A voucher scheme for insecticide treated nets in Ghana: development of a methodology for delivery systems evaluation

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Statement of own work

I, Jayne Webster, confirm that the work presented in the thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. I acknowledge the work of Dr Margaret Kweku and Thomas Aguro in co-ordinating the fieldwork for the household surveys, the findings of which are presented in Chapter 4 and Chapter 5.

Signed:..... Date:.....

Jayne Webster, August 2011

Abstract

The key to effective scaling-up of coverage with insecticide treated nets is multiple effective delivery systems that are complementary, each one adding incrementally to the overall coverage. Generally, individual systems have been studied. A methodology is needed for studying the effectiveness of individual delivery systems, mixes of delivery systems and their relative contribution to coverage within a defined delivery system context. The insecticide treated net voucher scheme in two regions of Ghana provided an opportunity to develop a method of delivery systems evaluation.

The thesis consists of eight chapters. Chapter one is the introduction, and chapter two a review of the literature on the delivery of ITNs. Chapter three presents the study justification, aim, objectives, conceptual framework, a description of the study setting and the methods used in the study.

The thesis has four results chapters. In the first of these the quantitative coverage outcome evaluation of the voucher scheme is presented. Delivery attribution is used to evaluate the success of the voucher scheme. In the second results chapter, the intermediate processes in the delivery system are defined and the effectiveness of each one is assessed overall and by geographic area and socio-economic groups. In the third results chapter, qualitative methods are used to interpret the quantitative findings and to describe and explain the impact of the delivery systems context on the effectiveness of the intermediate processes of the voucher scheme. In the fourth of the results chapters' recommendations on a methodology of delivery system evaluation for ITNs and other public health interventions are made.

The final chapter is a discussion of the findings of the study in the two regions of Ghana and their implications for the evaluation of delivery systems for ITNs and other public health interventions particularly in relation to malaria control.

Summary

The aim of the study was to develop a methodology for delivery systems evaluation through the experience of evaluating an ITN voucher scheme in Volta and Eastern Regions, Ghana.

Outcome and process evaluations of the voucher scheme were undertaken through regionally representative pre- and post- implementation household surveys in each region. The source of the mosquito net and use of a voucher in its purchase was used to attribute the mosquito net to the voucher scheme. Qualitative interviews with a range of providers were undertaken to understand the context within which the voucher scheme was implemented and contextual changes that occurred during this period.

In Volta region, ownership of mosquito nets rose from 38.3% pre-implementation to 45.4% ($p=0.06$) post implementation of the voucher scheme. Formal private sector nets purchased with a voucher subsidy reached 6.5% of households. In Eastern Region, the proportion of households owning at least one net increased during the implementation of the voucher scheme from 15.0% to 26.0% ($p<0.001$). However, formal private sector nets purchased with a voucher subsidy reached only 0.5% of households. In Volta and Eastern Region, two delivery processes were ineffective. Just 40.7% and 21.1% of eligible pregnant women were offered a voucher at ANC in Volta and Eastern Regions respectively. Amongst those women who received a voucher, 36.0% and 30.7% used the voucher to purchase a mosquito net. A range of contextual factors were found to have influenced the effectiveness of the voucher scheme.

The ITN voucher scheme was not effective in increasing household ownership of mosquito nets in Volta and Eastern Regions during the evaluation period. There were two processes that were ineffective which were the offer of the voucher to a pregnant woman and the use of the voucher by the woman in exchange for a mosquito net. Inclusion of questions on source of an ITN in a household survey can be used to attribute an ITN to a specific delivery system, to enable a plausibility inference on the effectiveness of a delivery system in the context of the presence of multiple delivery systems. A mix of quantitative and qualitative process evaluations can provide evidence on the effectiveness of intermediate processes within the delivery system and reasons for loss of effectiveness in these processes.

Table of Contents

Acronyms

3ie	International Initiative for Impact Evaluation
ACSD	Accelerated Child Survival and Development
ACT	Artemisinin Combination Therapy
ANC	Antenatal Clinic
CBO	Community Based Organisation
CI	Confidence Interval
CMO	Context-Mechanism-Outcome
CMS	Central Medical Stores
CWC	Child Welfare Clinic
DALY	Disability Adjusted Life Year
DfID	Department for International Development
DHMT	District Health Management Team
DHS	Demographic and Health Surveys
DOT	Directly Observed Treatment
DPT	Diptheria Pertussis Tetanus
EPI	Expanded Programme on Immunisation
fANC	Focussed Antenatal Care
GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
GHS	Ghana Health Service
GMP	Global Malaria Programme
GSMF	Ghana Social Marketing Foundation
IMCI	Integrated Management of Childhood Illness
IPTc	Intermittent Preventive Treatment of children under5 years of age
IPTi	Intermittent Preventive Treatment for infants
IPTp	Intermittent Preventive Treatment for pregnant women
ITN	Insecticide Treated Net
KINET	Kilombero and Ulanga Treated Net Project
LCS	Licensed Chemical Seller
LLIN	Long Lasting Insecticidal Net
LGA	Local Government Authority
MCH	Maternal and Child Health
MDG	Millennium Development Goals

MICS	Multiple Indicator Cluster Surveys
MIS	Malaria Indicator Surveys
MoH	Ministry of Health
MRC	Medical Research Centre
MSH	Management Sciences for Health
NGO	Non-governmental Organisation
NID	National Immunisation Day
NMCP	National Malaria Control Programme
PATH	Programmes for the Assessment of Technology in Health
PCA	Principal Components Analysis
PSI	Population Services International
RBM	Roll Back Malaria
RCT	Randomised Controlled Trial
RHD	Regional Health Directorate
SES	Socio-Economic Status
SMITN	Social Marketing for ITNs project
SMOPH	Senior Medical Officer for Public Health
SP	Sulphadoxine-pyrimethamine
SPA	Service Provision Assessment
TNVS	Tanzanian National Voucher Scheme
UN	United Nations
UK	United Kingdom
UNICEF	United Nations Childrens' Fund
USAID	United States Agency for International Development
USD	United States Dollar
WHO	World Health Organization

List of Tables

List of Figures

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Chapter 1: Introduction

1.1 Delivering Insecticide treated nets

In the poorer countries of the world, a large proportion of child mortality is caused by a few preventable diseases. Effective interventions against these diseases exist [1], but the Millennium Development Goal (MDG) of reducing child mortality by two-thirds by the year 2015 will not be achieved unless there is a massive increase in the coverage of these interventions [2], especially in the poorest and most vulnerable groups [3]. One of these interventions is insecticide treated nets (ITNs) which have been shown to reduce child mortality by approximately 20%, saving 6 lives for every 1,000 under-five children protected per year in countries of sub-Saharan Africa [4-5]. ITNs have been shown to be cost-effective with an estimated cost per disability adjusted life year (DALY) averted of USD48 [6]. However, coverage of ITNs, defined as use by children under 5 years of age is currently low at 20% across 21 countries in the World Health Organization (WHO) African Region [7]. Use of ITNs by pregnant women is lower at 17% across 32 countries of sub-Saharan Africa for which data is available [8]. We need to ensure that we are not only able to increase global and regional coverage, but that we are also able to sustain this increase over time.

Global goals for ITN coverage have been a moving target over the last decade, firstly in terms of the proportion of the target population who should be covered, and more recently in the definition of the target population. In April 2000 the Heads of State, and other senior government officials, of forty four malaria endemic countries in Africa signed the Abuja Declaration by which they agreed to seek to achieve that "at least 60% of those most at risk of malaria, particularly pregnant women and children under five years, benefit from the most suitable combination of personal and community protective measures such as insecticide treated mosquito nets by 2005" [9]. By 2004 it was already clear, based on coverage measured using surveys conducted between 1997 and 2001[10], that this target would not be met in the majority of African countries. Despite the challenges in achieving the Abuja targets, a 2005 World Health Assembly resolution urged member states to aim to achieve that 80% of those at risk from malaria should benefit from major malaria control interventions, including ITNs by 2010 [11]. In 2006, an ITN Position Paper from the WHO Global Malaria Programme (GMP) began to address the emerging debate on the target group

for delivery of ITNs. This position paper recommended targeted distribution of ITNs to pregnant women and children under five years in areas of perennial malaria transmission, and delivery to the total population within defined high risk geographic areas, in unstable malaria transmission areas. [12]. In April 2008, the UN Secretary-General Ban Ki-Moon called for universal coverage with ITNs by 2010 [13]. The shift in strategy from targeting those at greatest biological risk to "universal coverage" was formalised later in 2008 with the publishing of the Global Malaria Action Plan. This plan was in essence, a global strategy for the achievement and maintenance of universal coverage with malaria control interventions, including ITNs, for the total population at risk [14].

Historically, mosquito nets were sold in markets in Africa and Asia long before the development of the new technology of ITNs [15]; these nets were untreated, unsubsidised and seen as a consumer good rather than a public health product. ITNs were originally provided free by researchers to selected populations taking part in efficacy trials, and were therefore mainly delivered by research teams, free of charge [16-20]. These efficacy studies confirmed ITNs as a powerful intervention for reducing child morbidity and mortality [4] and were followed by effectiveness studies to determine impact under programme conditions [21-24]. Effectiveness studies involved a variety of delivery systems, the first one being The Gambia National ITN Programme [22], where insecticide was delivered free (though charges were implemented subsequently) to treat mosquito nets purchased through the retail sector. The focus of both efficacy and early effectiveness studies was impact of ITNs on malaria morbidity and mortality; the systems through which the ITNs were delivered were not evaluated.

In order to increase coverage of ITNs, the systems through which they are delivered must reach the total target population, at the frequency required to maintain coverage. Typically delivery systems have two components: (1) the channels through which a product moves from the national level to the end user; and (2) the strategies applied to facilitate movement of the product from step to step of the delivery channel. The delivery channels may be within the public sector such as antenatal clinics (ANC) and campaigns, the private sector such as Licensed Chemical Sellers (LCS), or composed of a mix of the two such as voucher schemes, which deliver a voucher through the public sector delivery channel which is redeemed at private retail sector outlets. The strategies to facilitate movement of the product applied to

these channels include pricing policies (level of subsidy), the type or brand of product, the extent and form of training and motivation of health workers, the formulation and packaging, and the nature of promotion activities.

The details of the strategies may vary with different interventions, for example formulation and packaging applies more to drug based interventions than other types of intervention. There are therefore a multitude of potential delivery systems for most public health interventions and most interventions will be delivered at any one time through more than one delivery system (different channels, strategies, or both). A public health programme such as a malaria control programme will consist of multiple interventions delivered through a multitude of delivery systems.

In comparison with other public health interventions, ITNs are delivered through a diverse range of systems, probably due to their being both a health intervention and a household good. With a diverse range of possible systems for delivering ITNs the key is a co-ordinated national strategy. The delivery systems within this strategy should be complementary, that is the addition of a second system should result in incremental additional coverage, relative to the first system. Additional delivery systems that share the existing coverage with little or no increase in coverage will lead to a loss in efficiency.

Debates have raged over the last two decades on the most effective systems through which to deliver ITNs. The debates have broadly centred upon the level of subsidy and the resulting price to the end user [25-26], the utility of the private sector and public-private partnerships [27], the socio-economic disparities in coverage achieved by different delivery strategies [28-31], and the relative merits of campaign and routine delivery systems within the public sector [29, 32-33]. Campaign delivery has included piggy-backing ITNs onto measles campaigns [28, 34], polio campaigns [35] and integrated child health campaigns including ITNs, measles vaccination, vitamin A and mebendazole [36]. Routine delivery has mainly been through ANC and the expanded programme on immunisation (EPI).

Much of the focus of implementation and resources over the last 5 years shifted to campaign delivery with comparatively little attention paid to routine systems. It was accepted, however, that 'one strategy will not fit all' for delivery of ITNs [12] that the key to success is

diversity in delivery [37] and that both campaign and routine systems were needed. Whilst acknowledging the successes of campaign systems in the rapid scale-up of coverage with ITNs, there is a recent push for the use of a more equal share of resources for continuous delivery systems for ITNs to those that have been made available for campaigns [38]. The term routine delivery system was replaced by 'continuous delivery systems' as routine is often considered synonymous with the public health system whereas the ongoing or continuous delivery of ITNs may include other sectors such as the commercial sector. As the focus shifts to continuous delivery systems it will be important to evaluate different delivery systems in order to determine 1) the most effective and equitable mix of delivery systems to ensure coverage of the target group; 2) the mix of delivery systems that are complementary rather than competitive; and 3) factors that facilitate effective implementation by providers within delivery systems and rolling out of effective delivery systems at a national scale.

1.2 Approaches to evaluation

Several approaches including programme evaluation, complex interventions evaluation, realist evaluation, impact evaluation, process evaluation and theoretical approaches to intervention adoption have been applied to evaluate the effectiveness of interventions within routine programmes. Although these approaches are developed to evaluate the effectiveness of the intervention itself, several methodological elements of these approaches could be applied to evaluate delivery systems.

Three types of programme evaluation have been defined based upon the strength of inference of the causal relationship between the interventions that are implemented and the outcomes. In increasing order of complexity and strength of inference, these are adequacy, plausibility, and probability evaluations [39]. Probability evaluations are randomised controlled trials (RCTs) that are typically used to determine the efficacy of interventions. This experimental study design with randomisation of participants to the intervention and control groups has strong internal validity as this focuses on the effect of the intervention on pre-defined health outcomes in a specific study population. This does not, however, provide sufficient insight into why the intervention may or may not work in different settings. A multitude of contextual factors will impact upon the effectiveness of the intervention when it is implemented under routine operational conditions [40]. The use of RCTs has been said to strip away the context such that the findings are only relevant to other 'context-less'

situations [41]. Furthermore, differing levels of inference are required depending upon the evaluation objectives; therefore experimental design and randomisation, essential to probability evaluations, is not always necessary, nor feasible.

Plausibility evaluations are studies with non randomised control groups to evaluate the effects of an intervention implemented in a routine programme. This design measures an effect that can be attributed to a specific intervention over and above the effect due to other interventions and external factors in a given context. The strength of the plausibility inference varies depending to a large extent upon the nature of the control group and its ability to control for confounding factors. Control groups may be historical, internal or external. Typically historical controls are the same population in which an intervention is introduced but the outcomes are measured prior to implementation of the intervention. Varied types of internal control groups are possible but are generally constructed from among those in the target population who should have, but did not, receive the intervention; alternatively, an internal control group can take the form of groups that received varying "doses" or intensities of the intervention allowing for the testing for a dose response relationship between the intensity of the intervention and the outcome achieved. The most common form of external control groups is comparable geographic areas which do not receive the intervention.

Adequacy evaluations evaluate whether required changes have taken place over time [39]. For ITN programmes these evaluations require the setting of targets for a level of coverage to be achieved, or for an increase in coverage. No attempt is made in adequacy evaluations to attribute outcomes to interventions.

Complex interventions are broadly defined as interventions that contain several interacting components within a causal pathway, all of which influence the final outcome measure [42]. The causal pathways of public health interventions are relatively long, and each of the intermediate processes that form the pathway need to be effective to translate efficacious interventions into effective interventions. The complexity of the relationship between the intervention and the outcome increase when a delivery system has a long causal pathway with several intermediate processes. The effectiveness of intermediate processes should therefore be addressed in evaluations. The United Kingdom (UK) Medical Research Council (MRC) developed a framework in 2000 [42-43] for evaluating complex interventions which

has since been updated [44]. More recently this definition was expanded by Shiell *et al* who suggested that the complexity is not just due to multiple components but also to having the properties of complex systems which undergo constant change in non-linear ways [45]. The MRC guidance stresses the use of experimental designs with randomisation whenever possible, and recognises the value of process evaluation to inform on how and why an intervention is successful or fails. The concept of complex evaluations is often attributed to this guidance and the recommendations of the guidance applied to programme evaluations. However, the guidance was developed for the evaluation of 'complex interventions' in the context of 'proof-of-concept', rather than for programme evaluation. Consequently, there are limitations in the applicability of this methodology to programme and to delivery system evaluation.

Both the programme evaluation and the complex interventions evaluation acknowledge the need to understand the processes, or intermediate steps, involved in reaching the intervention outcomes. Delivery system evaluation too, should not be just measuring the overall outcomes but should also assess the functions and relationship of individual processes within a delivery system and investigate the effectiveness of each of these processes. In order to increase the effectiveness of the delivery of efficacious interventions all of the intermediate steps in delivery must be effective. Investigating each of the intermediate steps enables the identification of ineffective processes and therefore the design of interventions targeting improvement of specific processes. Quantitative process evaluation may be used to identify processes which are not effective and qualitative methods may then explore the underlying cause of lack of effectiveness. The context within which an intervention is delivered may influence both the effectiveness of the intervention and the system through which it is delivered. Context is a non-specific term which covers a wide-ranging array of factors. For malaria control interventions, these include but are not exclusive to, malaria epidemiology, policies, demographics, health system factors, health facility factors, health worker factors, the intervention complexity, and the delivery systems context.

Contextual factors were brought directly into the evaluation framework by Pawson and Tilley in their realist evaluation approach [46]. Realist evaluation looks at how a programme works, for whom and in what circumstances, based upon the assumption that outcomes of a programme are explained by the action of specific mechanisms in specific contexts. Realist

evaluation may be seen as a recent interpretation of a theory driven approach to evaluation [47] where Context-Mechanism-Outcome (CMO) configurations are used to establish patterns that explain outcomes. In this way realist evaluation is able to increase the external validity of single examples of evaluations or case studies [48]. Impact evaluation which is receiving increased interest and funding to measure the impact of development programmes provides a further example of theory-based evaluation where causal attribution rather the health outcomes per se are the main focus[49].

The recognition that both simple and complex interventions are usually implemented within complex systems [45] presents a paradigm shift in consideration of the methods required for programme evaluation, and a step towards recognising the need for delivery systems evaluation. The 'systems thinking' approach [50] implicitly links intervention design to evaluation in recognition that the system has an effect on the intervention and the intervention has an effect upon the system. Here, evaluation is used to assess how the system will react to the intervention and what positive effects may be augmented and negative effects mitigated. Examples of interventions are presented along a continuum of low to high intervention complexity, system wide effects, and need for systems thinking in intervention design and evaluation. The integration of vouchers for malaria bednets into ANC is presented as an example of a highly complex intervention that will have high system-wide effects, and has a high level need for systems thinking in its design and evaluation. The systems thinking model of assessing presents a way of approaching the design and evaluation of interventions to be delivered through health systems.

Impact evaluation was developed for social sector programmes in developing countries and aimed to ask whether targets have been achieved and what would have been the change over the time period of the intervention if it had not been implemented. In order to assess this 'counter-factual' effect, impact evaluation has attribution of outcomes to the intervention at its core [51]. The International Initiative for Impact Evaluation (3ie) have defined the six key principles of impact evaluation as: "1) map out the causal chain (programme theory), 2) understand context, 3) anticipate heterogeneity, 4) rigorous evaluations of impact using a credible counterfactual scenario, 5) rigorous factual analysis, 6) use mixed methods" [49].

Process evaluation aims to identify the components of an intervention that are effective or ineffective; for whom each component is effective or ineffective; and in what conditions or contexts the intervention is effective or ineffective [52]. The concept of process evaluation was introduced into the programme evaluation literature in the 1960s [53], but has gained momentum in the last decade. Approaches to process evaluation, however, and what is measured within the evaluation have varied widely [52], making comparisons impossible. Steckler *et al* [52]recommended that at the least process evaluations should include information on the reach, the dose (delivered and received), the fidelity of the intervention and the context within which it was delivered. Whilst there is scope to use a wide range of methods to evaluate processes, there is little guidance available on what are the most appropriate methods to assess the processes of different kinds of interventions, and delivery systems. There are certain overlaps between the concepts of process evaluation and implementation fidelity [54]. Whilst Steckler *et al* include fidelity of implementation within their list of key components of evaluation; frameworks for implementation fidelity have included elements of process evaluation [55-56].

The concept of community effectiveness is similar to that of process evaluation and has been defined as the efficacy of control interventions at the community level [57-58]. In this concept the main driver of efficacy at the community level is its effective application rather than the efficacy of the intervention [59] and effectiveness is measured as coverage outcomes [60]. The steps on the path from efficacy to community effectiveness are plotted and the effectiveness of each may be assessed, effectiveness across socio-economic groups may also be included in assessments of community effectiveness [61].

A more established theoretical approach which may be seen as a subset of programme evaluation, where the focus is the introduction of a new intervention, is the diffusion of innovations [62]. The literature on the diffusion of innovations has focussed, to a large extent, on the innovation itself. Recently a conceptual model has been developed for considering the determinants of diffusion, dissemination, and implementation of innovations in health service delivery (and other service organisations) [63]. This model includes the innovation itself; the adoption/assimilation process; communication and influence; the inner (organisational) context; the outer (inter-organisational) context; and the implementation process. This model provides the possibility of considering not just the elements of the

innovation itself, but also how these fit within the health system into which they are introduced.

In parallel to the above approach, an analytical conceptual framework on integration of interventions into health systems has been developed [64]. This approach too, builds upon the diffusion of innovations with health interventions described as complex innovations. Integration has been defined as "the extent, pattern, and rate of adoption and eventual assimilation of health interventions into each of the critical functions of a health system" [65]. The analytical conceptual framework developed by Atun *et al* [64] comprises of five elements that influence the way in which an innovation is adopted into a health system, which are: the nature of the problem; the intervention; the adoption system; the health system characteristics, and the context within which the innovation diffusion occurs.

Evaluation of the effectiveness of delivery systems (single and multiple) is essential to provide an evidence base for making strategic decisions. Although there has been substantial methodological development in evaluating the effectiveness of interventions in routine programmes, the methodology for evaluating delivery systems has not been well defined. In this thesis, the introduction of a voucher scheme for ITNs in two regions of Ghana is used as a case study to explore methodological issues in evaluating ITN delivery systems. The study encompasses quantitative outcome and process evaluations together with qualitative evaluation of both processes and the context. In particular, the focus is on the impact of multiple delivery systems on coverage outcomes and the relationship between the alternative delivery systems. The concept of delivery attribution is used to represent the proportion of coverage outcome that can be apportioned to a specific delivery system, and the methodology for doing this with varying levels of inference is developed. An overview of the aim, objectives and conceptual framework of the thesis is presented below and in more depth in Chapter 3.

1.3 Thesis outline

The thesis consists of eight chapters. Chapter one is the introduction as presented above, and chapter two a review of the literature on the delivery of ITNs over the last two decades. In the review delivery systems are characterised and evidence collated on the outcomes

(coverage and socio-economic disparities) of alternative systems; and the methods used to evaluate delivery of ITNs. Chapter three presents the study justification, aim, objectives, conceptual framework, a description of the study setting and the methods used in the study. In the study setting, the context of ITN delivery systems and coverage with nets and ITNs prior to the commencement of the voucher scheme in Ghana, and the ITN voucher scheme design and processes are described.

The thesis has four results chapters. In the first of these the quantitative coverage outcome evaluation of the voucher scheme is presented. The primary outcome, 'proportion of households with at least one mosquito net', is assessed pre and post implementation of the voucher scheme, and across socio-economic groups. In this chapter delivery attribution is used to evaluate the success of the voucher scheme. In the second results chapter, the intermediate processes in the delivery system are defined and the effectiveness of each one is assessed overall and by geographic area and socio-economic groups. In the third results chapter, qualitative methods are used to interpret the quantitative findings and to describe and explain the impact of the delivery systems context on the effectiveness of the intermediate processes of the voucher scheme, and subsequently on the voucher scheme as a whole. Reasons for loss of effectiveness which are identified in the quantitative process analysis are explored from the perception of stakeholders, using the diffusion of innovations theoretical framework of behaviour change. In the fourth of the results chapters' recommendations on a methodology of delivery system evaluation for ITNs and other public health interventions are made.

The final chapter is a discussion of the findings of the study in the two regions of Ghana and their implications for the evaluation of delivery systems for ITNs and other public health interventions particularly in relation to malaria control. A refined conceptual framework, developed from the diffusion of innovations framework used in the qualitative analysis, and based upon the interplay of processes and context is developed to aid in focussing of a methodology for delivery systems evaluation.

Chapter 2: Review of ITNs delivery systems and the methodology of their evaluation

2.1 Introduction

The diversity of products constituting an ITN, and the corresponding diversity of systems through which they can be distributed from manufacturers to households, has led to considerable debate on how to scale-up and maintain coverage. The need to scale-up coverage with ITNs was recognised after the findings of the efficacy and effectiveness studies of the mid-1990s, and was consolidated in the Abuja Targets in 2000 by African Countries and international organisations [9]. In 2002, Roll Back Malaria (RBM) attempted to provide guidance on delivery mechanisms by developing a consensus framework based on existing evidence, which provided strategic recommendations for developing national strategies for scaling-up delivery of ITNs in sub-Saharan Africa [66]. The framework proposed a two-pronged approach: targeted and sustained subsidies for those at greatest risk (biological, economic or geographic risk), and the development of an enabling environment for expansion of the commercial sector. Justifications for involvement of the commercial sector at this time were based upon the fact that mosquito nets were household goods; there were good examples of domestic commercial production, and concerns on the sustainability of financing to maintain public sector delivery.

There have, however, been few attempts to clarify strategic options faced by national malaria control programmes by clearly defining and classifying delivery systems for ITNs and their evaluation. Hanson *et al* [67] described four models for the delivery of nets and insecticides 1) purely public sector delivery; 2) community-based projects; 3) social marketing; and 4) encouraging the development of the private sector. Fielden [68] distinguished the delivery and financing of nets and constructed a matrix of public, mixed, or private sector delivery and public, mixed, or private sector financing (for distribution, logistics, sales and services). A similar approach was taken in the Management Sciences for Health (MSH) Long Lasting Insecticidal Net (LLIN) business plan [69] where the separation of delivery from financing source/mechanism was used to help identify where different stakeholders participate in the mosquito net industry. Lines [70] focussed on the delivery of insecticide, distinguishing between public and private routes through which insecticides for net treatment could be delivered to users.

Delivery systems for mosquito nets and ITNs have diversified over the last two decades. There is a need to develop frameworks for classifying these systems so that their effectiveness can be compared in different settings. Knowledge of effectiveness may then be used to facilitate strategic decisions on which delivery systems or mix of systems to use in different settings. The effectiveness of a delivery system may be assessed by measuring the outcome it achieves, that is, the coverage of ITNs at the household level.

