CI: 1.21-2.32).

It was only when participants in qualitative interviews were asked to describe concrete examples of situations in which they slept without a bed net, that they began to acknowledge and describe a number of factors that could interrupt LLIN use, sometimes for only a night but often for extended periods of time. The most commonly identified barriers to net use were intermittent contextual or conditional factors that vary from day-to-day somewhat randomly and unpredictably, rather than factors such as knowledge or attitudes which tend to follow a unidirectional trajectory of change, when and if they change. The factors are interrelated, and many have the potential to either exacerbate or mitigate the effects of the others. The relative strength and directionality of the influence of certain factors is likely to vary according to the season. These factors are described below.

Fatigue and workload. When women who generally sleep under a bed net (of any kind) were asked to describe the conditions associated with the last time that they slept without a net, the most common response was that they were just too tired to hang and/or tuck in their nets. As one woman put it, "there are days when you are so tired you can't do anything but sleep. You can't pull down your net. You can only sleep." When explaining the circumstances of the last time she had slept without a net, another woman said that she lay down on her mat to close her eyes for a few minutes, intending to hang her net after a short rest, and when she woke up she found it was morning. These examples are representative of the responses offered by many qualitative interview participants.

Fatigue and competing time demands vary somewhat according to the season. During the planting and harvest seasons, women generally spend long hours in the fields, and often have to walk long distances between home and field. During these periods, they return home later and are more physically exhausted than during other times of the year. The inhibitive effects of increased fatigue on net use during the planting season are particularly important to consider since this period corresponds with the rainy season, and with associated increases in the risk of malaria transmission.

Location and type of sleeping space. The ultimate effects of fatigue and competing demands on women's time on net use (both her own and that of her children) is influenced by the type and location of the sleeping spaces over which nets must be hung. Sleeping space characteristics determine what households do with their nets during the day and, by extension, how much work and time are required to prepare the nets for sleeping at night. In Segou, sleeping spaces inside houses basically fall into three categories: 1) beds with permanent posts or frames from which a net can be hung, 2) sleeping spaces on the floor in rooms designated for sleeping that are not used for other purposes during the day, and 3) sleeping spaces on the floor in areas that are used for other purposes during the day or where people need to walk during the day.

Nets can be left permanently suspended over the first two kinds of sleeping spaces and the sides of the net are generally just draped over the top during the day to protect them from dust or potential damage (also likely for aesthetic reasons). The ease of preparing nets for sleeping in this scenario was emphasized by a woman who asserted that she had no difficulties using her net every night and invited the interviewer to examine her net, saying: "If you come into my chamber now, you'll see that the mosquito net is already suspended. There's nothing left for you to do but to pull down the sides when you want to go to sleep." However, in smaller households, many of the sleeping spaces are in the third category. Nets hung over these sleeping spaces must be completely removed during the day, or at least detached at two corners so that they lie flat against a wall. Even in households where nets potentially could be left hanging during the day, they may be taken down to protect them from wear and tear, or for aesthetic reasons. Taking down the nets during the day means that more time and effort are required to re-attach them at night. When a woman is tired or particularly busy, she may be more likely to use her net if she doesn't have to re-attach it, though some women indicated that their exhaustion is sometimes too great for them to even pull down the sides of a permanently attached net and tuck it in.

The type and location of sleeping space is also in turn influenced by seasonality. During the rainy season and the cold season people generally sleep inside their houses and, if the house is large enough, can leave their nets suspended from the walls or bed frames at all times. However, during the hot season, many people sleep outside under wood and thatch canopies. Because the canopies provide essential shade for meal preparation and other activities during the day, and also due to the personal and private nature of bed nets, few people leave their nets hanging from these canopies during the day. People without canopies suspend their bed nets from branches or posts inserted into the ground, but still rarely leave them hanging during the day. Thus, during the hot season, most people experience increased time and labor demands associated with net use. Additionally, during the transition between the "hot dry season" and the "hot rainy season,"

storms sometimes come in the middle of the night and the rains drive people inside. Some may take the time to detach and re-hang their nets inside, but many will not.

Seasonal trends in agricultural activities also can influence where people sleep. If a family's fields are far from their home and they need to work late during the planting or harvest season, or if they fear destruction or theft of their crops, some household members may sleep in the fields, rather than returning home, and may be less likely to use a bed net given the added bulk to carry and the potential lack of surfaces from which to hang it. Young boys who herd livestock may also sometimes sleep out-of-doors with their animals and are unlikely to carry a net with them.

Temperature, allergies and the availability of traditional ("marriage") nets. While temperatures and allergies to insecticide were both occasionally mentioned as possible determinants of net use, they were mentioned more as factors influencing the kind of net used rather than as outright and absolute barriers to net use. In general, other motivating factors (protection from malaria, mosquitoes and other biting insects) were seen as sufficient to overcome any minor physical discomforts associated with sleeping under nets.

One of the clearest net use patterns revealed during qualitative interviews and discussion groups was a practice of exchanging LLINs for traditional cotton nets during the cold season. People generally preferred LLINs for protection from mosquitoes and other biting insects, as well as for use during the hot season. However, during the cold season, traditional nets were preferred over LLINs because they provide superior protection from the wind and trap more body heat to insulate people against the cold. People who didn't have access to a traditional net said that they used their LLINs during the cold season because they were "better than nothing," but would have preferred a heavier net if one was available. These trends were supported by the survey data from Segou District[3] which indicated that 70% of respondents prefer traditional cotton nets over LLINs at certain times of the year (95% CI: 65.3-72.7%). Of these, 94.4% (95% CI: 92.2-96.7%) said that they prefer traditional nets during the cold season. Participants frequently suggested that

health facilities should distribute two kinds of LLIN, one made from the lightweight mesh fabric and the other resembling the densely woven, opaque marriage nets. This way they could benefit from the insecticidal properties of LLINs during all seasons of the year, while still being able to adjust to changes in temperature.

In contrast to expectation, many participants in the qualitative research actively asserted that hot temperatures were not a barrier to net use, indicating that the LLINs provided by the health facilities had large enough holes to keep them cool. Thought it was the most commonly mentioned disadvantage of LLINs in household survey data, only 3.52% (95% CI: 2.25-4.80%) of survey participants said that LLINs are too hot to sleep under.

People who experience allergic skin reactions to the insecticide on LLINs or have difficulty breathing under LLINs may also choose to use a traditional untreated net at all times of the year, if one is available, regardless of the availability of LLINs or the temperature.

Disruptions to intrahousehold access to bed nets. Net use can also be interrupted due to disruptions in intrahousehold access to a bed net, usually due to the fact that a person is not sleeping in his or her usual sleeping space. This most commonly occurs when someone is traveling, but could also occur when a person arrives home late at night and sleeps in a different space so as to avoid disturbing others, or when daily household responsibilities require sleeping some place other than the family compound (e.g. in the fields).

In general, people do not carry bed nets with them when they travel, given the bulkiness of nets and the lack of space on most common forms of transportation (bus, boat, motorcycle, bicycle, or donkey cart). Thus travel was sometimes cited as the reason that a usual net user last slept without a net. Travel also tends to vary seasonally, as a function of the agricultural schedule and the timing of holidays. The hot season is a frequent time for travel, given the increased availability of liquid assets and the decreased agricultural labor demands.

For married men, intrahousehold access to a bed net may be determined by whether or not his wife owns a net. For men in polygamous marriages, access may vary from night to night

depending on which wife he spends the night with. In general, men spend equal numbers of nights with each wife, on a rotating schedule. They spend the night with whichever woman cooked for the household that day. If that wife has young children (<2-3), it is likely that she will have an LLIN and that the man will sleep under it that night. If his other wife has older children, or does not have children, he is less likely to be protected when he spends the night with her. This pattern was exemplified by a young father who was actively involved in his children's care, personally hanging the bed net over them and taking them to the health center when they were sick. He was convinced of the importance of bed nets (at least for his children) but himself only slept under a net half of the time because only one of his wives owned a net.

Factors with the Potential to Outweigh or Overcome Barriers to Consistent Net Use among Adults with Access to Nets

Certain motivating factors were described by participants as sufficient to overcome any of the barriers described above, with the exception of household net ownership or intrahousehold access to nets.

Nuisance Mosquitoes, Biting Insects and other Pests. According to participants in the qualitative research activities, if one is bitten by enough mosquitoes, is bothered by enough other flying or biting insects, or has a sufficient fear of frogs[4] or snakes, one will overlook any of the other factors that inhibit net use. Respondents said that even when fatigue, laziness or inconvenience cause people to lie down to sleep without a net, "if one or two mosquitoes bite you, you will remember." Even the few people who had skin reactions to insecticide or just didn't like nets said that they would use nets when there were many mosquitoes. The representativeness of this incentive to use nets was illustrated by data collected during the household survey: 88.2% (95% CI: 86.7-89.8) of respondents mentioned protection from biting mosquitoes as an advantage of sleeping under an LLIN, compared to the 51.2% (95% CI: 48.5-

53.8) that explicitly mentioned protection from malaria. Protection from insects was mentioned by 24.7% (95% CI: 22.4-27.1) of respondents.

Locally-circulating conventional wisdom about areas with particularly large or fierce mosquito populations can even overcome the significant barriers to net use while traveling. Several participants in qualitative interviews indicated that, while they didn't usually bring a bed net with them when they travel, they always brought a net when traveling to certain places. When asked if people bring nets with them when they travel, one retired schoolteacher and vice president of a community health association replied:

> Well, there is a zone, for example the zone of Niono. Everyone knows that this is a region where there are many mosquitoes, and people say "If you go to Niono, you must take your mosquito net in your hand**."**... If it's not Niono, well, one doesn't think of a mosquito net to go elsewhere but to Niono, ah, I don't think that one could go there without a mosquito net.

Places near irrigation projects, on islands or near slow-moving parts of the Niger River are perceived to have more mosquitoes than other locales, and thus people are more likely to bring a bed net when they have to spend the night there so as to be able to sleep peacefully during the night.[5] Again, the motivation seems to have more to do with avoiding nuisance mosquito bites than being protected from malaria.

Desire for privacy. Given the close proximity of many sleeping spaces in small houses or in the courtyards of compounds, bed nets offer the added advantage of increased privacy. This is likely particularly desirable for couples, though the qualitative data suggest that it was a more salient benefit for men than for women.[6] When men and women share a sleeping space, that added privacy may be a sufficient advantage to outweigh other barriers. People explained that one of the benefits of net use is that "no one can see you." One father described the mosquito net as *sutara* space (secret, protected and concealed), while a woman explained that, if you use a net when you sleep outside, "it's like you're not sleeping outside."As this last comment indicates, the benefits of privacy are likely to be greatest during the hot season, when people sleep outside.

The household survey data indicate that this particular incentive to use nets is less important for women than the benefits of protection from malaria, mosquitoes or other insects. Among the mothers who participated in the household survey, fewer than 2% spontaneously mentioned privacy as an advantage of LLINs (95% CI: 0.96-2.13). Because this question was only asked of mothers during the survey, it is not possible to draw statistical conclusions about the relative importance of privacy for men and women.

Social support. Social support is commonly divided into four categories: emotional support (empathy, concern, love and trust), appraisal support (positive feedback, affirmation and positive comparisons), informational social support (advice, suggestions or directives), instrumental social support (providing direct services or assistance to help someone, including financial and in-kind support) (Heaney & Israel, 2008). With respect to social support for net use in Segou, the latter two forms of social support were the most salient in qualitative data from this study, though there were a few examples of appraisal support.

The availability of instrumental support for net use varied greatly within the sample of participants in qualitative interviews. The particular form of instrumental support most often discussed by participants was assistance with hanging nets, though instrumental support could also potentially include helping with other household responsibilities to free up more time for a woman to hang nets, loaning people money to buy a net or sharing extra nets with household members who do not own one.

According to traditional norms and social expectations, women in Mali are responsible for hanging bed nets for themselves, their husbands and their young children. The household survey data demonstrate that this is still largely the case. During the household survey, 96.3% (95% CI: 96.3-97.7) of respondents reported that mothers are the ones who hang bed nets for young children, while 5.85% (95% CI: 4.70-7.00%) said that fathers were involved in hanging nets for their children, and 2.86% (95% CI: 1.97-3.76) said that older female children hang bed nets for their younger siblings.[7] Single adults and older children are generally expected to hang

their own nets. Hanging the bed net that your husband will sleep under is viewed as an important duty of a good wife and is seen as a demonstration of respect. Asking anyone else to take over this task would be considered inappropriate given the association between a couple's bed (and bed net) and sexual intimacy. If women are responsible for hanging multiple bed nets, particularly if those nets are detached during the day and re-suspended at night, the lack of instrumental support could exacerbate the effects of fatigue or competing demands on her time. However, within the qualitative research population, there were some examples of women who managed to mobilize support for hanging nets, and thus minimize some of the barriers to net use.

Data from qualitative interviews and discussion groups suggested that the norms regarding gendered responsibilities for hanging nets are beginning to change. While there were certainly examples of women who believed that women should continue to have all of the responsibility for hanging nets, and believed that this was an important way for women to demonstrate respect for their husbands, the majority of women either asserted a belief that men should help with hanging bed nets or reported that they were already receiving help from other household members, including but not limited to their husbands.[8] It must be noted, however, that the assistance provided by the husbands was often limited to situations in which women were unable to hang nets, either because they were absent from home or were ill.

Women commonly teach their children (especially female children) to hang their own bed nets and those of their younger siblings once they reach an age where they are capable of doing so. People had differing opinions about the age at which a child could be entrusted with the responsibility for hanging nets, ranging from 10 to 18. This kind of apprenticeship learning is common in Mali. For example, female children learn to complete tasks associated with food preparation, child care and other household responsibilities by performing these jobs under the supervision of an older female household member and receiving feedback.

Informational support was the most common kind of support recommended by participants in the study when they were asked about recommended strategies to increase net use

in their communities. Most people suggested that health care providers at the community health center and community health workers (as opposed to friends or family members) should educate and sensitize people to the importance of using a net, using the French term "sensibilisation."[9] Personnel at community health centers do sometimes remind people to use bed nets in the context of medical consultations and vaccination clinics.[10] Informational social support is also provided to households in some zones of the Segou District by community health workers who visit households regularly to assess a specific set of health behaviors and provide health education. Different NGOs work in different zones and thus the existence and consistency of these activities varies as a function of the specific NGO responsible for training and supervising volunteer health workers. While health care providers, community leaders and community health workers explained that community health workers visited households to inspect their nets and provide educational messages about nets, very few mothers were aware of these activities and even fewer reported that they had received such visits.

Social support for net use could also potentially be provided by other household members in the form of verbal reminders to use nets (informational support). However, only one respondent clearly reported using this strategy to encourage her husband, who didn't like bed nets, to sleep inside a net. And even then, she said that she often had to hang the net over his sleeping body herself in order to get him to use a net.

Social pressure and sanctions. The threat of negative reinforcement also has the potential to influence net use. While there were no data suggesting that people use affirmational appraisal support, such as praise or rewards to encourage net use, people did discuss blame, shame or sanctions as possible strategies to increase net use in the community. When discussing a hypothetical scenario of a person who owns a net but does not use it, people used very critical language, referring to such a person as "ignorant" and "negligent," as someone who "doesn't care about her children" or as a person so is "looking for illness." There were clear implications of

individual responsibility which were associated with the potential for blame if adverse consequences were to result from a failure to use a net.

This reflects a common, though not universal, trend in interpersonal health communications in this region, and one that was frequently modeled by health workers during mass education sessions. Women who admitted to doing anything other than the recommended health behaviors or who didn't know the answers to the quiz-like questions posed by health workers risked being publicly criticized in front of other attendees of vaccination clinics. Women commonly explained that fear of "shame"[11] or public embarrassment was the reason that they did not ask questions of health workers, and refrained from participating in discussions in the context of health education sessions or group discussions. In one health zone, there were consistent reports that a young female intern at the health facility withheld bed nets as a way to penalize mothers who were "dirty," the implication being that they did not take good care of their children and thus were not deserving of nets.

A few examples of community members using negative social pressure or sanctions in the context of malaria control were also reported. During one group discussion, the women collectively reported that they had recently visited a young mother in the community whose children were sleeping without bed nets. They described her as a "bad person" and said that they visited her to accuse her of not caring about her children with the hope that this would convince her to hang a bed net for her children, if not for herself. While there was no evidence that fines were imposed upon households that failed to use bed nets, this strategy *was* employed to enforce weekly "hygiene days," during which all households are expected to clean their yards and the area of the road in front of their houses in an effort to fight malaria by reducing potential breeding sites.

Behavior change strategies involving public humiliation, criticism and sanction have traditionally been employed to enforce village rules and to encourage appropriate behavior in Mali. One village leader explained that, whenever someone in the village is behaving in an

inappropriate way or in a manner that harms other community members, he convenes a meeting during which the offender must sit and listen while all members of the community are given an opportunity to voice their complaints and criticisms of his behavior. He gave an example of a man who was publically chastised for letting his cattle graze unrestricted and unaccompanied, to the detriment many community members' fields. A leader in a different village explained that, historically, many people were driven from their villages by this kind of public shaming because the humiliation was too great for them to stay. He indicated that the strategy of "sensibilisation" in order to "bring someone to reason" is new and is not the "Bambara way," but he expressed an opinion that this new way is much better.[12]

DISCUSSION

With LLIN ownership beginning to reach target levels in many parts of Sub-Saharan Africa, the global malaria community is beginning to focus more attention on the challenge of achieving universal net use, recognizing that LLIN ownership, while a necessary prerequisite, is not sufficient to guarantee use. There is a recognized need to develop a stronger and more nuanced understanding of the factors that influence LLIN use (Pulford, et al., 2011). The findings from Segou, Mali presented here contribute to the growing body of knowledge about net use in a number of potentially important ways, not only by highlighting the kinds of variables that are likely to influence net use once high levels of LLIN ownership and malaria/LLIN knowledge have been achieved, but also by suggesting possible relationships between these variables and illustrating the ways that the relative influence of different factors may vary between different seasons of the year. Figure 4.1 presents a proposed conceptual model of these factors.

Constructs Included in the Multi-level Model of LLIN Use

Access to a net is still likely to be the strongest predictor of net use where there is a strong existing culture of net use and where attitudes towards LLINs are already predominantly

positive. Demographic characteristics and relationships with other household members influence a person's ability to access an LLIN for nightly use, either by obtaining one through free distribution channels, by purchasing one or receiving one as a gift. Even for those who own nets, a number of factors may periodically make nets unavailable to their owners: these include travel, the arrival of visitors, the unavailability of the net when it is being washed or mended and, for men in polygamous marriages, rotations between sleeping partners who do and do not own nets.

While access to an LLIN is essential for use, it is unlikely to be sufficient. The research identified a number of factors with the potential to influence motivation to use an LLIN. Knowledge and perceived risk of malaria are likely important direct determinants of the intention to use LLINs. However, in certain conditions, barriers such as fatigue or physical discomfort related to temperature (hot or cold) or reactions to insecticides may prevent even those with adequate knowledge of the protective benefits of LLINs and awareness of the risks of malaria from using any net or may lead them to use an untreated traditional net instead of an LLIN.

The results of this study also suggest a number of intermediate factors which may modify the impacts of the more distal barriers and incentives. These include the level of available instrumental social support, the complexity and time associated with hanging the LLIN (linked to type and location of sleeping space), and the availability of a traditional bed net which may be more attractive than an LLIN for certain people and during certain times of the year. Certain factors may have the power to overcome the influence of more distal barriers to LLIN use. For example: high mosquito density, social pressure and sanctions, or a desire for privacy. Together, this combination of factors is hypothesized to determine the strength of an LLIN-owning individual's motivation to use the LLIN, and ultimate use of it.

This proposed model includes the individual-level factors that have been associated with net use in other contexts (Pulford, et al., 2011), including demographic characteristics (Alaii et al., 2003; Baume & Marin, 2007; Graves et al., 2011; Ng'ang'a et al., 2009), access to a net (Eisele, Keating, Littrell, Larsen, & Macintyre, 2009), knowledge (Adedotun, Morenikeji, &

Odaibo, 2010; Hwang et al., 2010; Makemba et al., 1996), and attitudes, including those associated with physical discomfort experienced while sleeping under a net (Aikins, Pickering, & Greenwood, 1994; Alaii, et al., 2003; Cohee et al., 2009; Toé et al., 2009).

However, it also highlights the importance of factors at levels beyond the individual, contributing to a small but growing body of research that demonstrates the importance of household and community factors for determining net use and challenges the idea that there is a simple direct linear relationship between LLIN knowledge, attitudes and use (Agyepong & Manderson, 1999; Alaii, et al., 2003; Dunn, Le Mare, & Makungu, 2011). In Segou, these higher level factors, which include household composition, relationships between household members, type and location of sleeping space and social support for net use, may be the ones that ultimately determine whether a person is able to act on his or her desire to sleep under a net.

This hypothesized conceptual model is proposed as a guide for subsequent research to facilitate a stronger understanding of the determinants of net use and the relationships between them. Better and more nuanced instruments are needed to measure each of these potential determinants in the context of representative household surveys so that the posited mediating and moderating relationships can be statistically assessed.

Seasonal Variations in Motivations and Deterrents of Net Use

The culture of net use in Segou differs from that observed in many other contexts (Alaii, et al., 2003; Atkinson et al., 2010; Cohee, et al., 2009; Winch et al., 1994; Yohannes et al., 2000) in that people reportedly use nets year round, though the motivations and deterrents of use differ somewhat between seasons.

This year-round use is linked to a specific set of interrelated geographic, social and cultural factors that influence people's sleeping arrangements and net preferences in particular ways. These are likely to differ greatly between contexts. For example, in places where security concerns or cultural norms prohibit people from sleeping outside during the hot season, people

may be more likely to discontinue use at this time due to elevated temperatures in the absence of the additional motivation associated with the desire for greater privacy while sleeping outside. Desire for additional protection from the cold and wind during the cold season has recently been reported as an incentive for net use in other West African contexts (Moiroux et al., 2012), but has elsewhere.

The factors presented in boxes with dotted outlines in Figure 4.1 are those that vary seasonally: interruptions to access to nets, workload and fatigue, temperature, complexity and time demand associated with hanging nets, and the abundance of nuisance mosquitoes and other pests. The relative influence of these factors varies from season to season in ways that encourage year-round net use.

While the influence of the desires to avoid nuisance mosquitoes and prevent malaria on LLIN use may primarily be limited to the rainy season, there are other strong motivations of LLIN use during most other seasons. Cold temperatures motivate net use (though primarily traditional net use) during the cold dry season (from December to January/February), and a desire for privacy can motivate LLIN use during the hot dry season, when most people sleep outside (March-early May). The one time of year when there are no particularly strong motivators of net use is the period commonly referred to as the "solder period," between the end of planting time (the end of the rainy season), and the beginning of the harvest (at the start of the cold dry season). At this time, temperatures are comfortable for sleeping and most people sleep inside, so an LLIN is not seen as particularly necessary for offering protection from the cold or privacy. Mosquito densities decline at this time and, as a result, perceived risk of malaria is lower than during the rainy season.

These seasonal variations in motivations of net use suggest that it may be possible to tailor persuasive behavior change communications to the particular season for greater effect. During the rainy season, when even powerful incentives to use nets are sometimes neutralized by fatigue induced by laboring in the fields, information alone is likely not to be enough. It is at this

time of year that it will be most important to develop not only a culture of net use but also a culture of instrumental social support for net use. This type of support could be modeled in health communications pertaining to malaria and LLIN use.

Recommended Strategies for Achieving Targets for Consistent Universal Use of LLINs

The potentially modifiable factors influencing LLIN use in Segou are outlined in bold in Figure 4.1. These include: access to LLINs, availability of owned LLINs for a given user on a given night (intrahousehold access to nets), knowledge, attitudes, the amount of time and effort associated with hanging a net and social support for net use.

While the shift to a universal access distribution strategy will greatly increase access to LLINs in Mali, it is unlikely to guarantee that every household member has access to an LLIN, particularly in households where the numbers of people of appropriate ages and genders to share a sleeping space are not evenly divisible by two. Social marketing approaches are a possible strategy but, in places like Segou where attitudes towards LLINs are already positive and demand is already high, they may not be enough. The cost of an LLIN is likely to remain an insurmountable barrier for many individuals in the absence of significant subsidies.

There are a number of existing cultural practices that could be mobilized in order to encourage the purchase of additional nets to supplement those received through free distribution. Given that mothers are already accustomed to purchasing mosquito nets for their daughters' marriage trousseaus, they could be encouraged to give their daughters both a traditional net and an LLIN. Alternatively, communication campaigns could encourage people to give LLINs as wedding gifts, in place of some of the fabric they currently purchase for the bride. Another strategy could build on the rotating credit-and-savings systems ("cotisation") commonly employed by women's associations and youth associations to provide access to sufficient funds for large investments or expenditures (Luery, 1989; McCorkle, 1986; Morduch, 1999; Paxton & Cuevas, 2002; Sika & Strasser, 2001; Toulman, 1992). Each week or month, members of the

association contribute a small amount to a communal fund. The name of one member is drawn at random and that person receives the full amount in the fund. The next week, that person's name is removed from the list and a different name is drawn. Associations could be encouraged to set up a designated rotating savings and credit fund to specifically facilitate the purchase of additional bed nets for the members' households.

In order to achieve universal use, in addition to universal access, among all segments of the population, malaria communication campaigns accompanying net distribution activities should emphasize the advantages of bed nets that are unrelated to malaria, in addition to the causes, symptoms and costs of malaria. Most individuals in Segou are already knowledgeable about malaria and can repeat the key messages of radio and television broadcasts, down to the detail that it is "female anopheles" mosquitoes that transmit malaria. They have been so saturated with malaria information that many have begun to tune out these broadcasts, assuming that it is "always the same malaria" and that they've heard it all before.[13] In order to attract and hold people's attention when it comes to messages about net use, it is likely going to be necessary to take a different approach and emphasize new and unexpected messages in memorable ways.

Health communications and other behavior change interventions should also model strategies for eliminating or reducing the barriers to consistent bed net use. Modeling could occur in the context of skits or serial dramas produced for television and radio broadcasts, performances by local acting troupes, songs sung by *griots*, public service announcements by celebrity role models, or demonstrations performed by health workers, community volunteers or peer educators. Modeled behaviors could potentially include reminding other members of the household to sleep under their nets, discussing the benefits of net use with other members of your social network, or determining in advance whether you will have access to a net at your destination when you travel and planning to carry a net with you if not. Role models could also demonstrate the use of affirmation, praise and rewards to encourage net use rather than shame or criticism which may

only serve to prevent potential net users from asking for the help or information they need to be able to use a net consistently and correctly.

Health care providers or community volunteers could demonstrate how to construct portable posts for hanging bed nets that can easily be moved out of the way or moved between indoor and outdoor spaces without detaching the net. These can be made using locally available materials by pouring cement into metal or plastic containers (for example, the ubiquitous powdered milk cans in Mali) and inserting branches into them. Nets can be hung from four of these posts which can be moved to the corners of the sleeping space when the net is in use and pushed together when the space is needed for other purposes.[14]

If the ultimate aim is to ensure that people sleep under LLINs (as opposed to nets of any kind) during all times of the year, it may be necessary to produce LLINs that can compete with traditional nets when it comes to providing privacy and protection from the cold, as well as durability. Research conducted in Peru, where there is a similar existing practice of using traditional nets, suggests that the failure of LLINs to provide the same benefits offered by heavy-weight muslin nets can lead people to reject LLINs (Harvey et al., 2008). If LLINs can be modified to offer the advantages of traditional nets, in addition to the ones they already provide, the full package of benefits could be sufficient to outweigh the disadvantages for people who currently are reluctant to use nets.

However, while the technology to produce heavy opaque LLINs exists, it is likely to be prohibitively expensive for most settings. Alternatives would be to re-introduce insecticide retreatment kits at community health centers and encourage people to treat their traditional nets with insecticide, or to market some form of opaque "liner net" that could be attached to the inside of an LLIN during the cold season or when increased privacy was desired. Some individuals in Mali already fabricate makeshift liners themselves from sheets or blankets.[15] Education about the long-lasting insecticide used to treat LLINs could also help people to recognize the superiority of these nets. Because many people currently think that the insecticide only lasts for a limited

number of months, and cannot withstand washing, they may not consider LLINs to be any more effective at killing mosquitoes than untreated traditional nets after a certain amount of time.

Ultimately, however, with respect to universal LLIN use, the results of this study suggest that it may be difficult (i.e. time- and funding-intensive) to increase rates of nightly net use once a certain threshold has been achieved. Increasing access to LLINs, augmenting knowledge about malaria and LLINs, and heightening awareness of the risks of malaria and the benefits of LLINs can certainly bring about dramatic increases in net use, particularly in areas where LLIN use was previously low. However, addressing these factors is not likely to be sufficient to guarantee net use every night by all individuals. In places like Segou, Mali, where net use is high among vulnerable groups and there is an established culture of net use, the factors that determine whether a usual or sometimes net user will sleep under a net on any given night are likely to be intermittent, recurrent, unpredictable and, sometimes, non-modifiable. Targeting these kinds of inconsistent conditional and contextual factors with interventions is likely to prove more challenging and potentially more costly than developing individual level interventions to modify knowledge and attitudes.

Implications for the Measurement of LLIN Ownership and Use

Many publications in the malaria literature discuss the "gap" between LLIN ownership and LLIN use (Astatkie & Feleke, 2009; Atieli et al., 2011; Eisele, et al., 2009; Macintyre et al., 2006; Rickard et al., 2011), highlighting the fact that rates of LLIN ownership are higher than rates of LLIN use. However, in most malaria surveys, the indicators for measuring LLIN ownership and use are based on different units and have thus have different denominators. Ownership is measured at the household level while use is measured at the individual level. The number of LLINs distributed to a household is often based on the number of household members, rather than the number of sleeping spaces. This means that many households could still receive an insufficient number of LLINS to protect all household members given that the number of

people who share a sleeping space can vary greatly from household to household, depending on the age and sex composition of the household, among other factors. Unless households have a sufficient number of nets to cover all sleeping spaces, differences between rates of net ownership and net use are likely to reflect a gap in access to nets, rather than a failure to use available nets. Recently published recommendations regarding the number of nets required to achieve universal coverage estimate that calculations of net needs should be based on a ratio of fewer than two persons per net (Eisele, et al., 2009), a ratio that to date is rarely achieved in practice.

Discussions of the gap between ownership and use generally reflect an underlying assumption that all nets owned by a household are equally available for use by all members of the household. The logical conclusion that follows from this assumption is that net non-use by an individual in a household that owns a sufficient number of nets to protect all household members must be an active choice on the part of the individual. However, this study presents an important challenge to that assumption. In Segou, bed nets are considered the property of the *individual* who receives or purchases them, rather than the property of the *household*. Between the household members, there may be a sufficient number of nets to theoretically cover all sleeping spaces, but that does not necessarily mean that all individuals in the household have an equal potential to use them. This concept of inequitable intrahousehold access to bed nets presents challenges for interpreting net ownership and use data in this and other similar contexts and suggests that it may be more appropriate to measure net ownership at the individual level, rather than at the household level. The data also highlight the importance of developing stronger analytical methods for interpreting the often collected but rarely reported data on the percentage of LLINs that are in storage rather than in use.

A number of different approaches have been developed to address the challenges associated with measuring net ownership and use. One strategy is to focus on the percentage of available nets that were used the previous night, rather than to only measure the number of individuals who slept under a net. Alternatively, analyses of net use data are often restricted to

households owning nets in order to isolate factors other than ownership that are associated with use (Eisele, et al., 2009; Macintyre, et al., 2006).

A recent publication presented a framework for measuring net use and non-use at the individual level which incorporates both household net ownership and individual net use into a single indicator (vanden Eng et al., 2010). This framework separates individuals into four ITN use categories in an attempt to understand the reasons that people do not sleep under bed nets: 1) those living in households not owning an ITN, 2) those living in households owning but not hanging an ITN, 3) those living in households owning and hanging ITNs, and 4) those sleeping under an ITN. While this system offers a useful approach to measuring bed net use, the results of this study conducted in Segou suggest that it may be necessary to consider additional categories, including households that suspend their nets during the night and take them down during the day, in order to gain a more complete understanding of the determinants of net non-use. Additionally, future surveys should do more to assess the influence of different types of sleeping spaces on net use behaviors.

Strengths and Limitations of the Study

The 15-month process evaluation of the EPI-CM, in which this examination of net use was embedded, provided a valuable opportunity to conduct an extensive ethnographic study of LLIN use, using a variety of different methods as a check on the validity of individual self-reported data from household surveys. The extended duration of the project facilitated the development of increased knowledge about the ways that determinants of net use may vary seasonally.

However, the fact that this study was conducted as a secondary sub-study within a larger project introduced a number of limitations for the examination of LLIN use behaviors. The sampling strategy was driven by the primary objective of the study, the evaluation of the EPI Contact Method, as well as by a secondary objective which was to examine parent-provider

communication in the context of consultations for children with febrile illness. While the household survey data was collected from a random sample representative of the total population, all of the parents who participated in qualitative interviews were recruited while they sought care or services at the community health center. Given that these health centers are the primary distribution point for bed nets, parents who attend the health center likely have higher net ownership and use, and possibly more positive attitudes towards nets than the general public. The perspectives of people who had not sought services from the health center were potentially reflected in the group discussions and in the household surveys but, given the involvement of health workers in the recruitment for these discussions, most participants were likely to frequent the health centers. Recognizing these limitations of the qualitative data, the analysis presented in this paper focused on factors that influence LLIN use among adults *with access to nets*. With the shift to a universal access distribution strategy, there will be less variability in access to nets and the factors discussed here are likely to become more and more important as Mali strives to achieve universal net *use* as well as ownership.

In addition, the vast majority of participants in both the household survey and the qualitative interviews were women. The perspectives of men were represented only in the discussion groups and a few interviews. The inclusion of any male perspectives at all is already an improvement over many previous studies, given that standard malaria surveys tend to collect data on net use determinants only from women. Because the determinants of net use are likely to differ somewhat between men and women (as in the example of the relative importance of privacy as a perceived advantage of net use), it will be very important to begin including men within the samples for large-scale malaria indicator surveys and in more qualitative studies as countries move towards universal coverage strategies. It will also be important to collect detailed data on net use and sleeping spaces for all members of the household; this study only collected this data for children under-two years of age given that that was the target age group for the EPI-CM intervention.

Due to dramatic fluctuations in health facility attendance as well as several widespread and prolonged interruptions in vaccination service delivery due to polio campaigns and vaccine shortages, interviews were not evenly distributed throughout all seasons of the year, though that had been the intention.[16] Additionally, all qualitative data collection activities were interrupted for the month of August while the staff was on vacation. Given the fact that people's responses to questions about net usage trends and attitudes toward net use are likely to reflect the most salient patterns and concerns at the time of the interview, the fact that the majority of interviews (64%) were conducted during the rainy season, when mosquito densities and malaria prevalence are high, could potentially bias the results, exaggerating norms of consistent net use and minimizing perceived disadvantages of nets. Efforts were made to address this during data collection by explicitly asking people about net use and barriers during different seasons of the year.

Finally, as is the case with all self-reported data on net use, there is a possibility that participants' responses about their net use behaviors reflect social norms and expectations about net use rather than their actual practices, and that net use is not as high in Segou as reported. Malian women in rural villages rarely seem to differentiate between health workers and research staff. There is a possibility that they didn't want to admit to failures to use their nets for fear of being criticized or humiliated, or were ashamed to admit that they weren't using the free "gift" given to them by the government. In order to account for this possibility, during qualitative interviews, study team members asked participants to describe the last time they slept without a net, and asked them about net use in particular situations and under specific conditions. When asked these concrete questions, participants in qualitative interviews did acknowledge interruptions in consistent net use. Similar kinds of questions should be developed for use in quantitative surveys to increase the validity of self-reported net use data from household surveys.

CONCLUSIONS

The results of this study suggest that universal coverage bed net distribution strategies are likely to be well-received in Segou, and that most residents will use the bed nets they receive. However, even in the context of a strong culture of net use, simply increasing access to nets among all segments of the population is unlikely to be sufficient to guarantee consistent and correct net use every night, by all members of the population, during all seasons of the year. This study proposes a conceptual model for net use that should be subsequently tested using quantitative methods and modeling techniques. In order to increase rates of consistent use of nets by all segments of the population, communications campaigns accompanying distribution campaigns will likely need to focus more on increasing social support for net use, and accentuating the other benefits of net use in addition to protection from biting mosquitoes and malaria.

However, given that many of the factors identified here as possible determinants of net use will be very difficult to change, these findings raise the question of how much net use should be considered 'good enough." Expectations that LLINs alone will be sufficient to achieve the ambitious goal of elimination are modest to begin with (Alonso et al., 2011; Moonen, et al., 2010). Even for countries like Mali that are still focused on the target of malaria control, rather than elimination, LLINs alone will likely not be enough to achieve targets for morbidity and mortality reduction. While bed nets certainly have saved many lives, their protective effects are far from complete. The individual effectiveness of ITNs has been reported at 40% when clinic cases were compared to clinic controls (95% CI: 10-60%) (Mathanga, Campbell, Taylor, Barlow, & Wilson, 2005). In Mali, where rates of net use are higher than in any other Sub-Saharan country and yet malaria prevalence still shows little evidence of significant decline, it may be time to begin focusing more on alternative strategies such as indoor-residual spraying and improved housing (insecticide-treated wall coverings, ceilings and screens), rather than expending large amounts of resources to try to get every last person under a net.

Table 4.1 Comparison of Net Ownership, Condition and Use Variables in Segou and Baraoueli Districts

		Segou District		Baraoueli District		
	N	%	95% CI around point estimate	%	95% CI around point estimate	p-value*
HOUSEHOLD LEVEL VARIABLES						
Own at least one net	3283	96.2	95.1-97.4	96.0	94.9-97.1	0.78
Own more than one net	3283	68.9	65.3-72.4	64.0	60.4-6.76	0.06
Mother hangs nets	3283	97.1	96.2-98.1	96.9	95.8-98.0	0.73
Father hangs nets	3283	5.46	3.9-7.0	4.2	4.5-7.9	0.51
Older female child hangs nets	**3283**	**3.8**	**2.3-5.2**	**2.0**	**1.0-3.0**	**0.04**
NET LEVEL VARIABLES						
LLINs	**2985**	**78.9**	**75.3-82.6**	**91.8**	**90.1-93.5**	**<0.0001**
Traditional cotton or locally fabricated nets	**2985**	**17.0**	**13.5-20.5**	**2.63**	**1.38-3.58**	**<0.0001**
Good condition (no holes)	**2985**	**79.8**	**77.1-82.4**	**79.1**	**76.6-81.6**	**0.01**
Holes	2985	18.7	16.2-21.3	19.8	17.4-22.2	
Hanging at time of survey	2985	100	100-100	100	100-100	-
INDIVIDUAL LEVEL VARIABLES						
Child slept under net the previous night	3282	90.1	88.5-91.7	91.7	89.9-93.5	0.19
Experienced LLIN stock-out	3283	32.8	29.9-35.6	32.6	29.6-35.5	0.92
Able to get LLIN after stock-out	1072	26.3	21.6-31	32.2	26.8-37.5	0.1

* Rao-Scott Chi-Square to account for clustering

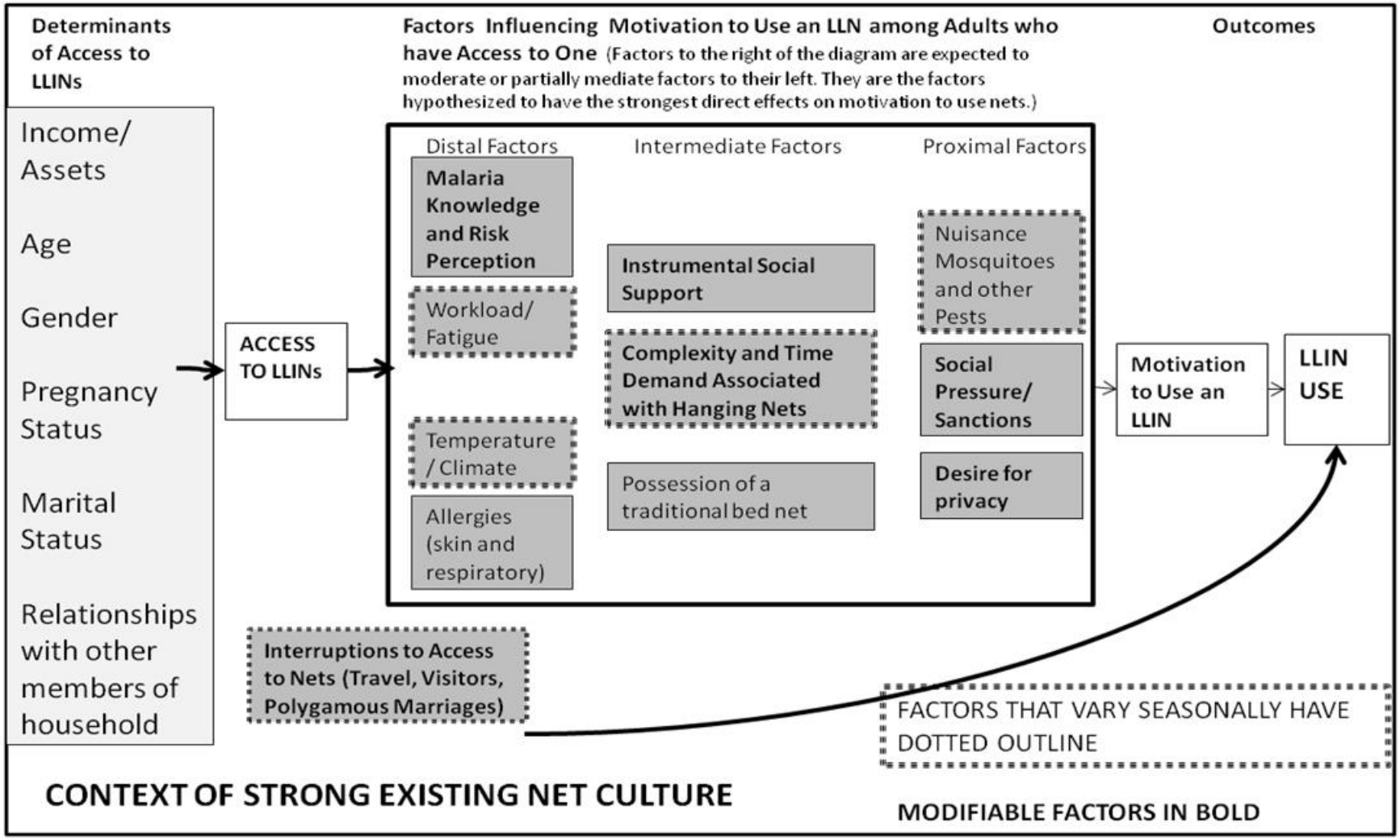

Figure 4.1 Proposed Conceptual Model of Determinants of LLIN Use

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Chapter 4 Notes

[1] Multiple responses were possible for this question.