The objectives of this review were:

1) To propose a classification of ITN delivery systems

2) To group existing systems according to this classification

3) To synthesise evidence about the levels of coverage, and socio economic disparities in coverage, achieved by each system

4) To provide a critique of the methods used to evaluate delivery systems for ITNs. The findings of the review were then used to identify analytical gaps and future priorities[1].

2.2 Methods

Two separate comprehensive reviews were conducted: review one was for objectives 1 to 3, and review two was for objective 4. For both reviews the PubMed electronic online database (US National Library of Medicine, Bethseda, USA) with no language restrictions was searched. For review one the key search terms were: net, bednet, bed net, mosquito net, insecticide treated, and ITN. For review two search terms included: insecticide treated nets, ITNs, bednet, bed net, delivery, distribution, coverage, and evaluation. The reference list of each paper thus identified was searched for further relevant publications. In acknowledgement that many evaluations of ITN programmes are not published, the PubMed search was supplemented with a search through grey literature sourced from consultation with experts.

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[1] Elements of this review have been published in two papers:

Webster, J., Hill, J., Lines, J., Hanson, K. (2007) Delivery systems for insecticide treated nets in Africa: categorisation and outcomes achieved. *Health Policy and Planning* 22: 277-293.

Webster, J., Chandramohan, D., Hanson, K. (2010) Evaluation of delivery systems for scaling-up malaria control interventions *BMC Health Services Research* Jul 2:10 Suppl 1:S8

Papers and grey literature were included if they described the delivery of mosquito nets and/or ITNs.

For objective 4, studies were included if they involved evaluation of the delivery of ITNs, through one specific delivery system, through multiple systems, or through a new delivery system. Studies were excluded unless they referred to a specific delivery system(s), or a component of a specific delivery system. This review focused on the delivery channel. Thus, evaluations of delivery strategies to improve uptake and use such as pricing policies, education of providers and other such strategies were excluded. For each study, the objective, evaluation method, primary outcome, type of control group and scale of operation of the programme or the evaluation were extracted.

The first review was conducted in 2006 in order to define the focus the thesis and was published in 2007 [71]. This review was updated in March 2010. The second review was conducted in 2009 as part of a wider investigation of methods for evaluating delivery systems for malaria control interventions (including ITNs, IPTp Intermittent Preventive Treatment for pregnant women (IPTp) and case management for fever) and was published in 2010 [72].

2.3 A matrix for classification of delivery systems for ITNs

The coverage outcomes of different delivery systems amongst different target groups and socio-economic groups vary substantially. In order to facilitate the comparison of the coverage outcomes of different delivery systems amongst different populations, the matrix developed by Feilden [68] was adapted to classify ITN delivery systems (Table 2.1). Rows of the matrix represent delivery *sectors* (public, mixed public-private, private and community based), that is, the source of logistical or human resource input into moving the ITNs from manufacturer to end user; and columns represent cost to the end user (free, partially subsidised and unsubsidised).

Delivery sectors were further divided into delivery *channels*, which are the route through which the ITNs pass from manufacturer to end user. Public sector is defined as largely under the control of central/local government, and private sector includes all those outside of the public sector whether their aim is philanthropic or commercial [73]. Public sector delivery channels include routine health services, enhanced routine services (intermittent mass

delivery with no additional funding), and campaigns (intermittent mass delivery with additional funding). Mixed delivery channels involve both public and private sector input into delivery of ITNs (which includes logistic and/or human resource input in addition to purely financial input). This channel includes voucher schemes and instances where delivery through public sector outlets is assisted by the private sector (NGOs or commercial organisations). Private sector delivery includes employer based schemes including those supported by non-governmental organisations (NGOs), 'non-profit' organisations facilitating delivery through commercial outlets, and the retail sector. Community based delivery involves a heterogeneous mix of systems where the point of delivery is within the community and involves a philanthropic aim (not necessarily exclusively) either through links with the public sector, NGOs, or community-based organisations.

In the matrix, cost to the end user can be free, partially subsidised or unsubsidised. An assumption is made that the channel through which an ITN is delivered and the cost to the end user are the major factors affecting outcomes, and the source of any subsidy does not enter into the classification of the delivery system. For example, where donor money is used to assist the private sector, without public sector activities in the delivery, this is classified as private sector delivery. Subsidies were defined as those directly applied to the ITN, and did not include subsidised promotion and other forms of financial support not directly applied to the ITN itself, delivery systems involving such forms of support were therefore described as unsubsidised.

Delivery systems were placed in the matrix based on project descriptions identified in the literature. The range of delivery systems that have been employed over the last two decades to deliver ITNs (excluding efficacy trials), as described in available published and grey literature, is presented in Table 2.1. The classification combined delivery sector and cost to the end user in a 4 by 3 matrix, which was extended to a 9 by 3 matrix when delivery sector was expanded to include different delivery channels.

Table 2.1: Matrix of net/ITN/insecticide delivery systems by category and cost to the end user

Delivery sector			Cost to the end user		
Public	**Delivery channel**		**Free**	**Partially subsidised**	**Unsubsidised**
	Routine services	ANC/EPI/MCH/Child clinics	**Kenya** [74-75] **Eritrea** [76-77] **Uganda** [78] **DRC** [79] **Malawi** [80]	**Ghana** [81] **Kenya** [29, 32]	
		Intervention packages – mixed delivery	**Mali** [82]	**Benin** [82] **Ghana** [82] **Senegal** [82]	
	Enhanced routine	Child Health Week / Days	**Ghana** [82] **Senegal** [82]		
	Campaigns	Measles	**Ghana** [28] **Togo** [83-84] **Zambia** [85] **Kenya** [29, 86]		
		Polio NIDs	**Niger** [35, 87]	**Ghana** [88]	
		Ivermectin/Albendazole	**Nigeria** [89]		
		Integrated child health	**Tanzania** [33, 36]		
Mixed public-private	Assisted routine services	ANC/EPI		**Kenya** [29, 32, 90-91] **Malawi** [92-94]	
	Voucher scheme	Routine service – retail		**Ghana** [95] **Senegal** [96] **Tanzania** [31, 33, 97-99]	
		Campaign – retail	**Zambia** [85]		
Private	Employer-based	Workplace		**Kenya** [100-101]	
	'Non-profit' organisations	Retail outlets		**Ghana** [102] **Kenya** [29, 32, 86, 91] **Malawi** [103] **Mozambique** [104] **Tanzania** [105-107]	
	Retail sector	Formal / Informal			**Cameroon** [108] **Ethiopia** [109] **Kenya** [91, 110-111] **Ghana** [112] **Mali** [113] **Mozambique** [113-114] **Nigeria** [115-116] **Senegal** [117-118] **Tanzania** [33, 119] **Uganda** [120-121] **Zambia** [122-123]
		Formal sector			**Burkina Faso** [124]
		Informal sector			**The Gambia** [15, 125-128]
Community-based	Community – based	Community (CBOs, NGOs, women's groups etc.)	**Kenya** [129] **Tanzania** [130] **Eritrea** [86]	**Mali** [131] **Zambia** [132]	

Delivery of ITNs through routine health services has involved public-free and public-partially subsidised categories of delivery systems. Child Health Days and Child Health Weeks are a form of expanded routine activities, and fall into the public-free category of delivery system. Combined delivery of ITNs with immunisation campaigns has involved both public-free and public-partially subsidised categories of delivery system; however, the former has been more commonly used to date. Mixed-partially subsidised was by far the predominant delivery category within the mixed public-private sector, however, there were examples of mixed-free delivery. Within the private sector, delivery of ITNs and mosquito nets has involved both private-partially subsidised and private-unsubsidised categories of delivery system.

2.3.1 Public sector delivery channels

2.3.1.1 Routine services

Two main channels of delivery have been used to provide ITNs through routine health services: routine clinics, such as ANC and EPI, and intervention 'packages' such as the United Nations Children's Fund (UNICEF) Accelerated Child Survival and Development (ACSD) programme in West Africa [82, 133]. Delivery through routine health facilities has involved either full or partial subsidies to the end user. Although there are now many examples of delivery of free ITNs through ANC and to a lesser extent EPI in Africa [74-80, 134-135], documented experiences are relatively few. In Ghana, delivery of subsidised ITNs though ANC was managed by the National Malaria Control Programme (NMCP), the Regional Health Directorates (RHDs) and the District Health Management Teams (DHMTs). The cost of the ITN to the pregnant woman was approximately USD2.20. In Eritrea, ITNs were delivered to pregnant women through ANC free of charge [77].

The ACSD programme involved a package of interventions termed ANC+, EPI+ and Integrated Management of Childhood Illness+ (IMCI+). ACSD was originally implemented in four countries of West Africa (Benin, Ghana, Mali and Senegal) and then expanded to other countries including Burkina Faso, Cameroon, Chad, The Gambia, Guinea Bissau, Guinea Conakry and Niger [82]. Strategies for delivering ITNs through ACSD varied among countries, including delivery of ITNs through routine health services and through community based agents. In Benin, Ghana, and Senegal the end user had to pay a small fee, for example the fee to pregnant women in Ghana was approximately USD0.50. In Mali, the ITNs were free to the end user.

2.3.1.2 Expanded routine

Child Health Days and Child Health Weeks have delivered packages of child survival interventions such as the EPI vaccinations, vitamin A supplementation and de-worming tablets. ITN (re)treatment has been added to the package in some countries including Ghana, Malawi, Senegal and Zambia. In some districts of Ghana and Zambia ITNs were also delivered through Child Health Weeks, but less frequently than (re)treatment. All interventions were generally delivered free of charge to the end user.

2.3.1.3 Campaigns

The first documentation on the combined delivery of ITNs with immunisation campaigns was from four countries (Ghana, Niger, Togo and Zambia), although combined campaigns have now taken place in other countries. ITNs were delivered alongside measles campaigns in Ghana, Kenya, Togo and Zambia; in Ghana and Niger, ITNs were delivered during a polio national immunisation day (NID) and in Nigeria together with mass distribution of ivermectin/albendazole. The first of the combined measles and ITN campaigns was conducted in Ghana, with the activity taking place in one district (Lawra, Upper West Region) during a national measles campaign in 2002. This was followed by implementation in 5 districts of Zambia, four in which ITNs were delivered directly, and one in which the (full) subsidy was delivered in the form of a voucher to be redeemed in commercial sector outlets. Togo provided the first example of the combined delivery of ITNs with a measles campaign at the national level, in which ITNs were delivered free of charge to the end user. During the 2004 polio NIDs in Ghana, ITNs were delivered with vaccinations in one Region (Central Region). Unlike measles campaigns which involve vaccination at static points, polio NIDs involves door-to-door delivery of vaccinations. In order to avoid the logistical difficulties of volunteers carrying bulky heavy ITNs, vouchers were delivered to those vaccinated. The voucher entitled the holder to buy an ITN for approximately USD4 at designated health facility delivery points, thereby providing a partial subsidy (approximately USD2.20) on the ITN. This is the sole example identified of partial subsidies on ITNs delivered through a campaign.

Since the change in strategic direction from goals of covering pregnant women and children under 5 years, towards universal coverage of the whole population in areas of malaria risk, the focus has changed from integrated campaigns to stand-alone 'universal campaigns'.

Although these have been implemented in some States of Nigeria and Tanzania, data on coverage outcomes achieved are not yet publically available.

2.3.2 Mixed public-private sector delivery channels

In voucher schemes, the subsidy was generally delivered through the public sector, and the product delivered through the private sector. This allowed targeting of the subsidy at the public sector level whilst still allowing the private sector to benefit from a sale, as well as allowing the programme to take advantage of an existing distribution system. Where the voucher has been delivered through routine health services all subsidies have been partial, with the end user paying a top-up fee when exchanging the voucher for an ITN. However, in the Zambia pilot study where delivery was through a combined measles and ITN campaign, the ITN subsidy was delivered via a voucher which provided a 100% subsidy in one district.

In many countries the delivery of partially subsidised ITNs through routine health facilities has been supported by an NGO, Population Services International (PSI). The scale of distribution varied from one district (Angola) to national level (Malawi and Kenya) and the cost to the end user from USD0.40 in Malawi to USD2.80 in Angola. Although this model of delivery was often referred to as the 'ANC model' of social marketing [136], it was quite different from classical social marketing and in addition, ITN delivery was not limited to pregnant women through ANC services but often included children less than 1 year of age who were reached through EPI. This delivery channel is defined here as assisted routine services.

2.3.3 Private sector delivery channels

Private sector delivery of mosquito nets has involved a diverse array of traders including manufacturers, wholesalers and retailers selling ITNs through a wide range of outlets. It was difficult to determine which part of the private sector was involved in many of the documented experiences. Classical social marketing supported by NGOs with delivery of the ITNs through retail outlets may be viewed as an 'assisted private sector' approach. The same applies to projects such as NetMark where the NGO provides technical and marketing support to the private sector, and the Futures programme in Nigeria with a subsidy on promotion. These latter projects where the subsidy was not directly applied to the product were also sometimes referred to as social marketing. Due to the diversity of approaches for

delivery of ITNs that are loosely called social marketing it was preferable to develop more specific categories.

Programmes in which NGOs provided support to ITN delivery through retail outlets were 'non-profit' and defined as assisted private sector delivery. In such channels, the ITNs have usually been delivered to the retail outlets by the NGO rather than being sourced by the retailer themselves, and are subsidised (in the form of subsidised product and/or subsidised marketing and promotion) before reaching the retail outlets. Assisted private sector delivery of ITNs has involved costs covered by donors such as technical support, marketing and distribution even where the price of the ITN itself was not directly subsidised.

Within the 'non-assisted private sector', there were two different types of delivery system defined by their delivery points. The 'formal commercial sector' included static or 'closed' outlets such as shops, supermarkets and pharmacies where products remain in the outlets overnight, and the 'informal commercial sector' included markets, kiosks and itinerant traders where products were removed from their point of delivery at the end of each trading day.

No examples of free nets or ITNs delivered through the private sector were found; though social marketing through retail outlets has involved partial subsidies on ITNs.

2.3.4 Community based delivery

Most community based distribution of ITNs has been through small-scale projects. Such projects have been implemented in many countries since the 1980s; most have operated on a limited geographic scale, focussing on a few villages or districts [137]. Projects involving community based delivery are heterogeneous in structure, some with government support such as the Ministry of Health (MoH)/UNICEF supported project in Luapula Province Zambia [138], and others with no government input. Some projects have delivered ITNs to the community free of charge but most have involved partial subsidies, the small charge to the end user often providing some level of incentive to the community based volunteer or sales agent. Kilian *et al* [139] have recently presented an alternative classification of delivery systems for ITNs in which they include campaigns amongst community based delivery systems.

2.4 Coverage outcomes by delivery system

RBM recommend three standard indicators to assess coverage outcomes of ITN delivery systems. They are "the proportion of households with at least one ITN", " the proportion of pregnant women who slept under an ITN the night before the survey", and "the proportion of children under five years of age who slept under an ITN the night before the survey" [140-141]. The ITN coverage outcomes reported by each of the studies presented in Table 2.1 were reviewed. In the studies of private sector delivery, outcome measures included coverage with untreated mosquito nets as well in order to capture the coverage achieved through the informal private retail sector. Although several projects have begun to support delivery of ITNs through the private sector, this is relatively recent and subsequent to most available data sources [30]. Where RBM indicators have been used to measure coverage outcomes, the reported coverage outcomes were shown in the relevant cells within the delivery system matrix (Table 2.2). Where the coverage indicators reported in the studies differed from the standard RBM indicators but could be explained with a simple qualification, they were also included in the matrix with the relevant annotation.

The equity ratio was used to compare equity of coverage achieved by the different delivery systems. Households were first divided into socio-economic quintiles based upon an index constructed from data on housing conditions and ownership of a range of household assets [142]. The equity ratio was then calculated as the ratio of coverage in the poorest quintile compared with the least poor (or richest) quintile.

The majority of data points available on coverage of ITNs were from household surveys undertaken following the implementation of specific programmes of delivery of ITNs. They tended to assume that most of the coverage could be attributed to the specific delivery system. In the matrix the same assumption was made. However, the validity of this assumption depended upon the history of delivery of ITNs within the area, particularly on private sector activity, and tended to over-estimate coverage achieved by a specific delivery system. A more important limitation was where the equity of coverage was assumed to be due to a specific delivery system. For example, a new programme may deliver ITNs in an area where coverage has previously been very inequitable. Unless baseline and post implementation surveys are undertaken, any improvement in equity may be masked.

Coverage data were available for the public-free, public-partially subsidised, mixed-partially subsidised, private-partially-subsidised and private-unsubsidised categories (Table 2.2). The country, scale, and timescale of delivery of ITNs and mosquito nets through each of the delivery systems varied. The evaluation surveys provided snapshots of outcomes which did not reflect changes over time, nor did they reflect the intended period of delivery, or point in the programme cycle. In Table 2.3 the country, duration of implementation, point in the programme cycle (completed or ongoing), the number of months after commencement or completion of the project at which the evaluation was undertaken, and scale of the programmes from which the coverage data were derived were clarified. The coverage data presented in Table 2.2 should be interpreted in the light of the duration of implementation presented in Table 2.3. Where the programme has ended, the level of coverage presented was likely to represent the highest level achieved by the specific system. In the absence of an alternative system or replacement system, coverage was likely to fall subsequently. An exception to this was where there were seasonal variations in use, depending upon the time of implementation of the survey by which coverage was assessed. For example, if use was assessed during the dry season where net use is often relatively low [35], then a survey a few months later may show an increase in use.

There were few variations in the definition of the household ownership indicator that was used, and where present these related to restrictions in the denominator; for example, presentation of the results by target group, that is households with a pregnant woman and households with a child under 5 years of age. Variations on the standard use indicator were found for both children under 5 years and for pregnant women. Evaluations of the measles campaigns used an indicator "proportion of households where the index child slept under an ITN the night before the survey", where the index child was the youngest child in the household who was above 6 months of age at the time of the survey. This meant that the denominator was households with at least one child meeting the age criteria rather than all children meeting the age criteria.

Table 2.2: Summary of coverage outcomes by different delivery systems and cost to the end users

Delivery category					
Delivery sector			Cost to the end user		
Public	**Delivery Channel**		**Free**	**Partially subsidised**	**Unsubsidised**
	Routine services	ANC/EPI/MCH/Child clinics	HH: 82.2%[75], 47.5%[80], 59.6%[80] PW: 84% (ht)[74]; 58% (lt)[74]; 52.4%[75], 79%[79],85%[79] <5s: 76.1%[75]		
		Intervention packages – mixed delivery	HH: PW: 67.6%[82] <5s: 70.7%[82]	HH: PW: 27.0%[82]; 26.0%[82]; 47.3%[82] <5s: 28.1%[82]; 21.0%[82]; 69.2%[82]	
	Campaigns	Measles	HH: 94.4%[28]; 85.2%[34]; 62.5%[143], 39.1%[144] PW: 35.8%[143] <5s: *[60.2%][28]; *[46.3%][34]; 43.6%[29]		
		Polio	HH: ****[65.1%][35]		
		Ivermectin/albendazole	HH (with an <5 or pw): 80%[89] PW: 27%[89] <5s: 39%[89]		
		Integrated child health	HH (with an <5): 37.3%[36] <5s: 21.5%[36]		
Mixed public-private	Assisted routine services	ANC/EPI		HH: 42.9% (26.1 – 87.5)[92] PW: 31.4% (3.5 – 69.6)[92]; 37.8%[80], 44.3%[80] 44.3%[80] <5s: 35.5% (17.3 – 63.4)[92]; 52.3%[80], 69.2%[80]	
	Voucher scheme	Routine service - retail		HH: 73%[105], 29%[31], 36%[31], 19.6%[104] PW: 18%[31]; 23%[31] <5s: 12.2%[31], 21%[31], 26%[31], 46%[105]	
Private (nets)	Employer-based	Workplace		HH: 54.3%[101] (any net)	
	'Non-profit' organisations	Retail outlets		HH: 19.9%[103] PW: <5s: 6.0%[91]; 24.0%U[103]; 3.3%R[103]; 9.6%[29]	
	Retail sector	Formal / Informal			HH: 49%[124]; 48%[108], ***44%[119], ****32%[119] PW: <5s: 2.7%[91],
		Informal sector			HH: PW: 67.2%[126] <5s: 67.7%[126]

Community-based		Community (CBOs, NGOs, women's groups etc.)		HH: 50%[132], 66.8%[86] PW: 46%[132], [56.6%][86] <5s: 33%[132]	

HH household ownership = 'proportion of households with at least 1 ITN
PW pregnant women = 'proportion of pregnant women who slept under an ITN the night before the survey'
<5s children under 5 years = 'proportion of children under five years who slept under an ITN the night before the survey'
[ ] = none standard indicators
* "proportion of households where the index child slept under an ITN the night before the survey" where index child is the youngest child in the household who was above 6 months of age at the time of the survey
** use a net regularly rather than the standard 'slept under an ITN the night before the survey"
***households with a pregnant woman
**** households with a child under 5 years of age
U = urban; R = rural; lt low transmission

Other variations included "proportion of women who slept under a net during their pregnancy", "use of a net regularly" rather than the night before the survey, and "proportion of children <5 who slept in a bed with a net hanging over it". Overall, surprisingly few data points were available, even whilst allowing the inclusion of non-standard indicators.

2.4.1 Public sector delivery of free ITNs (public-free)

Household ITN ownership data were available only from routine health facility delivery in Eritrea and Malawi, and from campaign deliveries in five countries. Household ownership was 82.2% in Eritrea [76] and varied from 47.5% to 59.6% in two intervention districts in Malawi[80]. Through campaigns household ownership has varied from 37.3% amongst households with a child under 5 years through an integrated child health campaign in Tanzania [36] to 94.4% through a measles campaign in one district of Ghana [28]. A greater number of data points were available for use by target groups and varied for pregnant women from 27% through a mass campaign with ivermectin/albendazole in two Local government Authorities (LGAs) of Nigeria[89] to 84% in high transmission areas across 35 districts of Kenya where ITNs were delivered through routine health facilities [74]. Use by children under 5 years varied from 21.5% in an integrated child health campaign in Tanzania[36]to 76.1% through routine health facility delivery across 2 *zobas* of Eritrea [76].

Amongst these examples of free public sector delivery, only the programmes in Eritrea and Mali are ongoing, the other examples from Kenya, Ghana, Togo and Zambia were all short-term delivery models (several months for Kenya, and several days for Ghana, Togo and Zambia). Coverage in the campaign categories of delivery was evaluated 1 to 6 months after completion of the campaign, and 12 to 18 months after commencement of delivery in the routine delivery category examples.