[2] Survey data suggest that the practice of storage LLINs for later use may be less common than the qualitative interviews indicated. Only 13 nets out of a total of 2,985 observed nets were observed to be in unopened packages or re-packed in their packaging. However, flaws in the questionnaire design make the interpretation of this data problematic. Net condition was observed by the enumerator, who then classified each net as being either 1) in unopened packaging, 2) in good condition (no holes), 3) with holes, 4) repackaged in its original packaging and 5) not observed. Only one response was possible, despite the fact that the response options were not mutually exclusive and covered two different dimensions of net condition (holes and whether it is currently in use). This means that an unknown proportion of the nets in good condition and the nets with holes were not currently in use at the time of the survey.

[3] This analysis was limited to Segou District since ownership of traditional bed nets was significantly higher there as compared to Baraoueli District.

[4] Women in Mali are often afraid of frogs, given beliefs that they have the power to cause spontaneous abortions and other adverse effects during pregnancy.

[5] Interestingly, research suggests that the risks of malaria are actually lower in these areas near the river and in places with irrigation due to the fact that the mosquitoes here tend to have shorter lifespans and thus less time to potentially be infected (Diuk-Wasser et al., 2007; Diuk-Wasser et al., 2005).

[6] Given women's reluctance to discuss anything even approaching the topic of sex in this context, the relative absence of discussions of privacy as a benefit of net use in interviews conducted with rural mothers may be more of a reflection of the sensitivity of the topic than an indicator that this benefit is unimportant to them. Ultimately, the reasons may not matter when it comes to future behavior change strategies. Even if privacy is a valuable asset of nets for women, communication strategies emphasizing this are unlikely to be well received given the cultural discomfort related to public discussions of women's sexual behavior.

[7] Multiple responses were possible for this question.

[8] This shift in social norms may be associated with a television service announcement developed by PSI Mali, in collaboration with the Ministry of Health and other partners, which was very popular at the time of this study. The overall message of this television spot was that men should involve themselves in hanging bed nets and making sure that their household members use them because it is ultimately they who will have to pay the medical expenses should one of their family members fall ill. The skit was humorous and many study participants were able to recite it almost verbatim, laughing as they did so.

[9] The approximate English translation for the French term *sensibilisation* is "awareness raising" but the term is used very broadly in Mali to include all manner of health education activities.

[10] While health care providers do provide information regarding net use, there is a need for much better education regarding net care and the differences between LLINs and the previously distributed ITNs. People in Segou, including many health care providers, were unaware of the fact that LLINs do not need to be retreated every 6 months. Additionally, very few people know

how often they should wash their nets, or are certain that insecticide will remain on the nets after washing. No health care providers were observed or reported to provide information about mending nets.

[11] While Malians translate the Bambara word "maloya" as "la honte" (shame) in French, the word has a range of uses depending on the context. While it means shame when discussing someone who has committed adultery or stolen or committed some other socially deviant behavior, when women talk about the reasons that they are hesitant to speak during interviews or during health education sessions the meaning is more closely related to the terms "embarrassment" or "humiliation" in English.

[12] The pervasiveness and cultural salience of the tradition of paying a fine to village leaders for infractions is illustrated by the fact that a light-hearted version of the practice has become a part of official meetings and trainings in the health and development sector. When listing the expectations for the meeting, such as "no cell phone use" or "arrive on time," meeting participants elect a "chef de village" (village chief) to whom people must pay package of candies if they break any of the rules. There is always a great deal of laughter associated with the designation of the chief and the payment of candies, but the sanctions are respected.

[13] Detailed data pertaining to the audience reception of malaria communications will be published subsequently in a separate publication.

[14] In 2011, workshops focusing on the construction of such net hanging posts were conducted as part of a community-based behavior change intervention supported by The Carter Center in Southeast Nigeria. This project was inspired by these results from Mali.

[15] While this was not observed during this particular study, one of the research assistants for the project reported that he had encountered this practice in other regions of Mali.

[16] No in-depth interviews were conducted with parents during the months of January, April, August or December, while 18% were conducted in February, 13% in June, 12% in July, 22% in October and 12% in November.

CHAPTER 5

Health Worker Performance of a Proposed Low-Cost Health Facility-Based Malaria Monitoring and Program Management Tool: Results from a Process Evaluation of the EPI-Contact Method in Segou, Mali

ABSTRACT

Background: The Expanded Program for Immunizations (EPI) Contact Method (EPI-CM) is a health facility-based malaria monitoring tool proposed as a lower cost alternative to household surveys that can produce more timely and more locally relevant data for program evaluation and management. Advocates of the method also emphasize its potential to encourage parents to adopt recommended child health behaviors through improved communication with health workers and repeated reminders. Key assumptions underlying the EPI-CM are that the method will be easy for health workers to implement, will not introduce an excessive additional burden on health workers, and will be inexpensive. While the EPI-CM has been introduced at scale in a few Sub-Saharan African countries, there have been no prior systematic evaluations of the method.

Methods: The data presented here were collected in the context of a mixed methods process evaluation of the EPI-CM, designed to examine the appropriateness of the key underlying assumptions of the method as well as to explain and contextualize the results of statistical assessments of the validity of the EPI-CM and its effects on health behaviors. Quantitative data were obtained from systematic observations of parent-health worker interactions during immunization clinics (N=1,394); health facility records on malaria and immunization activities; and a representative household survey (N=3,283). Qualitative methods included unstructured observations at community health facilities; participant observation during meetings and trainings at the national and district levels; semi-structured interviews with health workers (N=31); follow-up interviews with health workers after systematic observations (N=52); semi-structured interviews with parents of young children (N=80); and key informant interviews with supervisors and trainers of CSCom staff (N=8). Quantitative methods were used to assess the consistency,

completeness and quality of EPI-CM data collection and reporting, while qualitative methods were used to identify potential determinants of health worker performance of the EPI-CM.

Results: The EPI-CM was implemented inconsistently across time, between health facilities and even between individual clients attending the same vaccination clinic. Among the factors inhibiting or interrupting the collection of EPI-CM data were vaccine stock-outs, mass campaigns, lack of clear directives from above, insufficient health worker motivation, insufficient supervision, high EPI-clinic attendance, staffing shortages, health worker absences, and insufficient funds to purchase fuel for outreach activities. The implementation of the EPI-CM was more consistent during fixed EPI clinics than during outreach. Monthly reports were not submitted consistently, and there were significant discrepancies between the data reported to the district health facility in monthly reports and the data in health facility EPI-CM tally notebooks. Overall percent agreement between the values for key indicators found in monthly reports and those calculated from tally notebook data was 28%. The EPI-CM had no significant effects on health worker-client communication, and there was little evidence that EPI-CM data was used to inform programmatic activities. Health worker resistance to additional work without additional pay was a significant barrier to both the collection and reporting of EPI-CM data.

Conclusions: The results of this process evaluation challenge the primary assumptions of the EPI-CM, and suggest that health workers in the context of weak African health systems will not be able to implement the method with sufficient fidelity to obtain valid data, or to encourage significant behavior change. The data suggest recommendations for improving performance of the EPI-CM, but these would introduce substantial additional costs. The findings of this study do not support a recommendation for the widespread introduction of the EPI-CM. The health systems challenges identified as potential determinants of health worker performance of the EPI-CM are likely to have similar effects on other routine data collection activities at the community health facility level and thus should be addressed regardless of decisions about future applications of the EPI-CM.

BACKGROUND AND INTRODUCTION

Regular monitoring and surveillance data are essential for evaluating the intermediate outcomes and long-term impacts of health programs. However, in many African countries, the validity and utility of data obtained through routine health surveillance systems are compromised by health worker mathematical errors, incomplete data and inconsistent reporting. Given this, health programmers and national ministries of health often rely on large-scale household surveys to obtain the data they need to track their progress and modify intervention strategies accordingly. These surveys are expensive, are generally only conducted every 4-5 years, and often produce only regional or national level estimates. As a result, a number of alternative strategies for obtaining routine data have been developed (Alonso et al., 2011), including lot quality assurance sampling (LQAS) (Biedron et al., 2010) , school-based surveys (Ashton et al., 2011; Brooker, Kolaczinski, Gitonga, Noor, & Snow, 2009), health facility-based surveys (Rowe et al., 2009; Skarbinski, Winston, Massaga, Kachur, & Rowe, 2008) and integrated continuous surveys and quality management (Rowe, 2009).

The Expanded Program for Immunizations Contact Method (EPI-CM) is another such method. It involves the collection of child health data by health workers during routine immunization clinics, capitalizing upon the fact that, in many African countries, immunization services serve as the only consistent point of contact between the formal health sector and rural mothers. To date, there has been much debate about the potential strengths and weaknesses of the EPI-CM but it has only been implemented in a few countries, including Sierra Leone, Zambia and Benin.

The EPI-CM consists of asking parents a series of questions about routine child health indicators when they attend routine EPI vaccination clinics, tallying responses, providing tailored counseling as a function of the responses to the questions, preparing monthly reports on the EPI-CM indicators, charting monthly trends in the indicators, and using data to manage and improve

programmatic activities at the health facility level. Although specific EPI-CM questions can vary slightly due to differences in the priorities and policies of different ministries of health and their partner organizations, the basic list of questions asks about the child's bed net use the previous night, fever incidence and treatment, respiratory infections and treatment, diarrhea incidence and treatment, and exclusive breastfeeding. These questions can be asked of all parents attending vaccination clinics, or of a subset of parents of children receiving certain immunizations.

The EPI-CM has the potential to serve both as a routine monitoring tool, and as an intervention to increase a specific set of targeted child health behaviors. The method is hypothesized to encourage behavior change by providing direct reminders of recommended behaviors (cues to action) each time that parents hear the EPI-CM questions, as well as by improving communication between health care providers and parents. Additionally, the intervention is expected to improve child health by providing regular data that can be used to improve and tailor programmatic activities at the health facility and community levels. A conceptual model for the EPI-CM is presented in Figure 5.1.

Theoretically, the EPI-CM should be relatively simple for health workers (HWs) to implement, with minimal additional expenditures. Ideally, the EPI-CM indicators should be added to existing monthly EPI reporting forms, whenever possible, to avoid introducing an unnecessary reporting burden and to build on existing skills among health workers. The graphs for tracking monthly trends in EPI-CM data resemble those already used in the context of the routine EPI program.

The data presented in this paper were collected during a 15-month mixed methods evaluation of the EPI-CM in the Segou District of Segou Region, Mali. The process evaluation was embedded in a larger pilot study whose primary objectives were 1) to assess the validity of EPI-CM data as compared to the "gold standard" of a large-scale representative household survey, and 2) to evaluate the effectiveness of the EPI-CM as an intervention to increase recommended child health behaviors.

This was the first ever systematic evaluation of the EPI-CM to date, though a small number of studies have assessed the validity of data collected using other methods designed to approximate data obtained from the EPI-CM. The alternative data sources include health facility interviews conducted by study staff (instead of health workers) (Skarbinski et al., 2008) and subsets of household survey data restricted to those children who have been vaccinated (Cibulskis, Pujari, & Otten, 2012). The analysis of survey data from the subset of children who had been vaccinated demonstrated that health facility data should theoretically produce valid estimates of key child health indicators where vaccination coverage rates are high. However, previously published results of the effectiveness trial described in this paper revealed that the results of EPI-CM data, collected by health workers in the actual conditions of an African health system, different significantly (by more than 10%) from "gold standard" household survey data collected at the same time, in the same district (Wei et al., 2012a). Additionally, comparisons of household survey data collected in the district where the EPI-CM was implemented and data collected in a nearby comparison district revealed that the introduction of the EPI-CM had no significant effects on target health behaviors, presenting challenges for the hypothesis that the EPI-CM serves as an effective behavior change and program management intervention (Wei et al., 2012b).

The fact that data from the subset of individuals exposed to the EPI-CM should, at least theoretically, produce comparable estimates to those produced via random sampling from the entire population (Cibulskis, Pujari, & Otten, 2012) suggests that the failure to obtain similarly valid results during this trial in Segou is linked to operational factors influencing the implementation of the method in actual field settings. The process evaluation data presented here help to illuminate some of these factors with the potential to limit the validity and utility of EPI-CM data, with broader implications for all health facility-based data collection in this setting. Among the key dimensions addressed in this paper are the consistency and completeness of data collection and reporting, the impact of the EPI-CM on communication between health workers

and clients, and the utilization of EPI-CM data by health workers in program management and the treatment of childhood illnesses.

Process evaluations such as this one are essential for documenting the actual implementation of interventions in real-world conditions, identifying potential sources of so-called "Type Three Error" (error arising from the incorrect assumption that an intervention is implemented as planned (Basch, Sliepcevich, Gold, Duncan, & Kolbe, 1985)), assessing the appropriateness of the intervention for a particular context, and developing specific and appropriate recommendations for improving intervention implementation and outcomes in the future (Steckler & Linnan, 2002).

Expanded Program for Immunization (EPI) Services in the Context of Malian Health Systems

Routine immunization services in Mali are delivered primarily through the public health system, which consists of four main levels: national hospitals, regional hospitals, district reference hospitals (Centre de santé de reference – CSRef) and a network of community health centers (Centre de santé communautaire – CSCom). Each CSRef is supervised by a doctor who is also responsible for the overall management of the district health system and who serves as the supervisor of the CSCom (Médecin chef, hereafter referred to as the chief health administrator). Each CSCom is managed by a trained nurse or doctor, the Chef de poste médical (CPM), who is assisted by some combination of maternity nurses, vaccination technicians, interns/volunteers, pharmacists and guards – though many facilities have no more than three employees on staff. The CSCom are expected to offer a minimum package of services that includes primarily the diagnosis and treatment of uncomplicated illnesses and injuries, antenatal care, family planning, nutrition counseling and routine vaccinations for children 0-11 months of age through the EPI program. In addition to routine services, the staff assists with health campaigns, such as those

focused on polio or measles vaccinations or mass drug administration for the so-called Neglected Tropical Diseases (NTDs).

In Mali's decentralized health system, which places a strong emphasis on cost recovery, the financial management of the CSCom is the responsibility of a community health association (ASACO). The ASACO often pay the salaries of some vaccination technicians and nurses at the CSCom, though the director of the CSCom is generally paid by the state. Community health facilities in Mali are divided into two categories, functional and non-functional, according to whether or not an ASACO has been established to manage them. Functional CSCOM are more likely to have the necessary staff and supplies to provide routine health services. However, non-functional health centers are still supervised by the district medical officer, participate in monthly meetings, and sometimes submit monthly reports – though participation in all of these activities is generally inconsistent. They may provide vaccinations since vaccines are provided free of charge as part of the National Expanded Program for Immunizations, and in actuality it is sometimes hard to tell the difference between poorly performing "functional" facilities and highly performing "non-functional" facilities.

The EPI program in Mali consists of a combination of three strategies: fixed vaccination clinics conducted on a weekly basis at the CSCom, outreach activities conducted in rural villages on a rotating basis, and mass vaccination campaigns. In some parts of the country, where funding allows, there is an additional "mobile strategy" through which CSRef staff visit communities not reached by standard outreach activities in order to provide immunization services. Throughout this paper the term "vaccination clinic" will refer to a specific activity during which vaccinations are provided either at the health facility (fixed) or in one of the surrounding villages (outreach), and not to a location or physical structure.

A number of other child health interventions have already been integrated with standard EPI activities in Mali, including: Vitamin A distribution, health education, and the distribution of long-lasting insecticide-treated bed nets (LLIN) to children who have completed the full course of

vaccinations. During the time of this operational research study, the EPI contact method was added to this existing package of integrated interventions in the Segou District of Segou Region, Mali.

METHODS

Study Site Selection

The Segou Region of Mali comprises seven districts, two of which were selected for inclusion in this study: the district of Segou was selected for the intervention, while the district of Baraoueli was selected as the comparison district. The districts have similar population sizes (when the urban population of the regional capital, located in Segou District, is excluded), and comparable malaria transmission patterns. Malaria is endemic in both of these districts with seasonal fluctuations associated with weather conditions. There are 33 CSCom in Segou District and 18 in Baraoueli. However, only 22 (67%) in Segou and 13 (72%) in Baraoueli are classified as "functional," meaning that they have active community health associations (ASACO).

The Segou Region was selected primarily because of its high vaccination coverage rates in an effort to maximize the potential exposure to the EPI-CM during the course of the pilot study and to allow for a test of the validity of the EPI-CM data in a context where EPI clinic attendees represent a larger percentage of the population. Vaccination coverage rates in Segou were higher than the national average according to results from the 2006 Demographic and Health Survey (Demographic and Health Surveys, 2006). In 2007, close to 80% of children were vaccinated against measles in this region according to routine health information systems data (Cellule de Planification et de Statistique du Ministère de la Santé (CPS/MS), et al., 2007).

Baseline comparisons of the two districts (published elsewhere) revealed no significant differences in net ownership, mother's education, children's vaccination histories, or reported incidence of common childhood illnesses (fever, respiratory infection and diarrhea) (Wei et al., 2012b). However, ITN ownership and ITN use among children under-five were significantly

higher in Baraoueli District than in Segou District. The rates of ITN ownership exceeded the national target of 80% in both districts (92.4% in Baraoueli versus 88.1% in Segou, p=0.04) and ITN use among children under-five was relatively high in both districts (86.2% in Baraoueli versus 76.9% in Segou. p<0.01) (Wei et al., 2012b).

EPI-CM in Segou, Mali

The design and implementation of the EPI-CM in Segou were based on materials used when the method was introduced nationwide in Sierra Leone, as well as on standard EPI and malaria training materials produced by the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC). The final versions of the documents were produced in collaboration with representatives from the Malian National Center for Immunizations, the Malian National Malaria Control Program, the CDC Global Immunizations Division, the CDC Malaria Branch and Emory University.

In each of the three countries where the EPI-CM has been introduced it has taken a slightly different form, reflecting differences in health systems, as well as in the needs and agendas of the Ministries of Health and other partners. For this project in Mali, considerations of the national malaria control strategy, the cultural context and the pilot nature of the project had implications for the formulation of the EPI-CM questions, the set of caregivers who were asked the EPI-CM questions, and the structure and content of data collection and reporting forms.

The following questions were asked during EPI clinics in this field trial of the EPI-CM in Segou, Mali:

1. Did this child sleep under a bed net last night?
2. a. Did this child have a fever in the past two weeks?

   b. IF YES: Was the fever treated at a hospital/health clinic?
3. a. Did this child have a cough or difficult breathing in the past two weeks?

   b. IF YES: Was the cough or difficult breathing treated at a hospital/health clinic?

4. a. Did this child have diarrhea in the past two weeks?

   b. IF YES: Was the child treated with oral rehydration solution (ORS)?

Health workers were provided with a template of the format for tallying both affirmative and negative responses to the EPI-CM questions so that they could add the necessary rows and columns to the hand-drawn tables they were already using to tally vaccines administered as part of the EPI program (See Annex 2). The data in these integrated EPI and EPI-CM tally notebooks were then used to calculate monthly totals for each indicator for inclusion in monthly reports submitted to the district references hospital at the same time as the monthly EPI reports.

The Malian National Strategic Plan for Malaria Control and Prevention defines appropriate treatment for malaria as "treatment with an appropriate antimalarial *after a positive diagnostic test*" (Programme National de Lutte Contre le Paludisme, 2006). Thus, because diagnostic tests are only available at authorized health facilities, appropriate treatment" for malaria was defined as "any treatment received at an authorized health facility (public or private clinic or hospital)."[1] For this pilot study, all parents attending EPI clinics (rather than a subset) were asked the EPI-CM questions in order to maximize exposure to the EPI-CM and thus the potential for intervention effects. Also, the EPI-CM report was introduced as a separate parallel report, despite significant overlap with the EPI monthly report. While the forms would ideally be integrated if introduced at a national level, The National Center for Immunizations in Mali did not authorize the replacement of the EPI monthly reporting form with an integrated EPI/EPI-CM reporting form in the context of this study because the EPI-CM was only introduced in one district and the resulting data were not submitted to the national or even the regional level. The data in the standard EPI forms, in contrast, were reported up through the national health information system and compiled with data from all other districts and regions of the country.

Health facility directors (CPM) and vaccination technicians from all community health centers (CSCom) in the district of Segou, as well as select personnel from the district reference hospital, were invited by the district chief health administrator (Médecin Chef) to attend the

training on the EPI-CM in September 2008. In all, 55 health workers were trained, including 19 directors of community health facilities, 19 vaccination technicians and 17 additional staff members from the CSComs and district reference hospital who either assisted with vaccination clinics or supervised those who do. Directors and vaccination technicians from all health facilities (N=33) were invited to attend the training. Twenty-six facilities (79%) sent at least one staff member (Functional=22 (100%), Non-functional=4 (36%)). Twenty-three (70%) sent two representatives (Functional=22; Non-functional=1), as instructed. Some CSCom directors sent other staff members in their place rather than attending the training themselves. Representatives from the regional health office were also invited to attend though none did. Separate trainings were held for CPMs and vaccination technicians, given concerns that technicians would not speak openly or participate actively if their supervisors were present.

The training was facilitated by representatives from the National Center for Immunizations and the National Malaria Control Program, with assistance from the district health administrator and the principal investigator (PI) for the project. Training materials were produced in French, given that literacy in Bambara is limited, and the training was conducted primarily in French, according to the preference of the facilitators. The training consisted of a combination of lectures, role-play exercises, brainstorming sessions in small groups, and practice exercises (e.g., completing monthly reports and graphing monthly trends using hypothetical data). Topics covered during the training included: 1) The National Malaria Control and Prevention Strategy, 2) Introduction to the EPI-CM, 3) Routine EPI and EPI-CM Data Collection and Monitoring, 4) Applying Routine EPI and EPI-CM Data in Program Management, 5) Introduction to Behavior Change Communication, 6) Client-Provider Communication During EPI-CM Encounters, 7) Using EPI-CM Data for Community Mobilization, and 8) Planning to Use EPI-CM Data in Your Health Facility.

An additional follow-up training for supervisors was held in April 2009, when it became apparent that the majority of district-level staff responsible for conducting supervision at

CSCOMs had not attended the initial training. CSCom directors (CPMs) were also given time to ask questions and discuss concerns regarding the EPI-CM during the first few monthly meetings of CPMs following the training, though few took advantage of this opportunity. By August 2009, it had become apparent that health workers were collecting EPI-CM data inconsistently and infrequently. Thus, one day of refresher training was held for all CSCom directors, and an additional day of refresher training was also conducted for vaccination technicians in an attempt to improve both the quality and the frequency of EPI-CM data collection.

The district health facility supervision team conducted supportive supervision activities in 17 of the 22 functional CSCom between April and June 2009 in order to assess health worker performance of the EPI-CM and provide advice, recommendations and additional instruction pertaining to the EPI-CM as needed. Supervision was delayed due to polio and measles campaigns, and because of delays in the provision of funding for routine integrated supervision activities. Given this, in order to ensure that EPI-CM activities would be supervised at least once during the study period, the decision was made to provide additional funding for fuel and per diem specifically for stand-alone EPI-CM supervision in the absence of other routine supervision visits to rural CSCom.[2]

Overview of the Mixed Methods Process Evaluation Design

The data presented in this paper were collected in the context of a mixed methods process evaluation of the EPI-CM in Segou, Mali. The process evaluation was embedded within a larger quasi-experimental study consisting of large-scale representative baseline and follow-up household surveys in both the intervention district of Segou and a nearby comparison district, Baraoueli (See Chapter Two).

The aims of the process evaluation were to describe the implementation of the EPI-CM, identify potential determinants of health worker performance of the EPI-CM and understand the potential effects of the EPI-CM on health facility program management and on health behaviors

at the community level. Domains of health worker performance that were considered during the process evaluation included: implementation of routine EPI activities, EPI-CM data collection, communication with caregivers in the context of vaccination clinics, monthly reports, and applications of data in routine program management. The possible determinants of health worker performance of the EPI-CM and, by extension, EPI-CM validity and effectiveness that were examined included: health worker characteristics (e.g. demographics, training, motivation); health facility characteristics (patient volume, frequency of supervision, management of drug and supply stock, records storage and management); health system financing at district and health facility levels (e.g. salary payment system, per diems, sources of funding); client factors (e.g. demographics, attitudes towards health facility and EPI-CM); historical socio-political relationships between communities, community health associations and health facilities; social and cultural factors (e.g. beliefs and practices pertaining to childhood illness, communication norms, social roles determined by gender, age and ethnic group/caste); and environmental factors (e.g. weather, road conditions).

The mixed methods process evaluation began during the EPI Contact method training in September 2008, and continued throughout the next 15 months, with activities in both the intervention and control districts. A variety of quantitative and qualitative methods were used (See Table 5.1). Quantitative data allowed for the identification of key trends in the implementation of the EPI-CM, while qualitative data provided rich detail to contextualize and explain these trends. Quantitative data were collection from CSCom EPI registers, EPI-CM tally notebooks, monthly EPI and EPI-CM reports, and an anonymous questionnaire administered to health workers in the EPI-CM district at the end of the study, as well as through systematic observations of interactions between health workers and parents during EPI clinics. The qualitative methods included unstructured observations, participant observation, follow-up interviews with parents and health workers observed during EPI clinics, in-depth interviews with

health workers and key informant interviews. Each of the methods employed is described further below.

The data were examined and discussed by the research team as they were collected, and the guides for subsequent interviews were modified, based on these conversations, in a continuous iterative process inspired by methods of grounded theory (Charmaz, 2006; Glaser & Strauss, 1967; Strauss & Corbin, 1990). This allowed for more in-depth explorations of phenomena that were not anticipated when the original guides were developed, and it facilitated efforts to explain unexpected or contradictory findings from early data collection activities. The triangulation of a variety of different methods and data sources served to strengthen the validity of findings. When seemingly contradictory data were identified (either from different people or different methods), efforts were made to collect additional information in real time so as to resolve or explain the contradiction. The study was designed to reflect the perspectives of all categories of health workers involved in the implementation of the EPI-CM, as well as to identify any variations in the performance of the method at different times of the year.

Certain data collection activities specifically related to the EPI-CM were conducted only in the intervention district (See Table 5.1). Nine health zones (six intervention and three comparison) were selected for additional data collection activities. Six health facilities in the intervention district were purposively selected for a more intensive examination of the implementation processes of the EPI-CM as well as the contextual factors that might impact the validity of the data collected and the effectiveness of the EPI-CM as an intervention. Three health facilities in the neighboring comparison district of Baraoueli were also included to facilitate comparisons of EPI activities in intervention and non-intervention facilities, and to identify potential impacts of the EPI-CM on EPI procedures and health worker behavior. The facilities were selected to represent a range of different distances from the district health facility and different levels of functionality and performance, as rated by the district chief health administrator (Médecin Chef). They represented variety in the following characteristics: gender

of health facility director, training of health facility director, number and type of staff, and funding sources.

Process Evaluation Data Collection Methods

The quantitative data collection methods employed during this study included: collection of data from CSCom registers, record and reports; anonymous health worker questionnaires; and systematic observations of interactions between health workers and parents during EPI clinics. The following qualitative methods were used: follow-up qualitative interviews with health workers and parents who participated in observed EPI clinics; unstructured observations at health facilities; participant observations during trainings, supervision and meetings; semi-structured interviews with health workers at CSCom; and key informant interviews with staff at the district reference hospital (CSRef).

Data Collection from CSCom EPI registers, EPI-CM tally notebooks, monthly EPI and EPI-CM reports. Routinely collected and reported data pertaining to routine EPI activities and the EPI-CM were collected from both the district and CSCom levels.

District level. At the end of the first week of every month, copies were made of the EPI and EPI-CM reports that had been submitted to the CSRef health information systems office on time, as well as any reports from earlier months that been submitted after the reporting deadlines. The reported values for the number of doses of vaccine administered by each CSCom, as well as for the full set of EPI-CM indicators, were entered into an Excel database with separate spreadsheets for each month. When reports were submitted late, this was noted. This data base was used to evaluate the completeness, timeliness and consistency of reporting by each health facility over time, as well as to examine monthly trends in EPI-CM indicators and identify inconsistencies and inaccuracies with calculations. Trimester reports for each CSCom were also collected from the CSRef to obtain additional information regarding stock management, campaign activities, and malaria treatment activities.

CSCom level. At the end of the project, a member of the study team visited every CSCom in Segou District (EPI-CM district) to actively collect the data from the EPI-CM tally notebooks. The data were entered directly into a personal handheld computer (PDA) that had been pre-programmed using Visual CE Version 11 (Syware, Cambridge, MA). For each day of vaccination activities, the research assistant entered the date, the location, the type of strategy (fixed, outreach), the number of tallied affirmative and negative responses to each EPI-CM question and the number of doses of each vaccine administered. This allowed for comparisons between the data reported to the district level in monthly reports and the data collected at the CSCom level (which theoretically should be identical), as well as for an assessment of the accuracy and completeness of the tallies, identification of particular problems with the way tally data were entered, and classification of the vaccination clinics according to strategy.

Anonymous health worker questionnaire. At the end of the study, an anonymous questionnaire was administered to all of the health workers who participated in the pilot of the EPI-CM (CPM=24, Technicians=21). The questionnaire was distributed during the final debriefing meeting for CSCom staff and completed questionnaires were collected by the CSRef accounts manager to ensure anonymity. The questionnaire covered the topics of EPI-CM training, consistency of implementation and reporting, usability of the tally and reporting forms, additional burden associated with the EPI-CM, advantages and disadvantages of the EPI-CM, applications of the EPI-CM, and suggested modifications to the EPI-CM.

Systematic observations of interactions between health workers and parents during EPI clinics. In the nine health zones selected for intensive study (six intervention and three comparison) structured, systematic observations of interactions between health care providers and caretakers (Total=1,394; Segou, N=993; Baraoueli, N=401) were conducted during 42 different EPI clinics (18 fixed clinics, 24 outreach clinics).[3] Observation data were directly entered on a handheld computer (PDA) programmed using Visual CE Version 11 (Syware, Cambridge, MA). Observers recorded each of the EPI-CM questions asked (if any), the parents' responses to those

questions, and whether health workers provided specific key messages about malaria prevention and treatment. The duration of the interaction was also recorded.

Follow-up interviews with health workers who participated in observed EPI clinics. In order to better understand the motivations, logic and constraints driving observed health worker actions, brief follow-up interviews were conducted with health workers at the end of each day of observations. A total of 31 short follow-up interviews were conducted with the vaccination technicians and health center directors at the nine CSCom selected.

Interviewers asked questions about specific actions observed or information communicated to health workers during the day of observation. For example, if the EPI-CM was not conducted at all, or if information on the importance of bed nets was provided to some participants but not others, the interviewer would ask why. The interviewers also used these conversations as an opportunity to obtain clarification and additional detail regarding information obtained during previous data collection activities at the same health facility and to ask new questions that the study team developed based on ongoing preliminary analyses. No structured interview guide was used for these interviews, given the inability to predict in advance what would happen during a given day of observations. These interviews generally lasted between 15-20 minutes, and were conducted either at the community health center (CSCom) or at the health worker's home, depending on his or her preference. Interviews were conducted in either French or Bambara (depending on the preferences of the participant), were recorded using digital audio recorders, and were subsequently translated into French (if necessary) and transcribed.

Follow-up interviews with parents who participated in observed EPI clinics. Semi-structured interviews were also conducted with 50 randomly selected parents (all women) whose children were vaccinated during observed immunization clinics. During each day of vaccination clinic observations, three parents whose children were vaccinated were randomly selected for follow-up interviews based on the order in which they arrived. For logistical reasons, parents

were excluded from participation in interviews if they lived outside of the health zone where they were seeking care.

Parents were asked to describe their recent experiences at the health center (on the day when observations were conducted) in order to facilitate comparisons of health worker, parent and observer interpretations of the same events. Follow-up questions were asked to elucidate what parents understood about malaria and vaccinations based on their communications with health workers, to learn about parent perceptions of the quality of care received and to assess parent satisfaction with the treatment provided at the CSCom. In addition to these questions, all participants in these interviews were asked about their experiences with LLIN distribution activities, their exposure to communications about malaria and LLINs, their general knowledge and attitudes regarding LLINs, and their malaria treatment seeking and net use behaviors.

Interviews with parents were conducted two to seven days after the observed vaccination clinic, at a time and place selected by the participant, and generally lasted one to two hours. Interviews were conducted in Bambara (depending on the preferences of the participant), were recorded using digital audio recorders, and were subsequently translated into French and transcribed.

Unstructured observations. The members of the research team spent several days a week at the nine community health facilities (CSCom) selected for intensive study. Whenever they visited these facilities to conduct other data collection activities (including systematic observations of patient-provider interactions, vaccination clinic exit interviews, and interviews with health workers), they conducted unstructured observations of routine health facility activities and communications between health workers and clients. They paid particular attention to determinants of health worker performance, departures from recommended practices for EPI, EPI-CM, LLIN distribution, or malaria case management, and the strengths and weaknesses of integrating malaria control interventions with EPI. They also engaged in informal conversations with health facility staff, during which they asked questions about the events and activities

observed, often using concrete data recorded in health facility registers and reports to stimulate conversation.

At the end of each day, the members of the research team wrote detailed field notes using a standard format with designated sections for: 1) descriptions of observed events and summary of interview content, 2) comparisons with previously collected data from the same health facility or others, 3) questions to be followed up on in subsequent interviews with the key actors in observed activities to better understand why certain actions were taken and how they were understood by the various people involved, 4) comments about how the presence of the observer may have influenced the behaviors of health workers and clients at the health facility (reflexivity) (Barry, Britten, Barber, Bradley, & Stevenson, 1999; Finlay, 2002) and 5) a list of key themes and topics relevant to the observations (for example, "applications of EPI-CM data," or "modifications to the EPI-CM").

Participant observation. Much of the knowledge about the determinants of health worker performance of the EPI-CM was obtained through participant observation during the EPI-CM training, and during monthly meetings of CSCom directors (CPM) at the district reference hospital CSRef. While assisting with the training, members of the study team took notes on the questions that health workers asked about the EPI-CM and on the aspects of the method that seemed the most challenging to master. At this time, it was also possible to observe the health workers as they completed practice exercises and thus to identify potential challenges associated with the format of the data entry and reporting forms, During the monthly meetings, the health workers shared their experiences and, in this setting, spoke very candidly about the challenges, particularly when they were asked by their supervisors to explain tardy and incomplete submission of EPI-CM reports. After each day of participation in these activities, the members of the study team wrote detailed field notes which were then discussed during subsequent research team meetings. The potential determinants of performance identified during these activities were explored in greater depth in subsequent qualitative interviews with health workers.

Semi-structured qualitative interviews with health workers. Semi-structured qualitative interviews were conducted with health workers who were involved in EPI and malaria control activities at the nine CSCom selected for intensive study. Multiple interviews were conducted with CSCom directors at three CSCom and the vaccination technician at one CSCom in order to obtain additional information about topics not thoroughly addressed in the first interview. In all, twelve interviews were conducted with CSCom directors, ten with vaccination technicians, six with maternity nurses and one with a medical intern.

The topics addressed in the semi-structured interview guide included the roles and responsibilities of each category of staff at the CSCom, the major challenges and rewards associated with work at the CSCom, ways to improve health worker performance and job satisfaction, sources and applications of data pertaining to key malaria indicators, EPI-CM training, advantages and disadvantages of the EPI-CM, challenges experienced with the implementation of the EPI-CM, and recommendations for improving the EPI-CM. Additional questions were included to learn about malaria case management practices, LLIN distribution, and malaria behavior change communications. The interviewers were trained to ask follow-up questions based on participants' responses in order to obtain rich descriptive detail, and they were encouraged to depart from the interview guide to explore unanticipated topics relevant to the larger research questions and objectives of the overall project. Interviews were conducted either at the health facility or at the home of the health worker and generally lasted one to two hours. The interviews were conducted in either French or Bambara (depending on the preferences of the participants), recorded using digital audio recorders, and subsequently translated into French (if necessary) and transcribed.

Key informant interviews. Key informant interviews were conducted with district reference hospital personnel involved in the supervision and training of community health center staff in Segou District (N=8). Topics explored during the interviews included differences between observed EPI practices and those recommended by the WHO, barriers to complete and

correct data collection and reporting, potential uses of the EPI-CM and the results of supervision activities. The interviews were conducted in French and lasted between one to two hours. They generally took the form of informal conversations directed by a general list of topics rather than a structured interview guide, and were not always recorded. Recorded interviews were transcribed verbatim. Detailed notes on the content of unrecorded interviews were written up as field notes to be included in subsequent analyses.

Analysis

EPI registers, EPI-CM tally notebook data and EPI-CM monthly report data. The main outcomes for the analysis of the EPI register and EPI-CM tally notebook data were the monthly point estimates for each of the EPI-CM and EPI indicators, and the number (%) of EPI clinics during which the EPI contact method was conducted. These descriptive statistics were generated using the Proc Freq command in the statistical software package SAS 9.2. This analysis was unadjusted because it was conducted on a census of all tally data from all CSCom in the intervention district. The consistency and completeness of EPI-CM data collection were compared across time, between health facilities, between "functional" and "non-functional" health facilities and between fixed and outreach EPI clinics. EPI-CM indicator estimates calculated from data actively collected from EPI-CM tally notebooks were compared to those submitted to the district level in EPI-CM monthly reports to check the validity of monthly report data.

Anonymous health worker questionnaire. Questionnaire data were entered into Microsoft Excel 2007 for analysis both in the aggregate and by category of health worker. Totals and percentages were separately calculated for responses from CPMs and vaccination technicians from the same health facility.

Systematic observations of interactions between health workers and parents during EPI clinics. Descriptive statistics for the following variables from the systematic observation

data were generated using the Proc SurveyFreq command in the statistical software package SAS (version 9.2): percentage of observed interactions during which each EPI-CM was asked and percentages of observed interactions during which specific messages about malaria prevention and treatment were provided. Accounting for clustering at the health facility and vaccination clinic levels, Rao-Scott chi-square tests were conducted to identify any statistically significant differences in health provider-client communication between districts.

Qualitative interviews. The study team members who collected and transcribed the data made an initial list of key themes after reviewing each transcribed document, and entered them into a matrix with a row for each interview and a column for each theme. Team members met several times a month to discuss the expanding matrix of themes and to develop and refine a list of codes and associated definitions for subsequent detailed analysis. In addition, team members shared their developing theories and discussed questions to explore during subsequent data collection. The initial codebook developed by the team was modified and refined by the PI during the final analysis to reflect additional emerging themes and theories. Final analyses were conducted by the PI using the qualitative management software package MaxQDA (version 10): codes were attached to relevant segments of text, text retrieval functions were used to examine all text segments related to a particular code, and patterns of co-occurrence of codes were examined to develop a stronger understanding of the relationships between themes.

Unstructured and participant observation data. Data from unstructured observations were discussed in regular team meetings and informed the continuous iterative process of modifying and revising the qualitative interview and group discussion guides to reflect new findings and preliminary theories.

Institutional Review and Ethical Clearance

The study was reviewed and approved by Institutional Review Boards at the Emory Rollins School of Public Health, the University of Bamako and the US Centers for Disease

Control and Prevention. Written informed consent was obtained from all health care providers, while oral consent was obtained from community leaders, parents, grandmothers, many of whom were illiterate.

RESULTS

The results presented below describe health worker performance with respect to each of the main activities comprising the EPI Contact Method: collecting data, providing tailored communication and counseling, managing data, reporting monthly totals and trends, and applying data in routine program management. Performance was highly variable and inconsistent, both within and across health facilities. This paper focuses primarily on describing the quality and consistency of health worker performance of the EPI-CM. Qualitative data are presented throughout to help explain the quantitative findings related to health worker performance, suggesting a set of potential determinants of performance at multiple levels of the health system.

Data Storage and Management at the CSCom Level

Overall, the retention of monthly EPI-CM data and the ability to easily locate the data on demand were low, which has important implications for health facilities' abilities to retrospectively examine trends in EPI-CM indicators over time and make programmatic decisions based upon the data. When health facilities were visited at the end of the intervention period, only five of 32 CSCom were able to locate and produce their EPI-CM tally notebook data for the entire period of data collection. While more CSCom were able to produce their routine immunization tally data upon request than could produce their EPI-CM data (14 total=11 functional and three non-functional), this was still only 42% of the included facilities. Nine health zones, including two CSCom officially classified as functional, were unable to locate any raw tally data (routine immunization or EPI-CM data), despite the fact that they had submitted monthly summary reports to the district level. For approximately 18% of all reports submitted to

the district reference hospital, and 23% of reports submitted by functional CSComs, no corresponding tally data could be located at the CSCom level.

When asked about missing EPI-CM tally data, vaccination technicians offered a number of different explanations, including never having collected the information in the first place. Other reasons mentioned were misplacing the tally notebooks, or being unable to access tally notebooks because other staff members had taken them home with them and not returned them. A fourth explanation offered by a few vaccination technicians during the end-of-study debriefing meeting was that they didn't understand that they were supposed to add columns for EPI-CM data to their *existing* EPI tally notebooks, based on the template provided during training. Thus, they never collected the data because they were waiting, throughout the entire study period, for registers or tally sheets to be distributed for this purpose.[4]

Frequency and Consistency of EPI-CM Data Collection

While some CSCom never introduced the EPI-CM, the CSCom that *did* implement it practiced the method inconsistently.[5] A partial explanation for the fact that EPI-CM data were collected less frequently than expected is that vaccination clinics in general were conducted less often than officially scheduled. Each functional CSCom was supposed to hold at least one day of fixed vaccination services at the health center each week, in addition to one to two days of vaccination outreach activities for a total of eight to twelve clinics per month. In reality, the average number of vaccination clinics conducted per month, according to tally data, was fewer than four. While fixed clinics were generally conducted more consistently than outreach clinics, they were periodically cancelled due to vaccine shortages, mass campaign activities, or staff absences.