Table 2.3: Implementation characteristics, time of assessment and coverage outcome measures by type of delivery system across countries

Category of delivery system	Country	Scale	Duration of Implementation	No. months post commencement (c) or completion (co) of delivery at which evaluation was undertaken	Household ownership	Use of ITNs by <5s (district range)	Use of ITNs by pregnant women (district range)	Equity ratio of household ownership with ITNs
Public-free								
Routine – ANC	**Kenya** [75]	35 districts	4 months 2001	16 months (c) 12 months (co)	-	-	[84%][2] ht [58%][2] lt	-
Routine - ANC	**Eritrea** [76]	2 zobas	2002 to date	12 months (c)	82.2%	76.1%	52.4%	-
Routine – ANC + assisted routine retail	**Burkina Faso** [145]	1 province	7 months	7 months (c)	43%[12] 31%[13]	-	-	-
Routine - ANC	**DRC** [79]	1 clinic	12 months	6 to 12 months (c)	-	-	79%[15] 85%[16]	-
Routine – intervention package	**Mali** [82]	6 districts	2001 to date	Approx. 18 months (c)	-	70.7	67.7	-
Campaign – measles	**Ghana** [28]	1 district	6 days 2002	5 months (co)	94.4%	[60.2%][1]	-	[0.92][1]
Campaign – measles	**Togo** [83]	National	7 days 2004	1 month (co)	62.5%	[43.5%][1]	35.8	[1.02][1]
Campaign – measles	**Zambia** [85]	5 districts	6 days 2003	6 months (co)	82.3% urban 88.0% rural	[46.3][1]	-	[Rural 0.88 Urban 1.19][1]
Campaign - polio	**Niger** [35]	National	2 months	6 to 9 months (co)	65.1%	55.5%	48.2%	[0.79][10]
Campaign – ivermectin/albendazole	**Nigeria** [89]	2 LGAs	5 months 2004	4 – 10 months (co)	[80%][8]	39%	27% 50%[9]	-
Campaign – integrated child health	**Tanzania** [36]	1 region	3 days	3 months (co)	37.3%[10]	21.5%		0.48[10]
Public-partially subsidised								
Routine – intervention package	**Benin** [82]	6 districts	2001 to date	Approx. 18 months (c)	-	28.1	27.0	-
Routine – intervention package	**Ghana** [82]	6/110 districts	2001 to date	Approx. 18 months (c)	-	21.0	26.0	-
Routine – intervention package	**Senegal** [82]	2 districts	2001 to date	Approx. 18 months (c)	-	69.2	47.3	-
Mixed - partially subsidised								
Assisted routine – ANC/EPI direct product	**Malawi** [92]	National	2000 (pilot) 2002 (national)	Approx 18 months (c) national	42.9 (26.1-87.5)	35.5 (17.3 – 63.4)	31.4 (3.5 – 69.6)	[0.35]

Routine - EPI	**Malawi** [80]	3 districts	15 months	16 months (c)	47.5%, 59.6%	52.3%, 69.2%	37.8%, 44.3%	
Assisted routine – ANC/EPI	**Kenya** [90]	3 provinces	2002 2004 (national)	Approx 12 months	44% (national)	46%	50%	-
Assisted routine – retail + community	**Mozambique** [104]	20 sites in 9 districts	2001 - 2003	3 years	19.6%	-	-	-
Voucher scheme – routine service – retail + assisted routine – ANC/EPI	**Tanzania** (i) [105] (ii) [98] (iii) [3]	2 districts	1997 to date	(i) 18 months (c) (ii) 1 – 12 months (c) (iii) 36 months (c)	73% (iii)	46% (i)	[53%][7] (ii)	0.3 (1997) 0.6 (2000)
Voucher scheme – routine service – retail	**Tanzania** [31]	National	3 years (2004-2007)	1,2, and 3 years (c)	18% (2005) 29% (2006) 36% (2007)	12% (2005) 21% (2006) 26% (2007)	11% (2005) 18% (2006) 23% (2007)	0.11[14] (2005) 0.29[14] (2007)
Private-unsubsidised (nets)								
Employer based	**Kenya** [101]	4 sites	1992 - 2002	0-6 months (co)	54.3%[11]	-	-	-
'Non-profit' organisations – retail	**Kenya** [91]	4 districts	2001 to date	-		6.0%	-	0.14
'Non-profit' organisations – retail	**Malawi** [103]	1 district	1998	-	19.9%	24.0%[3] Urban 3.3%[3] Rural	-	-
'Non-profit' organisations – retail	**Tanzania** [73]	4 districts	2000-2002	-	58.5%	67%	-	0.44[2]
Retail sector - informal commercial	**Burkina Faso** [124]	1 province	Unknown	-	49%	-	-	-
Retail sector - formal /informal commercial	**Cameroon** [108]	1 city	Unknown	-	48%	-	-	-
Retail sector - formal /informal commercial	**The Gambia** [126]	National	Unknown	-	-	67.7% (<1s)[4] 71.8% (1-4s)	67.2%	-
Retail sector - formal /informal commercial	**Kenya** [91]	4 districts	Unknown	-	-	2.7%	-	-
Retail sector - formal /informal commercial	**Kenya** [111]	4 districts	Unknown	-	-	-	[7.2%][6]	-
Retail sector - formal /informal commercial	**Kenya** [110]	1 district	Unknown	-	-	[5%][5]	-	-
Retail sector - formal /informal commercial	**Uganda** [120]	1 municipality	ongoing	-	55.0	-	-	-
Community based – partially subsidised								
Community based – partially subsidised	**Zambia** [138]	1 district	1997		50%	33%	46%	-
Community based - free	**Eritrea** [86]	3 *zobas*	2002 to date	1 year approx.	66.8%	[56.6%][17]	-	-
Mixed strategies								
Campaign – measles and stand alone	**Kenya** [29]	4 districts	2004 to date	various	79.3%[3,18]	80.3%[3,18]	-	1.0[18]

+ routine ANC + retail						41.2%[3,19] 43.6%[3,20] 9.6%[3,21]	0.79[19] 1.42[20] 0.38[21]
Campaign – measles and stand alone + routine ANC + retail	**Kenya** [32]	46 districts	2004 to date	various	50.7% 39.1%[20]	51.7%	1.0
Voucher, campaign (integrated child health), retail	**Tanzania** [33]	31 villages	various	various	-	49.0%[22] 39.8%[23]	

[ ] = non-standard indicators

[1] "proportion of households where the index child slept under an ITN the night before the survey" where index child is the youngest child in the household who was above 6 months of age at the time of the survey

[2] sample group were those pregnant women who had received a free ITN, not the general population of pregnant women. ht = high transmission, lt = low transmission

[3] Any net – not necessarily an ITN

[4] In one region (Central) a proportion of the nets may have been delivered through trials rather than the commercial sector

[5] Proportion of children <5 who slept in a bed with a net hanging over it

[6] Slept under a net during their pregnancy

[7] Defined as use a net regularly rather than the standard 'slept under an ITN the night before the survey"

[8] Amongst households with a pregnant woman and/or a child under 5 years

[9] Pregnant during the distribution

[10] Amongst households with a child under 5

[11] Any net (treated and untreated)

[12] ANC + assisted routine retail

[13] Assisted routine retail

[14] Use in children <1

[15] use of bednet the night before survey, asked at delivery

[16] use of bednet night before survey, asked 6 months post-partum

[17] proportion of households with all children <5 years under an ITN

[18] use from any source

[19] use from PSI-MCH programme health facilities

[20] use from free mass campaign

[21] use from retail outlets

[22] ITN use in children <1 year

[23] ITN use in children >1 to 5 years

Note, these are coverage data from household surveys in areas where the specified interventions were implemented, they do not necessarily represent direct outcomes of the specified intervention alone

Private –unsubsidised is nets not ITNs – other sections are all ITNs (currently treated)

LGA – Local Government Authority

2.4.2 Public sector delivery of partially subsidised ITNs (public-partially subsidised)

Outcome data on public-partially subsidised delivery of ITNs was available only for intervention packages of the ACSD programme and from the assisted delivery through ANC clinics in Kenya. These programmes did not assess household ownership. Use by pregnant women and children under 5 years varied from 26% and 21.0% respectively through an intervention package in 6 districts of Ghana [82], to 47.3% and 69.2% respectively through a similar intervention package system in 2 districts of Senegal [82]. These data represent findings two to three years post commencement of the ACSD programmes.

2.4.3 Mixed delivery of partially subsidised ITNs (mixed-partially subsidised)

Where the delivery system involved both public and private sectors, household ownership varied from 19.6% with assisted retail and community based delivery in 9 sites of Mozambique[104] to 73% through a mixture of social marketing and a voucher scheme in two districts of Tanzania [105]; use by pregnant women was 18% and 23% at the end of the second and third years respectively, of implementation of a national voucher scheme in Tanzania[31] and 53% through a mixed voucher and retail sector social marketing programme in two districts of Tanzania [98]. Use by children under 5 years varied from 12.2% to 26.0% over a period of 3 years through the national level voucher scheme in Tanzania. With national scale public-private delivery of ITNs through routine health facilities, there is a marked disparity across districts in household ownership of nets in Malawi, ranging from 26.1 to 87.5 [92].

2.4.4 Private sector delivery of partially subsidised ITNs (private-partially subsidised)

Available data showed household ownership of 19.9% through retail sector social marketing in one district of Malawi [103] in a survey undertaken just over a year after commencement of the project. No data on use by pregnant women of ITNs delivered through retail sector social marketing or other private sector delivery systems involving partial subsidies was identified. Use by children under 5 years through this same category of delivery system varied from 3.3% in a rural area of one district of Malawi [103] to 24% in an urban area of the same district.

2.4.5 Private sector delivery of unsubsidised nets (private-unsubsidised)

Ownership of unsubsidised nets reaching the households through the unassisted private sector, where formal and informal distinctions were not made, varied between 49% in 1 province of Burkina Faso [124] and 32% in one district of Tanzania [119]. No data within this category was identified on use by pregnant women; use by children in 4 districts of Kenya was 2.7% [91]. Use of nets delivered through the informal commercial sector was 67.2% for pregnant women and 67.7% for children under 5 years of age at the national level in The Gambia [126].

2.4.6 Community-based delivery: Most community-based delivery has been conducted on a small scale and has not been evaluated, or if evaluated the results were not published and not widely circulated; therefore data was not available on the coverage outcomes achieved through the variety of systems within this category. Data was identified from one district of Zambia only where household ownership of nets was 50%, use by pregnant women 46% and use by children <5 years 33% [138]. Although (re)treatment rates were assessed in the household survey from which this data was obtained, data on ownership and use of ITNs was not presented.

2.4.7 Cost to the end user

It was clear from the matrix (Table 2.2) that there were very few examples of delivery through specific delivery systems with different levels of subsidy and subsequent costs to the end user. The only study identified that focussed on the impact of varying cost to the end user, had uptake of ITNs as an outcome and found that increasing this cost from zero to USD0.75 resulted in a 75% reduction in uptake [146].

2.4.8 Activities at a national scale

Seven countries were identified as having at least one large-scale defined delivery system for ITNs with some evidence on delivery system outcomes. These were Eritrea, Kenya, Malawi, Niger, Senegal, Tanzania and Togo. Three of these, Eritrea, Kenya, and Tanzania, had two defined large-scale delivery systems operating or that have operated. In Eritrea ITNs were delivered through public sector routine health systems and through community health workers supported by the local (Kebabi) administration. In Kenya national scale delivery through a mixed public-private sector approach where the MoH is supported by an NGO in routine delivery of ITNs through

health facilities, was supplemented by two large-scale campaigns targeting children under 5 years of age. In Tanzania a mixed public-private sector approach using vouchers delivered through routine Maternal and Child Health (MCH) services was supported by large scale delivery through the private retail sector.

The cumulative impact of these dual systems contributed to 76.1%, 51.7%, and 26% of children under five years using an ITN in Eritrea, Kenya and Tanzania, respectively [31-32, 76]. In Kenya, data from four sentinel sites chosen to represent the varying levels of transmission within the country showed 33.8% and 31.2% of children under 5 years using nets (not necessarily treated) from the campaign delivery and the public-private routine health system delivery systems, respectively[29]. Cross-sectional data collected after a sub-national campaign for ITNs to children under 5 years in Rufiji district, Tanzania showed 36.2% of 0 to 1 year olds and 8.7% of >1 to 5s using nets from the voucher scheme, and 20.9% of 0 to 1 year olds and 22.9% of under- 1 to 5 years olds using nets from the private retail sector, respectively [33]. This survey conducted after a child health campaign included delivery of ITNs; 23.5% of 0 to 1 year olds and 43.6% of under-1 to 5 years olds were found to use ITNs delivered through this campaign.

In Malawi, Niger, Senegal, and Togo large-scale delivery has been supported by a single major defined delivery system. In Malawi, the major delivery system is the same NGO-supported delivery through routine health facilities as is operating in Kenya. In Niger and Togo, campaigns delivering ITNs to children under 5 years have been conducted, and in Senegal the main delivery system is the private retail sector. The reviewed studies report that 52.3% to 69.2%[80], 55.5%[35], 69.2%[82], and 43.5%[2][143] of children under 5 years using an ITN in Malawi, Niger, Senegal, and Togo, respectively.

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[2] "proportion of households where the index child slept under an ITN the night before the survey" where index child is the youngest child in the household who was above 6 months of age at the time of the survey

Together with the defined delivery systems each of the seven countries with national scale delivery had varying levels of ITN distribution through other systems operating in the public and private sectors. Public sector delivery may involve purchasing of ITNs by District Health Management Teams and *ad hoc* delivery through health facilities, larger scale delivery through health facilities and the community such as through the UNICEF ACSD programme in West Africa, NGO delivery through health facilities and the community, and delivery through the formal and informal retail sector. Substantial numbers of untreated nets have been delivered through the private informal retail sector in many countries of West Africa in particular[30]. Due to the myriad of systems in operation it should not be assumed that all ITNs in households can simply be attributed to a system which is operating at a large-scale or at a national level.

Kenya and Tanzania are the only countries where any attempt was identified to attribute net/ITN coverage to a specific delivery system. Consequently very little is known about the coverage achieved by specific delivery systems, either where there is just one major system in operation or where there is more than one.

2.5 Equity of coverage by delivery system

Twelve data sources were identified where it was possible to calculate an equity ratio of coverage amongst the lowest and highest socio-economic quintiles (Table 2.3). Five of these assessed the equity ratio of household ownership of ITNs in households with a child targeted by a campaign, three from measles campaigns, one from a polio campaign and one from an integrated child health campaign. The others included one assisted routine delivery through ANC/EPI, two voucher schemes, two systems of unsubsidised retail delivery through non-profit organisations, and two involving a mix of delivery systems. Due to the diversity of systems and differences in the indicators used, the findings cannot be directly compared.

However, based on non-standard indicators the measles campaigns have achieved equitable coverage, even in rural areas (equity ratio: 0.92 in one district of Ghana [28]; 1.19 9 [urban], 0.88 [rural] in 5 districts of Zambia [85]; and 1.02 at the national level in Togo[83]). Coverage achieved through a polio campaign at the national level in Niger was less equitable (equity ratio:

0.79 amongst households with a child under 5) [35], and the bias towards the less poor households was higher from an integrated child health campaign in one region of Tanzania [36].

Household ownership at the national level through public-private delivery of ITNs in health facilities in Malawi was classified by wealthiest, medium and poorest socio-economic groups, rather than by socio-economic quintiles. Ownership in the wealthiest households was nearly three times that in the poorest [147]. Using the few data points available coverage achieved through mixed delivery systems with partial subsidies, that is social marketing and voucher schemes, has generally been quite inequitable varying from 0.11 in 2005 and 0.29 in 2007 for use by children under 5 years of age via a voucher scheme at the national level in Tanzania[31], to 0.6 for a scheme involving both social marketing and vouchers in 2 districts of Tanzania [3]. However, it is unclear whether these schemes have increased or decreased any previously existing socio-economic disparities in coverage. Socio-economic disparities are likely to vary considerably according to the point in time and average level of coverage at which the household assets are assessed.

In Kenya a survey across 46 districts found that there were no socio-economic disparities in the proportion of households with at least one ITN[32] where ITNs had been delivered through a mix of systems. Use of ITNs by children under 5 years delivered through the same delivery systems as the previous study was assessed in 4 districts of Kenya and use was attributed to specific delivery systems. Use of ITNs received through the mass campaigns in Kenya was higher amongst children from poorer households (equity ratio: 1.42), higher amongst less poor households for ITNs delivered through the assisted routine system of ANC/EPI (equity ratio: 0.79) and strongly biased towards the least poor households for ITNs purchased through the retail sector (equity ratio: 0.38) [29].

2.6 Methods for evaluating ITN delivery systems

An initial screening of 1,039 study titles identified 65 papers on ITNs that were relevant to delivery system evaluation. Upon reviewing the abstracts of these publications, 27 papers met the inclusion criteria. The majority of the exclusions were due to a lack of focus on a delivery

system. Studies remaining in the review were divided into evaluations of new delivery systems and evaluations of existing delivery systems (including components of systems). Studies included 20 evaluations of new systems, and 7 evaluations of existing systems (Table 2.4).

New systems for delivery of ITNs in the public sector included routine delivery through ANC/EPI, campaign delivery integrated with other interventions (immunisations and ivermectin), and voucher systems. In the private sector, delivery has involved social marketing. Three of the studies of new systems were comparisons of two different systems: employer versus community based systems [101], sales through commercial shopkeepers versus groups of community leaders [104], and social marketing alone and together with free delivery through ANC [145]. Each of these 3 studies had a primary outcome of 'the proportion of households with at least one net/ITN', one was a cluster randomised controlled trial and the others used observational cross sectional surveys with comparison between geographic areas where each of the interventions were implemented.

Amongst the 20 studies of new delivery systems, 16 used observational cross sectional surveys, 5 including both pre-and post delivery surveys through the new system and 11 post-only surveys. Two of the pre- and post delivery studies used an internal control, attribution of nets in households to the system through which they were delivered [31, 148]; whilst the others used external geographic controls [80], or no controls [149]. Of the post- delivery only surveys, 1 used the colour of the net to attribute it to a specific delivery system, 5 used an historical internal control, 3 used an external geographic control, and 1 used no control. Historical internal controls used questions in post ITN-vaccination campaigns on ownership and/or use of ITNs prior to the campaign.

One out of the 7 studies with a focus on existing ITN delivery systems aimed to evaluate two specific systems [34], two evaluated one specific system [86, 91], and the remainder evaluated the mix of existing systems. Six of the studies used observational cross sectional surveys and 6 collected data in such a way that it was possible to attribute nets in households to the system through which they had been delivered.

Table 2.4: Summary of delivery system evaluations

Delivery system	Primary outcome	Design	Scale	Country	Reference
ITNs: a) New systems					
Retail sector social marketing	Proportion of households that own at least one net. Proportion of children under 5 who slept under a net the night before the survey	Observational cross sectional survey (post only) Internal control: attribution to delivery system[3] by colour of net	1 district	Malawi	Holtz *et al* 2002 [103]
Routine ANC	Proportion of nets procured that were distributed to pregnant women within 12 weeks	Interviews with health staff, ANC attendees and health facility audits No control	35 districts	Kenya	Guyatt *et al* 2002 [74]
Routine delivery through clinics and NGOs	Proportion of families who purchased a net	Observational cross sectional survey (pre-, mid, and post) No control[4]	12 villages	Afghanistan	Rowland *et al* 2002 [149]
Routine ANC	Proportion of pregnant women who use the free ITN	Longitudinal No control	2 districts	Kenya	Guyatt et al 2003[75]
Mass distribution in Internally Displaced Person camps	Proportion of households with at least one ITN Proportion of persons sleeping under a net	Observational cross sectional survey (post only) No control	22 camps	Uganda	Spencer *et al* 2004 [150]
ITN-measles vaccination campaign	Non-standard indicators Proportion of caregivers who reported their youngest child had slept under an ITN received during the campaign	Campaign exit interviews + observational cross sectional survey (post only) Historical internal [5] control	1 district	Ghana	Grabowsky *et al* 2005 [28]
ITN-measles vaccination campaign	Non-standard indicators (children's ITN ownership)	Observational cross sectional survey (post only) Historical internal control	5 districts	Zambia	Grabowsy *et al* 2005 [85]

[3] 'Attribution to delivery system' refers to the use of the source or other distinguishing features of the net such as colour or type to assign outputs or outcomes as due to the net reaching the household via a specified or defined delivery system.

[4] No control was included within the cross sectional surveys. These were conducted alongside a case control study which had an objective of assessing the effectiveness of ITNs rather than the delivery system *per se*.

[5] Historical internal control: questions were asked on pre-campaign ownership of ITNs in a post campaign survey and use is reported on use of a campaign net

Community based social marketing and unassisted private sector	Proportion of households with at least one net	Observational cross sectional survey (pre- and post) External geographic control	Intervention 6 villages, control 1 division	Tanzania	Kikumbih et al 2005 [119]
Lymphatic filariasis mass drug administration programme	Proportion of households with at least one ITN	Observational cross sectional survey (post only) Historical internal control	1 LGA in each of 2 states	Nigeria	Blackburn *et al* 2006 [89]
ITNs, Vitamin A, measles vaccination and mebendazole campaign	Proportion of households with an under 5 owning at least one bednet and/or ITN	Observational cross sectional survey (post only) Historical internal control	1 district	Tanzania	Skarbinski et al 2007 [36]
Commercial shopkeepers and community leaders	Proportion of households with at least one net	Observational cross sectional survey (post only) External geographic control	20 sites in 9 districts	Mozambique	Brentlinger *et al* 2007 [104]
Employer and community based	Proportion of households with at least one net	Observational cross sectional survey (post only) External geographic controls	4 'sites'	Kenya	Wacira *et al* 2007 [101]
Public sector clinics and village based volunteers	Non-standard indicators. Access to nets by socio-economic groups	Observational cross sectional survey (post only) External geographic control	3 districts	Zambia	Agha *et al* 2007 [151]
ITN-polio vaccination & Vitamin A campaign	Proportion of households owning an ITN	Observational cross sectional surveys (2 x post campaign) Historical internal control	National	Niger	Thwing *et al* 2008 [35]
ANC and retail sector social marketing programme	Proportion of households owning at least one Serena ITN	Cluster randomised controlled trial Intervention: ANC + social marketing Control: social marketing only	1 province	Burkina Faso	Muller *et al* 2008 [145]
ITN voucher scheme	Proportion of pregnant women using an ITN	Observational cross sectional surveys (pre and post surveys) Internal control: attribution[1] of nets to delivery system by reported source	National	Tanzania	Hanson *et al* 2009 [31]
Routine ANC	Proportion of pregnant women using an ITN	Cohort study Attribution of nets to delivery system: based on type	1 clinic	Democratic Republic of Congo	Pettifor *et al* 2009 [79]
Routine immunisation services	Proportion of children 12 to 23 months using an ITN	Observational cross sectional surveys (pre and post surveys) External geographic control	3 districts	Malawi	Mathanga *et al* 2009 [80]
ITN-measles vaccination campaigns	Proportion of households with any mosquito nets.	Observational cross sectional surveys (post only) No control	16 Local Government Areas (LGA)	Nigeria	Afolabi *et al* 2009 [152]
ITNs: b) Existing systems					
Multiple delivery strategies	Proportion of households with at least one net. Proportion of households newly owning a net from the initiative	Observational cross sectional survey (single survey + sales records Internal control: attribution of nets by reported source	6 villages + 1 town	Tanzania	Fraser-Hurt *et al* 1998 [153]

Community based delivery	Proportion of children under 5 years not under an ITN in ITN owning households	Observational cross sectional survey (single survey) No control	3 *zobas*	Eritrea	Macintyre *et al* 2006 [86]
Multiple delivery strategies	Proportion of children who slept under a net the night before the survey Proportion of nets that were from the retail sector	Observational cross sectional survey (single survey) Internal control: attribution of nets by reported source	4 districts	Kenya	Noor *et al* 2006 [91]
ITN-measles campaign + routine clinic delivery + commercial market	Non-standard indicators (children's ITN ownership)	Observational cross sectional studies (single survey) Internal control: attribution of nets by reported source	1 district	Ghana	Grabowsky *et al* 2007 [34]
Multiple delivery strategies	Proportion of children <5 years who slept under any net the night before the survey	Longitudinal cohort study Internal control: attribution of nets by reported source	4 districts	Kenya	Noor *et al* 2007 [29]
Multiple delivery strategies	Proportion of nets used by infants and young children (12-59 months)	Observational cross sectional survey (single survey) Internal control: attribution of nets by reported source	31 villages	Tanzania	Khatib *et al* 2008 [33]
Multiple delivery strategies	Proportion of children <5 years who slept under any net the night before the survey	Observational cross sectional survey (single survey) Internal control: attribution of nets by reported source	1 district	Tanzania	Bernard *et al* 2009 [154]

2.7 Discussion

In order to go to scale with ITNs, an evidence based understanding of the most effective delivery systems is needed. Although delivery systems for ITNs have been debated over the last few years, most of the debates have focussed on a) whether delivery should be free or subsidised and b) upon the necessity of involving the private sector [25-26], and more recently on the relative merits of campaign and routine delivery systems [27]. The evidence used in these debates has been limited to data from small scale research projects and therefore does not necessarily reflect what could be expected from large scale programmes. Rigorous methodological approaches are used to evaluate the effectiveness of ITNs and other preventative interventions for malaria control. Since the effectiveness of the delivery system will increase or decrease the effectiveness of the intervention, similarly structured approaches using rigorous methods are also needed to assess the effectiveness of these different delivery systems. Approaches to determining the effectiveness of the various delivery systems should involve 1) defining and categorising delivery systems, 2) synthesising the literature on effectiveness of delivery systems using an analytical framework to assesses changes over time, 3) comparing coverage and equity outcomes achieved by each delivery system from the existing evidence base, 4) defining of a methodology to evaluate the effectiveness of alternate delivery systems.

The emphasis on scaling-up delivery of ITNs shifted the focus from small scale projects to national scale systems. ITN delivery has been reported to have taken place 'at a national scale' in at least seven countries of sub-Saharan Africa. Three of these involved public sector delivery through routine health facilities in Eritrea (with some delivery also taking place to high risk communities and the military), a combined polio and ITN campaign in Niger, and a combined measles and ITN campaign in Togo. Three of the other four experiences involved mixed public-private sector delivery, in Kenya and Malawi through routine health facilities with the support of a 'non-profit' NGO, in Tanzania through a voucher scheme where the subsidy was delivered through routine health facilities and the product through the private retail sector. In Senegal delivery was through the private retail sector and was partially subsidised. ITNs were free to the end user through public sector delivery in Eritrea, Niger and Togo, and involved partial subsidies through mixed delivery in Kenya, Malawi, Senegal and Tanzania. The number of countries in which there was 'national scale' unassisted private sector delivery of nets through either the formal or informal private sector was unclear.

Findings of this review suggested that The Gambia is one such country and the relatively high coverage of never-treated nets in Guinea Bissau (59% use by children <5) [30] would suggest that this was another. Malawi, Tanzania, and Togo were the only three of these countries where national level data for all three RBM coverage indicators was accessible.

Delivery 'at the national scale' should be defined within the context of the different categories of delivery system, as well as malaria epidemiology. Where delivery is through the public sector or via mixed systems, should 'national scale delivery' be defined as delivery of ITNs (or ITN subsidies) in every district? Should targets be defined for each district, for example, achieving delivery through a certain proportion of facilities? How do we define national scale delivery through the private sector? These questions need to be answered bearing in mind that malaria epidemiology varies across districts of endemic countries, with not all districts being endemic so that effective coverage at national level may not require providing ITNs in each district.

As more programmes scale-up, the geographic disparities across countries will certainly need to be addressed as in the case of Malawi described above. There are lessons to learn from EPI which, in recognition of district level disparities in coverage, now has a target of 90% national coverage (with 3 doses of Diptheria Pertussis Tetanus (DPT) in children 1 year of age), with at least 80% coverage in all districts.

This review of the literature has identified three areas relating to delivery of ITNs where clarity is needed, or diversity recognised. The first relates to a general lack of clarity in the description of delivery channels. In particular, the term social marketing should be avoided and replaced by a more specific description of the delivery channels as represented in the analytical matrix presented here. For example, in the existing literature social marketing is variously applied to mixed public-private sector delivery of ITNs through routine health facilities with partial subsidies, private sector delivery through retail outlets with partial subsidies on the ITNs, and assisted private sector delivery where the ITNs *per se* are unsubsidised, but marketing, promotion or technical support are given. A further example of lack of distinction is where 'non-profit' organisation and retail sector delivery channels use retail outlets as their delivery point. There are two distinct types of delivery system. In 'non-profit' organisation channels the ITNs are generally 'pushed' to a retailer and sold at a

subsidised price determined by the organisation. Private sector delivery involves a 'pull' on a wholesaler or other supplier from the retailer in response to an identified demand (a pull from consumers), and prices will vary according to market forces. 'Non-profit' organisation delivery through retail outlets is dependent upon donor money for the subsidy (either for the ITN itself, promotion or pushed distribution) and the programme infrastructure. Unassisted private sector delivery is independent of donor and other public sector input.

The review suggested that after distinguishing private sector delivery from assisted private sector delivery by 'non-profit' organisations of ITNs through retail outlets, further distinctions should be made within the private sector. The coverage and the equity of coverage achieved through formal and informal delivery outlets varies enormously, with the informal commercial sector being particularly successful in countries of West Africa [112, 116-118, 121-122, 155-159]. In much of West Africa there has been a tradition of using mosquito nets for many years, the majority of which have been supplied through markets [160]. These nets are made from a variety of materials and the reasons for using them and the preferences for the different fabrics vary substantially [127]. There is a lack of evidence on whether the bias towards the poorest households of nets delivered through the informal sector is due to the nature of and accessibility of the delivery points, that is markets rather than supermarkets and pharmacies, or whether it is due to the type and/or cost of the 'local nets'. Delivery of a range of ITNs through the informal sector, thereby increasing choice, may help to answer this question.