Many CSCom went weeks or months without conducting any outreach activities. In the subset of vaccination clinic tally notebook data for which the type of vaccination strategy was recorded (1199 of 2912 clinics), only 32% of all clinics were outreach, as opposed to the expected

66-75%. Interruptions in outreach were explained by vaccine shortages, staff shortages, motorcycle fuel shortages, motorcycle breakdowns, CSCom director absences for routine monthly meetings and periodic trainings at the district reference hospital, weather and conflicts with other health facility activities. In a few health zones, conflicts between the CSCom and local communities were also cited as reasons that outreach activities were conducted infrequently. For example, in one village, leaders were upset by the fact that the CSCom was built in a neighboring village instead of in theirs. As a result they discouraged village inhabitants from going to the health facility, and banned EPI outreach activities within the village boundaries. In health zones where outreach activities were very rarely or never conducted, the lack of additional financial incentives for conducting outreach was commonly cited as a reason. Health workers reported that, in the past, they had been paid per diem for every day of EPI outreach. When these payments stopped, they stopped doing outreach regularly.

The irregularity of immunization activities, however, only partially explains the low number of EPI-CM tally records that were available at the CSCom in Segou. EPI-CM tally data were provided by CSComs for only 60% of the vaccination clinics for which EPI data were retrieved. Among the 24 CSCom that were able to locate any immunization tally data, six (25%) collected EPI-CM data during fewer than 20% of vaccination clinics while 14 (58%) collected EPI-CM data more than 80% of the time. Only five (21%) collected it during every vaccination clinic. Since EPI and EPI-CM tallies were recorded in the same notebook, it is unlikely that these results are an artifact of lost EPI-CM data. The available data suggest that the EPI-CM was generally performed more during fixed clinics than during outreach.

Qualitative interview and observation data suggest a number of reasons for the inconsistent and infrequent implementation of the EPI-CM even when EPI activities were conducted. The EPI-CM did introduce some logistical complications as it necessitated a change in usual EPI tally practices in Segou. Though WHO recommends that tallies be conducted at the same time that vaccines are administered, health workers in Segou generally completed all tallies

before vaccinating the first child of the day. Thus, rather than simply building on existing practice, the EPI-CM introduced a change in practice. In facilities with only two to three full-time staff, health workers found it difficult to manage the additional tasks associated with the EPI-CM while also vaccinating children and treating patients. Facilities with larger staff were able to divide the various tasks between different health workers. Additionally, the EPI-CM added substantial amounts of time to EPI clinics, particularly when attendance was high and the added time required to ask the EPI-CM questions was multiplied by as many as 100 times. Thus, health workers explained that they were more likely to conduct the EPI-CM when clinic attendance was low.

In some health zones, people other than those most directly involved in EPI clinics were the ones who attended the EPI-CM training, and they failed to transfer the knowledge gained to those who were ultimately expected to implement the EPI-CM. A few CPM sent substitutes to the training in their place and never made an effort to learn about the substance of the training, resulting in a total lack of supervision or oversight of EPI-CM activities conducted by vaccination technicians. There was one notable exception of a health zone in which the CPM held a debriefing meeting for the full CSCom staff following every monthly meeting and training held at the CSRef, during which cascade training and information transfer occurred. In this zone, even the temporary interns had a basic understanding of the EPI-CM processes and objectives.

Perhaps a more important influence on the consistency with which the EPI-CM was conducted was a lack of internal or external motivation on the part of health workers. Little attention was paid to the EPI-CM by supervisors at the district and regional levels, and thus health workers received little encouragement or pressure to collect the data. Few health workers seemed empowered to use the data or even fully understood the potential for the data to be used to help them improve their performance at the CSCom and community levels. Additionally, and probably most importantly, health workers were resistant to the fact that they were being asked to

do additional work without additional pay, especially as they knew that this was a pilot project and that their counterparts in other districts were not being asked to perform this additional task.

Variability in EPI-CM Data Collection between Clients During the Same Vaccination Clinic

Not only did health facilities implement the EPI-CM inconsistently between different days of vaccination activities, their practices varied between clients attending a given vaccination clinic.[6] Data were collected for at least one EPI-CM indicator during 74.1% (95% CI: 57.1, 91.1) of directly observed interactions between health workers and parents while the full set of EPI-CM questions was asked 64.5% of the time (95% CI: 48.2, 80.9).

Systematic observers also reported that the EPI-CM questions were phrased differently by different health workers, and sometimes even by the same worker with different clients. These differences changed the meaning of the questions, with implications for the interpretation of clients' responses. Qualitative interview data suggest that this was sometimes due to a lack of comprehension of the questions or the purpose of the EPI-CM on the part of the health worker, and sometimes due to increasing time pressure towards the end of the day of vaccinations. This pressure could be self-imposed, when health workers were in a hurry to finish work for the day, or externally imposed by mothers who complained about delays. Additional complications were introduced during translation into local languages which generally have more than one illness term corresponding to a given biomedical disease (Patterson et al., 2005). Whether a parent responded affirmatively to questions regarding a child's recent illness was likely to depend on the term applied by health workers. When health workers were themselves not fluent in the language spoken by the parent, they were less likely to ask the EPI-CM questions.

Monthly Variability in EPI-CM Data Collection across all CSCom in Segou District

On average, 15 CSCom (45%) collected EPI-CM data each month, but there was considerable fluctuation in the percentage of clinics during which the EPI-CM was conducted

from month to month (See Figure 5.2). The number of CSCom collecting EPI-CM data declined in December 2008, during a transition between district chief medical administrators, and again in August 2009, during the most intense period of the rainy season. There were increases in the percentage of facilities collecting the tally data in February, May and September of 2009. In February, the new district medical administrator received an orientation on the EPI-CM and began to follow-up on the related activities with CPMs. May and September were, respectively, the months during which supervision and refresher training activities were conducted.

Performance of the EPI-CM during outreach activities varied more from month to month than performance during fixed clinics, suggesting that health workers' ability and motivation to conduct the EPI-CM during outreach is more sensitive than EPI-CM during fixed clinics to external factors such as the weather and events such as refresher training, stand-alone mass vaccination and drug administration campaigns, and holidays. In addition, health workers are under more pressure to complete outreach vaccination clinics quickly, given that they generally conduct outreach in more than one village each day, and have to travel several hours by motorcycle over the course of the day.

Tailored Counseling and Communication with Clients

The frequency with which health workers communicated messages related to the prevention and treatment of childhood illnesses, and provided essential information about immunizations and vaccine-preventable diseases was significantly higher in the intervention district than in the comparison district (See Table 5.2). However, though statistically significant, the differences can be expected to have negligible public health significance (effects on behavior change). Communication about these topics in the intervention district was too infrequent and inconsistent to support any reasonable expectations of a significant impact on caregivers' health behaviors.

With regard to the three specific messages about mosquito nets and malaria treatment that health workers were instructed to provide, only 59 caregivers (6.0%, 95% CI: 3.0, 9.01) received messages about mosquito nets (many of whom were individuals who received nets during the clinic), only 12 individuals were told anything about chloroquine resistance (1.2%, 95% CI: 0.3, 2.1) and only three persons, over the course of the entire study period, were informed that malaria treatments for children are available at no cost at government health clinics and hospitals. There was a trend towards increased communication in the intervention district, but few of the differences were statistically significant and the percentage of parents receiving recommended counseling was still low.

A small subset of caregivers did receive some form of tailored counseling, loosely defined as receiving any information about a recommended behavior that the client had failed to perform. Of 234 observed caregivers in Segou who responded that their child had had a fever in the past few weeks, 51 (22%, 95% CI: 9.1, 34.4) were given advice regarding treatment, and 44 (26.2%, 95% CI: 9.8, 42.5) of the 168 caregivers whose children had not been treated for the fever were provided with instruction about treatment. Of the 93 individuals in Segou District who reported that their child had not slept under a mosquito net the previous night, 25 (26.9%) received information about the importance of sleeping under an insecticide-treated net every night, but this result should be interpreted with caution given the wide confidence interval around the point estimate (95% CI:8.8, 45).

It is important, to consider these results in light of the fact that many health workers reported using the EPI-CM as a screening tool for childhood illness. Recently ill children who had not previously been treated were immediately sent for a medical consultation. In CSCom where this was the practice, the vaccination technicians may have assumed that the necessary and relevant information would be provided in the context of those consultations, and thus did not always provide it themselves. Because this trend was not anticipated, it was not reflected in the

systematic observation checklist and thus there are no quantitative data to describe the percentage of clients who were sent on for additional consultations.

Monthly Reporting and Trend Monitoring

Submission of monthly reports. Monthly EPI-CM reports were only submitted by a subset of CSCom each month. Fewer than 50% of *all* CSCom, on average, and approximately 66% of functional CSCom, submitted their EPI-CM reports each month. Of the reports submitted, many were submitted late, sometimes even several months late. Many facilities submitted multiple missing reports all at once after a monthly meeting of CPMs during which the percentage of reports submitted by each CSCom to date was presented to the entire assembled group. In contrast, EPI reports were generally submitted by all functional CSCom each month, as the receipt of additional vaccine supply was linked to report submission.

There was a fair amount of variation, from month to month, in the percentage of CSCom submitting reports. For functional CSCom, the percentage of reports submitted each month ranged from 37-95%. Seven CSCom (21%) never submitted monthly reports (six non-functional and one functional), and only two submitted reports for all months. Among functional CSCom, the majority submitted at least 60% of the reports expected during the study period.

There were no negative consequences for the failure to submit EPI-CM reports on time, or at all, with the exception of the potential embarrassment experienced on the one occasion when the reporting rates were reported during the monthly meeting at the CSRef. There also were no positive incentives to submit these reports. There was some confusion about the relative responsibilities of the CPM and vaccination technician when it came to the collection and reporting of EPI-CM data, which could also explain failures to submit monthly reports. In one health zone it became apparent only at the end of the project that the vaccination technician had been diligently performing the EPI-CM, but the CPM had never submitted an EPI-CM report to the district level.

Discrepancies between data collected at the CSCom level and data reported to the district level. Comparisons of data submitted in monthly reports and data actively collected by the study team from CSCom tally notebooks revealed many differences between EPI-CM indicator values in the two sources. To begin with, much of the data could be found only in one source (tally notebook or monthly report), but not in both.[7] Observation and interview data indicated that this was likely due to a combination of poor data management and record keeping, health worker data entry and reporting error, and acts of resistance to the introduction of additional work without additional pay which took the form of fabricating or withholding of data.[8] In addition, the extent of the differences between what was recorded in the tally notebooks and what was reported in monthly reports varied across different EPI-CM indicators, suggesting that data for some indicators were easier for health workers to collect and tabulate than for others.

In addition to differences between the number of data points recorded in monthly reports and tally notebooks, there were also large discrepancies between the specific values of EPI-CM indicators in the two data sources. The analysis of the percent agreement between monthly totals submitted in monthly reports and those calculated from CSCom tally notebooks was limited to the subset of data points available from both sources: monthly reports and tally notebooks. The total number of report-tally pairs differed slightly for each EPI-CM question, demonstrating that some questions were asked more than others, and monthly data were submitted more frequently for some indicators than others. Figure 5.3 shows the overall percent agreement between monthly report data and tally notebook data for each EPI-CM indicator, as well as the average for all EPI-CM questions over the entire period of the study. When the EPI-CM indicators were assessed collectively, there was agreement between the values in the monthly reports and the values calculated from the tally notebook data 28% of the time (34% for functional CSCom). With the exception of the number of children who did not sleep under a mosquito net the previous night, agreement between tallies and reports was slightly better when the analysis was limited to functional health facilities, but remained below 40% agreement.[9]

The magnitude of the differences between the values reported in monthly reports and those calculated from the raw tally notebook data was often quite large (See Figures 5.4 and 5.5). Neither the values in the reports nor those in the tally notebooks were consistently higher than the others. This presents a challenge to the theory held by staff at the district reference hospital that health workers consistently inflate their results in monthly reports in order to create a picture of better health facility performance. The differences generally decreased over time, and the points at which the two sources of data demonstrated the greatest agreement generally corresponded to the months following supervision (May-June) and refresher training (September).

Quality of monthly report data and types of difficulties experienced by health workers in completing monthly reports. Close examination of the monthly reports raised a number of concerns about the quality of the data, and suggested that health workers had trouble following the instructions for completing the reports and performing the necessary calculations. The most common problem observed was a failure to accurately report the total number of negative responses to each question, in addition to the affirmative responses. Health workers often left these spaces blank, making it impossible to calculate denominators for certain indicators. Without the tallies for negative responses, it was not possible to determine the percentage of children who had had a specific illness in the past two weeks. There was also no way to differentiate between the children who did not have a fever, for example, and the children whose parent was not asked if they had had a fever (See Figure 5.6).

In addition, the reports revealed that health workers were not sufficiently aware of the distinction between a zero value and a missing value. Given that they were instructed to tally one response, either affirmative or negative, for each EPI-CM question for each parent, the sum of the affirmative and negative responses for each question should have been equal to the number of children vaccinated, and should have been equal across all EPI-CM questions. The sums of responses to the questions regarding illness and treatment were generally lower than the combined number of children who did and did not sleep under mosquito nets, and the totals

varied greatly between questions (See Figure 5.7). In many cases, the sum of positive and negative responses was zero even when large numbers of children were vaccinated on a given day, indicating that health workers had entered "0" rather than leaving the space blank to represent missing data.

Some monthly reports raised suspicions about falsified data. For example, for almost every month, one CSCom reported that the total number of children who had a fever was equal to the number of children with respiratory infections and equal to the number of children who had experienced recent diarrhea. The number of children who received appropriate treatment for fever was exactly the same as the number receiving appropriate treatment for respiratory infections and exactly the same as the number receiving ORS for diarrhea. The actual tallies in his EPI-CM notebook differed from the numbers he wrote in the reports. When asked about this, the vaccination technician explained that he had been instructed by his supervisor to fill out the reports in this way, and acknowledged that this was fictional data.

Graphing monthly trends in EPI-CM indicators. When asked about practices related to the graphing of EPI-CM data, 68% of the 24 CSCom directors who completed anonymous questionnaires at the end of the study reported that they had charted monthly trends in EPI-CM data on the graphs provided, and 60% indicated that they had posted those graphs in a visible location in their health center. However, when vaccination technicians from the same set of CSCom were asked the same questions, only 48% and 38% respectively replied affirmatively (N=21). Moreover, only one health facility of the 17 that received supportive supervision was observed to have completed and posted the graphs charting monthly trends in EPI-CM indicators. At the time of supervision (eight to ten months after the training), most were not able to locate the blank graph templates and many of the directors of the CSCom seemed to have forgotten that they were supposed to be graphing monthly trends. In contrast, the EPI graphs for charting vaccination coverage were visibly posted in most health facilities visited, with the exception of a few classified as "non-functional."

Applications of the Data in Program Management and Community Mobilization

Health workers at all levels had very limited understanding of the potential ways that one could apply data to tailor and improve routine programmatic activities at the community health facility level. There does not seem to be a strong existing culture of such data-driven practice in this region. During qualitative interviews, when health workers were asked to give examples of ways that they had used or applied the EPI-CM data, they responded almost without exception that the way they had *used* the data was to pass it on to the next level in the health information system. Vaccination technicians responded that they gave the data to the directors of the CSCom, either in the form of tallies or completed monthly reports. Directors of CSCom reported that they submitted data to the staff in the office of Health Information Systems at the district reference hospital. Health Information Systems staff responded that they had given it to the members of the research team. This trend was not limited to the EPI-CM data. When the new chief health administrator asked the directors of CSCom to develop microplans for the coming year, using routine data, very few complied with the request. At the monthly meeting during which they were supposed to present their microplans, it became apparent that most did not understand how to complete the assignment, did not know how to design activities based on their own data, and were accustomed to receiving standard programs of activities from above that they implemented without thoughtful or intentional modification.

There were exceptions, however. Staff from nine (53%) of the CSCom visited during routine supervision reported that they had discussed the EPI-CM results with community leaders to encourage them to mobilize the community to change behaviors related to child health, and said that they had developed specific programmatic activities based on the EPI-CM data. Staff from six of those facilities indicated that they had actually implemented the planned activities. In anonymous surveys, CSCom directors (N=25) reported that they had taken the following actions in response to EPI-CM data: developed a microplan for the health facility (60%), modified

outreach activities (56%), and discussed results with community health workers to motivate them and facilitate their work (84%). In addition, 72% of health center directors reported having discussed the data with members of the community health association. Only six (24%) of participating health facility directors reported that they did not use the data at all.

Observed applications of the data included some expected applications, such as using the data to inform decisions about the content and emphasis of health education sessions conducted at the health facility or during village outreach, but also a few unanticipated applications of the EPI-CM to improve health facility performance. As mentioned previously, at the six health facilities where intensive observations and interviews were conducted, health workers used the EPI-CM as a screening tool to identify sick children who had not yet received treatment for fever, respiratory symptoms or diarrhea. When these children were identified using the EPI-CM, they were sent to the director of the CSCom for consultation and treatment. From the health worker perspective, use of the EPI-CM to increase the reported treatment rates at the health facility was often the greatest perceived advantage of the method. Increased treatment rates lead to higher performance evaluation ratings and, importantly, to increased health facility revenue within the full cost-recovery health system. Many health workers also saw the EPI-CM as a tool for increasing health facility attendance. They felt that parents viewed it as an added service or benefit, which consequently increased satisfaction with the care provided. However, there was little concrete evidence that the EPI-CM had actually increased attendance, or that the EPI-CM actually influenced parents' motivation to attend vaccination clinics. When making this argument, the health workers mostly pointed to anecdotal evidence, or to increases in monthly attendance rates which were likely to be subject to much potential confounding by other seasonal factors such as weather, agricultural labor demands and road conditions.

There were essentially no applications of the EPI-CM data at levels higher than the CSCom. While the CSCom submitted monthly reports to the district health facility each month, they were placed in a folder and were rarely looked at by staff at the district level. The data were

not entered into a database, nor were they used in program management at this level. Because the project was a pilot operational research project, the staff at the district level seemed to feel little ownership of the data and was not motivated to find ways to analyze or apply it. Data managers vocalized a belief that the data belonged to the PI of the project, and not to them, despite efforts to encourage different views. The district level information systems staff expressed a need for more training on the management and analysis of monthly EPI-CM data than was provided.

Representatives from the regional health department were invited to offer feedback on the intervention tools and to attend trainings and meetings, but they only occasionally responded or participated. Conversations with regional health department staff indicated that this was at least in part due to the lack of a clear mandate from the Ministry of Health. While the project was approved by and developed in collaboration with the Ministry of Health and the National Center for Immunizations, and the project staff presented signed letters of approval to both the regional and district health offices, the national level did not communicate directly with the regional level about the project, its importance or the expected participation by regional level staff. Thus, regional representatives saw this project as a low priority given their numerous other activities and responsibilities. However, in the absence of a clear directive from the regional office and without regional office participation, health workers at the district level expressed some concerns about participating in the project and engaging actively with the data.

DISCUSSION

The EPI-CM offers many potential benefits as a monitoring tool program management tool and behavior change intervention, and theoretically should produce valid data in contexts where vaccination coverage rates exceed 70% (Cibulskis et al., 2012). However, the theoretical potential of the EPI-CM has little programmatic relevance if health workers are unable to implement the method as designed in actual field settings.

The results of this process evaluation in Segou, Mali suggest that it will be extremely difficult, if not impossible, to realize the potential benefits of the EPI-CM in the context of weak health systems in Sub-Saharan Africa. Mali has one of the better performing EPI programs in Sub-Saharan Africa and yet, even in this context, health worker implementation of the EPI-CM was poor. Health workers had difficulty balancing the demands of the EPI-CM with existing EPI activities, struggled to fill out monthly reports, were uncertain about the ways to directly apply the data at their level, and generally lacked motivation to implement the EPI-CM data, particularly in the absence of additional financial incentives to do so.

Inconsistencies in data collection, poor data management and storage practices, as well as limited health worker capacity to complete the simple tallies and basic calculations likely explain the finding that the EPI-CM data differed significantly (by more than +/- 10%) from household survey data (Wei et al., 2012a). Time pressures, logistical complications and language barriers contributed to the fact that the EPI-CM had little impact on the quality of health worker-client communication during EPI clinics. In the absence of improved communication, it is unsurprising that the EPI-CM had no effect on recommended child health behaviors (Wei et al., 2012b). Additionally, limited health worker capacity to analyze, interpret and apply data to inform programmatic decisions, as well as limited possibilities for bottom-up decision-making in Mali's hierarchical health system, meant that the potential for the EPI-CM data to be used for program management purposes was not realized. While this process evaluation provided some evidence that improvements in the performance of the EPI-CM are possible, especially immediately following additional training and supervision, these improvements would likely require prohibitively large inputs of human and financial resources.

Strategies for improving health worker performance of the EPI-CM suggested by this process evaluation include: 1) the printing and distribution of standardized EPI-CM tally forms and a register in which daily totals for each EPI-CM indicator would be recorded, 2) extended trainings for *all* health workers rather than cascade training, 3) frequent formative supervision

conducted at the health facility level with ample opportunities for health workers to practice EPI-CM activities, ask questions and receive feedback on their performance, 4) the provision of standardized databases for data entry at the district, regional and national levels, 5) additional workshops to help staff at all levels of the health system learn how to apply routine data to tailor programmatic activities and 6) performance-based incentives to encourage improved quality of implementation and reporting. All of these strategies would be associated with significant added implementation costs, and would like have limited effect without an overall strengthening of the health system, and a shift in organizational norms regarding the collection and application of data.