The second point concerns clarification of the objectives of voucher schemes. The objective of a voucher scheme is to provide targeted subsidies through the public sector whilst delivering the product through the private sector, thereby promoting private sector growth, and ultimately its sustainability. The retailers involved in the scheme therefore exchange a voucher for an ITN, usually with the addition of a top-up fee; this transaction represents a public-private partnership in delivery. Voucher schemes also aim to facilitate a general increase in availability such that those not targeted by subsidies may also buy ITNs at full commercial price, which would involve a purely private sector transaction. These schemes should be distinguished from delivery which involves a 'paper' subsidy through the public sector where the product is also delivered through the public sector. An example is the combined polio NID and ITN distribution in Central Region Ghana, where vouchers were given

to the caretakers of children <5 years of age. This voucher entitled the bearer to purchase a subsidised ITN at a pre-determined number of sites which were mainly health facilities. The voucher was used simply as a method of delivering the right to a subsidy, and of avoiding logistical problems of transport of ITNs by immunisation volunteers.

The third issue concerns timing. There are at least five dimensions of timing which are relevant: duration of delivery, intended duration of delivery (that is programme objectives and timeframe), changes in the nature of the programme over time, seasonality in coverage and time of its measurement, and tempo or pace of coverage increase. Timing may therefore impact on coverage outcomes achieved, coverage outcomes measured, and should be considered in the interpretation of relative achievements. Delivery of ITNs through integration with immunisation campaigns provides a 'quick fix' or 'catch-up' solution to scaling-up coverage. The maximum level of household ownership is achieved within the few days of the campaign. Where no other system is in place to 'keep-up' this coverage, then ownership is transient and will fall as the ITNs wear out. Delivery of ITNs/nets through routine systems (public and/or private) may also be used to 'catch-up' coverage, but the pace is slower. These systems however, are also designed to 'keep-up' coverage. In order to compare the effectiveness and cost effectiveness of these two systems they should be mapped over time and for a period of at least three to five years [161]. These issues of timing should be addressed directly when results are reported, so that there is an explicit statement of the time elapsed between the commencement of delivery, intended period of delivery and the point at which coverage is measured.

Programmes can also change over time, suggesting that they may move between cells in the matrix, which is why the proposed matrix should be used repeatedly at suitable periodic intervals. Finally, use of ITNs/nets is seasonal and therefore the coverage measured is highly influenced by the season in which the survey is undertaken. Surveys undertaken in the dry season will estimate lower levels of net use than those undertaken during the rainy season when mosquitoes are a greater biting nuisance. This should be taken into account in interpreting the outcomes of delivery systems as measured through cross-sectional surveys such as the Demographic and Health Surveys (DHS).

Using the defined categories, some intra-category variations were found, and some inter-category overlaps were identified. All examples of intervention packages were from the UNICEF ACSD programmes in West Africa. These generally involve delivery through routine health facilities, but sometimes this occurs via community agents either in the facilities, as in Upper East Region of Ghana, or within the communities. This is therefore a combination of two types of delivery, routine health services and community-based. The Kilombero and Ulanga Treated Net Project (KINET) programme in Tanzania was primarily a social marketing programme, but also introduced the delivery of discount vouchers for ITNs delivered to pregnant women through ANC.

Although RBM has recommended three outcome indicators for ITN programmes, these are often not used or are modified so that direct comparisons across programmes and countries are not possible. 'Coverage' is a term which is loosely used, such that it is often difficult to interpret. Coverage is variably used to refer to household ownership, use by pregnant women or use by children under 5 years of age. Coverage of ITNs and nets should always be qualified as either household ownership, or use by a specific target group.

The review focussed on two outcomes which were effectiveness and equity; other outcomes include cost-effectiveness and sustainability. A review of cost and cost-effectiveness studies on ITNs emphasised the diversity of methods used [162]. Sustainability has not been addressed in the literature. A wider review of sustainability is beyond the scope of this review and, indeed, is not possible with existing published data sources which tend to report coverage achieved at a single point in time. A compilation of coverage data over time has recently been undertaken[139] and shows that campaign delivery generally achieves high coverage rapidly, but this also decreases quite quickly, whereas routine system increases, although slower continue to increase steadily, with as yet, no evidence of a decrease overtime.

This review has outlined the diversity of delivery systems for ITNs and the weakness of the evidence base currently available to aid in strategic decision making for national scale-up with the increased funding now available to countries. Where data are available, they show that ITNs have been delivered by programmes which have been implemented at a variety of scales, in different countries, and over different time periods, making it impossible to draw

clear conclusions as to their relative merits. There are no comparative studies from which definitive evidence can be drawn in the way that randomised control trials study the efficacy of interventions such as ITNs.

The response to the debates on whether delivery should be free or subsidised and upon the necessity of involving the private sector will be different depending upon the country of focus and upon the context of ITN delivery systems used within that country. The variation in impact of another large-scale intervention, IMCI, between different contexts has been shown across five countries [40]. Research is needed on the contextual factors which either enable or act as barriers to the delivery of ITNs through the various categories of delivery systems currently used. The matrix presented here could be expanded to include relevant features of context to be studied systematically. It may then be possible to ascertain under what circumstances free, partially subsidised or unsubsidised ITNs are necessary/most appropriate, and whether and under what circumstances the private sector may make important contributions to ensuring that children under 5 years and pregnant women are protected from malaria by ITNs.

Attribution of ITNs in households to a specific delivery system

The data points included in the review are taken mainly from post delivery household surveys undertaken by programmes using a specific category of ITN delivery. The assumption has been that the contribution of ITNs delivered through other systems to this coverage has been negligible. In some instances this may have been true, but should not be assumed. Methods are needed such that coverage achieved at the household level (ownership and use by target groups) collected in household surveys may be attributed to specific delivery systems.

There have been attempts to attribute ITNs to the system through which they are delivered, perhaps to a greater extent than there have been with other malaria control interventions [72]. These methods have included whether the net was treated or not [30], the source or delivery point of the net [29], and whether a voucher was used in the purchase of the net [31, 163]. However, the defining of simple methods for attribution of coverage outcomes to a specific delivery system and their recommendation for wider use across malaria control interventions and those targeting other diseases is required. NetMark surveys focused on the source of nets (proportion of nets/ITNs in households that came from each source). A further

step of linking this data to target groups would allow the assessment of the three RBM coverage indicators by delivery system. Inclusion of these methods in the DHS, Malaria Indicator Surveys (MIS) and the UNICEF Multiple Indicator Cluster Surveys (MICS) surveys would allow collection and collation of the urgently needed data to compare the effectiveness of different delivery systems for ITNs within a range of contexts.

Other ITN delivery system evaluations have used longitudinal cohort studies and observational cross sectional surveys with attribution of the outcomes to the system through which the ITNs reached the target population. The outcomes of these studies have been both household ownership and use by the target group.

Few studies have described in sufficient detail the structure of the delivery systems being evaluated, and only in a minority has the implementation pathway been described [104, 164] and several intermediate processes assessed [31, 74-75, 148]. Generally, very little information is provided on the intermediate processes of the delivery of the intervention. Only by describing the required processes including the individual intermediate processes and the summary or composite processes (the combination of each intermediate process) is it possible to identify the likely implementation effect modifiers and to ensure that these are included in the evaluation. There is perhaps a greater tendency towards assessment of health outcomes (that is evaluation of the effectiveness of the intervention) than to greater exploration of the delivery system and its enabling and disabling factors.

A comprehensive mapping of systems, outcomes and the processes by which the outcomes are achieved is needed, incorporating an analysis of the influence of context, with a view to providing evidence to guide strategic decision making. Currently, even basic information about household ownership and use by target groups is lacking thereby severely restricting our ability to make evidence based decisions about the most effective delivery systems for any given context.

In summary, the reviews outlined that after nearly two decades of delivering ITNs there is relatively little evidence on the effectiveness of different delivery systems and their coverage outcomes at the national scale, across geographic areas and across socio-economic groups. Although across sub-Saharan Africa it is rare that ITNs are delivered exclusively through a

single system, assessments of the relative achievements of more than one delivery system have been conducted rarely. This is partly because structured approaches for comparing the outcomes of alternative delivery systems have not been developed, but also because there is a tendency to assume that changes in coverage must be due to the delivery system of interest at the time. The current move towards greater emphasis on continuous delivery systems for ITNs recognizes that a mix of such systems is needed to reach all target population groups. Methods are therefore needed by which the relative effectiveness of specific ITN delivery systems can be assessed within a mix of systems. The interaction between these systems and their impact on the effectiveness of each and contribution to the overall coverage outcomes should be assessed.

The need for such methods was strongly demonstrated in Ghana, where a new ITN delivery system was implemented within the context of a mix of existing and alternative delivery systems. The next chapter presents the aims and objectives of the thesis, a conceptual framework for evaluating ITN delivery systems, and the methods used in evaluating the ITN voucher scheme in Volta and Eastern Regions.

Chapter 3: Aim, objectives and methods

In the previous chapter the findings of two literature reviews showed that, after more than two decades since the efficacy of ITNs was shown, relatively little advance has been made on how best to deliver ITNs so that they are accessible to all at risk of malaria and are used consistently. In this chapter the aim and objectives of the thesis are presented, together with the a basic conceptual framework for the action of contextual factors in the delivery of public health interventions, followed by the methods used in the thesis.

3.1 Study justification

The key to scaling-up of coverage with ITNs is a nationally co-ordinated strategy consisting of multiple delivery systems that are complementary, each one adding incrementally to the coverage achieved overall. The evidence base needed to achieve such efficient and effective combinations of delivery systems is lacking partly because there has been a tendency to study and debate the relative achievements of individual systems, rather than looking at the contributions of each to the whole. There has, however, been acknowledgement that a combination of routine and campaign delivery systems is needed, and in the present policy context of higher priority given to routine or continuous systems we will necessarily need to focus on mixes of such systems. There is currently scant data to define optimum combinations of delivery systems appropriate for different contexts.

In order to understand what combination of delivery systems is most effective in a given context, methods of evaluation should be able to: 1) attribute coverage outcomes to specific delivery systems and thus quantify the achievements of each specific delivery system; 2) understand the strengths and weaknesses of each delivery system by quantifying the effectiveness of the component processes within the system; 3) assess the reasons for any loss of overall system effectiveness due to problems in the component processes ; 4) describe the delivery systems context and assess the interaction and synergies between the delivery systems.

Currently, methods for evaluating delivery systems have not been defined. Methods for assessing whether multiple delivery systems are synergistic or competitive have not been

developed but will become more important as we move more firmly towards a focus of continuous systems for maintaining universal coverage.

3.2 Aim of the research

The aim is to define a methodology for delivery systems evaluation using the experience of evaluation of a voucher scheme for ITNs together with a review of the literature on the delivery of ITNs. The study will examine how a specific delivery system functions within the presence of other delivery systems, and how contextual factors can be incorporated into delivery systems evaluation.

3.3 Objectives

The objectives for the thesis are:

1) To assess the coverage outcomes achieved, and socio-economic disparities in coverage, of a voucher scheme for ITNs in two regions of Ghana
2) To understand the effectiveness of intermediate processes, including socio-economic disparities in process effectiveness, involved in delivering nets through a voucher scheme for ITNs
3) To describe the delivery systems context, understand the reasons behind any losses of effectiveness of individual processes, and assess the interaction between the voucher scheme and alternative delivery systems
4) To define a methodology for delivery system evaluation based upon the findings and conceptual approach to the evaluation of the ITN voucher scheme in Ghana

3.4 Basic conceptual framework

The basic conceptual framework within which the ITN is delivered, taken into the household, used and has a health impact is presented in Figure 3.1. For ITNs, there are two distinct coverage outcomes: ownership and use of the ITNs. The outcome achieved by a public health intervention depends upon the mechanism and the context within which it is delivered [46]. The influence of context (external influences) upon the achievement of outcomes by interventions complicates programme evaluations and the inferences that can be drawn from these. Contextual factors can be either confounders or mediating factors depending upon their relationship to the outcome of interest and to the intervention. Factors which are

independently associated with the intervention and the outcome are confounders. Mediating factors are associated with both the intervention and the outcome but unlike confounders, they lie on the causal pathway between the two [39]. The importance of each contextual factor will differ with both the outcome and with the intervention. Contextual factors may modify the effect of the intervention in two ways, which are through implementation-related effects, and through impact related effects [39]. Implementation-related effect modifiers of public health interventions usually relate to the systems through which the interventions are delivered.

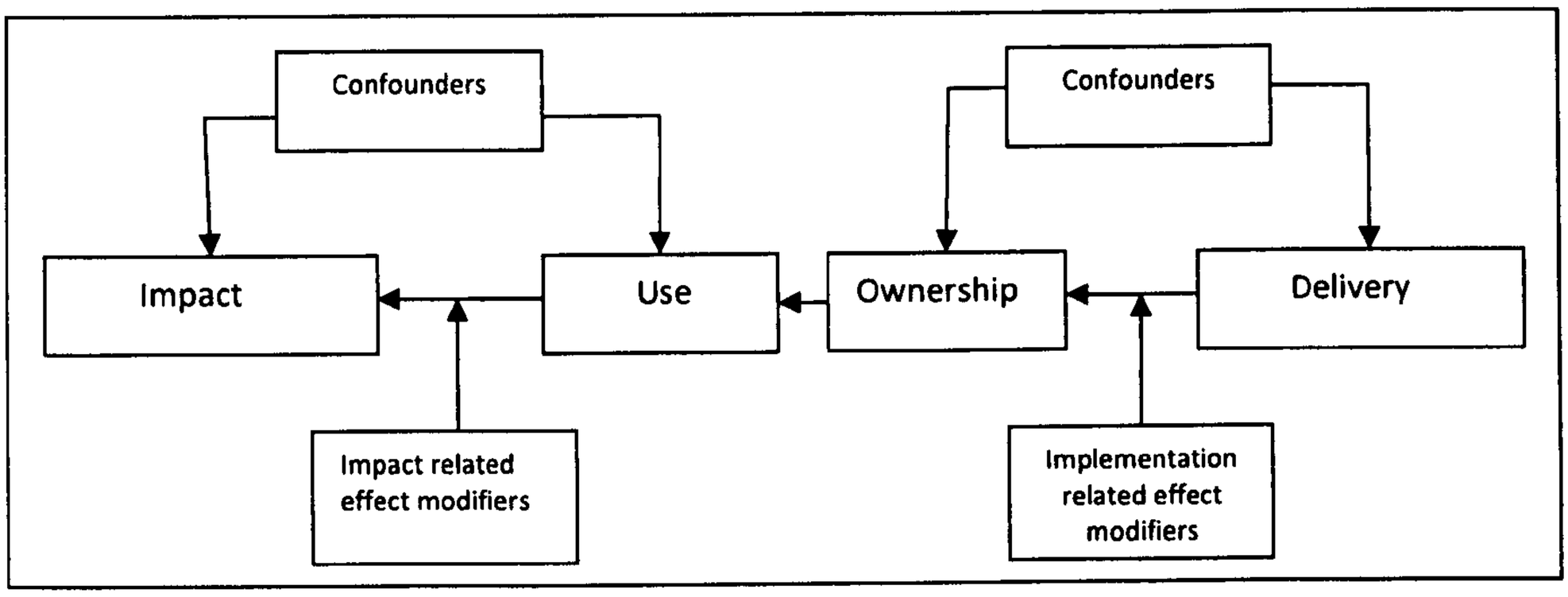

Figure 3.1: Action of confounders and effect modifiers in evaluation of interventions

3.5. Over view of the application and development of the conceptual framework

The factors leading to coverage outcomes, that is, household ownership and use of ITNs were explored using the data collected for evaluating the voucher scheme in two regions of Ghana. The methods used for this evaluation are described in sections 3.7.4 to 3.7.8 of this chapter and in more detail at the beginning of each of the results chapters 4, 5 and 6. The conceptual framework was developed further using the observations and methodological challenges encountered in the analyses that form this thesis and the revised conceptual framework is presented in the discussion Chapter 8.

In order for ITNs to have an impact in reducing morbidity and mortality due to malaria, they should be delivered to the target group so that they are owned by a household; they should then be used by the target group. The proportion of households with at least one ITN both pre and post delivery may be measured through an outcome evaluation. However, it is necessary, where there is more than one delivery system, to attribute the coverage outcomes to the system that delivered it. A coverage outcome evaluation of the ITN voucher scheme in Volta and Eastern Region, with attribution of the source of ITNs in the household to a specific delivery system, is presented in Chapter 4.

Delivery systems are composed of multiple intermediate processes. The number and nature of these processes for delivery of ITNs vary by the sector and also within sectors, depending upon both the design of the delivery system itself and the structure of the system into which delivery is introduced. The processes in delivery of ITNs through the voucher scheme in Volta and Eastern Region are described in section 3.6.7 of this chapter. The effectiveness of each intermediate process is then evaluated and the socio-economic disparities in the reach of each of the delivery processes are assessed (Chapter 5).

Two main groups of contextual factors influence the effectiveness of the systems through which ITNs are delivered and proportions of the households that own an ITN. These are strategy related factors and implementation related factors. Strategy related factors include the product itself, the type of ITN, its size, shape and colour; the price at which the ITN is available to members of the target group; and the place at which it is available. In the design of the voucher scheme, place includes the place of delivery of the subsidy, that is the voucher, and the place of delivery of the ITN itself. Implementation related effect modifiers are contextual factors relating to the health facilities, the health staff, retail facilities, retailers, distributors in the retail sector and the clients that may act to change the way that implementation occurs. The factors influencing adoption of the voucher scheme including process and contextual factors are investigated using in-depth interviews with different cadres of providers, and the findings are presented in Chapter 6.

Where a new delivery system for nets/ITNs is introduced in the presence of existing delivery systems the existing (alternative) delivery systems may influence the success of the new one. The existing delivery systems may act by competing at the levels of ownership and therefore

use. In assessing the success of the new delivery system, the impact of the existing alternative delivery systems upon this success should be taken into account, and where possible assessed. The coverage outcome evaluation assesses the change in coverage achieved, and includes both ownership and use as coverage measures. In order to determine the proportion of the change in coverage that is due to the new system, it is necessary to attribute changes in coverage to the delivery system through which the change occurred. If we are able to match nets/ITNs in households to the system that delivered them to the house then we can attribute ownership to a particular delivery system. By undertaking such an evaluation we are able not only to assess the adequacy of coverage achieved and whether it is plausible that changes were due to the specific system under study, but also the proportion of the coverage achieved that was due to other systems.

In order to fully investigate the success of a new delivery system and the way in which this is impacted by existing systems, a variety of approaches are needed. These approaches constitute outcome, and quantitative and qualitative process evaluations incorporating an assessment of contextual factors. The new system (here, the voucher scheme) has strategies in place such as the price to be paid (via the subsidy and the top-up), the type of ITN, and the point at which it is delivered to reach the target population. The success of these strategies may be influenced either positively or negatively by the existence of alternative delivery systems. It is possible that the presence of alternative delivery systems may act upon, or they themselves become, implementation related effect modifiers of the new system. The effect of existing alternative delivery systems upon the success of the voucher scheme cuts through Chapters 4 to 6, in terms of coverage outcomes, processes and the influence of contextual factors.

3.6 Study setting and the voucher scheme

3.6.1 Study setting

Ghana is situated on the West Coast of Africa, and is bordered by Burkina Faso to the North, the Gulf of Guinea to the South, Togo to the East and Cote d'Ivoire to the West. It covers an area of 238,538km^2. The climate is tropical with wet and dry seasons. The seasons vary between the north and the south of the country, with a short wet season in the north from May to August, and a longer one in the south from April to November. The country has three distinct ecological zones which are the southern coastal plains, the rainfall middle belt and

the northern savannah. Malaria is hyper-endemic in Ghana, accounts for more than 44% of out-patient visits and an estimated 22% of under-five mortality [165]. *Plasmodium falciparum* is the predominant parasite species [166]. According to the 2003 DHS (the latest survey data available at the time of planning for the voucher scheme), nearly one fifth (17.6%) of households owned a mosquito net and 3.2% an ITN [167].

The studies took place in two regions of Ghana, which were Volta Region and Eastern Region. Volta Region lies to the extreme east of the country and shares a border with Togo. Like Ghana as a whole, Volta Region has three ecological zones with grassland along the southern coast, semi-deciduous forest in the central zone and semi-Savannah in the North. The central and southern zones have two wet seasons, the major one from May to July and the minor one from September to November. The north of the region has one wet season from May to August. The population of Volta Region was 1.6 million according to the 2000 population census. The latest data at the time of the studies showed that, of the ten regions in Ghana, Volta Region had the highest household ownership of mosquito nets at 46.1%, however ownership of ITNs was much lower at 2.5% [167]. There are 13 districts in Volta Region, and 12 of these were involved in the voucher scheme. One district (Nkwanta) was excluded as the district director did not wish to be involved.

Eastern Region lies to the south of the country and borders Greater Accra and Central Region to the south, Volta Region to the east, Brong Ahafo and Ashanti Regions to the west and north. The region has areas of highland forest to the north of the region and relatively low lying plains with isolated hills to the south. The Volta Lake lies to the northeast of the region. The region has two rainy seasons, the first from May to June, and the second from September to October, there is little variation between districts. According to the 2003 DHS just 10.3% of households had at least one net, with ITN ownership even lower at less than 1% having at least one ITN. At the beginning of the voucher scheme there were 15 districts in Eastern Region; during the course of the implementation of the scheme the number of districts increased to 17.

3.6.2 The health system

The Ghana Health Service (GHS) was established in 1996 (but not launched until February 2003) as the implementing body for public sector services of the Ministry of Health (MoH).

Whilst service delivery is the mandate of GHS, responsibility for policy remains with the MoH and regulatory roles are with specific designated bodies such as the Food and Drugs Board. Alongside the establishment of the GHS the health sector included the government health services, private, traditional, and non-government providers, civil society and community groups, with the MoH having some responsibility of each of these.

The Regional Health Administration provides supervision and management support to the districts, and the regional hospitals provide specialized care as the level of referral from district hospitals. District hospitals provide clinical care at the district level and act as the first level of referral from health centres. The health centre is traditionally the entry point to the health system for the client. Health centres provide basic curative, preventative and reproductive health services. The polyclinic is the urban equivalent of the rural health centre. Private maternity homes are under the governance of the Ghana Registered Midwives Association, and offer reproductive and family planning services.

Volta Region has a total of 285 health facilities, 203 of which are administered by the GHS. Amongst these GHS facilities there are 1 regional and 9 district hospitals, 1 polyclinic, 143 health centres and 49 clinics. Eastern Region has 390 health facilities, 239 of which are administered by the GHS. These consist of 1 regional and 9 district hospitals, 6 other hospitals, 59 health centres and 164 clinics. The voucher scheme was implemented in all GHS and Mission health facilities within the regions which had a midwife and/or ANC.

3.6.3 Structure of delivery systems and types of nets delivered at the national and regional scale

A review of published and grey literature on strategies for delivery of ITNs in Ghana at the national scale and at regional scale specifically in the two study regions was conducted. This was supplemented by interviews with national (Senior Entomologist and ITN specialist, NMCP) and regional level stakeholders (Senior Medical Officer for Public Health (SMOPH) Volta Region and senior disease control officer, Eastern Region). Details of national strategies, target groups, subsidy levels, geographic focus and dates of programmes were extracted from the documents available for review. Delivery details specific to Volta and Eastern Regions were then further extracted and used to construct a matrix of delivery systems operating in the region by the type of nets/ITNs delivered through each of these systems.

3.6.4 Delivery systems at the national scale

Collation of characteristics of the different delivery systems for mosquito nets and ITNs across the country up to and including December 2004 clearly outlines the diversity of strategies employed (Table 3.1). Ghana's first ITN policy formulated in February 2002 was built around a 'twin track approach' for distribution, broadly involving targeting of subsidies to vulnerable groups through the public sector, and promotion of widespread availability and distribution of ITNs through the private sector. During 2002, three forms of delivery within the public sector were operating which were theACSD 'intervention package' sponsored by UNICEF [82], ITNs provided by the NMCP to districts for delivery through routine health facilities, and a one-off delivery integrated with a measles campaign [28] [34]. These systems had different delivery points, costs to the end-user, and scale of implementation. Alongside these systems some DHMTs were proactive in managing the '*ad hoc*' delivery of nets/ITNs through health facilities within their districts. In Upper East and Northern Regions some districts have been beneficiaries of both the ACSD and NMCP ITNs. The differing pricing policies caused some confusion. The policy on cost to the recipient for ACSD ITNs was USD 0.56[6] for pregnant women and children <5, and USD 2.22 to the rest of the population; whereas the NMCP ITNs were USD 2.22 to pregnant women and children under 5 years.

During 2003, funding from the GFATM facilitated another round of ITN distribution by the NMCP to the districts, which was extended to include distributions to community based NGOs. The 20 districts targeted for this distribution were different to the 20 targeted for the NMCP distribution in 2002. In October 2004, encouraged by the success of the integrated delivery of ITNs with measles immunisation during 2002, the NMCP embarked upon a distribution integrated with polio immunisations in Central Region. During this integrated delivery discount coupons were given along with polio immunisations to children under 5. In Ghana the use of a paper subsidy delivered in the public sector for redemption in the private sector was called a voucher, whereas those delivered in the public sector for exchange for an ITN in the public sector were called coupons. The coupons were then exchanged together with a top-up value of USD 2.22 for an ITN.

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[6] Ghanaian cedis, ¢9,000 = USD 1

Table 3.1: Delivery of mosquito nets and ITNs in Ghana

Programme	Delivery Strategy	Target groups	Direct subsidy on product	Geographic focus	Dates
Public sector					
UNICEF	ACSD intervention package delivery through ANC and child welfare clinics (CWC) + community based delivery	PW, children <5, paupers, all population	Cost to: PW and children <5 USD 0.56; paupers free; all population USD 2.22	All 6 districts in Upper East Region + 4 districts in Northern Region	2002 to date
NMCP: RBM	Distributed to districts and delivered through hospitals to children under 5 and ANC	PW and children <5	Cost to PW and children <5: USD 2.22	20 districts – 2 from each of the 10 regions.	2002
Integrated measles campaign	Integrated campaign delivery of measles vaccine and ITNs at vaccination posts	Children 9 – 60 months	100% subsidy	Lawra District, Upper West Region	Dec 2002
NMCP: GFATM round 2	Distributed to districts and delivered through routine ANC and CWC + NGO community based	PW and children <5	Cost to PW and children <5: USD 2.22	20 districts – 2 from each of the 10 regions.	2003
Integrated polio campaign	Integrated house-to-house delivery of polio vaccine and discount coupon for ITN, with collection points for ITNs.	Children <5	Cost to children <5 USD 2.22 with discount coupon	Central Region	Oct 2004
Regional / District / NGO: *ad hoc*	Delivered through routine ANC and CWC + NGO community based	Mainly children <5 and PW	Variable	Unknown	Ongoing
Public-private sector mix					
GSMF partnership	Public-private partnership increase demand and affordability.	Population of 10 regions	No direct subsidy on product	10 regions	Dec 1999 – Sept 2002
Private sector					
Informal retail sector	Pure retail	No defined target group	None	Unknown: outlet local markets	Ongoing
Formal retail sector	Pure retail	No defined target group	None	Unknown: outlets mainly urban	Ongoing
Community based					
NGOs	Mixed strategies	Variable but mostly PW and children <5	Mostly USD 2.22 to PW and children <5:	Unknown	Ongoing

The 2002 ITN policy was preceded by a public-private partnership for the sustainable marketing of insecticide treated materials which began in 1998 and finished in 2002. The project was supported by USAID and involved MoH, GSMF, international NGOs, Basics, Programmes for the Assessment of Technology in Health (PATH), UNICEF, United States Agency for International Development (USAID), local funding partners and the commercial sector [168-169]. The lead implementing partner of the project was Ghana Social Marketing Foundation (GSMF). The objectives of the 3 year GSMF project were the creation of increased demand for nets, increased demand for net (re)treatment, and increased availability of nets and insecticides for net treatment through making them more affordable. The project was implemented across all 10 regions of the country.

The length of time during which the private sector have been delivering mosquito nets in Ghana is undetermined. However, it is clear that there is a long tradition of use of nets [170-171]. Nets are delivered through the formal retail sector where the outlets are a variety of types of shops, and through the informal retail sector where the outlets are mainly local market stalls and itinerant vendors within these markets. As of 2003, formal private sector partners included: AgriMat, Vestergaard Frandsen, Transcol, and NetMark/Group Africa (GSMF's funding ceased in 2002). AgriMat marketed Dawa net, a factory pre-treated ITN, K-O net which was an untreated net bundled with insecticide, and K-O Tab which was a deltamethrin tablet for the (re)treatment of nets. As of 2003 AgriMat were supplying nets to all regions of the country through their agricultural distribution networks, with the exception of the northern regions where they were not able to compete with the highly subsidised UNICEF nets. Delivery points for AgriMat products were within the formal retail sector including pharmacies, chemical sellers and general shops. Vestergaard Frandsen was marketing PermaNet, an LLIN, through outlets including Total and Mobil petrol stations, pharmacies and supermarkets. Vestergaard Frandsen products were distributed by Transcol. NetMark, established by USAID with the aim of increasing coverage with insecticide treated nets through partnerships with private sector companies, launched their activities in Ghana in November 2002, and worked with all the above listed importers, wholesalers, distributors and retailers.

Within the informal retail sector the majority of mosquito nets were untreated and made from a variety of materials and fabrics [172], although ITNs were also found in the markets that are the mainstay of the informal sector.

3.6.5 Delivery systems in Volta and Eastern Regions

Public sector delivery through health facilities, hospitals, ANC and Child Welfare Clinic (CWC), of ITNs and mosquito nets took place in four districts of Volta and Eastern regions (Table 3.2). Two districts of each region received distributions from the NMCP in 2002 and two further districts in each region in 2003. The type of nets and ITNs distributed by the NMCP varied depending upon availability and on donations. The levels of activity of the formal and informal private sector for mosquito nets within Volta and Eastern Regions are unknown.

Table 3.2: Delivery system characteristics in districts of Volta and Eastern Regions*

Delivery sector and channel	Delivery point	Type of net: netting type; treated or untreated and brand	Districts
Public	Hospitals, ANC, CWC	ITN variety of brands + unbranded, bundled nets and untreated nets with separate insecticide treatment tablets	Volta Region: Hohoe, Nkwanta, Keta, North Tongu Eastern Region: Suhum Kraboa Coaltar, Manya Krobo, Kwahu South, Kwabibirim
Private retail **formal commercial sector**	General shop Pharmacy Chemical seller	ITN variety of brands including (PermaNet, DawaNet, K-O Net, IcoNet, Olyset) + untreated various brands	Extent unknown
Private retail **informal commercial sector**	Market Local kiosk Street hawker Table-top vendor	**Majority are non-standard netting** + untreated nets – standard netting + ITNs including (PermaNet, DawaNet, K-O Net, IcoNet, Olyset)	Extent unknown
Community based	Community	ITN variety of brands + unbranded, bundled nets and untreated nets with separate insecticide treatment tablets	Volta Region: South Tongu, Jasikan, Ho, Kadjebi

* DHMT managed *ad hoc* delivery is not included

The NMCP distributed ITNs to a number of NGOs within the country for community based delivery in 2003. These NGOs included 3 NGOs in Eastern Region, (Micro-enterprise Development Fund, Drama Network, and Rural Watch Ghana) and 6 NGOs in Volta Region, 3 in South Tongu (Planned Parenthood Association of Ghana, Learning-Helping-Living, and Homes Foundation), one in Jasikan (Needy Club of Ghana), one in Ho (Strong Tower Foundation) and one in Kadjebi

(Women in the Lord's Vineyard). They were each given between 750 and 1,000 ITNs with the aim of reaching and operating in communities with poor access to health facilities.

3.6.6 Structure of the delivery systems in Volta and Eastern Region

Delivery systems within the public sector of each region involve logistical movement from the central medical stores directly to DHMT then to health facilities, or via RHD to DHMTs and on to health facilities. The variety of steps comprising the logistical movement of product from the central level or point of importation to the delivery point for the public sector, formal and informal commercial sectors, and for community based systems are depicted in Figure 3.2.

The public sector pricing strategy for ITNs delivered through health facilities was a cost of USD2.22 to the end user. Nets delivered through the formal and informal sector were priced depending upon market forces. ITNs delivered through community based systems and supplied to the NGOs and Community Based Organisations (CBOs) by the NMCP had the same pricing strategy as those delivered through health facilities, that is, USD2.22 to the end user.

3.6.7 The voucher scheme

With the aim of scaling-up coverage with ITNs in Ghana by priming the commercial sector, support was given by the Department of International Development (DfID) Ghana and USAID to the design, implementation, and monitoring and evaluation of a voucher scheme in two pilot regions: Volta Region and Eastern Region. The objectives of the voucher scheme were: 1) to improve access to ITNs for pregnant women; 2) develop a sustainable system for delivering targeted subsidies; 3) strengthen the private sector for ITNs through market priming; and 4) enhance health staff capacity. The Volta Region pilot began in April 2004, eight months ahead of that of the Eastern Region in December 2004.

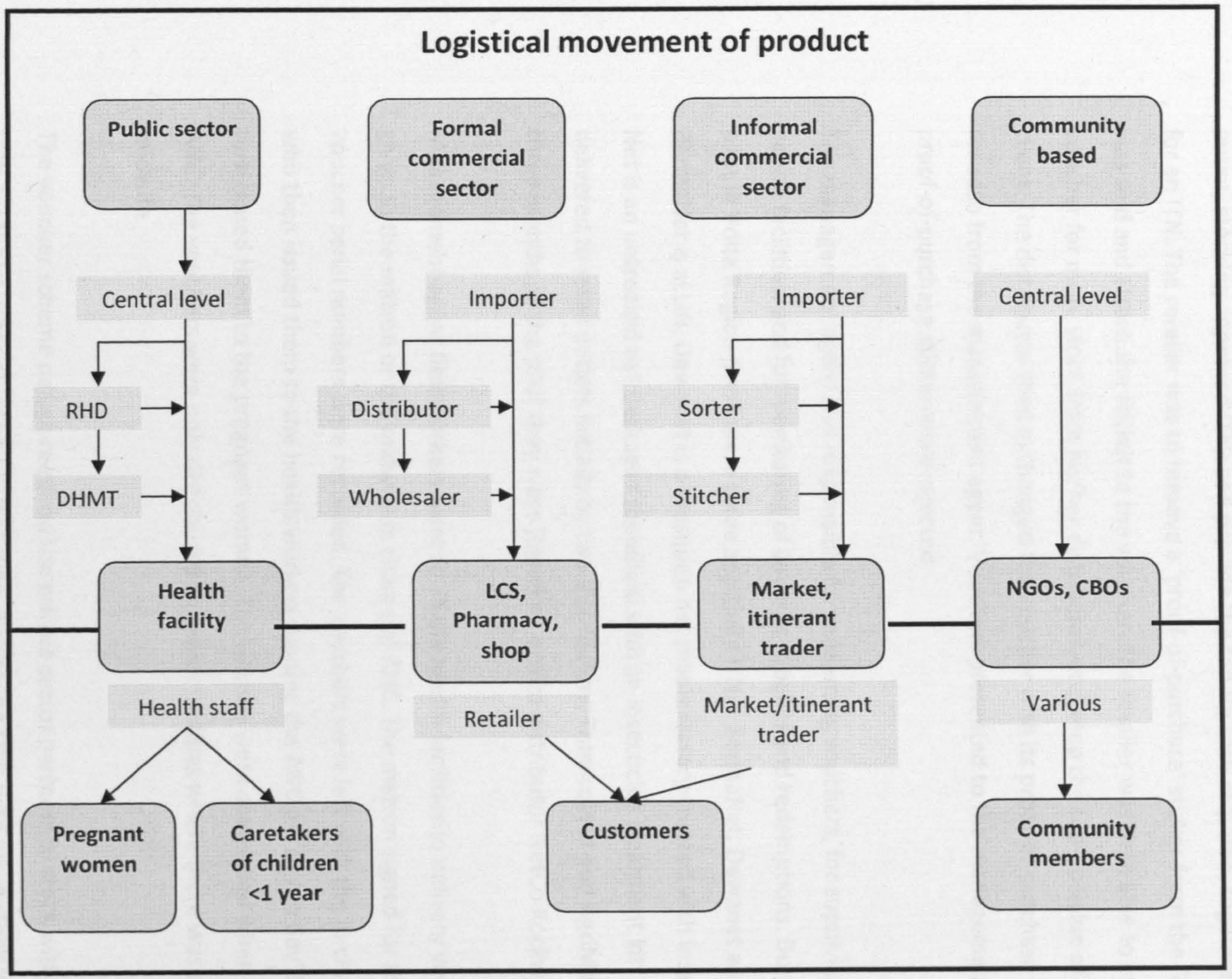

Figure 3.2: Delivery systems for mosquito nets in Volta and Eastern Regions

The voucher scheme was designed such that discount vouchers were given to pregnant women during their first presentation at antenatal clinic. The voucher entitled the recipient to a discount of approximately USD4.20 on the purchase of an ITN available through retail outlets. The recipient or their representative was instructed to take the voucher to a participating retail outlet, stocking approved ITNs and provide the top-up cash required, together with the voucher, for an ITN. The retailer was to remove a 'proof-of-purchase' sticker from the ITN packaging as it was sold and attach the sticker to the voucher. The retailer was then able to exchange the voucher for more stock from his/her distributor, and keep the top-up value of cash from the client. The distributor then exchanged the voucher with its proof-of-purchase sticker attached, for cash from the management agent. Vouchers presented to the management agent without a proof-of-purchase sticker were rejected.

The management agent was responsible for redeeming vouchers, for supplying vouchers to the health facilities, and for monitoring of voucher supplies and redemptions. During the one year pilot in Volta Region there were three approved ITNs: PermaNet, Dawanet and K-O Net. PermaNet is aLLIN, Dawanet is a mosquito net that is factory-treated with insecticide, and K-O Net is an untreated net packaged (bundled) with an insecticide treatment kit. These were delivered to retail outlets initially by two distributors, Transcol Ltd and AgriMat. During the last three months of the pilot they were joined by a third distributor NetCo Rockville.

Management agent fieldworkers went to all the health facilities to delivery vouchers; these were given to the matron or the midwife in charge of ANC. The matron signed for them and the voucher serial numbers were recorded. The vouchers were left with the in-charge of the ANC who then issued them to the health workers running the ANC on 'day to day' basis, and they in turn issued them to the pregnant women. The women were counselled when they attended ANC. The vouchers were only distributed to health facilities where there was at least one midwife.

The voucher scheme design required the private sector partners to stock with ITNs, exchange the ITNs for the voucher plus top-up, and then replace the ITNs with more stock in exchange for the

voucher. In recognition that the partners did not have the financial capacity to lay out money for this stock, NetMark provided stock advances to the distributors, who were then expected to pass the stock on to the retailers. The theory was that as the distributors would have more stock, they would be more adventurous and reach to wider geographic areas. A requirement of the stock advance was that the distributors would put up an equal quantity of the stock themselves to the advance that they were given. This additional intervention had the aim of increasing geographic coverage of the voucher scheme and was based upon the premise that it is only when the partners have lots of stock that they can 'sacrifice' and take stock to areas where it will stay in the system for longer. When they don't have adequate stock they go for where they sell the fastest.

Training of health workers was conducted by the regional teams together with support from NetMark. This involved formal presentation of the nature of ITNs and the protection they offer, the current situation in the country in terms of malaria and ITN coverage, the justification for using the voucher scheme to deliver ITNs to pregnant women, and the mechanisms of the voucher scheme. Role plays were conducted on the roles of the various partners in the voucher scheme, including the midwife issuing the voucher, the pregnant woman going to the retail outlet with the voucher, and the retailer exchanging the voucher and top-up for an ITN. In Volta Region the training was done in 4 zones, that is, the districts were grouped together and brought to a central point. In Eastern Region with a greater number of districts, the training was broken down into smaller zones containing two to three districts and the training team moved from zone to zone.

3.7 Methods

3.7.1 Selection of methods

The study employs an explanatory mixed methods approach to evaluation where qualitative data helps to explain and build upon quantitative findings [173] comprising outcome, process, and context evaluations. The starting point for consideration of an appropriate methodology for delivery system evaluation was the literature on programme evaluation. A range of approaches to programme evaluation have been previously suggested and employed by different groups.

These approaches to programme evaluation that are used mainly to evaluate the combined effect of the intervention itself and the system in which they are introduced were outlined in the introduction (Chapter 1.2).

After considering the range of approaches to programme evaluation and the introduction of interventions into health systems, the following combination of approaches were selected for the evaluation of the ITN voucher scheme: 1) an outcome evaluation based upon the approach to programme evaluation of Habicht *et al [39]*, 2) a quantitative process evaluation similar to that recommended by both Habicht *et al* [39]and the MRC, and 3) a qualitative process evaluation using a nested analytical framework based upon the conceptual approach of Rogers [62], of the adoption and dissemination of innovations in service organisations, and integration of targeted interventions into health systems. Recognition of the need for higher than an adequacy level of inference in outcome evaluations and the limitations of using a geographic control, a novel approach of using alternative delivery systems as internal controls to achieve a plausibility inference, was adopted.

The study consisted of four household surveys conducted pre and post implementation of the voucher scheme in each of the two regions providing quantitative data for the outcome and process evaluations, and in-depth interviews providing qualitative data for the process and context evaluations. In Volta and Eastern Region the voucher scheme was implemented within the context of alternative delivery systems for ITNs. The methods employed were therefore selected in order to attempt to distinguish the coverage outcomes of the voucher scheme from those of the other alternative systems. The quantitative and qualitative process analysis was designed to describe the context in the study areas and to illuminate the processes that were effective and ineffective in the context described. The findings were then used to define a methodology for delivery system evaluation.

3.7.2 Fieldwork

The fieldwork for this research was conducted through a consultancy contract with the UK Department for International Development, Ghana Country Office. The Terms of Reference of the

consultancy were to provide support to the monitoring and evaluation of the voucher scheme in Volta and Eastern Region. The data collection and monitoring were implemented by regional teams led by two key people in each region: the SMOPH, together with a District Director in Volta Region, and a Regional Communicable Diseases Officer in Eastern Region. Each regional team conducted pre and post voucher scheme implementation household surveys together with a variety of intermittent monitoring activities, mainly involving semi-structured interviews with health staff and LCS. The management agent also kept routine records of vouchers distributed and vouchers redeemed.

My designated role within the consultancy agreement was to provide technical advice to the teams in both regions on the methods, tools and timing of the monitoring and evaluation activities. In terms of the research outputs of this work, I was constrained to working within the bounds of the consultancy agreement for which the funding was available and therefore had to be opportunistic in the data collection activities. I designed the overall evaluation including all of the work presented in this thesis. I designed all elements of the household survey and in-depth interview method and tools. I developed interviewer and supervisor manuals to help in the training and to provide a reference guide during implementation of the fieldwork. I supported the regional leads in training for and piloting of the household surveys, and I conducted the in-depth interviews. I conducted all analyses and interpreted the findings of the analyses.

Teams were trained for implementation of each of the 4 household surveys. Each team consisted of 30 interviewers and 6 supervisors, therefore 6 teams of 5 interviewers with one supervisor. The fieldwork was co-ordinated by a District Director in Volta Region and a Regional Communicable Diseases Officer in Eastern Region. Training for each survey included: 1) familiarisation with the questionnaire with a review of each question and changes made where deemed necessary, 2) role plays with fieldworkers taking the role of interviewer and respondent, 3) presentation, discussion, and practising the adapted EPI random walk sampling technique, 4) piloting of the survey in households close to the training centre in clusters not included in the sample list, 5) review of the questionnaire with adaptations post piloting, 6) presentation of the clusters to be included in the sample and logistics discussion on distribution of the clusters

amongst the 5 teams, 7) development of schedules for the fieldwork. The trainings were conducted over a period of 5 to 6 days and each survey was implemented over a period of 3 to 4 weeks. The timeline for each of the surveys in relation to implementation of the voucher scheme in each region is presented in section 3.7.3 below.

I conducted the in-depth interviews over a period of 6 months. I was unaccompanied at the national level interviews and was accompanied by a regional representative at all interviews conducted in Volta and Eastern Regions.

3.7.3 Timeline of project and evaluation implementation

The surveys were not undertaken during the same time period due to different timings in introduction of the regions into the voucher scheme and unavoidable implementation delays. Surveys were undertaken in Volta Region during March 2004 and April 2005 and in Eastern Region during July 2004 and July 2006 (Figure 3.3). The post implementation survey in Volta Region was undertaken one year following the baseline survey, and in Eastern Region the post implementation survey was undertaken 24 months after the baseline survey. However, post implementation surveys in both regions were undertaken one year after implementation of the voucher scheme.

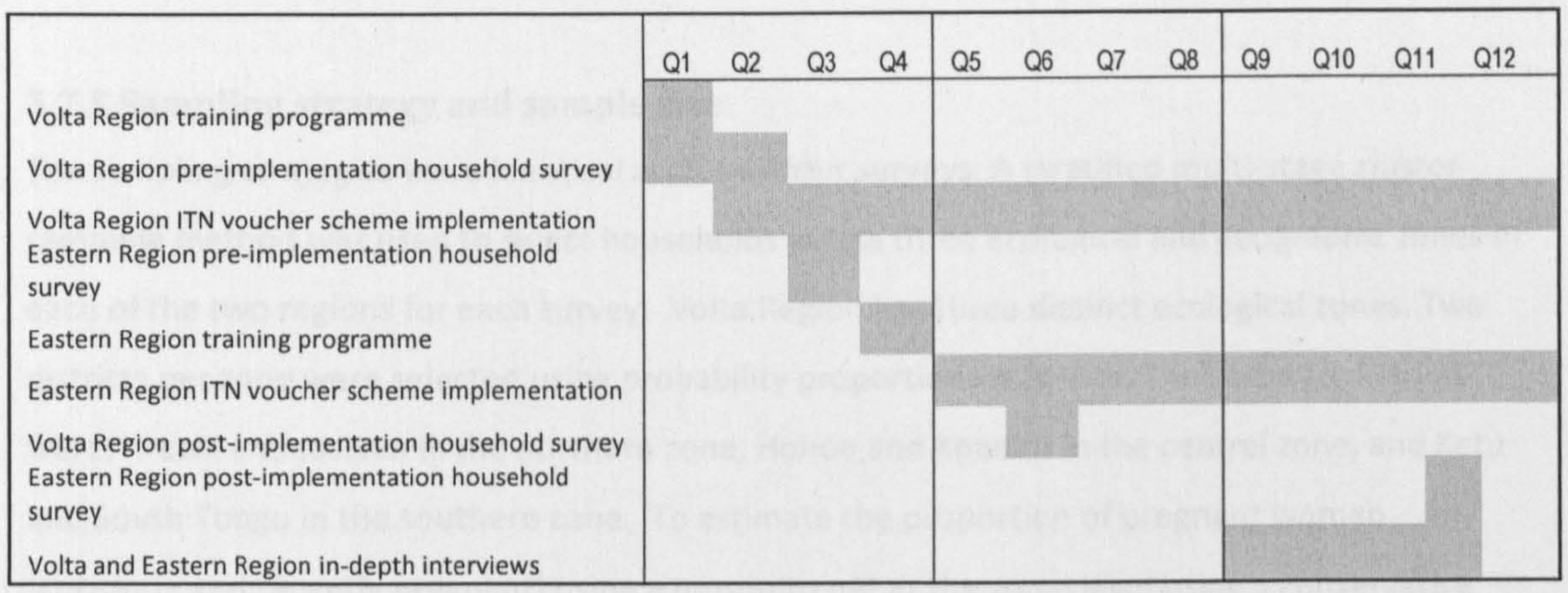

Figure 3.3 Timing of project and evaluation implementation

Delays in implementation of the planned start date of the voucher scheme in Eastern Region meant that one year after the baseline survey the scheme had only been under implementation for 6 months. Due to the seasonality of both malaria and use of mosquito nets it is vital that pre and post intervention surveys with a focus on malaria control are implemented during identical seasons.

3.7.4 Household surveys

Pre and post voucher scheme implementation household surveys were undertaken in both Volta and Eastern Regions before implementation of the voucher scheme and 12 and 18 months following implementation in Volta and Eastern Regions respectively. Volta Region was originally selected by the ITN Partners in Ghana as the pilot region for the voucher scheme. The reasons for selection of this region are not entirely clear but were influenced by the diversity of the region with the north, central and southern areas of the region thought to be representative of regions within these geographic categories at the national level. Eastern Region was selected as a second pilot region for logistical ease because it borders with Volta Region. However, the results of previous surveys suggested that the regions provided ideal scenarios for contrasting case studies in terms of their existing coverage with mosquito nets, 46.1% and 10.3%, of households with at least one net in Volta and Eastern Regions respectively [167].

3.7.5 Sampling strategy and sample size

The sampling strategies were identical across all four surveys. A stratified multi-stage cluster sampling method was used to select households across three ecological and geographic zones of each of the two regions for each survey. Volta Region has three distinct ecological zones. Two districts per zone were selected using probability proportionate to size. The selected districts were: Krachi and Jasikan in the northern zone, Hohoe and Kpando in the central zone, and Ketu and South Tongu in the southern zone. To estimate the proportion of pregnant women (currently and recently pregnant) using a mosquito net at the zonal level using a conservative 50% coverage with 10% precision and assuming a design effect of 2, and a non-response rate of 10%, a sample of 210 households with a pregnant woman was required [174]. To achieve this sample size, within each of the zones 30 clusters were randomly selected, using probability

proportionate to size. Within each cluster 7 households with a pregnant woman and 7 with a mother of a child under-one year were randomly selected for interview using an adapted EPI random walk sampling method [175]. Using this sampling scheme over the 3 zones the total sample was estimated to be 630 households with a pregnant woman plus 630 households with a child <1 year.

In Eastern Region a similar sampling scheme was used. Eastern Region has two rather than three ecological zones, with the second of these, the tropical forest zone, covering both the central and southern areas of the region. Sampling was designed around these two ecological zones with two-thirds of the sample from the tropical forest zone, and one third from the north of the region (Savannah zone). However, whilst analysing the data it became clear that there were major differences between the central and southern areas of the tropical forest zone and the findings of these areas have therefore been presented separately. The districts where sampling took place in the north of the region were Kwahu South and Manya Krobo, in the central areas of the region East Akim and Suhum Kraboa Coaltar, and in the south Kwapim South and Birim South.

The surveys were therefore conducted amongst 1,260 households, 630 with a pregnant woman (currently pregnant) and 630 with a mother of a child under-one year of age[7] (recently pregnant), in each region. Households with a mother of a child under one year were included, in order that coverage of nets/ITNs could be evaluated in the same group pre- and post-implementation. A household was defined as in the 2003 DHS "*a person or a group of persons, related or unrelated, who live together in the same house or compound, share the same housekeeping arrangements, and are catered for as one unit*" [167].

[7] Many of the pregnant women who benefit from the scheme during the first few months of its implementation will be mothers of children under-one year during the one year post implementation evaluation

3.7.6 Questionnaires

The layout of the questionnaire was based upon that of the Ghana DHS [167], with adaptations to include sections enabling both delivery attribution of the coverage outcomes to the voucher scheme and other alternative delivery systems (Chapter 4), and a process analysis of delivery of ITNs through the voucher scheme (Chapter 5). The questionnaires were structured with no open ended questions. All questions had a set of response categories with facility for 'other' responses as necessary. All 'other' responses were accompanied by a 'specify' option.

Both pre and post voucher scheme implementation surveys included sections on: household listing; ownership, age and condition of mosquito nets; source of mosquito nets owned in the household; insecticide treatment status of mosquito nets; cost and method of payment for nets; antenatal history; information on ITNs; and household assets. The household assets included: source of drinking water; type of sanitation facility; source of cooking fuel; material of flooring; and household durable assets. The standard form of the question on cooking fuel in the DHS asks about the *main* form of cooking fuel. In Ghana, this was changed to the *two main* forms of cooking fuel to fit with local practices. The post voucher scheme implementation questionnaire also included sections on voucher offer and acceptance during ANC; and on the use of vouchers in exchange for ITNs. The pre-implementation surveys included an option of voucher as a response category on methods of payment for ITNs, but did not include these more detailed questions relating to the ITN voucher scheme.

3.7.7 Data entry and analysis of survey data

Data was double entered in Epi -6.0, validated and then transferred into STATA 9.0 software for analysis. Adjustments to take account of the cluster sampling were incorporated into all analyses. The survey design was self weighting as all pregnant women within the selected districts had equal probability of being sampled.