This findings of this process evaluation present important challenges for the key underlying assumptions of the EPI-CM: that the method will be relatively easy for health workers to implement and will not greatly overburden health workers, that the method will be a low-cost way to obtain valid and locally-relevant monitoring data and that health workers will be empowered to use the data to improve routine programmatic activities.

Strengths and Limitations of the Evaluation Design

The inclusion of a detailed process evaluation in this, the first ever systematic evaluation of the EPI-CM, made it possible to identify factors that could explain the failure to demonstrate that the EPI-CM produced valid data or had significant effects on child health behaviors or program management. The process evaluation data suggest limits for the interpretation of the quantitative findings, given that the intervention was not implemented as designed.

The continuous presence of the research team for the duration of the EPI-CM pilot period was both a strength and a weakness of the study. The extended exposure to the study team led health workers to develop a degree of familiarity and comfort with them which reduced the risks of observation bias when the study team collected data at the CSCom level. Health workers often failed to conduct EPI-CM activities even when members of the study team were observing, and spoke very openly with them about problems experienced with the EPI-CM and about their

frustrations with the expectations of additional work without additional pay. The fact that several health workers even openly admitted to falsifying data for EPI-CM tallies and reports further suggests that observation bias was likely to be minimal. Additionally, the extended continual presences of the study team allowed for an understanding of changes in EPI-CM performance over time, and the factors that could explain these patterns.

However, the presence of the study team served as a constant reminder that this was an operational research project rather than something introduced by the MOH as a routine activity, and may have led to a decreased sense of ownership of and responsibility for the data on the part of health workers at the CSCom and district levels. It also may have encouraged the sort of "everyday resistance" (Scott, 1986) demonstrated by the group of health workers who collectively agreed to stop collecting and reporting EPI-CM data when they finally understood that no additional financial incentives were forthcoming for this work. Because the PI for the project was based in the study district and had frequent contact with health facility staff, some health workers felt that this form of protest would effectively communicate their demands and encourage the project staff to locate additional funds to pay for the data that was, in a way, being "held hostage."

The research design called for a wide variety of data collection activities to be conducted during routine EPI clinics at the six CSCom selected for the intensive process evaluation. Data were to be collected throughout the year to capture any potential seasonal variations in behaviors and potential determinants of health worker performance. It was ultimately impossible to achieve the desired sample sizes for these activities due to the fact that far fewer EPI clinics were conducted than expected, and ultimately impossible to evenly distribute the days of data collection across seasons due to extended disruptions in EPI services. The gap between the desired sample size and the sample size obtained was greater for outreach clinics than for fixed EPI clinics. However, the inability to achieve target sample sizes for observations of EPI clinics and fever consultations was ultimately an important finding itself, as it revealed large differences

between the number of planned fixed and outreach EPI clinics planned for a given year and the number actually conducted, and highlighted factors that prevent health workers from adhering to the schedule for immunization activities.

CONCLUSIONS

Ultimately, the findings of this process evaluation, coupled with the results of the evaluations of the validity and effectiveness of the EPI-CM (Wei et al., 2012a; Wei et al., 2012b) do not support a recommendation for future applications of the EPI-CM as a routine child health monitoring and program management tool. However, even if the EPI-CM is never introduced at scale in Mali, it will still be important to address the various potential determinants of health worker performance identified during this process evaluation. The same factors that compromised the validity of the EPI-CM data are likely to have negative impacts on the quality of other data routinely collected at the community health facility level, including vaccination coverage data. The same factors that may explain the failure of the EPI-CM to improve child health behaviors are likely to influence the effectiveness of other health interventions delivered at the CSCom level, particularly those that are also delivered in the context of routine EPI clinics (including health education and LLIN distribution). This study contributes to growing understandings of the ways that factors at various levels influence health worker performance (Rowe, de Savigny, Lanata, & Victora, 2005), and highlights ways that various health systems components interact to influence the success of new interventions (de Savigny, 2009).

The findings of this study resonate with increasingly strong calls for improved and better coordinated health-systems strengthening activities (Sundewall et al., 2011). New tools for malaria monitoring and program management are essential to the success of the global malaria elimination and eradication efforts. However, in the absence of health systems strengthening, alternative monitoring strategies may more no more successful than the EPI-CM was found to be in this pilot study.

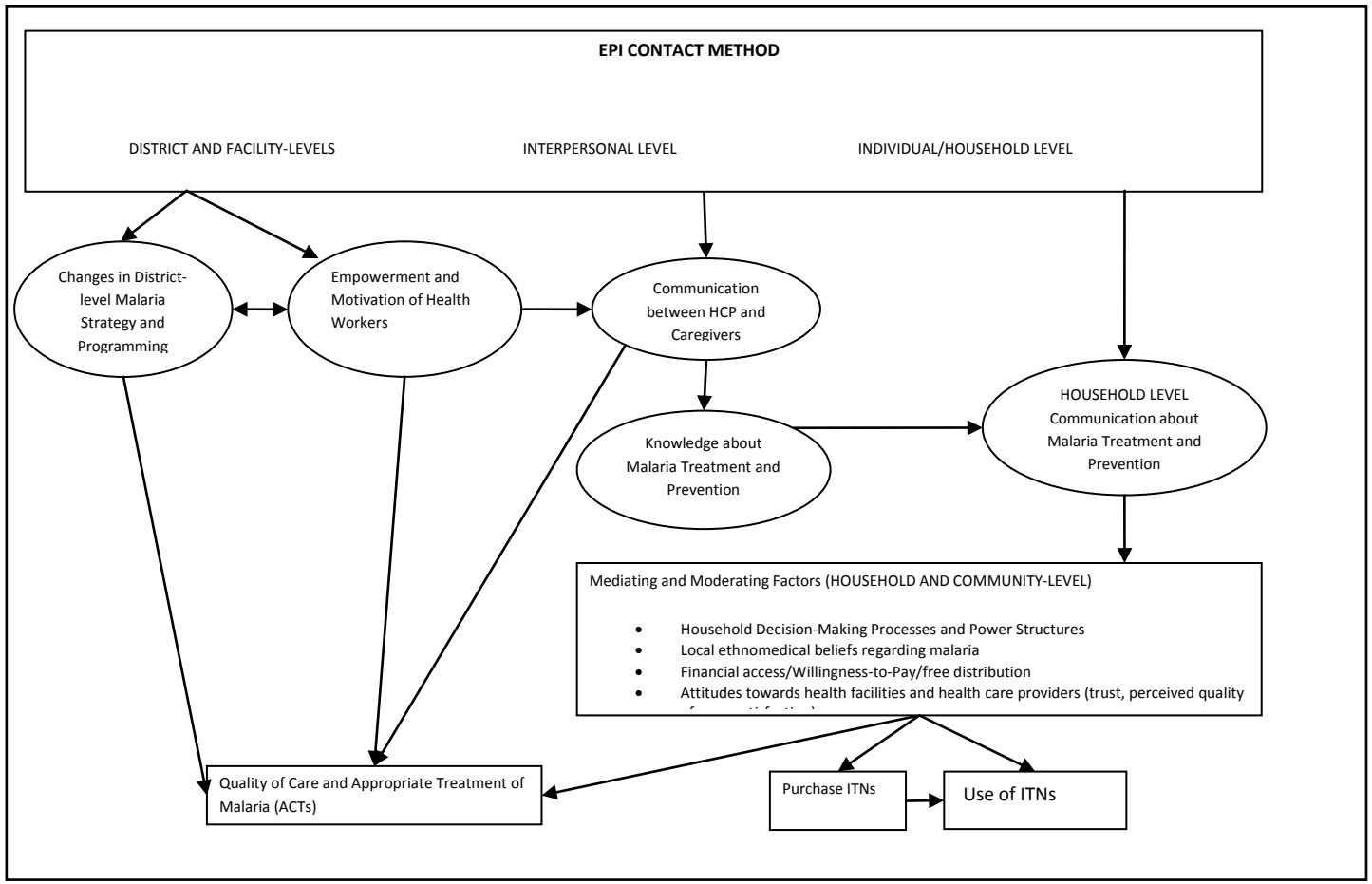

Figure 5.1 Multi-level Conceptual Model of the Effects of the EPI-CM

Table 5.1: Methods Overview

	Level	Sample	Type of Method
Passive collection of data from monthly reports and trimester reports	Office of health statistics; CSRef	All CSCom in Segou District (EPI-CM district)	Quantitative
Active collection of data from CSCom EPI-CM tally notebooks	CSCom	All CSCom in Segou District (EPI-CM district)	Quantitative
Anonymous health worker questionnaire	CSRef	24 CPM 21 vaccination technicians	Quantitative
Structured observations of EPI clinics	CSCom	Total =1,394 health worker-parent interactions (Segou, N=993; Baraoueli, N=401) during 42 different EPI clinics (18 fixed clinics, 24 outreach clinics).	Quantitative
Follow-up interviews with health workers who participated in observed EPI clinics	CSCom	31 health workers from nine CSCom	Qualitative
Follow-up interviews with parents who participated in observed EPI clinics	Village	50 parents from nine health zones	Qualitative
Semi-structured interviews with health workers	CSCom	CPM=12; Vaccination technicians=10; Maternity nurses=6; Medical intern=1	Qualitative
Key informant interviews	CSRef	Chief medical officer=1; Director of EPI=1; Doctors=4; Health information systems staff=2	Qualitative
Unstructured Observations	CSCom, CSRef	35 health zones (32 in Segou District, three in Baraoueli); 2 CSRef	Qualitative
Participant Observations	CSRef	EPI-CM trainings=3; EPI-CM refresher trainings=2; EPI-CM supervision visits=4; Monthly meetings of CPM at CSRef=7	Qualitative

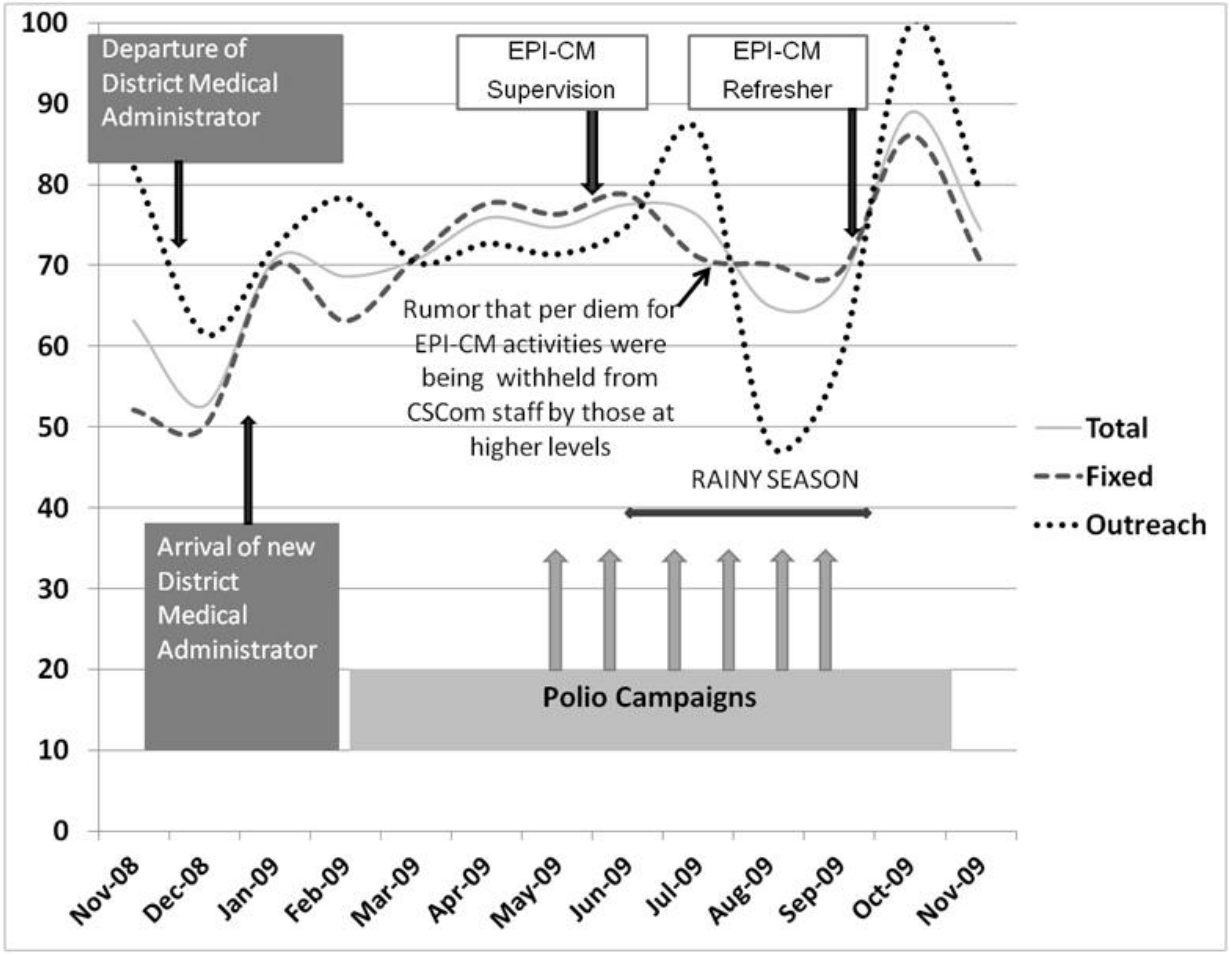

Figure 5.2 Variability in the Percentage of Vaccination Clinics during which EPI-CM Data were Collected

Table 5.2: Differences in the Information Communicated during Observed Vaccination Clinic Client-Provider Interaction in Segou (Intervention) and Baraoueli (Comparison) Districts

		INTERVENTION (Segou)		**COMPARISON (Baraoueli)**		
# of Observed Provider-Caregiver Interactions		993		401		
		% (#)	95% CI	% (#)	95% CI	p-value*
MALARIA COMMUNICATION	It is important to sleep under insecticide-treated mosquito nets.	5.9 (59)	2.9-8.9	2.2 (9)	0-7.0	1.1 (0.295)
	Chloroquine is no longer effective for the treatment of malaria in Mali.	1.2 (12)	0.5-1.9	0 (0)	-	-
	Malaria treatments for children are free at government health facilities.	0.30 (3)	0-0.65	0 (0)	-	-
	Any information about preventing malaria	6.4 (64)	3.10-9.79	2.2 (9)	0-7.00	2.033 (0.154)
	Any information about treating malaria	7.0 (70)	1.74-12.34	0 (0)	-	-
IMUNIZATION COMMUNICATION	Specific diseases the child is being vaccinated against	**27.8 (276)**	**14.5-41.1**	**7.2 (29)**	**0-19.0**	**3.995 (0.046)**
	Side effects of vaccines administered to child	4.6 (45)	1.6-7.6	7.1 (28)	0-16.4	0.341 (0.56)
	Date that the child's next immunizations are due	64.4 (639)	49.9-78.8	45.4 (182)	13.4-77.4	1.227 (0.268)

***** Rao-Scott Chi-square to adjust for clustering

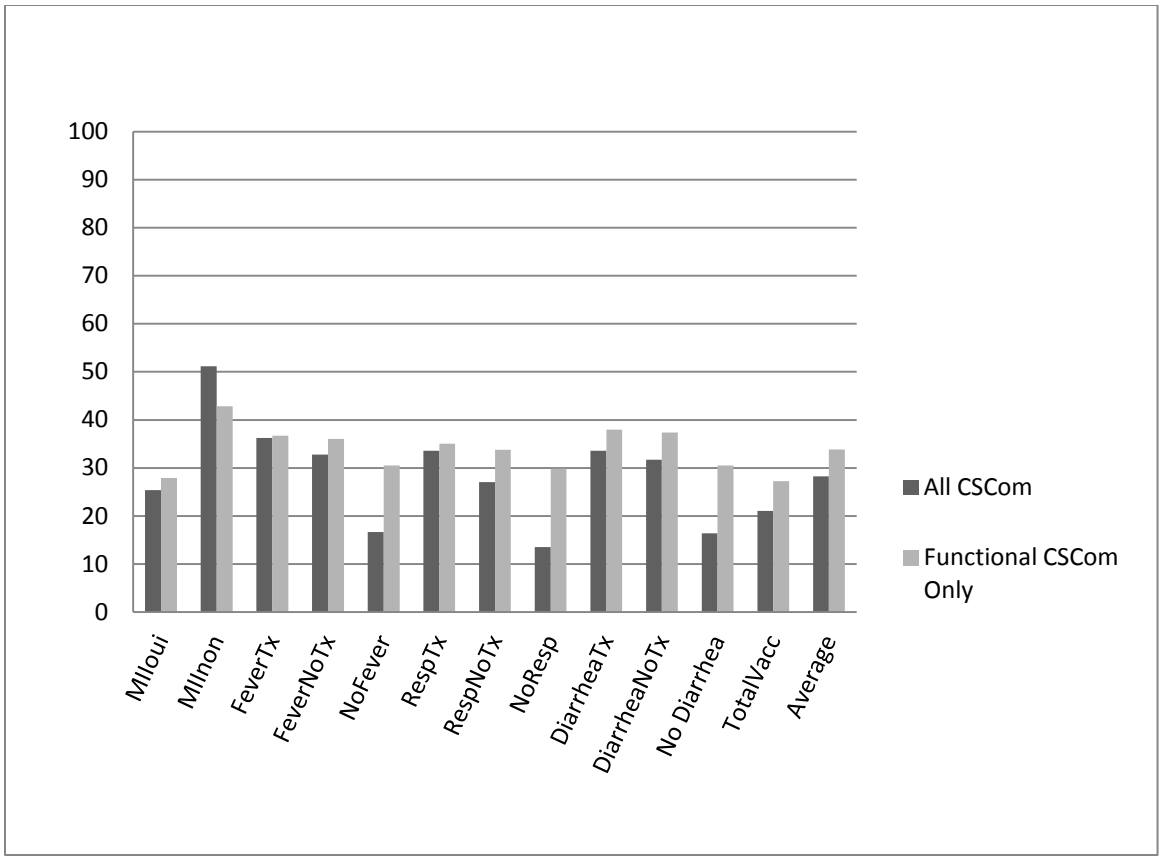

Figure 5.3 Percent Agreement between Monthly Totals for EPI-CM Indicators in Reports and Tallies (for the subset of monthly report values for which corresponding tally data could be located)

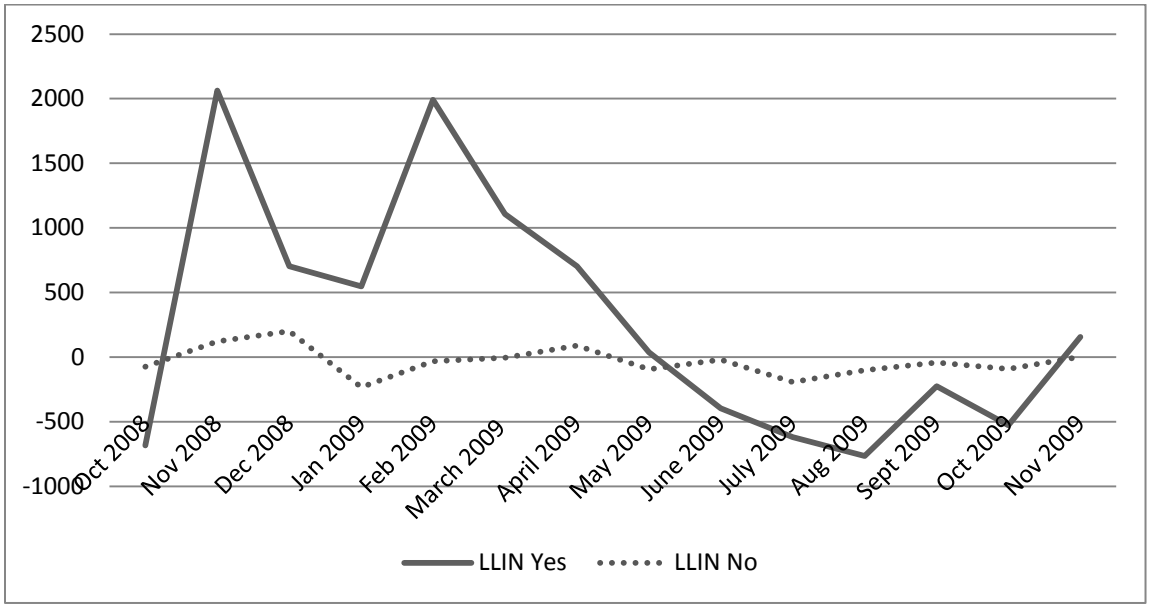

Figure 5.4 Differences between Monthly District Totals for the Number of Children who Slept Under a Net the Previous Night Reported in Monthly Reports and Calculated from EPI-CM Tally Notebook Data