Two methods were used to assess socio-economic disparities in ownership and use of mosquito nets: the equity ratio and the concentration index [176]. The equity ratio compares coverage in only the highest and lowest quintiles, thereby using only 40% of the data, but has been used as a

measure of socio-economic disparity in a number of studies of mosquito net / ITN ownership [28, 34-36, 91-92, 105, 143] and use [29, 31]. The concentration index is defined based upon the concentration curve [177] where households are ranked by socio-economic status (SES), and the cumulative percentage of households with the characteristic is plotted against the cumulative percentage of all households on the y-axis and x-axis respectively. If the characteristic is equally distributed amongst all SES levels, the result is a 45º straight line, the line of equity; otherwise, it is a curve, the concentration curve, which is concave if the characteristic is concentrated in richer households or convex if it is concentrated in poorer ones. The concentration index is defined as twice the area between the concentration curve and the line of equity [178]. A concentration index of 0 is indicative of perfect equity, -1 the highest degree of pro-poor inequity and +1 the highest degree of pro-rich inequity. The concentration index provides a measure of equity across all 5 quintiles which is relatively independent of the overall level of coverage, that is higher coverage does not necessarily entail less inequality [179]). The Excel spreadsheet developed by the World Bank based upon the formula developed by Kakwani [180] was used to calculate concentration indices, their standard errors and 95% confidence intervals.

3.7.8 Classification of households to socio-economic quintiles

In order to examine the relationship between key outcomes and socioeconomic status (SES), principal components analysis (PCA) was used to create an asset index [181-182]. All assets were included in the PCA as binary variables. The asset index was then used to construct socio-economic quintiles from the poorest households through to the least poor. This method has been validated in other surveys with information on both assets and income or expenditure [181]. Ownership of each asset across the socio-economic quintiles was then quantified.

Analyses of the asset scores were undertaken on each of pre-implementation surveys to assess internal coherence [181, 183-184], and to detect the presence of clumping or truncation [183-184]. Clumping occurs where there are insufficient asset indicators leading to clustering of households. Truncation occurs where indicators are narrowly spread so that they are not able to distinguish sufficiently between adjacent quintiles, such as the very poor and the poorest or the least poor and the less poor. Stability of household classifications was assessed through

examination of the proportion of households that remained in the same quintile, or moved one or two quintiles up or down upon the removal of assets from the PCA [185]. Stability to the addition of education of the respondent and to removal of household having electricity was assessed. Findings of these asset score and household classification analyses were used to select the structure of the quintiles used in further analyses. It was assumed that 1) undertaking these checks in the pre-implementation surveys would be sufficient to make assumptions on the post implementation surveys as identical sampling methods and assets were included in pre and post surveys, and 2) that there was no major economic change in the period which would have affected the distribution of ownership of assets.

The first principal component accounted for 12.0%, and 16.6% of variation in the Volta Region and Eastern Region data, respectively. Amongst the sampled households in the two regions the greatest differences between assets was in sources of drinking water and in use of different kinds of toilet facilities. There was a lesser degree of variation between regions in the proportions of sampled households in terms of the main kinds of cooking fuel, main material of flooring, and electricity supply. Approximately half of sampled households in Volta Region in 2004 got piped drinking water outside of the house, a quarter got drinking water from a well or borehole and a quarter from surface water (rivers, streams or lakes) (Table 3.3). In comparison with Volta Region, the sampled households in Eastern Region survey included less households that got their drinking water piped to the outside of the house (40%) and a greater proportion of households that got their drinking water from a well or borehole (31%). Access to toilet facilities was very different between the two regional samples with approximately half of households in Eastern Region using traditional pit latrines in their house or compound compared with only 17% of the households in Volta Region. In Volta Region, greater than 60% of the sampled households had no toilet facilities, whilst this was the situation for only 14% of households in Eastern Region.

Table 3.3: Asset means, standard deviations and scores for Volta Region and Eastern Region surveys in 2004

Asset	Volta Region 2004			Eastern Region 2004		
	mean	Standard deviation	asset score	mean	Standard deviation	asset score
Source of Drinking Water						
Gets drinking water piped into the house	0.03	0.149	0.12	0.03	0.171	0.21
Gets piped drinking water outside of the house	0.50	0.500	0.09	0.40	0.490	0.15
Gets drinking water from a well or borehole	0.23	0.419	-0.03	0.31	0.461	-0.12
Gets drinking water from surface water	0.24	0.428	-0.12	0.22	0.414	-0.11
Toilet Facilities						
Has a flush toilet in house or compound	0.03	0.179	0.12	0.02	0.150	0.21
Has a traditional pit latrine in house or compound	0.17	0.375	0.03	0.49	0.500	-0.14
Has an improved pit latrine in house or compound	0.16	0.367	0.18	0.22	0.416	0.11
Has no toilet facilities in house or compound	0.63	0.484	-0.21	0.14	0.439	-0.05
Main Cooking Fuel						
Uses electricity as a main source of cooking fuel	<0.001	0.075	0.06	0.00	0.000	0.00
Uses gas as a main source of cooking fuel	0.03	0.162	0.23	0.06	0.233	0.28
Uses kerosene as a main source of cooking fuel	<0.001	0.098	0.12	0.01	0.105	0.06
Uses charcoal as a main source of cooking fuel	0.58	0.493	0.18	0.47	0.499	0.21
Uses firewood as a main source of cooking fuel	0.78	0.414	-0.22	0.75	0.431	-0.29
Main Material of Flooring						
Earth/sand is the main material of the floor	0.09	0.289	-0.18	0.11	0.312	-0.10
Cement is the main material of the floor	0.85	0.358	0.09	0.76	0.428	-0.08
Carpet is the main material of the floor	0.02	0.132	0.05	0.03	0.181	0.14
Linoleum is the main material of the floor	0.03	0.159	0.10	0.09	0.285	0.12
Has electricity	0.54	0.499	0.28	0.37	0.484	0.29
Household durable assets						
Owns a radio	0.71	0.453	0.22	0.80	0.403	0.09
Owns a tv	0.23	0.420	0.38	0.27	0.444	0.31
Owns a video deck	0.06	0.233	0.33	0.09	0.293	0.32
Owns a landline telephone	0.01	0.106	0.21	0.02	0.128	0.19
Owns a mobile telephone	0.02	0.141	0.25	0.06	0.246	0.30
Owns a fridge	0.09	0.288	0.34	0.10	0.305	0.33
Owns a bicycle	0.37	0.482	0.13	0.18	0.388	0.02
Owns a motorcycle	0.03	0.159	0.12	0.02	0.125	0.12
Owns a private car	0.01	0.117	0.11	0.02	0.145	0.17
Owns a taxi	0.04	0.190	0.14	0.05	0.219	0.08

In Volta Region, the assets contributing the greatest positive weights to the household scores were mainly household durable assets including owning a radio (0.22), a television (0.38), a video deck (0.33), a landline (0.21), a mobile telephone (0.25) and a fridge (0.34); others included using gas as one of the two main sources of cooking fuel (0.23), and having electricity (0.28). The assets

contributing the greatest negative weights were having no toilet facilities (-0.21), and using firewood as a main source of cooking fuel. There were some differences in the relative weights contributed by household assets between the two regions. In Eastern Region, there were highly positive contributions from at least one asset within each asset category including getting drinking water piped into the house (0.21), having a flush toilet in the house or compound, using gas (0.28) or charcoal (0.21) as a main source of cooking fuel, having electricity (0.29), and amongst durable assets owning a television (0.31), owning a video deck (0.32), owning a fridge (0.30), and owning a bicycle (0.33). The highest contribution to negative weights was using firewood as a main source of cooking fuel (-0.29).

3.7.8.1 Internal coherence:

In the survey undertaken in Volta Region in 2004, assets commonly associated with wealth increased across the quintiles from the poorest to the least poor households, and assets commonly associated with the poorest households decreased across the quintiles from the poorest households to the least poor. For example, use of an improved pit latrine in the house or compound increased from 0% of the poorest households to 36.9% of the least poor, and having no toilet facilities in the house or compound decreased from 91.6% of the poorest households to 36.1% of the least poor. There was therefore clear internal coherence for these assets. Similar internal coherence was seen for other categories of assets main cooking fuels, main material of flooring, and household durable assets.

In the Eastern Region 2004 survey the majority of assets show internal coherence such as those relating to source of drinking water, main cooking fuel, and household durable assets. However, although twice as many of the poorest households 'have no toilet facilities' (14.7%) in comparison to the least poor households (7.1%), the proportions of households across the remaining 3 quintiles having no toilet facilities are higher than would be expected (17.7%, 17.4%, 15.0%).

3.7.8.2 Clumping and truncation

Histograms of the distribution of asset indices were constructed to provide a visual assessment of clumping and truncation (Figure 3.4). It can be seen from this figure that there was no evidence

of clumping in either of the surveys. Both histograms have long tails on the left-hand side indicating that they are likely to be able to strongly determine inequities between the poorest households. However there is marked truncation on the right hand side the histogram particularly in the eastern region survey (Figure 3.4). This suggests that the assets are weak in their ability to determine inequalities between the richer households.

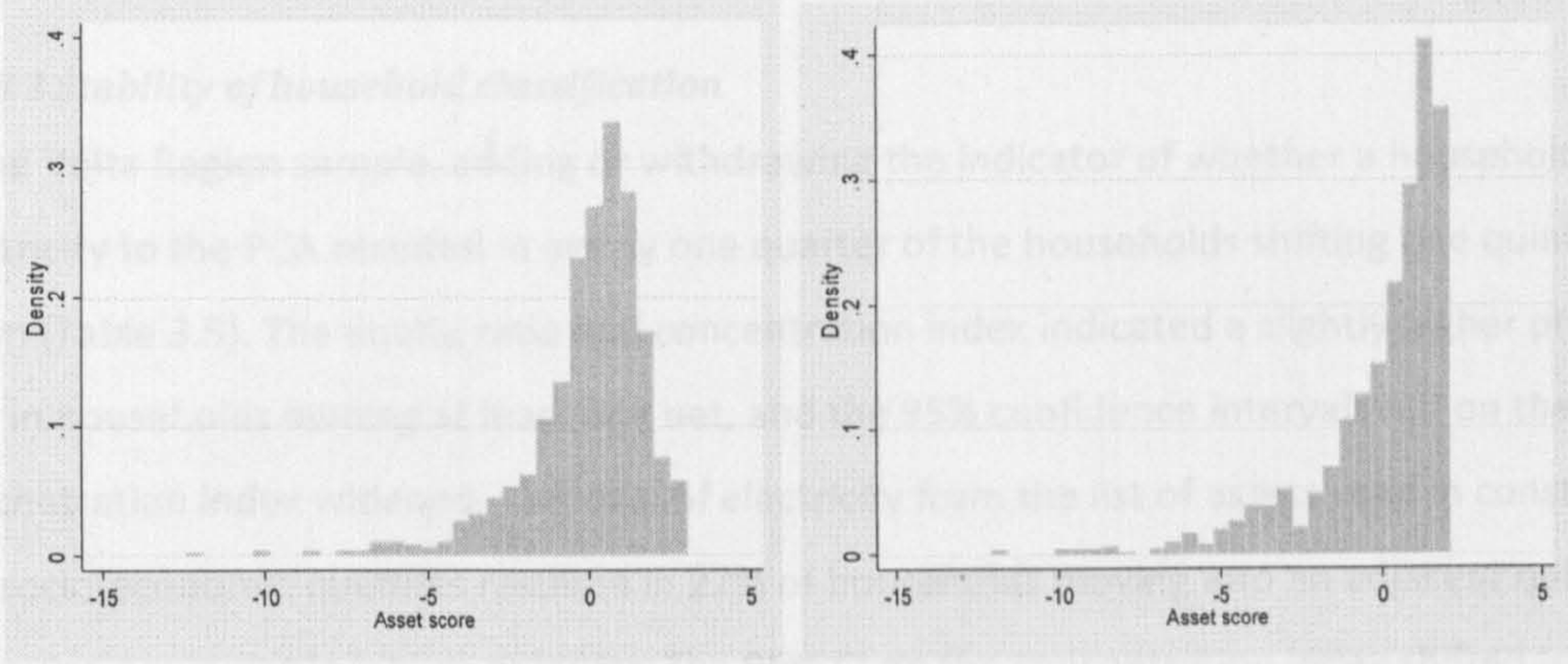

Figure 3.4: Histograms of the distribution of asset indices

Truncation is caused by assets being spread over a very narrow range of households. In an attempt to deal with the truncation, video deck and taxi were removed from the PCA as this was shown to be present only in the least poor households. This decreased the level of truncation. The impact of removing these assets on the outcome of household ownership of at least one net was tested. Although the resulting concentration indices (with the 2 assets and without) were different (concentration index of 0.011 with the assets and -0.05 without), the 95% confidence intervals were overlapping (Table 3.4), and therefore were not removed from the quintiles for further analyses. Inclusion of the educational level of the respondent in the construction of asset scores improved the levels of truncation, however as it was deemed likely that the educational level of mother is a determinant of household possession of mosquito nets and we wished to test for this, educational level of the respondent was excluded from the construction of the assets.

Table 3.4: Impact of truncation on disparities in household ownership of mosquito nets in Eastern Region 2004 survey

Eastern Region 2004	Q1	Q2	Q3	Q4	Q5	Equity ratio	Concentration index	
							Index	95% CI
All assets	11.5	17.9	16.7	11.8	16.5	0.70	0.011	-0.083 to 0.105
2 assets removed*	11.9	18.1	16.2	13.5	15.0	0.79	-0.005	-0.089 to 0.079

*Removal of ownership of a video deck and a private taxi to reduce truncation

3.7.8.3 Stability of household classification

In the Volta Region sample, adding or withdrawing the indicator of whether a household had electricity to the PCA resulted in nearly one quarter of the households shifting one quintile up or down (Table 3.5). The equity ratio and concentration index indicated a slightly higher pro poor bias in households owning at least one net, and the 95% confidence intervals (CI) on the concentration index widened. Removal of electricity from the list of assets used in constructing the socio-economic quintiles resulted in 27% of households moving into an adjacent quintile, that is moving one quintile higher or lower. The 95% CI on the concentration index shifted to the left that is towards a higher pro-poor bias in household ownership of nets.

In Eastern Region, the addition of respondent education resulted in a comparatively lower number of households moving quintiles than was the case in Volta Region (18% moved one quintile up or down), however, this movement caused a concentration index with a slight pro-rich bias to change to a concentration index suggesting a slight pro-poor bias. Conversely, removal of electricity from the PCA moved the concentration index and its 95% CI to the right, that is, further towards richer households.

Both respondent education and possession of electricity in the household were removed from the asset list used to construct the quintiles.

Table 3.5: Impact of stability of household classifications on disparities in household ownership of mosquito nets

Survey	% HH same quintile	% HH ±1 quintile	% HH ±2 quintiles	% HH ±3 quintiles	Equity ratio	Concentration index	
Volta 2004						**index**	**95% CI**
Original					1.28	-0.061	-0.067 to -0.055
+ respondent education	75.4	24.6	0	0	1.43	-0.091	-0.131 to -0.051
- electricity	73.5	26.5	0	0	1.36	-0.071	-0.111 to -0.031
Eastern 2004							
Original					0.70	0.011	-0.085 to 0.107
+ respondent education	81.7	17.9	0.4	0	0.87	-0.010	-0.08 to 0.06
- electricity	79.4	20.4	0.3	0	0.65	0.037	-0.053 to 0.127

3.7.9 Qualitative study

3.7.9.1 Sample selection

The qualitative study used purposive sampling to select a range of stakeholders in the public and private sectors [186]. Thirty nine in-depth interviews were undertaken with 26 stakeholders from the public sector and 12 stakeholders from the private sector (one stakeholder was interviewed twice). These interviewees were selected to ensure that perspectives of individuals with varied roles in the delivery of mosquito nets in the public and private sectors were addressed. Within the public sector the stakeholders included members of the NMCP, members of regional and district health management teams, and health facility staff. Within the private sector interviewed stakeholders included the voucher scheme management agent, importers and distributors of mosquito nets, LCS, pharmacists and members of staff of the NGO co-ordinator of the voucher scheme. The descriptions of working practices given during the interviews were used to describe the delivery system context over the period of the pilot voucher scheme.

The sample was not stratified to enable comparison across or within regions; however public and private stakeholders from both regions are represented in the sample. Likewise, the timing of data collection was not planned to enable an analysis of context and perception of the voucher scheme by time of implementation. This is a limitation of the study (Chapter 6.5).

The interviews were conducted during February, May and August 2006.

3.7.9.2 Interview themes and procedures

Themes were developed for the initial interviews with public and private providers based on the objectives of the study. Different themes were developed for different categories of provider. Broadly themes were constructed around stakeholder perceptions on 1) changes in the voucher scheme and other ITN delivery systems during the study period 2) external and health system factors that may have impacted upon implementation of the voucher scheme, 3) factors influencing the effective implementation of the voucher scheme and 4) the best strategic mix of delivery systems to ensure that all pregnant women received and used an ITN. Experiences from the household surveys and from discussions during meetings with stakeholders contributed to initial questions and discussions within each of the themes listed above. Reviews of the interview notes and recordings were conducted daily, and themes and questions were further developed using an inductive approach [187]. This approach enriched the data collection procedure, allowing for flexibility in themes.

Each potential interviewee was contacted by the study co-ordinator in their region and invited to be interviewed by me at a time convenient to them. The interviews were conducted in private places after presenting information about the study and gaining signed consent from the participant. The interviews were conducted in English and digitally recorded. English is commonly spoken in Ghana amongst educated people. As the stakeholders interviewed were employed within the public health sector, or were business people, no limitations were encountered in conducting the interviews in English.

3.7.9.3 Transcription

Audio recordings were downloaded onto a laptop from which they were transcribed by an audio typist. Verbatim transcripts were produced. Excerpts from each of the interviews were randomly checked by me to ensure that the tapes were accurately transcribed. Codes were used to identify the transcripts, no names were transcribed in order to preserve confidentiality, and when the data was transcribed the digital records were destroyed.

3.7.9.5 Data coding and analysis

The transcribed recordings were entered into N-Vivo version 8 for coding. Data coding and analysis was conducted in two stages. During the first stage the delivery systems context was described and the changes that occurred to this context during implementation of the voucher scheme elucidated. In the second phase content analysis was used to develop coding themes as presented in Chapter 6. A secondary analysis was then conducted where the themes developed from the content analysis were compared with the elements of frameworks for studying the diffusion of innovations within service organisations [62].

Objectivity was increased through a commitment to reflexivity in accounting for the possible effects of the author's role [188]in the voucher scheme and with partners, described in detail in Chapter 6.2.2.

3.8 Ethics

The study was approved by the ethics committees of the Ghana Health Service/Ministry of Health (GHS/MoH) and the London School of Hygiene and Tropical Medicine.

All respondents were presented with information sheets and had the objectives of the study explained to them and their written consent to involvement in the study was obtained before interviews began. Participants were informed that they were free to withdraw from the study at anytime without the need for explanation, and with no consequences to them.

Chapter 4: Outcome evaluation of the ITN delivery system

4.1 Introduction

At the time of the study, household ownership of at least one mosquito net (defined as any net whether currently treated, ever treated, or never treated) and of ITNs (defined as currently treated nets) was low at the national scale. The 2003 Ghana DHS show that ownership of mosquito nets was just 17.6% and ITNs 3.2% [167]. However, levels of household ownership of mosquito nets varied across the 10 regions of the country from a low of 8.7% in Central Region to relatively high ownership, 46.1%, in Volta Region. Eastern Region was at the lower end of the scale with 10.3% of households owning at least one mosquito net. Ownership of ITNs ranged from 0.7% of household in Eastern Region to 25.1% in Upper East Region. In Volta Region 2.5% of households owned at least one ITN. However, the coverage of ITNs among the target population which was the focus of this study that is, households with at pregnant woman or a child under one year of age were not available. Where pregnant women and/or children under 5 years of age have been the target of ITN projects or programmes, then the above mentioned estimates of ITN ownership would be underestimates of household ownership in the target groups.

Reasons for such widely ranging levels of household mosquito net ownership across the regions of the country were not known. However, it was likely that a multitude of factors acted independently or together to influence this coverage with mosquito nets. Mosquito nets had been delivered through diverse systems in both Volta and Eastern Regions, with relatively small scale activities targeting subsidies to vulnerable groups through the public sector, and promotion of widespread availability and distribution of ITNs through the private sector (Chapter 3.6.6). Untreated mosquito nets were available in most countries of Africa for many years before the introduction of the new technology of ITNs [15], and the market in untreated mosquito nets was known to be of greater volume in countries of West and Central Africa than those of East and Southern Africa [30]. Anecdotal evidence suggested that this market was prevalent in some areas of Ghana [172]. It was possible that the high level of mosquito net ownership in Volta Region was attributable to this market in untreated nets. Such markets are informal and composed of a

variety of traders in open markets, together with itinerant traders who travel from market to market. Mosquito nets sold through these markets are locally made from a variety of fabrics and are totally unsubsidised. Although as untreated nets, they offer reduced levels of protection in comparison to ITNs, they do offer a barrier to the biting of mosquitoes. In fact, there is evidence that untreated nets offer approximately half the protection of ITNs [24, 128, 189-193]. This informal market in mosquito nets may also be supplemented by sales of mosquito nets, both treated and untreated, in the formal private sector.

The geographic and socio-economic groups within the population reached by these informal and formal markets were not known. Neither was the extent to which the NMCP, RHD and DHMTs had intervened in delivery of ITNs through the public sector, known. The aim of introducing a new delivery system (the ITN voucher scheme) was to increase household ownership with ITNs and their use by the most vulnerable. Increasing household ownership in an equitable manner is the first step in achieving equitable use. Where a delivery system or the product that is being delivered is subsidised and resources are limited, it could be argued that the target should be the most vulnerable first, which is households with children under 5 years and/or pregnant women and especially such households who are amongst the poorest in the community.

Improving coverage of efficacious interventions requires focusing attention on the systems through which interventions are delivered. Methods traditionally used to assess the clinical effectiveness of interventions need adaptation to answer questions about the effectiveness of delivery systems at increasing intervention coverage [194]. Advances within this field of research are hampered by a plethora of sometimes distinct, but often overlapping terminologies and concepts. Clarity in the concepts and methods of evaluating effectiveness of interventions and their delivery systems would strengthen the potential for development of an evidence base for effective public health policies and programmes.

This chapter aims to contribute to the defining of methods for assessing the effectiveness of delivery systems for public health interventions. The approach used is based upon a number of assumptions: 1) approaches to evaluating delivery system effectiveness can be simpler than

those for evaluating intervention effectiveness; 2) such evaluations may rely on observational studies rather than introducing randomisation; 3) where the objective is to assess the effectiveness of a system that delivers interventions of known efficacy, and particularly its ability to achieve scaled up delivery of these interventions, the appropriate outcome measure is coverage of the intervention; 4) after attributing the coverage outcomes to a specific delivery system, it is possible to assess socio-economic disparities in coverage achieved by the delivery system.

Evaluation of the ITN voucher scheme in two regions of Ghana was used to test the hypothesis that pre- and post implementation cross sectional surveys with attribution of the source of the intervention (ITN) can provide a plausibility level of inference that coverage outcomes were due to the new delivery system. This pre- and post implementation evaluation assessed the coverage of household ownership of nets, disparities in ownership of nets between geographic regions and socio-economic classes, the relative contribution of different delivery systems of nets to changes in ownership of nets, and validated the method of attributing household ownership of nets to a specific delivery system. In this context the clinical effectiveness of the intervention (ITNs) has been proven through clinical trials and effectiveness trials in a range of settings, but the overall effectiveness of this delivery system (the voucher scheme) is yet to be demonstrated, as is its reach across geographic areas and socio-economic groups[8].

4.2 Methods

In 2004, the ITN voucher scheme started in Volta Region, and within a few months it was scaled-up to the adjacent region (Eastern Region). In the voucher scheme pregnant women attending ANC were eligible for a voucher which entitled them to a USD4.2 discount on an ITN. This discount voucher was to be used together with a 'top-up' cash payment, to purchase an ITN in

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[8] Elements of this chapter have been published as: Webster, J., Kweku, M., Dedzo, M., Tinkorang, K., Bruce, J., Lines, J., Chandramohan, D., Hanson, K. (2010) Evaluating delivery systems: complex evaluations and plausibility inference (2010) *American Journal of Tropical Medicine and Hygiene* 82(4):672-7.

the retail sector. Voucher scheme ITNs were available only in outlets that had agreed to take part in the voucher scheme. The intervention therefore consisted of delivery of a subsidy in the public sector and delivery of the ITN in the formal private sector. Informal private sector providers were not invited to take part in the voucher scheme.

This intervention was implemented within the context of the pre-existing delivery systems for mosquito nets (Figure 4.1). At the time of implementation of the ITN voucher scheme pilot in the two regions, the national strategy for delivery of ITNs to pregnant women was direct delivery for USD2.2 to be paid by the pregnant woman for the ITN upon visiting ANC. In the public sector subsidised nets were delivered directly to the end-user/client, the subsidy was applied directly to the product, and no voucher discount was involved. Private sector delivery systems were divided into those within the formal and informal sectors. When a client entered a formal private sector outlet to get a mosquito net they would either directly exchange cash for the net (direct transfer), or they would use a voucher to subsidise the purchase of the net. In the informal private sector the product (mosquito net) was transferred directly to the client and no voucher or direct subsidy was involved. The voucher scheme was characterised by the delivery of a subsidy (a voucher) in a public sector health facility and the exchange of the voucher for an ITN in a formal private sector outlet.

The NMCP in consultation with the Volta and Eastern RHD proposed that they would not supply ITNs to health facilities in these Regions during the period of the voucher scheme pilot. It was not clear at this time how many of the health facilities had mosquito nets/ITNs remaining from previous distributions, or had sourced nets independently from the private market.