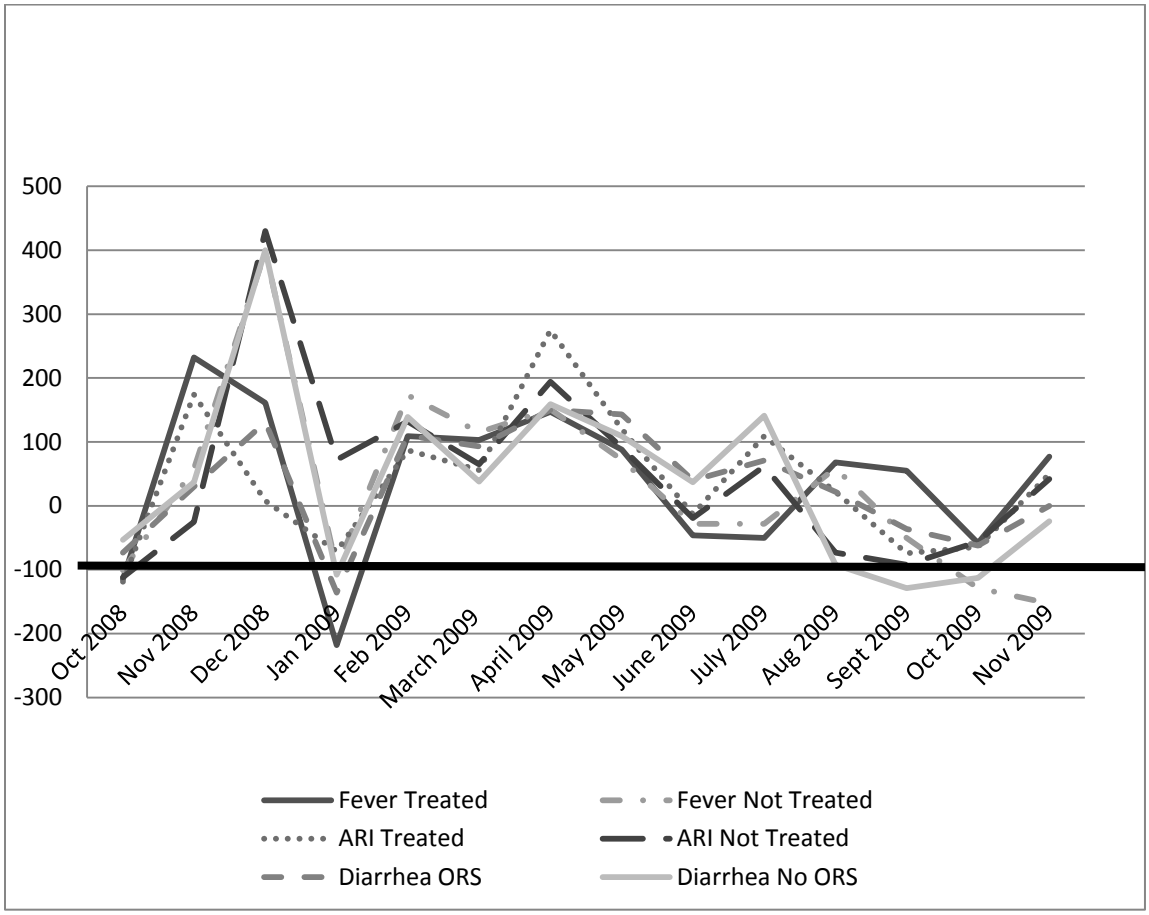

Figure 5.5 Differences between Monthly District Totals for EPI-CM Child Illness Indicators Reported in Monthly Reports and those Calculated from EPI-CM Tally Notebook Data

Groupe d'âge / Reponses Méthode Approche PEV et Vaccins			0 - 11 mois	12+ mois	Total (enfant)
Dormait sous moustiquaire la nuit dernière?			36	0	36
Pas dormait sous moustiquaire la nuit dernière ?			0	0	0
Fièvre pendant les deux semaines dernières?	Oui	Traitement approprié	8	0	8
		Traitement pas approprié	0	0	0
	Non		-	-	-
Toux ou respiration difficile pendant les deux semaines dernières?	Oui	Traitée à l'hôpital	23	0	23
		Pas traitée à l'hôpital	14	0	14
	Non		-	-	-
Diarrhée pendant les deux semaines dernières?	Oui	Traitée avec SRO	6	0	6
		Pas traitée avec SRO	0	0	0
	Non		0	0	0
BCG			36		
Polio 0			0		
Polio 1			10		
Polio 2			9		
Polio 3			7		
Hib1+DTC1-Hep B 1 (PENTA1)			10		
Hib2+DTC2-Hep B 2 (PENTA2)			5		
Hib3+DTC3-Hep B 3 (PENTA3)			7		
Rougeole			20		
Fièvre jaune			20		
Tétanos 1					
Tétanos 2					
Tétanos R					

Figure 5.6 Missing Values for Negative Responses in EPI-CM Tally Data

Groupe d'âge / Reponses Méthode Approche PEV et Vaccins			0 - 11 mois	12+ mois	Total (enfant)
Dormait sous moustiquaire la nuit dernière?			212	0	238
Pas dormait sous moustiquaire la nuit dernière ?			0	0	
Fièvre pendant les deux semaines dernières?	Oui	Traitement approprié	13	0	
		Traitement pas approprié	1	0	56
	Non		42	0	
Toux ou respiration difficile pendant les deux semaines dernières?	Oui	Traitée à l'hôpital	15	0	
		Pas traitée à l'hôpital	0	0	52
	Non		37	0	
Diarrhée pendant les deux semaines dernières?	Oui	Traitée avec SRO	3	6	
		Pas traitée avec SRO	0	0	51
	Non		48	0	

Figure 5.7 Failures to Differentiate between Missing Values and Zero Values in EPI-CM Tally Data

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Chapter 5 Notes

[1] This does not necessarily mean that the child received treatment based on the results of a diagnostic test, since health workers are still distrustful of RDT results and don't always have RDTs in stock. Presumptive treatment is still the norm in Segou. However, at authorized health facilities, there is at least a possibility of receiving a diagnostic test, which is not generally the case in private health facilities or shops.

[2] This study was initially planned as an "effectiveness study" which would evaluate the implementation of the EPI-CM in real world conditions. However, in order to ensure that sample size requirements were met for the planned analysis of the validity of the EPI-CM data, it was necessary to provide additional funding for supervision and refresher training beyond what would likely be available if the EPI-CM were to be implemented at the national level as part of routine health facility activities.

[3] The study protocol called for observations during 27 fixed clinics and 54 outreach clinics: one fixed clinic observation and two outreach clinic observation for each of the nine selected CSCom during each of the three main seasons (rainy, cold and hot). However, because of interruptions in EPI activities due to measles campaigns, vaccine shortages, holidays, health worker absences, and weather, it was not possible to observe the desired number of vaccination clinics. Extended disruptions of outreach activities made it particularly difficult to attain the desired sample of outreach clinics. Study staff called the directors (CPMs) or vaccination technicians of the six CSCom in Segou weekly to learn whether vaccinations would be conducted that week and adjusted their schedules whenever possible to attend if clinics were scheduled.

[4] The CPM for these facilities never asked the project staff for EPI-CM tally sheets, despite the fact that they saw members of the study team on an almost monthly basis at CPM meetings at the CSRef. The vaccination technicians in these facilities did not have regular contact with the project staff after the training, and thus didn't have the chance to raise this issue themselves.

[5] Given that CSCom are expected to conduct between 2-3 vaccination clinics a week, and that the EPI-CM was to be implemented during all vaccination clinics, EPI-CM data should have been collected during ~2688-4032 vaccination clinics (2-3 clinics a week x 14 months x 24 CSCom that were able to locate any tally data at the end of the study). However, EPI-CM tally data was only available for a total of 1096 vaccination clinics conducted by these facilities during this time period. Even considering the fact that data for some additional clinics may have been collected and subsequently lost, this number is far below what was expected and what would be desired for maximum validity and potential impact.

[6] Theoretically, the sum of the affirmative and negative responses tallied for a given EPI-CM question should be equal to the sum of response for each of the other questions, and should be equivalent to the total number of children vaccinated during the vaccination clinic. In contrast, within the tally data, the sums of positive and negative responses tallied for the EPI-CM questions frequently differed, and often quite dramatically.

[7] The total number of possible data points for EPI-CM indicator data is equal to the number of different EPI-CM indicators, multiplied by the number of months for which data were to be collected and reported, multiplied by the number of CSCom. For only 35% of all potential EPI-CM indicator data points were values available in both monthly reports and tally data (36% for functional CSCom). Values were missing in both sources for 40% of all expected data points

(23% for functional CSCom). For 18% of the data points with values recorded in the tally data, no values were reported in monthly reports (23% when limited to functional CSCom). For 14% of the data submitted in monthly reports (Functional CSCom=19%) no corresponding tally data could be located, a fact that certainly reflects the fact that health workers misplaced some of their tally data prior to the end of the project but also validates reports by health workers (in qualitative interviews and anonymous surveys) that either they themselves or their colleagues had fabricated EPI-CM data for the monthly reports.

[8] The presence of data in tally notebooks but not in monthly reports reflects the fact that some spaces were accidently left blank during the completion of monthly reports but also corroborates reports in qualitative data that some of the CSCom directors (CPM) decided to stop submitting reports at a certain point, despite the fact that vaccination technicians were still collecting data. This act of resistance was agreed upon by a subset of CPMs as a method of protesting the fact that there were no additional financial incentives provided for EPI-CM data collection.

[9] While it is impossible to rule out the possibility of mathematical error on the part of the research assistant who entered the data from tally notebooks into the handheld computer, the fact that the agreement was a bit better for the subset of functional CSCom suggests that these results reflect actual differences between the data in tally notebooks and the data in monthly reports, due to health worker error. One would expect interviewer error to remain relatively consistent between functional and non-functional CSCom, and thus, if his errors were completely responsible for the disagreement, one would not see this trend. In addition, the research assistant had a number of advantages that were likely to reduce the likelihood of error on his part, which the vaccination technicians did not benefit from. He had a university education, had access to a calculator and was able to perform these calculations in relative quiet with no competing tasks or obligations to distract him. In contrast, many vaccination technicians have at most a high school education, do not have consistent access to calculators and often are interrupted in the middle of completing reports by routine health center activities or patient demands.

CHAPTER 6

Summary and Conclusions

SUMMARY OF RESULTS AND RECOMMENDATIONS

The global malaria community has recently renewed its commitment to the ambitious goals of malaria elimination and eventual eradication (Campbell & Steketee, 2011; Enayati & Hemingway, 2010; Greenwood et al., 2008; Mendis et al., 2009; Tanner & de Savigny, 2008). Long-lasting insecticidal nets will continue to play an important role in the malaria strategic plan, both for countries in the elimination phase and those that are still pursuing malaria control, though there is little expectation that they will be able to interrupt transmission alone, in the absence of other technologies (Alonso, Besansky, et al., 2011; Alonso, Brown, et al., 2011; Beier et al., 2008; Moonen et al., 2010). A number of significant outstanding questions and challenges pertaining to LLIN distribution, behavior change interventions to encourage people to sleep under LLINs consistently, and the measurement and monitoring of LLIN ownership and use must be addressed before it will be possible to realize the full potential benefits of LLINs. New challenges have been introduced by the fact that more and more countries have begun to move away from a focus on vulnerable groups (pregnant women and children under-five) and to adopt universal LLIN coverage strategies.

Each of the three papers comprising this dissertation responded to a subset of these key questions and challenges related to global efforts to scale-up LLIN ownership and use, using data collected during a multi-phased mixed methods study conducted at multiple levels of the health system in Segou District, Mali from August 2008 to December 2009. The first paper focused on the advantages and disadvantages of a particular LLIN delivery strategy: integrated LLIN distribution and vaccination service delivery. The second responded to questions about the best ways to encourage consistent and appropriate use of LLIN by all members of the population in the context of recent transitions to “universal coverage” policies. Finally, the third addressed the

topic of monitoring and evaluating LLIN distribution programs, with particular attention to challenges associated with obtaining high quality, timely and locally-relevant LLIN data to guide programmatic decisions and tailor interventions.

The in-depth study of integrated LLIN distribution and EPI services identified a number of potential positive and negative synergies and cascade effects associated with the linking of the two interventions. The integrated delivery system has likely played an important role in the scale-up of both interventions. However, the data also illustrate a number of ways that problems related to one linked intervention can lead to significant challenges and possibly to reduced effects for the other. For example, barriers to vaccination clinic attendance that are specifically related to the costs, inconveniences or perceived risks associated with vaccinations become barriers to accessing a bed net. Calculations used to estimate vaccine needs, coupled with anxieties about vaccine wastage, limit eligibility for vaccines, and therefore LLINs, for certain groups of children. Challenges associated with calculating and allocating LLIN stock needs on a monthly basis for distribution through EPI clinics can result in stock-outs and anxieties about stock-outs, both of which result in inconsistencies and inequities in LLIN distribution, leading to the widespread view in Segou, Mali that "one gets a bed net by chance." Stock-outs of LLINs can lead to fluctuations in vaccine clinic attendance patterns and thus introduce additional challenges for vaccine stock management. In Segou, much more emphasis was placed upon the importance of achieving vaccine coverage targets than LLIN coverage targets in supervision and reporting activities. This likely at least in part explains limited attention to malaria during health education activities, and limited efforts to retroactively distribute LLINs to those who encountered a stock-out during EPI clinics.

The results of this study highlight possible ways that the outcomes of both EPI and LLIN activities are influenced by a wide variety of health systems factors related to health facility financing and management, information systems, availability of essential commodities, transparency and accountability, and the size and capacity of the work force on the outcomes of

each linked intervention and the relationships between them. Understanding and addressing these factors will be essential to maximize the benefits of linked interventions and minimize the unintended negative effects.

The findings presented in this paper suggest the need for a dramatic transformation of the discourse surrounding "wastage" and stock-outs in the context of EPI and LLIN distribution programs if health workers are to adhere to WHO guidelines for EPI and maximize the number of children protected by both vaccines and nets. This transformation could begin with a number of concrete changes to reporting formats and the equations used to estimate stock needs. Programmatic recommendations include the development of standard procedures for LLIN distribution to those who encounter stock-outs during EPI and ANC clinics, and the introduction of an established rotating schedule of topics for health education that sufficiently addresses the topics of LLIN distribution policies, self-efficacy and skills building for net hanging, social support for net use and appropriate LLIN maintenance.

The second paper presented findings on determinants of LLIN use among all segments of the population which can help to guide behavior change interventions in the context of Mali's current transition to a universal LLIN coverage strategy. In the context of the strong pre-existing culture of net use in Segou, attitudes towards LLINs are already very positive and the universal LLIN distribution campaigns are likely to be well-received. Access to an LLIN was described as the primary determinant of LLIN use, and the unavailability of a net was considered by many participants to be the only understandable and justifiable reason that a person would sleep without a net. Barriers to net use that have been commonly reported elsewhere, including heat, allergic reactions to insecticides, and lack of knowledge do not seem to be particularly important in Segou. However, even in this context where the reported norm is that everyone with access to a bed net uses it, there are a number of interrelated factors that can intermittently interrupt net use among usual net-users, leaving them vulnerable to malaria and thus perpetuating the cycle of malaria transmission.

Among the factors most commonly reported to inhibit or interrupt net use among individuals with access to a net in Segou were fatigue and travel. The impact of fatigue is likely to be moderated by the amount of time and energy required for an individual to prepare his or her net for sleeping. This in turn is largely determined by the type and location of a person's sleeping space. Social support, either in the form of direct assistance in hanging nets or reminders and information about the importance of using nets, could help people overcome the barriers to net use. Elevated mosquito abundance seems to be a strong enough motivator of net use to overcome most inhibiting factors. The culture of net use in Segou differs from that described in many other contexts in that nets are reportedly used throughout the year, though the primary motivators of net use differ seasonally.

Qualitative data collected in the context of this study can inform the development of better quantitative measures and scales to assess the determinants of net use. These would facilitate subsequent statistical testing and mathematical modeling of the hypothesized relationships between the factors included in the proposed explanatory model of net use.

The results of this research on LLIN use suggest a number of strategies for future interventions. Social behavior change strategies could focus on skills building and modeling to reduce the amount of time and hassled required to hang a net and increase social support for net use. Behavior change messages could be tailored to different seasons and highlight incentives for net use other than those related to malaria prevention. However, many of the identified potential determinants of net use are intermittent and recurrent, and are likely to be more difficult to change through intervention than the usual targets of knowledge and attitudes. The added benefits of consistent net use by all people, regardless of age, every night, and during every season of the year, may not justify the extreme effort and expense that will likely be required to attain full universal use, particularly in light of the fact that LLINs are far from 100% efficacious. Alternative vector control strategies and improved housing should be considered, particularly in light of the fact that these activities can be organized and conducted by communities, building on

existing community practices related to hygiene and the tradition of communal and cooperative labor in Mali society (Brock, Coulibaly, Ramisch, & Wolmer, 2002; Dembele, 1981; Lewis, 1978; N'Diaye, 1970; Paques, 1954; Toulmin, 1992).

The findings of process evaluation of the EPI Contact Method suggest that it is extremely unlikely that health workers in the context of relatively weak African health systems will be able to implement this method with sufficient fidelity for it to realize its promise as a valid, less costly, timely and locally-relevant alternative to large-scale representative household surveys. Health workers at the community health facility level found the method difficult to implement, and health personnel at all level were lacking the capacity, the motivation or the empowerment required for them to effectively utilize the EPI-CM for program management purposes. The quality and consistency of implementation of the EPI-CM varied greatly between months, between health facilities and even within a single day of vaccination clinic activities. These variations suggest that the validity of EPI-CM data is likely to be strongly influenced by variables such as weather and road conditions, vaccination clinic attendance rates, periodic mass campaigns, health worker absences for trainings and meetings, health facility staffing shortages, health facility financing, and the availability of financial or other incentives for health workers. Likely due to logistical, social and language constraints, the EPI-CM had no significant effects on communication between parents and health workers, which may explain the absence of significant behavior change in the district where the method was piloted (Wei et al., 2012b).

Though future implementation of the EPI-CM is not recommended, the factors identified as potential determinants of health worker performance of the EPI-CM are likely to have cross-cutting effects on other data collection and intervention activities at the community health facility level. In particular, the problems pertaining to extended interruptions in routine services, poor data storage and management, data entry errors and limited capacity to analyze and interpret data for improved program management should be addressed. In addition to improved training, pay-for-performance strategies should be considered to address problems with the consistency and

quality of data collection and reporting, as well as to encourage cascade training (Flodgren et al., 2011; Van Herck, Annemans, De Smedt, Remmen, & Sermeus, 2011). Potentially more significant challenges are related to health worker's resistance to conducting additional work during EPI clinics without additional pay, and the various strategies they employed in passive protest (fabricating data, deciding not to submit reports, etc.). While these actions on the part of health workers in Segou were likely due at least in part to the fact that this was an operational research project, they raise questions about the limits to the number of interventions that can be integrated with EPI activities without compromising the quality and effectiveness of all interventions.

Collectively, these three papers contribute to debates and discussions regarding the best ways to measure LLIN ownership and use and highlight limitations of current indicators. The data collected in Segou present challenges for interpreting differences between rates of LLIN ownership (measured at the household level) and LLIN use (measured at the individual level). Differences between the two are often reported as evidence of individual barriers to LLIN use *other than access to a net*, revealing implicit assumptions that nets counted at the household level are equally available for use by all individual household members and that the number of nets distributed to each household according to the national strategy will be sufficient to cover all individuals. The data from Mali challenge these assumptions, indicating that variability in intrahousehold access to a net may explain much of the gap between household net ownership and individual net use.

People in Segou described a strong culture of net use and indicated that the only reason someone would sleep without a net is that he or she didn't own one. In this context, nets are considered individual property, rather than household goods, likely due in part to the fact that they are distributed to individual pregnant women and children as "rewards" for attending ANC or EPI clinics, but also to the somewhat sensitive and personal nature of all things related to beds, given their association with sex. A net is considered the property of the woman who received it

during a campaign or routine distribution, and it is generally she who decides who will use it and when. Given inconsistencies and interruptions in LLIN distribution activities, women are not confident that they will be able to receive another net in the future, and thus may be inclined to keep extra nets in storage rather than sharing them with other members of the household. This has the potential to limit the number of total household members who will be able to sleep under a net, regardless of the number of nets owned at the household level. These proprietary attitudes towards nets, and the issues of inequitable intrahousehold access to nets will need to be carefully considered when deciding how to distribute LLINs in the context of the new universal coverage strategy which allocates one net for every two people in a household.

Comparisons of data on net use obtained using a variety of different methods in the context of this research also highlight the limitations of self-reported survey data for estimating rates of net use and identifying key targets for behavior change interventions. Estimates of net use obtained through the household survey were over 90%, while reported net use in EPI-CM data was close to 100%. Participants in the survey reported few barriers to net use. Data from the qualitative interviews and focus groups suggest that these high rates are likely at least in part the product of social expectations and perceived norms surrounding net use, and the realistic fear of being subjected to criticism, blame and humiliation by interviewers or health workers if one admits to not using a net. Participants in qualitative interviews almost all initially claimed to sleep under a net every night. It was only with extensive probing follow-up questions that women began to admit that there were certain conditions in which they slept without a net and to describe the various barriers to net use, illustrating differences between self-reports of normative general behaviors and actual individual practices. One suggestion for increasing the validity of self-reported survey data on net use is to ask individuals to report the last time they slept *without* a net and to describe the factors contributing to that event. An alternative to standard surveys would be to engage community members in routine household monitoring of LLIN ownership and use. People may be willing to speak more honestly about their net use with peers with whom

they have established relationships, and such community volunteers may be better able to discern when a person is giving a socially desirable rather than factual response. Unannounced nighttime spot-checks of net use, which have been used to validate self-reports of net use in other contexts (Frey, Traore, De Allegri, Kouyate, & Muller, 2006), are unlikely to be well received in this conservative culture where people are uncomfortable even talking about the fact that men and women share a sleeping space, let alone being observed to do so.