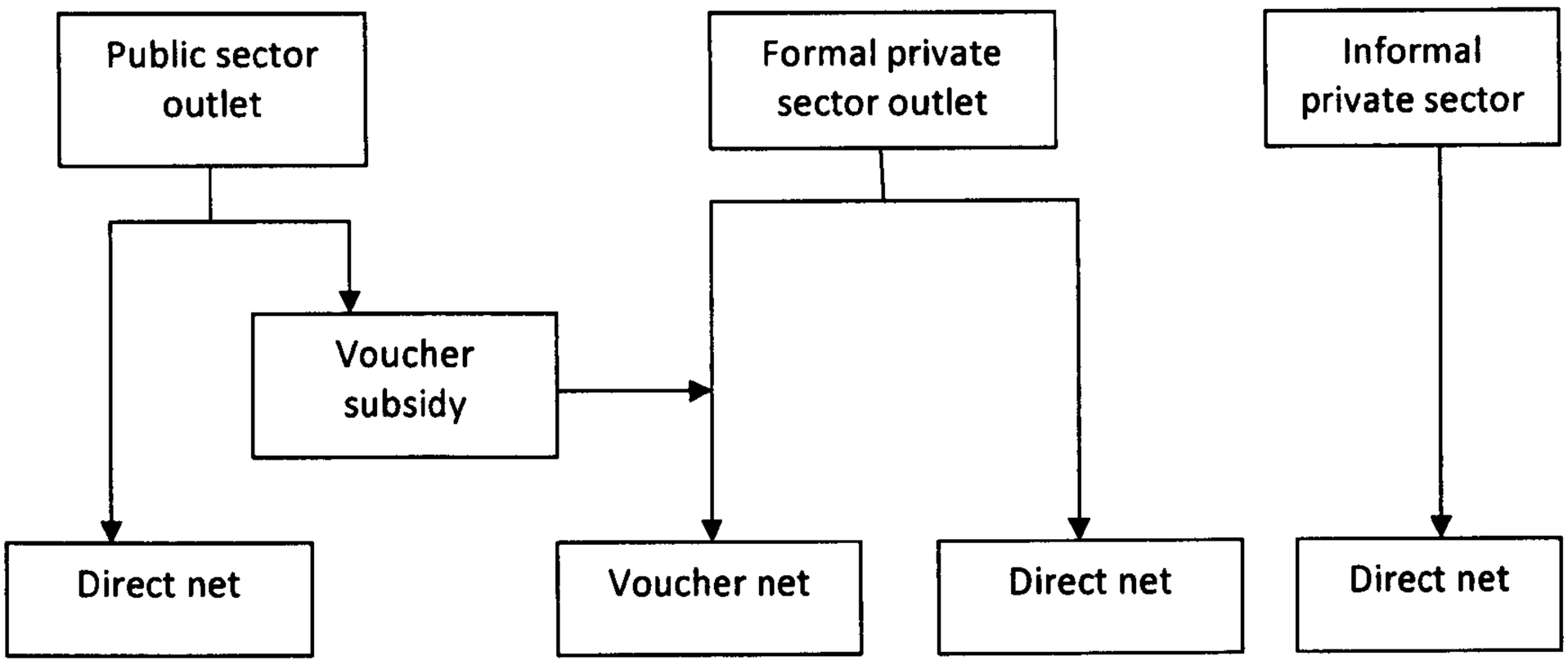

Figure 4.1: categorisation of delivery systems of nets (internal comparators)

4.2.1 Household surveys: control groups and attribution of ITNs to specific delivery systems

Pre- and post implementation household surveys were undertaken in March 2004 (pre) and April 2005 (post) in Volta Region and in July 2004 (pre) and July 2006 (post) in Eastern Region (Chapter 3.7.3). The sample population were households with a pregnant woman or a child under 1 year of age. To assess the effectiveness of the voucher scheme the other delivery systems in the two regions were defined as internal comparison groups. No external control arm was used because 1) the scheme was implemented in all districts of each of the two regions and 2) differences in contextual factors between the study regions and the other bordering regions would have precluded the usefulness of such an external control.

In the household surveys respondents were asked two questions to determine the source of each of the mosquito nets owned in the household: 1) Where did you get this mosquito net? 2) Did you use a voucher to pay for this net? The place where a mosquito net was obtained by a member of the household is usually synonymous with the final stage of the delivery system, which is the delivery point. However, the formal private sector outlets could deliver both voucher

subsidy nets and a pure private sector nets. Therefore an additional question, "whether a net was purchased with the aid of a voucher?" was asked to attribute the source of net to a specific delivery system. Nets that were purchased with the aid of a voucher were attributed to the voucher scheme and those purchased without the use of a voucher were attributed to the formal private sector. The source and voucher use questions were asked of each of the mosquito nets owned in the household.

4.2.2 Validation of the source of net

In order to validate the response on source of net, the nets in the households were inspected by interviewers and defined as standard or non-standard nets. Standard nets were those made from polyester or polyethylene typically delivered via the public and formal private sectors, and non-standard nets were those made from a variety of materials and sold through the informal private sector. The public sector delivers standard nets exclusively and therefore responses on public sector as a source of a net and the net being standard rather than non-standard can be used as a way of cross-validating the responses. Tools to identify the nets included swatches of fabrics used to make mosquito nets gathered from local markets, the formal retail sector, and from the public sector. Nets were categorised as: standard netting and non-standard netting. Non-standard netting had sub-categories of patterned non-standard netting, plain non-standard netting, non-netting, mixed, and plastic. Each interviewer carried an identification key including the swatches of materials and used this to categorise types of nets in households. Where the household owned multiple nets, each one was categorised separately.

4.2.3 Data entry and analysis

Based on the reported sources, nets were categorised to public, formal private or informal private sector nets. Public sector delivery points included clinics/hospitals, outreach clinics, and vaccination campaigns. Formal private sector delivery points included general shops, clothes/fabric shops, wholesalers, pharmacies, and chemical sellers, that is private sector outlets which are static and the goods remain at the point of sale overnight [71]. Informal private sector outlets included markets, local kiosks, table top vendors, and street hawkers (private sector non-static delivery points where the goods are stored elsewhere overnight [71]). NGO projects were

categorised as community based projects, and gifts and other difficult to adequately categorise responses were included amongst a general 'other' category. Formal private sector nets were further classified to un-subsidised net or voucher-subsidy net so that distinct delivery systems could be identified.

In order to assess the incremental contribution of alternative delivery systems to household coverage with nets, analysis of the proportion of nets in 1) households overall, 2) from the public and private sectors, 3) from the formal private and informal private sectors, and 4) direct versus voucher purchases were undertaken. At each of these steps analyses by geographic zone and by socio-economic quintile was undertaken to assess the geographic and socio-economic reach of the delivery systems. Analyses were conducted using STATA 9.0 software adjusting for the cluster design of the surveys. Pearson's design based F test was used to test the significance of the differences in proportions across geographic zones, socio-economic quintiles, and between surveys.

PCA was used to create an asset index in order to examine the relationship between key outcomes and SES (Chapter 3.7.8). All assets were included in the PCA as binary variables. The asset index was then used to construct socio-economic quintiles from the poorest households through to the least poor. The equity ratio was used to assess socio-economic disparities in household ownership of mosquito nets by delivery system. The equity ratio is the proportion of the poorest compared to the least poor that have the outcome of interest, and a ratio of 1.0 therefore indicates equity. A ratio of less than 1.0 indicates a bias towards the least poor households and ratios above 1.0 as a bias towards the poorest households.

Household net ownership was defined as "the proportion of households with at least one net of any type" [141, 195]. The effectiveness of the voucher scheme was assessed by comparing the proportion of households with any net and with a voucher-subsidy net between pre- and post-implementation time points in the regions separately. Pearson's design based F test was used to test the significance of the differences in proportions between the two cross-sectional surveys in each region.

4.3 Results

Total households sampled in Volta Region were 1,232 in the 2004 survey and 1,254 in the 2005 survey, and in Eastern Region 1,265 in the 2004 survey and 1,226 in the survey undertaken in 2006 (Table 4.1). Respondents were either currently pregnant women or mothers of children under one year of age. The majority of these respondents were between 20 and 39 years of age, with 20 to 29 representing the largest age band across all four surveys (Table 4.2). Nearly a fifth of all respondents had no formal education, ranging between 16.9% in the 2006 Eastern Region survey to 20.2% in the 2005 Volta Region survey. The majority of respondents across the four surveys had completed education to primary or middle level.

Table 4.1: Distribution of sample households

Volta Region			Eastern Region		
District	**Pre-implementation**	**Post-implementation**	**District**	**Pre-implementation**	**Post-implementation**
Krachi	197	204	Kwahu South	212	245
Jasikan	197	211	Manya Krobo	211	166
Kpando	168	168	East Akim	209	251
Hohoe	247	251	Suhum Kraboa Coaltar	211	168
Ketu	308	309	Akwapim South	211	149
South Tongu	115	111	Birim South	211	247
Total	1,232	1,254		1,265	1,226

The total number of individuals in sampled households in each survey ranged from 4,372 in the 2004 Eastern Region survey to 5,499 in the 2006 Eastern Region survey (Table 4.2). Numbers of pregnant women were quite consistent; 619 in the 2006 Eastern Region survey and 636 in the 2006 Eastern Region survey. More than 1,200 children were members of the households sampled for each survey (from 1,241 in the 2004 Volta Region survey to 1,346 in the 2006 Eastern Region survey).

Table 4.2: characteristics of sampled households

Characteristic	*Zone*	*Volta Region*		*Eastern Region*	
		2004 survey	**2005 survey**	**2004 survey**	**2006 survey**
Total individuals	Northern	1,918	1,625	1,778	1,744
	Central	1,778	1,594	1,343	1,892
	Southern	1,798	1,440	1,251	1,863
	Total	**5,494**	**4,659**	**4,372**	**5,499**
No. pregnant women	Northern	211	203	213	201
	Central	211	213	211	210
	Southern	211	219	212	208
	Total	**633**	**635**	**636**	**619**
No. children <5	Northern	424	455	484	443
	Central	403	403	432	445
	Southern	414	401	408	458
	Total	**1241**	**1259**	**1324**	**1346**

Table 4.3: characteristics of respondents

	Volta Region				*Eastern Region*			
	2004		**2005**		**2004**		**2006**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Age								
13-19	102	8.3	79	6.3	102	8.1	133	10.9
20 – 29	703	57.1	789	62.9	765	60.5	733	59.8
30 – 39	369	30.0	326	26.0	353	27.9	316	25.8
40 – 50	58	4.7	60	4.8	45	3.6	44	3.6
Education								
None	245	19.9	253	20.2	230	18.2	207	16.9
Primary	310	25.2	281	22.4	320	25.3	313	25.5
Middle	598	48.5	600	47.9	626	49.5	625	51.0
Secondary	72	5.8	117	9.3	78	6.2	73	6.0
Tertiary	7	0.6	0		0		8	0.7

Note: 3 missing from education in Volta 2005

4.3.1 Household ownership of any net

4.3.1.1 Volta Region

In Volta Region at baseline in 2004 more than one third of households (38.3%) already owned at least one mosquito net. There was however, significant variation across the zones of the region, from 13.3% in the central zone, through 28.6% in the northern zone to 71.9% in the southern zone ($p<0.001$) (Table 4.4). There was no significant variation in household ownership of any net across socio-economic quintiles.

After one year of implementation of the voucher scheme in Volta Region, household ownership of any net increased across the region from 38.3% in 2004 to 45.4% in 2005 and this increase was of borderline statistical significance (p=0.06). Disaggregating by zone, the increase was relatively small and insignificant in the northern and southern zones of the region, whereas the increase in the proportion of households with at least one net approximately doubled in the central zone from 13.3% in 2004 to 26% in 2005 (p=0.008). There was no significant increase in the household ownership of any net in the lower three socio-economic quintiles. Ownership increased from 34.2% to 46.5% in less poor households (p=0.03) and from 34.1% to 52.0% in the least poor households (p=0.002).

4.3.1.2 Eastern Region

In Eastern Region, just 15% of households owned any type of mosquito net at baseline in 2004. Although household ownership was slightly higher in the northern zone of the region there was no significant difference in ownership by either zone or by socio-economic quintile of the households.

One year post implementation of the voucher scheme household ownership increased significantly from 15.0% to 26.0% (p<0.001). Ownership at least doubled in the central (12.5% in 2004 to 25.5% in 2006; p=0.003) and southern (12.5% in 2004 to 27.9% in 2006: p<0.001) zones of the region. Although ownership increased from 18.8% in 2004 to 27.0% in 2006 in the northern zone, this increase was not significant. The increase in ownership between baseline and voucher scheme post implementation surveys was significant in all socio-economic quintiles with the exception of the very poor, however, the increase was highest in the least poor households (16.4% in 2004 to 37.7% in 2006; p<0.001).

Table 4.4: proportion of households with at least 1 net

	Volta Region					*Eastern Region*				
	2004		2005			2004		2006		
	n	%	n	%	p	n	%	n	%	p
Total	472	38.3	571	45.4	0.06	190	15.0	328	26.0	<0.001
Zone										
Northern	112	28.6 (20.6 – 38.4)	138	33.3 (26.5 – 40.8)	0.4	83	18.8 (10.8 – 30.7)	111	27.0 (20.3 – 35.0)	0.2
Central	55	13.3 (8.9 – 19.3)	109	26.0 (20.0 – 33.1)	0.008	50	12.5 (7.7 – 19.7)	107	25.5 (21.1 – 30.5)	0.003
Southern	304	71.9 (61.5 – 80.3)	324	77.1 (69.1 – 83.6)	0.4	57	13.5 (9.4 – 19.0)	110	27.9 (21.4 – 35.3)	<0.001
		p<0.001		p<0.001			p=0.4		p=0.8	
SE group										
Poorest	98	43.6 (33.0 – 54.7)	110	46.4 (37.1 – 55.9)	0.7	26	11.3 (7.2 – 17.1)	45	20.0 (15.1 – 26.0)	0.02
Very poor	108	44.4 (36.0 – 53.2)	102	42.0 (34.1 – 48.2)	0.7	48	18.5 (12.6 – 26.2)	55	23.9 (17.2 – 32.2)	0.2
Poor	89	36.3 (29.7 – 43.5)	109	41.0 (34.1 – 48.2)	0.4	40	16.2 (11.0 – 23.2)	65	27.1 (19.9 – 35.8)	0.02
Less poor	90	34.2 (27.9 – 41.2)	118	46.5 (38.5 – 54.6)	0.03	30	12.2 (8.7 – 16.7)	66	24.5 (18.9 – 31.1)	0.001
Least poor	86	34.1 (27.2 – 41.8)	132	52.0 (45.5 – 58.4)	0.002	46	16.4 (11.8 – 22.4)	95	37.7 (31.6 – 44.2)	<0.001
		p=0.1		p=0.2			p=0.2		p=0.002	
		equity ratio = 1.28		equity ratio = 0.89			equity ratio = 0.69		equity ratio = 0.53	

4.3.2 Household ownership of nets delivered via the public and private sectors

The source of 1,891 of the 2,019 (93.7%) of the nets in the sampled households was reported as known by the respondent. The remaining 128 were from sources that the respondent was not able to identify, including because they were received as gifts. The source of 442 (21.9%) nets was identified as the public sector and 1,429 (70.8%) as from the private sector. Less than 1.0% of households in each survey (Volta 0.65% in 2004, and 0.72% in 2005; and Eastern 0.65% in 2004, and 0.0% 2006) had nets in the household from both the public and private sectors, that is 'mixed ownership'.

4.3.2.1 Volta Region

The high level of household ownership of at least one net in Volta Region in 2004 can be attributed mainly to the private sector with 3.0% of households owning public sector nets and 33.1% owning private sector nets (Table 4.5). Where a household has a net from both sectors, it was recorded in both the public and private sector categories and was therefore double counted. However, this included less than 1.0% if households in each survey (Section 4.3.2).There was no disparity in ownership of public sector nets across the zones of the region (p=0.3). Ownership of public sector nets was significantly higher in the least poor households than in other socio-economic groups (p<0.001). The proportion of households owning private sector nets in 2004 varied enormously across the zones of the region from 8.2% in the central zone, through 22.8% in the northern zone, to 67.1% in the southern zone (p<0.001). Disparities across socio-economic groups were smaller than across the geographic and ecological zones, but were statistically significant with ownership of at least one net from the private sector favouring the poorest (39.8% in the poorest households compared with 24.2 in the least poor households).

The pattern of ownership of nets from the public versus private sectors remained similar after one year of implementation of the voucher scheme, with 8.4% of households with public sector nets versus 33.1% with private sector nets). The increase in ownership of nets delivered via the public sector from 3.0% to 8.4% was statistically significant (p<0.001) whereas the increase in nets delivered via the private sector from 33.1% to 36.0% was not statistically significant (p=0.4).

Household ownership of public sector nets increased across all zones of Volta Region with the greatest increase in the central zone (4.1% in 2004 to 12.7% in 2005; p<0.001). The increase in the northern zone was of borderline significance. These increases resulted in significant disparities in the proportion of households who owned nets delivered via the public sector across the zones of the region in 2005 (p<0.006). The proportion of households owning public sector nets increased significantly in the three higher socio-economic groups (borderline significance in the least poor). In the poor, ownership increased from 2.0% to 9.0% (p<0.001) and in the less poor from 0.7% to 10.2% (p<0.001). There was no significant increase in the proportion of households owning public sector nets in the households in the lower two socio-economic groups between 2004 and 2005.

Although there was no significant change in the proportion of households owning a net delivered through the private sector overall between 2004 and 2005, disaggregating by socio-economic group shows that there was a significant increase in ownership amongst the least poor households (24.2% in 2004 to 38.6% in 2005; p=0.007). This increase in ownership of private sector nets in the highest socio-economic group reduced substantially the disparities in ownership of private sector nets across socio-economic groups that had existed in 2004 (p=0.03 in 2004 to p=0.3 in 2005).

4.3.2.2 Eastern Region

At baseline in 2004 approximately double the number of households that owned nets had received them via the private sector as compared to the public sector: 4.8% households owned at least one net from the public sector and 9.9% from the private sector (Table 4.6). The higher proportion of households owning public sector nets in the central zone of the region was of borderline significance (p=0.06). There was no significant difference across socio-economic groups in the proportion of households owning at least one public sector net. There were significant disparities in the proportion of households owning private sector nets across the zones of Eastern Region, 3.8% in the central zone, 9.0% in the southern zone and 15.9% in the northern zone; p=0.01. There were no significant differences in the proportion of households owning private sector nets across socio-economic groups in 2004.

Table 4.5: proportion of households with at least one net: public sector versus private sector Volta Region

	Volta public sector					*Volta private sector*				
	2004		2005			2004		2005		
	n	%	n	%	p	n	%	n	%	p
Total	37	3.0	105	8.4	<0.001	408	33.1	454	36.0	0.4
Zone										
Northern	10	2.6 (1.4 – 4.7)	23	5.5 (3.5 – 8.7)	0.07	89	22.8 (16.2 – 31.1)	109	26.3 (20.0 – 33.7)	0.4
Central	17	4.1 (2.3 – 7.2)	53	12.7 (8.8 – 17.9)	0.001	34	8.2 (4.3 – 15.0)	56	13.4 (9.3 – 18.9)	0.2
Southern	10	2.4 (1.2 – 4.6)	29	6.9 (4.6 – 10.3)	0.01	284	67.1 (57.2 – 75.8)	286	68.1 (61.2 – 74.3)	0.9
		p=0.3		p=0.006			p<0.001		P<0.001	
SE group										
Poorest	4	1.8 (0.7 – 4.5)	8	3.4 (1.4 – 7.8)	0.2	89	39.6 (29.0 – 51.2)	97	40.9 (31.7 – 50.8)	0.8
Very poor	7	2.9 (1.0 – 7.7)	12	4.9 (3.0 – 8.1)	0.3	94	38.7 (30.3 – 47.8)	86	35.4 (28.9 – 42.5)	0.6
Poor	5	2.0 (0.9 – 4.6)	24	9.0 (5.7 – 14.0)	<0.001	79	32.2 (26.4 – 38.8)	82	30.8 (23.5 – 39.3)	0.8
Less poor	2	0.7 (0.2 – 3.1)	26	10.2 (6.5 – 15.8)	<0.001	84	31.9 (26.0 – 38.5)	88	34.7 (27.3 – 42.9)	0.6
Least poor	19	7.5 (4.5 – 12.4)	35	13.8 (9.7 – 19.1)	0.07	61	24.2 (17.9 – 31.9)	98	38.6 (33.1 – 44.4)	0.007
		p<0.001		p=0.002			p=0.03		p=0.3	
		equity ratio = 0.24		equity ratio = 0.25			equity ratio = 1.64		equity ratio = 1.06	

Table 4.6: proportion of households with at least one net: public sector versus private sector Eastern Region

	Eastern public sector					*Eastern private sector*				
	2004		2006			2004		2006		
	n	%	n	%	p	n	%	n	%	p
Total	54	4.8	222	18.1	<0.001	118	9.9	72	5.6	0.02
Zone										
Northern	9	2.5 (1.2 – 4.8)	78	19.6 (15.0 – 25.0)	<0.001	68	15.9 (8.2 – 28.4)	23	5.8 (2.9 – 11.1)	0.006
Central	31	8.1 (4.1 – 15.3)	80	19.5 (15.7 – 69.2)	0.007	14	3.8 (2.2 – 6.6)	18	4.4 (2.8 – 6.9)	0.7
Southern	14	3.7 (1.7 – 7.9)	64	16.8 (12.1 – 23.0)	<0.001	36	9.0 (5.9 – 13.4)	31	8.1 (4.8 – 13.5)	0.8
		p=0.06		p=0.7			p=0.01		p=0.3	
SE group										
Poorest	12	5.5 (2.8 – 10.6)	30	13.6 (9.7 – 18.8)	0.004	14	6.4 (3.5 – 11.4)	10	4.5 (2.4 – 8.4)	0.4
Very poor	9	4.1 (2.0 – 8.0)	34	15.1 (10.5 – 21.3)	<0.001	31	12.8 (7.1 – 21.8)	17	7.6 (3.9 – 14.2)	0.2
Poor	13	5.9 (2.9 – 11.8)	34	14.7 (10.3 – 20.4)	0.02	23	10.0(5.2 – 18.4)	24	10.3 (6.4 – 16.2)	0.9
Less poor	9	4.0 (1.9 – 8.1)	50	19.3 (14.1 – 25.8)	<0.001	20	8.4 (5.5 – 12.6)	6	2.3 (1.1 – 5.0)	0.002
Least poor	11	4.5 (2.4 – 8.2)	72	29.5 (24.3 – 35.3)	<0.001	30	11.3 (7.7 – 16.3)	15	6.1 (3.9 – 9.6)	0.04
		p=0.8		p<0.001			p=0.3		p=0.007	
		equity ratio = 1.22		equity ratio = 0.46			equity ratio = 0.57		equity ratio = 0.74	

Two years post implementation of the ITN voucher scheme, the proportion of households owning at least one net from a public sector delivery point increased significantly from 4.8% in 2004 to 18.1% in 2006 ($p<0.001$). This increase was highest in the northern zone of the region increasing from 2.5% in 2004 to 19.6% in 2006 ($p<0.001$) but was significant across all geographic zones of the region. These relative increases in household ownership of public sector nets resulted in the disappearance of the borderline disparities in ownership of public sector nets across the zones between 2004 and 2006.

Although there were significant increases in household ownership of public sector nets across all socio-economic groups, this increase was higher amongst the socio-economically privileged households. The proportion of the poorest households owning a public sector net increased from 5.5% to 13.6% and the least poor households from 4.5% to 29.5%. This introduced significant disparities in the ownership of public sector nets across socio-economic groups of the region ($p<0.001$).

The proportion of households owning nets purchased from the private sector decreased significantly in Eastern Region from 9.9% in 2004 at baseline to 5.6% in 2006 ($p=0.02$), two years post implementation of the ITN voucher scheme. The majority of this decrease was amongst households in the northern zone of the region 15.9% in 2004 to 5.8% in 2006 ($p=0.006$). This resulted in a reduction in the disparities in ownership of a least one private sector net across the zones of the region between 2004 and 2006. The decrease in the proportion of households owning a private sector net between 2004 and 2006 was significant in only the two higher socio-economic groups (8.4% to 2.3% in the less poor; $p=0.002$, and 11.3% to 6.1% in the least poor; $p=0.04$). These changes introduced a significant socio-economic disparity in the proportion of households owning a private sector net in the region ($p=0.007$).

4.3.3 Household ownership of formal and informal private sector nets

4.3.3.1 Volta Region

The majority of households owning a private sector net in Volta Region in 2004 owned nets that they received from an informal private sector outlet: 1.5% of households owned a formal private

sector net and 31.8% of households an informal private sector net. There were no significant disparities in ownership of formal private sector nets across either the geographic zones of the region or across socio-economic groups at baseline. Ownership of formal private sector nets increased significantly from 1.5% in 2004 to 10.4% in 2005 ($p<0.001$). This increase was significant across all geographic zones and all socio-economic groups.

Although ownership of formal private sector nets increased significantly across all geographic zones the increases were disproportionate and resulted in disparities in ownership of formal private sector nets across the zones of the region in 2005, ranging from 6.9% in the central zone, through 7.2% in the northern zone, to 16.9% in the southern zone ($p<0.001$). A similar pattern emerged across socio-economic groups resulting in disproportionately high ownership of formal private sector nets in the least poor households (ranging from 5.8% in very poor households to 21.3% in the least poor; $p<0.001$).

Ownership of informal private sector nets in 2004 varied significantly across the geographic zones of the region from 7.2% of households in the central zone, through 21.5% of households in the northern zone to 65.5% of households in the southern zone ($p<0.001$). There were also disparities in ownership of informal private sector nets across socio-economic groups with 20.6% of the least poor households owning a net and 39.6% of the poorest households owning an informal private sector net ($p=0.006$).

Across the region the proportion of households owning an informal private sector net decreased from 31.8% in 2004 to 27.2% in 2006, but this decrease was not statistically significant. This decrease was of borderline significance in the southern zone (65.5% in 2004 to 54.5% in 2006; $p=0.06$) and amongst the poor (31.4% in 2004 to 21.1% in 2006; $p=0.04$).

4.3.3.2 Eastern Region

The proportion of households owning a net was relatively low in Eastern Region in 2004 for both formal and informal private sector nets, compared with Volta Region. There were disparities in

the proportion of households with a formal private sector net across geographic zones of the region (p=0.07) and significant disparities across socio-economic groups.