STRENGTHS AND LIMITATIONS OF THE STUDY DESIGN AND METHODS

The complex mixed methods research design employed for this project facilitated a detailed understanding of the influence of numerous socio-cultural and health systems factors on LLIN distribution, use and monitoring at different levels of the health system, and permitted the identification of potential seasonal differences in these factors. The triangulation of methods, data sources, data collection points and investigators provided built-in validity checks, and allowed for the development of more nuanced understandings of the phenomena of interest than would have been possible otherwise. Qualitative data helped to explain quantitative findings pertaining to net ownership and use, while survey data were used to assess the representativeness of preliminary conclusions of qualitative research. However, the complexity of the research design and the enormous volume of data collected also led to significant challenges for training the research assistants, coordinating data collection activities at community health facilities, and managing and analyzing the data.

The sampling strategy and sample size calculations were driven by the primary objectives of evaluating the validity and effectiveness of the EPI-CM (Wei et al., 2012a; Wei, et al., 2012b). As a result, the majority of participants in qualitative interviews were female and belonged to the subset of the population that regularly attends EPI clinics. These individuals have greater access to LLINs than other members of the population, likely have more positive attitudes towards health workers, health facilities and biomedicine, and may be more inclined to comply with

recommendations for nightly net use. The qualitative data suggest that determinants of LLIN use are likely to vary between adult men and women, but the perspectives of men were inadequately represented in this sample so as to facilitate a strong understanding of these differences.

In order to compensate for the sampling limitations, discussion groups were conducted with men and women recruited at the community level and research assistants were instructed to purposively select individuals represented a wide range of experiences, ages, ethnic groups and occupations. However, the questions regarding LLIN use, malaria treatment and malaria communication would have been better addressed in both qualitative and quantitative data collection activities with an equal sample of men and women of all ages recruited at the community level, and purposively selected so as to include both individuals who seek care at the community health facility and those who do not. In the context of the shift to universal coverage, it will be essential to begin including men and women of all ages in the samples for all large-scale representative surveys on net ownership and use behaviors and well as to conduct more qualitative research with men.

Methodological challenges associated with social norms and communicative culture in Mali

Social norms and customs regarding communication and public behavior present a number of challenges for the collection of qualitative data in rural Malian settings.[1] Women in general, and particularly young women, are very reluctant to speak in the context of interviews or discussion groups (This hesitation also extends to participation in health education sessions at the community health facilities.). When explicitly asked about this, participants in qualitative data collection activities explained it in terms of *la honte* (shame or embarrassment). The discourse of female study participants and EPI clinic attendees was frequently punctuated by nervous laughter and awkward pauses. Health care providers, village leaders, older women and the Malian research staff all linked the reluctance to speak and the pervasiveness of *la honte* among young women to their lack of practice with public speaking, and their associated anxiety about

publically humiliating themselves. In Malian culture, young women are generally discouraged from speaking publically, particularly in front of their elders or people who are seen as their social or intellectual superiors (e.g. doctors or researchers). In Segou, women are also much less likely to have attended school than men, which means that they also have had fewer opportunities to develop the habit of responding to interrogative questions and are potentially less confident in their opinions.

In light of this, the experience of this study suggests that in-depth interviews and traditional discussion groups may not be particularly appropriate or effective among young rural Malian women, and that data collection methods should be modified to reflect culturally specific ways of learning and communicating information (Briggs, 1986). The interview data from young rural women was dominated by brief, generic, socially-appropriate responses. The same qualitative research team obtained detailed and rich responses from men and older women, indicating that the source of the sparse interviews with young mothers is not located entirely with the interviewers and discussion facilitators. Given the cultural communication norms and practices, traditional embedded ethnography is likely to be a much more effective approach to learning about the thoughts, attitudes, beliefs and behaviors of young mothers as it provides an opportunity for the researcher to establish rapport with participants as well as to observe what women do rather than what they say that they do. However, in the context of public health research, with its demands for timely and representative data, few projects can employ such an approach. Thus, it may be necessary to rely more on key informant interviews with individuals likely to have extensive knowledge of the community, or to engage respected community members to conduct systematic observations in their villages. A possible alternative to the discussion group or one-on-one interview could be the use of “dyads” (interviews conducted with two individuals simultaneously). If women in this context (and other similar ones) are able to choose one friend to participate in a conversation with an interviewer, they may be more at ease than when one-on-one or in a larger group. Additionally, if the women are friends, they may be

more likely to challenge or build upon each other's responses, creating a more detailed and nuanced understanding of particular events or attitudes.

Challenges associated with the pilot nature of the EPI-CM project.

The fact that this project was a small operational research project, conducted in a single district, and administered by a doctoral student presented a number of challenges for evaluating the EPI-CM. The study was originally designed to be an effectiveness study, designed in accordance with expectations about the way the intervention would be funded and implemented if introduced on a national scale. This meant that the training was facilitated by members of the Ministry of Health whose own experience with the EPI-CM was limited and was conducted in the language and pedagogical style they were most comfortable with, which may not be the ones most suited for adult learners in Mali. There were expectations that participants in the training would conduct cascade trainings for others at the CSCom level, that health workers would do the additional work without additional financial incentives, and that supervision of the EPI-CM would be conducted in the context of routine integrated supervision activities, without additional funding. In the context of this pilot project, none of these expectations were fully realized. This is likely due to attitudes towards operational research at multiple levels of the health system. Health worker behaviors were also likely influenced by the continuous presence of the research team in the intervention district.

While the Ministry of Health, as well as the National Center for Immunizations and the National Malaria Program gave their official authorization for the project and signed off on the training materials and reporting forms, this did not translate to active buy-in, likely due to the small-scale operational nature of the project and the fact that it was not associated with any additional revenue for the Ministry. They did not directly communicate with the regional or district levels about the importance and relevance of the project. Without a strong mandate from the national level, there was not only a lack of motivation to engage actively in project activities

at the regional and district levels, but also some expressed anxiety about the extent to which they should become involved.

At the district and community health facility levels, there was widespread awareness among health workers that this was a pilot project and that their counterparts in other districts were not being asked to do this additional work. This led to expectations of additional financial incentives for every day of EPI-CM data collection and, in the absence of these incentives, to resentment and acts of passive resistance on the part of some health workers.

At all levels, there was a pervasive view that this was "the American's" project, that the data belonged to "the American," and that the potential value of the project was for "the American." Ministry of health staff did not seem to recognize or value the potential opportunity to use the resulting EPI-CM data themselves, or to learn about operational issues related to multiple programs. The PI on the project ("the American") periodically asked staff at the national, regional and district levels if there were any additional topics or questions they would like added to the data collection instruments that would increase the utility of the research for them, but they never took advantage of the offer. The lack of active engagement in the implementation and supervision of the EPI-CM on the part of district and regional staff was likely at least in part because PI was known to be a doctoral student conducting the operational research as a dissertation project. Within the context of the Malian organizational culture, students at any level are often referred to as "stagières" (interns), and as such are assumed to have limited knowledge and expertise, and generally have little authority.

Involving the staff at the district and regional levels, as opposed to only the national level representatives, in the early decision-making processes and engaging their input on training materials and data collection forms from the very start, would likely have increased buy-in at these levels and encouraged better supervision and performance monitoring of the CSCom staff. Additionally, the district and regional level staff would likely have anticipated many of the challenges experienced in the context of this pilot project and could potentially have helped the

research team to address them in advance. If the staff at these levels had a better understanding of the EPI-CM and the project, they also may have been more able and more likely to use the resulting data to inform programmatic decisions.

CONCLUSIONS

These papers all illustrate the potential impacts of complex interactions between health systems and socio-cultural factors on the successful delivery, uptake and evaluation of interventions, and highlight the importance of "systems thinking for health systems strengthening" (de Savigny, 2009). In Segou, many of the observed challenges for LLIN distribution and monitoring in the context of EPI clinics had much more to do with weaknesses in health systems components generally than with the specific nature of each of these linked interventions and their suitability for integration with EPI activities. Many of the specific problems identified relate to current policies and practices for the procurement, management and reporting of vaccine and LLIN stock, and highlight the need for a dramatic transformation in the discourse about stock-outs and wastage. In addition, the papers collectively illustrate the need for better tools for measuring and monitoring net ownership and use in order to guide distribution practices and better understand the true barriers to net use. The qualitative findings presented here can help guide the development of such measures in the future. In the context of the transition to universal LLIN coverage, more thought needs to be given to intrahousehold variation in access to the nets owned by members of the household and the implications for calculations of the number of nets to distribute to a household and for delivery strategies.

Ultimately, LLINs alone are unlikely to be sufficient to interrupt malaria transmission given the complexities of the relationships between parasite, vectors and human hosts, as well as the challenges associated with achieving consistent use of LLINs by all people, every night, over any sleeping space, during all seasons of the year. However, LLINs will remain an essential tool in the global malaria elimination strategy and the results of this field work in Mali can help to

inform decision-making regarding some of the key outstanding questions and challenges related to the delivery, uptake and evaluation of LLIN distribution activities.

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Chapter 6 Notes

[1] Public speaking in Mali is considered to be a very powerful thing with the potential for dramatic consequences, and is thus addressed carefully and with respect. For this reason, the responsibility for speaking during ceremonies or celebrations was traditionally assigned to members of a specific caste, the *nyamakala*, which includes bards, blacksmiths and potters, who are more resilient to the potential negative ramifications of the power unleashed by public speech. Historically, each noble (*horon)* family was associated with a family of *griots* (bards) (Conrad & Frank, 1995). The *horon* family supplied all of the *griots* basic (and many non-basic) needs, in exchange for public speaking and mediation services. While this tradition has weakened, there is still a great reluctance to speak publicly if one is not confident in one's public speaking ability or does not have much experience with public speech.

Annex 1: Acronyms

ACT	Artemisinin-based Combination Therapy
ANC	Antenatal Care
BCC	Behavior Change Communication
BMGF	Bill and Melinda Gates Foundation
CQ	Chloroquine
CSCom	Centre de Santé Communautaire (Community Health Center)
CSRef	Centre de Santé de Référence (District Reference Hospital)
CPM	Chef du poste médicale
EIR	Entomological Innoculation Rate
EPI	Expanded Program for Immunizations
EPI-CM	Expanded Program for Immunizations Contact Method
GMAP	Global Malaria Action Plan
IEC	Information, Education, Communication
IPTp	Intermittent Preventive Therapy in Pregnancy
IRS	Indoor Residual Spraying
IVM	Integrated Vector Management
ITN	Insecticide-Treated Nets
LLIN	Long-Lasting Insecticidal Nets
M&E	Monitoring and Evaluation
MDA	Mass Drug Administration
MDG	Millenium Development Goals
MERG	Monitoring and Evaluation Reference Group
NGO	Non-Governmental Organization
NMCP/PNLP	National Malaria Control Program/Program National pour la Lutte Contre le Paludisme
OR	Operational Research
PMI	President’s Malaria Initiative

PSI	Population Services International
RBM	Roll Back Malaria
R&D	Research and Development
RDT	Rapid Diagnostic Test
SLIS	Local Health Information System *(Système Local d'Information Sanitaire)*
SSA	Sub-Saharan Africa
SUFI	Scale-Up for Impact
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization

Annex 2: EPI-CM Data Collection and Reporting Forms

Feuille de Pointage PEV plus Méthode Approche PEV

Aire de Santé :_____ Date de la séance :_____

Fixe – Nom de Centre :_____ Avancée/Mobile – Nom de Post :_____

ENFANT			**Enfants 0-11 mois**		**Enfants 12+ mois**	
			Pointage	**Totale**	**Pointage**	**Totale**
Moustiquaire nuit dernière - **Oui**						
Moustiquaire nuit dernière – **Non**						
Fièvre pendant 2 semaines dernières	Oui	Traitée avec médicament approprié				
		Pas traitée avec médicament approprié				
	Non					
Toux ou respiration difficile pendant 2 semaines dernières	Oui	Traité au CSCom, CSRef ou hôpital				
		Pas traité au CSCom, CSRef ou hôpital				
	Non					
Diarrhée pendant 2 semaines dernières	Oui	Traitée avec SRO				
		Pas traitée avec SRO				
	Non					
BCG						
Polio 0						
Polio 1						
Polio 2						
Polio 3						
PENTA 1						
PENTA 2						
PENTA 3						
VAA						
VAR						

FEMMES ENCEINTES	**Pointage**	**Totale**
VAT1		
VAT2		
VAT3		
VAT4		
VAT5		
Total VAT		
Total VAT2+VAT3+VAT4+VAT5		

Rapport Mensuel PEV plus Méthode Approche PEV (2 pages)

Région / District :_____ **PROGRAMME ELARGI DE VACCINATION**

Cercle / Commune :_____

Centre de santé : _____ **Nom et prénom du CPM :** _____

Mois:_____ **Ans:**_____ **Nombre de cartes délivrées :----**_____

Groupe d'âge / Reponses Méthode Approche PEV et Vaccins			0 - 11 mois	12+ mois	Total (enfant)	Femmes enceintes	Femmes non enceintes	Total (Femmes)	# de flacons utilisés	# de doses administrées
Dormait sous moustiquaire la nuit dernière?										
Pas dormait sous moustiquaire la nuit dernière ?										
Fièvre pendant les deux semaines dernières?	Oui	Traitement approprié								
		Traitement pas approprié								
	Non									
Toux ou respiration difficile pendant les deux semaines dernières?	Oui	Traitée à l'hôpital								
		Pas traitée à l'hôpital								
	Non									
Diarrhée pendant les deux semaines dernières?	Oui	Traitée avec SRO								
		Pas traitée avec SRO								
	Non									
BCG										
Polio 0										
Polio 1										
Polio 2										
Polio 3										
Hib1+DTC1-Hep B 1 (PENTA1)										
Hib2+DTC2-Hep B 2 (PENTA2)										
Hib3+DTC3-Hep B 3 (PENTA3)										
Rougeole										
Fièvre jaune										
Tétanos 1										
Tétanos 2										
Tétanos R										

VITAMINE A	Nombre d'enfants ayant reçu la Vitamine "A"	Nombre d'enfants ayant reçu la 2ème dose Vitamine "A"	Nombre de capsules distribués	
			100000 UI	200000 UI
6 - 11 mois				
12 - 59 mois				
FPPI				

PALUDISME: Ruptures de Stock			
CTA 1 (enfant)		TDR	
CTA 2 (adolescent)		Giemsa	
CTA 3 (adulte)		Lames	
Quinine		MII	
SP			

Code des ruptures: 0 = pas de rupture, <1 = moins que une semaine, >1 = p

Distribution des Moustiquaires	**Fixe**	**Avancée**	**Totale**
CPN			
PEV Routine			
Autre			

Signature du médecin-chef:_____ Date:_____

Tendances par rapport au % utilisation des MII – ENFANTS 0-11 MOIS, par mois, année: _____,

centre de santé:_____

% couverture		___% enfants 0-11 mois, fixe							---- % enfants 0-11 mois, avancée				
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

	1	2	3	4	5	6	7	8	9	10	11	12
a) Stratégie Fixe: Enfants 0-11 mois, sous MII (Numérateur)												
b) Stratégie Fixe: Enfants 0-11 mois, enfants vaccinées - totale (Dénominateur)												
c) 0-11 mois: % sous MII : stratégie fixe												
d) Stratégie Avancée: Enfants 0-11 mois, sous MII (Numérateur)												
e) Stratégie Avancée: Enfants 0-11 mois, enfants vaccinées – totale (Dénominateur)												
f) 0-11 mois: % sous MII : stratégie avancée												

Tendances par rapport au traitement de la fièvre– ENFANTS 0-11 MOIS, par mois, année: _____,													
Centre de Santé:_____													
	___ % enfants 0-11 mois, fixe								---- % enfants 0-11 mois, avancée				
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

		1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe : Enfants 0-11 mois, traitement approprié (Numérateur)													
Stratégie Fixe : Enfants 0-11 mois, fièvre (Dénominateur)													
0-11 mois : % traitement approprié : stratégie fixe													
Stratégie Avancée : Enfants 0-11 mois, traitement approprié (Numérateur)													
Stratégie Avancée : Enfants 0-11 mois, fièvre (Dénominateur)													
0-11 mois : % traitement approprié : stratégie avancée													

Tendances par rapport au traitement d'IRA– ENFANTS 0-11 MOIS, par mois, année: _____,

Centre de Santé :_____

	___ % enfants 0-11 mois, fixe							--x-- % enfants 0-11 mois, avancée					
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

	1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe: Enfants 0-11 mois, traitement au Centre de Santé												
Stratégie Fixe: Enfants 0-11 mois, IRA												
0-11 mois: % traitement approprie : stratégie fixe												
Stratégie Avancée: Enfants 0-11 mois, traitement au Centre de Santé												
Stratégie Avancée: Enfants 0-11 mois, IRA												
0-11 mois: % traitement approprié : stratégie avancée												

Tendances par rapport au traitement de la diarrhée– ENFANTS 0-11 MOIS, par mois, année: _____,													
Centre de Santé:_____													
	___ % enfants 0-11 mois, fixe							--x-- % enfants 0-11 mois, avancée					
Couverture (%)													
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

		1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe: Enfants 0-11 mois, SRO (Numérateur)													
Stratégie Fixe: Enfants 0-11 mois, diarrhée (Dénominateur)													
0-11 mois: % traitement approprie : stratégie fixe													
Stratégie Avancée: Enfants 0-11 mois, SRO (Numérateur)													
Stratégie Avancée: Enfants 0-11 mois, diarrhée (Dénominateur)													
0-11 mois: % traitement approprié : stratégie avancée													

Tendances par rapport au % utilisation des MII – ENFANTS 12+ MOIS, par mois, année: _____,

centre de santé:_____

% couverture		___% enfants 0-12 mois, fixe							---- % enfants 0-12 mois, avancée				
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

	1	2	3	4	5	6	7	8	9	10	11	12
a) Stratégie Fixe: Enfants 12+ mois, sous MII (Numérateur)												
b) Stratégie Fixe: Enfants 12+ mois, enfants vaccinées - totale (Dénominateur)												
c) 12+ mois: % sous MII : stratégie fixe												
d) Stratégie Avancée: Enfants 12+ mois, sous MII (Numérateur)												
e) Stratégie Avancée: Enfants 12+ mois, enfants vaccinées – totale (Dénominateur)												
f) 12+ mois: % sous MII : stratégie avancée												

Tendances par rapport au traitement de la fièvre– ENFANTS 12+ MOIS, par mois, année: _____,													
Centre de Santé:_____													
	___ % enfants 12+ mois, fixe							---- % enfants 12+ mois, avancée					
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

		1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe : Enfants 12+ mois, traitement approprié (Numérateur)													
Stratégie Fixe : Enfants 12+ mois, fièvre (Dénominateur)													
12+ mois : % traitement approprié : stratégie fixe													
Stratégie Avancée : Enfants 12+ mois, traitement approprié (Numérateur)													
Stratégie Avancée : Enfants 12+ mois, fièvre (Dénominateur)													
12+ mois : % traitement approprié : stratégie avancée													

Tendances par rapport au traitement d'IRA– ENFANTS 12+ MOIS, par mois, année : _____,													
Centre de Santé :_____													
	___ % enfants 12+ mois, fixe							--x-- % enfants 12+ mois, avancée					
100	-												
90	-												
80	-												
70	-												
60	-												
50	-												
40	-												
30	-												
20	-												
10	-												

		1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe: Enfants 12+ mois, traitement au Centre de Santé (Numérateur)													
Stratégie Fixe: Enfants 12+ mois, IRA (Dénominateur)													
12+ mois: % traitement approprie : stratégie fixe													
Stratégie Avancée: Enfants 12+ mois, traitement au Centre de Santé (Numérateur)													
Stratégie Avancée: Enfants 12+ mois, IRA (Dénominateur)													
12+ mois: % traitement approprié : stratégie avancée													

Tendances par rapport au traitement de la diarrhée– ENFANTS 12+ MOIS, par mois, année: _____,

Centre de Santé:_____

___ % enfants 12+ mois, fixe | --x-- % enfants 12+ mois, avancée

Couverture (%)												
100	-											
90	-											
80	-											
70	-											
60	-											
50	-											
40	-											
30	-											
20	-											
10	-											

	1	2	3	4	5	6	7	8	9	10	11	12
Stratégie Fixe: Enfants 12+ mois, SRO (Numérateur)												
Stratégie Fixe: Enfants 12+ mois, diarrhée (Dénominateur)												
12+ mois: % traitement approprie : stratégie fixe												
Stratégie Avancée: Enfants 12+ mois, SRO (Numérateur)												
Stratégie Avancée: Enfants 12+ mois, diarrhée (Dénominateur)												
12+ mois: % traitement approprié : stratégie avancée												