Although there was an overall decrease in the proportion of households with at least one formal private sector net in the region from 2.1% in 2004 to 1.4% in 2006, there was an increase in the central zone of the region. This increase was significant (p=0.02) but small 0.3% in 2004 to 2.1% in 2006. After two years of implementation of the voucher scheme in Eastern Region only 1.4% of households owned a net that was delivered through the formal private sector.

The proportion of households with a net obtained from the informal private sector was highest at baseline in 2004 in the northern zone of the region (3.3% in the central zone, through 5.7% in the southern zone, to 12.7% in the northern zone (p=0.01). There were no significant differences in the proportion of households owning an informal sector net across socio-economic groups.

The proportion of households in Eastern Region owning at least one net that they received from the informal private sector decreased from 7.4% in 2004 to 4.4% in 2006 and this was of borderline significance (p=0.04). There were significant decreases in the proportion of households owning at least one informal private sector net from 12.7% to 4.6% (p=0.01) in the northern zone of the region and in the less poor socio-economic households from 7.3% in 2004 to 2.2% (p=0.009) in 2006.

4.3.4 Household ownership of voucher scheme nets via the public and private sectors

4.3.4.1 Volta Region

Of the 108 nets reported to have been obtained from the public sector 43 (40%) were reported to have been obtained using a voucher (Table 4.7). This reported use of a voucher to obtain a net from a public sector outlet differed across geographic zones (p=0.01) being highest in the central zone, and also differed across socio-economic groups (p=0.008), being greatest amongst the higher socio-economic groups. In Volta 82 nets were purchased from the private sector with the use of a voucher. These 82 nets are the total number of nets in households, after one year of implementation of the voucher scheme that can be directly attributed to the voucher scheme.

Table 4.7: households with at least one net formal and informal private sector Volta Region

	Volta formal private sector					*Volta informal private sector*				
	2004		2005			2004		2005		
	n	%	n	%	p	n	%	n	%	p
Total	18	1.5	130	10.4	<0.001	392	31.8	341	27.2	0.2
Zone										
Northern	5	1.3 (0.4 – 3.6)	30	7.2 (4.7 – 11.0)	<0.001	84	21.5 (14.7 – 30.2)	83	20.0 (14.2 – 27.4)	0.7
Central	4	1.0 (0.4 – 2.5)	29	6.9 (4.7 – 10.1)	<0.001	30	7.2 (3.5 – 14.4)	29	6.9 (4.0 – 11.6)	0.9
Southern	9	2.1 (1.0 – 4.4)	71	16.9 (12.3 – 22.8)	<0.001	277	65.5 (55.6 – 74.2)	229	54.5 (47.7 – 61.2)	0.06
		p=0.4		p<0.001			p<0.001		p<0.001	
SE group										
Poorest	2	0.9 (0.1 – 6.1)	16	6.8 (3.6 – 12.4)	0.03	89	39.6 (29.0- 51.2)	83	35.0 (26.2 – 45.0)	0.5
Very poor	3	1.2 (0.4 – 3.8)	14	5.8 (3.4 – 9.7)	0.02	91	37.5 (28.8 – 47.0)	73	30.0 (23.3 – 37.8)	0.3
Poor	2	0.8 (0.1 – 6.1)	28	10.5 (7.0 – 15.4)	0.001	77	31.4 (25.4 – 38.2)	56	21.1 (15.3 – 28.2)	0.04
Less poor	2	0.8 (0.2 – 3.1)	18	7.1 (4.5 – 11.0)	<0.001	82	31.2 (25.3 – 37.7)	74	29.1 (22.3 – 37.0)	0.7
Least poor	9	3.6 (1.9 – 6.7)	54	21.3 (15.1 – 29.0)	<0.001	52	20.6 (14.3 – 28.8)	55	21.7 (15.8 – 28.9)	0.8
		p=0.2		p<0.001			p=0.006		p=0.03	
		equity ratio = 0.25		equity ratio = 0.32			equity ratio = 1.92		equity ratio = 1.61	

Table 4.8: households with at least one net formal and informal private sector Eastern Region

	Eastern formal private sector					*Eastern informal private sector*				
	2004		2006			2004		2006		
	n	%	n	%	p	n	%	n	%	p
Total	27	2.1	17	1.4	0.3	93	7.4	55	4.4	0.04
Zone										
Northern	13	2.9 (1.1 – 7.5)	4	1.0 (0.4 – 2.5)	0.1	56	12.7 (6.4 – 23.7)	19	4.6 (2.0 – 10.3)	0.01
Central	1	0.3 (0.0 – 1.9)	9	2.1 (0.9 – 4.9)	0.02	13	3.3 (1.8 – 5.8)	9	2.1 (1.2 – 3.7)	0.3
Southern	13	3.1 (1.5 – 6.1)	4	1.0 (0.3 – 3.2)	0.1	24	5.7 (3.3 – 9.5)	27	6.8 (3.9 – 11.7)	0.6
		p=0.07		p=0.3			p=0.01		p=0.09	
SE group										
Poorest	3	1.3 (0.5 – 3.6)	2	0.9 (0.2 – 3.4)	0.7	11	4.8 (2.7 – 8.4)	8	3.6 (1.9 – 6.7)	0.5
Very poor	5	1.9 (0.6 – 5.7)	3	1.3 (0.3 – 5.5)	0.7	27	10.4 (5.6 – 18.5)	14	6.1 (2.9 – 12.2)	0.2
Poor	4	1.6 (0.6 – 4.3)	4	1.7 (0.6 – 4.3)	1.0	19	7.7 (3.6 – 15.6)	20	8.3 (4.7 – 14.3)	0.8
Less poor	2	0.8 (0.2 – 3.3)	0	0	0.2	18	7.3 (4.6 – 11.5)	6	2.2 (1.0 – 4.8)	0.009
Least poor	13	4.6 (2.5 – 8.4)		3.2 (1.7 – 5.7)	0.3	18	6.4 (3.6 – 11.2)	7	2.8 (1.4 – 5.5)	0.05
		p=0.02		p=0.07			p=0.3		p=0.008	
		equity ratio = 0.28		equity ratio = 0.28			equity ratio = 0.75		equity ratio = 1.29	

There were no geographic disparities in the proportion of households who obtained a net from the formal private sector with the aid of a voucher. However, across socio-economic groups, there was a significant disparity ranging from 2.1% of the poorest households to 14.6% of the least poor households ($p<0.001$) owning at least one net that they purchased from the formal private sector with the aid of a voucher.

Table 4.9: households with at least one net public direct versus voucher and formal private direct versus voucher in 2005 in Volta Region

	Public sector nets Volta Region				*Formal private sector nets Volta Region*			
	Direct		Voucher		Direct		Voucher	
n	%	%	n	%			n	%
Total	65	5.2	43	3.4	50	4.0	82	6.5
Zone								
Northern	16	3.9 (2.0 – 7.2)	8	1.9 (0.9 – 4.0)	9	2.2 (1.1 – 4.2)	21	5.1 (2.9 – 8.6)
Central	29	6.9 (4.3 – 10.9)	25	6.0 (3.5 – 9.9)	4	1.0 (0.3 – 3.2)	25	6.0 (4.0 – 8.8)
Southern	20	4.8 (2.9 – 7.8)	10	2.4 (1.2 – 4.7)	37	8.8 (5.4 – 14.2)	36	8.6 (5.8 – 12.4)
		p=0.2		p=0.01		p<0.001		p=0.1
SE group								
Poorest	4	1.7 (0.5 – 5.4)	4	1.7 (0.6 – 4.3)	11	4.6 (2.4 – 8.8)	5	2.1 (0.8 – 5.4)
Very poor	8	3.3 (1.7 – 6.1)	4	1.6 (0.6 – 4.1)	3	1.2 (0.3 – 5.3)	11	4.5 (2.4 – 8.4)
Poor	16	6.0 (3.2 – 11.0)	8	3.0 (1.6 – 5.5)	12	4.5 (2.6 – 7.8)	18	6.8 (4.1 – 10.9)
Less poor	17	6.7 (3.7 – 11.7)	10	3.9 (2.1 – 7.2)	7	2.8 (1.2 – 6.2)	11	4.3 (2.3 – 8.2)
Least poor	20	7.9 (5.2 – 11.7)	17	6.7 (3.9 – 11.4)	17	6.7 (4.2 – 10.5)	37	14.6 (9.6 – 21.5)
		p=0.02		p=0.008		p=0.04		p<0.001
		equity ratio = 0.22		equity ratio = 0.25		equity ratio = 0.69		equity ratio = 0.14

4.3.4.2 Eastern Region

Of the 222 nets reported to have been obtained from the public sector 49 (22%) were reported to have been obtained using a voucher (Table 4.10). This reported use of a voucher to obtain a net from a public sector outlet did not differ across geographic zones, but differed significantly across socio-economic groups ranging from 1.9% of the poorest households to 10.9% of the least poor households ($p<0.001$). One year post implementation of the voucher scheme, just 17 nets in the sampled households had been purchased from the formal private sector, and 6 (35%) of these with the use of a voucher.

Table 4.10: households with at least one net public direct versus voucher and formal private direct versus voucher in 2006 in Eastern Region

	Public sector nets Eastern Region				*Formal private sector nets Eastern Region*			
	Direct		**Voucher**		**Direct**		**Voucher**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Total	173	15.0	49	4.3	11	0.9	6	0.5
Zone								
Northern	62	16.5 (12.0 – 22.3)	16	4.3 (2.3 – 7.6)	4	1.0 (0.4 – 2.5)	0	0
Central	63	16.1 (12.5 – 20.4)	17	4.3 (2.5 – 7.4)	4	1.0 (0.4 – 2.4)	5	1.2 (0.4 – 3.2)
Southern	48	13.8 (9.5 – 19.5)	16	4.6 (1.9 – 10.9)	3	0.8 (0.2 – 3.2)	1	0.3 (0.0 – 1.8)
		p=0.7		p=1.0		p=0.9		p=0.06
SE group								
Poorest	26	12.4 (8.6 – 17.5)	4	1.9 (0.7 – 4.8)	2	0.9 (0.2 – 3.4)	0	0
Very poor	29	13.9 (9.2 – 20.5)	5	2.4 (1.0 – 5.6)	1	0.4 (0.1 – 3.1)	2	0.9 (0.1 – 6.1)
Poor	28	13.5 (9.0 – 19.6)	6	2.9 (1.3 – 6.1)	4	1.7 (0.6 – 4.3)	0	0
Less poor	42	16.6 (11.5 – 23.3)	8	3.2 (1.6 – 6.0)	0	0	0	0
Least poor	47	20.5 (16.1 – 25.8)	25	10.9 (6.0 – 19.1)	4	1.6 (0.6 – 3.9)	4	1.6 (0.6 – 4.0)
		p=0.2		p<0.001		p=0.2		p=0.3
		equity ratio = 0.60		equity ratio = 0.17		equity ratio = 0.56		equity ratio = 0

4.3.5 Effectiveness of the voucher scheme

The effectiveness of the voucher scheme was assessed by the proportion of households with at least one voucher-subsidy net in the post-implementation surveys. Comparisons of proportions of nets from alternative delivery systems pre- and post-implementation of the voucher scheme were used to attribute changes in household ownership to specific delivery systems. These are a summary of the analyses presented above, but aggregating across geographic zones and socio-economic groups because of the small cell sizes for some of the delivery systems. In Volta Region, ownership of mosquito nets rose from 38.3% pre-implementation to 45.4% (p=0.06) post implementation of the voucher scheme Table 4.11. Formal private sector nets purchased with a voucher subsidy reached 6.5% of households. In Eastern Region, the proportion of households owning at least one net rose during one year's implementation of the voucher scheme from 15.0% to 26.0% (p<0.001). However, formal private sector nets purchased with a voucher subsidy reached only 0.5% of households.

An assessment of the change in proportion of nets reaching the household via alternative delivery systems pre and post implementation of the voucher scheme provides greater insight into the impact of the voucher scheme in each of the regions. In Volta Region, prior to the implementation of the voucher scheme, 3% of households owned at least one net that

they got from the public sector, 1.5% from the formal private sector and 31.8% from the informal private sector. Post implementation of the voucher scheme households with at least one public sector net increased to 8.4% ($p<0.001$), households with a formal private sector net to 10.4% ($p<0.001$), and households with an informal private sector net decreased to 27.2%. Approximately 60% of those households who got a net through the formal private sector used a voucher in the purchase. Surprisingly, 3.4% of households reported using a voucher in the process of acquiring a net through the public sector. The voucher subsidy net was used by 9.9% of households, 3.4% public sector and 6.5% formal private sector.

In Eastern Region, prior to implementation of the voucher scheme 4.3% of households owned at least one net that they received from the public sector, 2.1% from the formal private sector and 7.4% from the informal private sector. Post implementation of the voucher scheme 17.6% ($p<0.001$) of households owned a mosquito net from the public sector, 1.4% from the formal private sector and 4.4% ($p=0.05$) from the informal private sector. The increase in households owning at least one net during the voucher implementation period was almost entirely through the public sector delivery system. Fifteen percent of households purchased a net directly through a public sector outlet. As in Volta Region, 4.3% of households reported purchasing a net through a public sector outlet and using a voucher subsidy in this purchase. This means that the voucher was used to purchase a net in the clinic, rather than at a retail outlet.

Table 4.11: Delivery system coverage outcomes pre and post implementation of the ITN voucher scheme

Source of net	Volta Region		Eastern Region	
	Pre-implementation n (%)	Post-implementation n (%)	Pre-implementation n (%)	Post-implementation n (%)
Public sector				
Directly subsidised	37 (3.0)	65 (5.2)	54 (4.3)	173 (13.7)
Voucher subsidised	0	43 (3.4)	0	49 (3.8)
Total[12]	**37 (3.0)**	**105 (8.4)*** **	**54 (4.3)**	**222 (17.6)*** **
Formal private sector				
Unsubsidised	18 (1.5)	50 (4.0)	27 (2.1)	11 (0.9)
Voucher subsidised	0	82 (6.5)	0	6 (0.5)
Total[12]	**18 (1.5)**	**130 (10.4)*** **	**27 (2.1)**	**17 (1.4)**
Informal private sector				
Unsubsidised	392 (31.8)	341 (27.2)	93 (7.4)	55 (4.4)*
Total with at least 1 net[12]	**472 (38.3)**	**571 (45.4)**	**190 (15.0)**	**328 (26.0)*** **
Survey population	**1,232**	**1,254**	**1,265**	**1,260**

* p≤0.05 **p≤0.005 ***p≤0.001

[1]Totals ≥ component parts due to nets from 'other' sources such as gifts

[2]Totals ≤ component parts dues to households with more than one net from different sources

4.3.6 Validation of attribution method

A total of 2,019 nets were reported from households across the 4 surveys, 718 in Volta Region in 2004, 735 in Volta Region in 2005, 229 in Eastern Region in 2004, and 337 in Eastern Region in 2006. The source of 442 (21.9%) of these nets was identified as the public sector, and 1,429 (70.8%) were reported as being from the private sector. Interviewers examined a total of 1,896 nets, 663 (92.3%) in the Volta 2004 survey, 702 (95.5%) in the Volta 2005 survey, 220 (96.1%) in the Eastern Region 2004 survey, and 311 (92.3%) in the Eastern Region 2006 survey.

Of the 731 nets identified by the interviewers as being standard nets, 393 (53.8%) of these were reported to have been delivered via the public sector, 147 (20.1%) via the formal private sector, and 135 (18.5%) by the informal private sector. Of the 1,164 nets identified by interviewers as being non-standard nets 16 (1.4%) were delivered by the public sector, 68 (5.8%) by the formal private sector, and 995 (85.5%) by the informal private sector. It is unlikely (though not impossible) that non-standard nets have been delivered through any public sector outlet. We assume therefore, that the 16 nets identified by interviewers as non-standard and described by respondents as being obtained through the public sector

represent misclassification of attribution. The findings therefore suggest that there was misclassification of the source of 16 of the 1,164 non-standard nets that is 1.4% of non-standard nets were misclassified and wrongly attributed to a public sector delivery system.

This assessment of misclassification is likely to represent the lower bounds of misclassification as it is based only on that by the respondent and does not include any misclassification by the interviewer. Misclassification may also have been higher amongst standard nets but the source of these was much harder to validate.

4.4 Discussion

In this chapter the change in coverage outcomes, that is the proportion of households owning a mosquito net, was used as an indicator of the success of a voucher scheme for delivering ITNs. The evaluation included an attempt to attribute coverage outcomes to the voucher scheme and other delivery systems for mosquito nets known to be in operation before and during the voucher scheme.

4.4.1 Household ownership of mosquito nets pre- and post-implementation of the voucher scheme

The aggregate increase in the proportion of households owning at least one mosquito net was of borderline significance in Volta Region and significant in Eastern Region. These changes are small, as could be expected with implementation of a complex system such as that of a voucher scheme, in comparison to more rapid increase in coverage that could be expected from less complex delivery systems such as campaigns. For example, household ownership of nets increased steadily from 44% in 2005, to 57% in 2006 and 65% in 2007 during the national ITN voucher scheme in Tanzania [31]. The pre- and post- implementation evaluation of delivery outcomes suggested that, particularly in Eastern Region, in comparison with findings from Tanzania, an adequate increase in the proportion of households owning at least one mosquito net occurred within the timeframe of implementing the voucher scheme.

Annual increases in household ownership of mosquito nets in the voucher schemes in two regions of Ghana and at the national level in Tanzania were less than were achieved at the national level in Kenya, where direct delivery of subsidised nets/ITNs through ANC was the major delivery system. Here, household ownership of mosquito nets increased from 24.5% in 2004/5 to 46.3% in 2005/6 as measured in four sentinel districts [29]. With integrated campaigns increases in household ownership have been much higher and have taken place over short periods of time, usually less than one week, although the planning period has taken several months. Household ownership of LLINs increased from 8.0% to 62.5% when delivered through a national scale measles campaign in Togo [143] and ITN ownership from 6.3% to 65.1% through a polio campaign conducted at the national scale in Niger [35].

4.4.2 Geographic disparities in household ownership of mosquito nets pre-post implementation of the voucher scheme

At baseline, household ownership of mosquito nets varied across geographic zones Volta Region being very high in the southern zone. The majority of the households in the southern zone of Volta Region received their nets from the informal private sector. The southern zone of Volta Region has a large surface area of water and swampy land. Anecdotal evidence suggests that there is a tradition of using mosquito nets in this area. There have been reports from The Gambia, where there are similar long-standing traditions of using mosquito nets that the geography/ecology of the land influences levels of ownership of mosquito nets [196]. There were no significant disparities in the proportion of households owning at least one net across the zones of Eastern Region. Two thirds of the nets in households at baseline in Eastern Region were from the private sector and mainly from the informal private sector, particularly in the northern zone of the region. The northern zone of the region borders on Lake Volta, whilst the other zones of the region are mainly semi-deciduous forest.

Post implementation of the voucher scheme in Volta Region these geographic disparities in net ownership were still statistically significant, even though ownership of mosquito nets in the central zone increased significantly. The regional capital Ho is within the central zone of Volta Region and it is likely that the voucher scheme was most active in this zone. In Eastern

Region household ownership of nets increased significantly after one year of implementing the voucher scheme in the central and southern zones of the region, but not in the northern zone. The increases did not result in overall geographic disparities in household ownership of mosquito nets across the zones of the region.

There has been little focus on geographic disparities in coverage of mosquito nets via alternative delivery systems across regions/provinces of countries. Regional/provincial level mosquito net coverage data is presented in DHS survey reports but not attributed to delivery systems. As DHS are not representative at the district level, coverage of mosquito nets and other interventions is not available in the surveys for the district level. Some studies have reported urban rural disparities in coverage of mosquito nets and noted changes in these disparities after introduction of a new delivery system for ITNs [85, 144]. However, comparison is difficult because definitions of urban and rural vary, sometimes defined at the district level or at the community level.

4.4.3 Socio-economic disparities in household ownership of mosquito nets pre-post implementation of voucher scheme

There was no socio-economic disparity in overall (from all sources) household ownership of mosquito nets in Volta Region pre-implementation of the voucher scheme. However, disaggregating by delivery system showed that the least poor households were more likely to own public sector nets than the poorest (equity ratio 0.24). These findings are consistent with access to public sector interventions through health facilities reaching least poor households [30] and the poorest households only as population coverage is very high. However, continuous delivery of ITNs through ANC in Kenya was found to be only marginally biased towards the least poor [29]. This contrasts with integrated immunisation and ITN campaigns which have been consistent in reducing socio-economic disparities in coverage of ITNs [28, 35-36, 85, 143].

The reverse situation was found for private sector nets in Volta Region. Pre-implementation of the voucher scheme the poorest households were more likely to own a private sector net

(equity ratio 1.64). These findings complement those of a review across 26 countries of sub-Saharan Africa which found that the majority of nets in households were from the private sector and that across West African countries use by children under 5 years of age of these nets from the private sector was as equitable as coverage of childhood vaccinations. In contrast, ownership of nets acquired through the public sector and projects was low and inequitable[30].

Disaggregating formal and informal private sector nets in Volta Region showed that aggregating the 'private sector' masks substantial socio-economic disparities in the reach of the formal and informal private sectors. Prior to implementation of the voucher scheme few households owned formal private sector nets and ownership of these nets was biased towards the least poor (equity ratio 0.25), while informal private sector nets were concentrated in the poorest households (equity ratio 1.92). Socio-economic disparities with a bias towards the least poor have been well documented for the formal retail sector both in the presence and absence of social marketing programmes [29, 91]. However, social marketing with formal private sector was found to reduce socio-economic disparities in ownership of mosquito nets in Tanzania between 1997 and 2000 [3].

One year after the voucher scheme was implemented household ownership in Volta Region had increased significantly only in the top two SES quintiles (less poor and least poor households). The socio-economic disparity in ownership of public sector nets decreased slightly (equity ratio 0.25), as did that of formal private sector nets (equity ratio 0.32). The bias towards the poorest households in ownership of informal sector nets decreased (equity ratio 1.61). Socio-economic disparities in household ownership of at least one net were introduced during the period of the voucher scheme pre- and post evaluation in Eastern Region. Post implementation of the scheme the least poor households were more likely to own a net (equity ratio 0.53). Household ownership of nets increased across all socio-economic quintiles with the exception of the very poor (quintile 2). Lower uptake of ITNs through discount voucher schemes was also seen in the KINET project [97] and the Tanzanian National Voucher Scheme (TNVS) in Tanzania [31].

4.4.4 The relative contribution of different delivery systems to household ownership of mosquito nets

4.4.4.1 Coverage outcomes of delivery systems pre-ITN voucher scheme

The coverage outcomes of public sector delivery at baseline were minimal in both regions, and the majority of nets in households could be attributed to the informal private sector. The proportions of households owning nets differed substantially between regions and within zones of the regions, and these differences were due to ownership of informal private sector nets. Prior to introduction of the voucher scheme in Volta Region household ownership was relatively high (33%). The majority of households owning at least one net at this time had purchased their net/s from the private sector, and more specifically from the informal private sector. The majority of these nets were made from a variety of materials and stitched within the markets or purchased from other informal sources already stitched (data not shown). These nets are part of a trade in second-hand clothes locally known as *'fos'* and arrive in Ghana in bundles with these second-hand clothes, or are purchased across the border in Lome, Togo, where there is also a vibrant trade in locally stitched 'second-hand' nets.

4.4.4.2 Coverage outcomes of the voucher scheme on household ownership of mosquito nets

Within the classification of delivery systems used here, those who benefit from the voucher scheme as it was initially designed, are those who report getting their net through a formal private sector outlet and report that they used a voucher in the net purchase. Using information linking the coverage achieved to the specific delivery systems presents a different picture of the effectiveness of the new delivery system in comparison with a focus on overall coverage outcomes alone. The overall increase in coverage was 7.1% in Volta Region (38.3% in 2004 to 45.4% in 2005) and 11.0% in Eastern Region (15.0% in 2004 to 26.0% in 2006). However, using the reported delivery point to attribute the nets in households to the specific system through which they were delivered and reached the household suggested that only 6.5% and 0.5% of households with pregnant women or a child under 5 years in Volta and Eastern Regions, respectively, had a mosquito net that was delivered in a formal private sector outlet via the voucher scheme. In Eastern Region, the majority of the increase in the coverage of ITN during the first year of implementation of the

voucher scheme was due to direct delivery of mosquito nets through the public sector. In Volta Region the impact of the voucher scheme on household ownership with mosquito nets did not vary across the zones however, there was a socio-economic disparity in its impact with 14.6% of the least poor households owning a voucher scheme net in comparison with just 2.1% of the poorest households (equity ratio 0.14).

Assessing the household ownership of nets pre and post implementation of the voucher scheme provided a measure of the aggregate change in coverage that occurred during this time. However, where there is more than one delivery system operating for a particular intervention, distinguishing the contributions of each individual system to the aggregate coverage change becomes important. In this case, it would have been inappropriate to attribute the total change in coverage to the voucher scheme. In fact if this interpretation had been made, the effectiveness of the voucher scheme would have been over estimated. Attributing the nets in the household to the system through which they were delivered provided a strong inference on the proportion of the measured change that was due to each specific delivery system including that of the new voucher delivery system.

4.4.5 A method of attributing household ownership of mosquito nets to a specific the delivery system

In recommending the use of cross sectional observational studies with a plausibility inference for the evaluation of delivery systems the limitations and advantages with respective to other methodologies must be considered. This plausibility inference is achieved in this study by using information collected in the survey about the change in ownership that could be attributed to the voucher scheme. The cross sectional studies with a plausibility inference used here are more explicitly, based upon the comparison of outcomes in an intervention group with a non-randomised control group. Cross sectional observational studies with non-randomised controls have generally weaker internal validity than studies using randomised controls, but the structured sampling techniques used here serve to improve this validity by reducing selection bias and random errors. This simple pre-post evaluation of coverage does not assess or adjust for any contextual factors, and this is recognised as a limitation.

However, the use of alternative delivery systems as internal controls has the advantage that each of the systems will be influenced by the same temporal trends in external contextual factors.

While having potentially greater internal validity, the findings of a randomised controlled trial may have limited external validity even with respect to the population in the area in which the trial was conducted. Well conducted cross sectional observational studies will have good external generalisability to the population from which they were sampled. Therefore if a survey is undertaken at the national scale, then the findings are generalisable to the entire country. Cross sectional observational studies with a plausibility inference have the advantage that they are less complex and expensive than studies using randomised controls and are therefore more applicable at scale. These observational studies are also not limited in their applicability by whether an intervention is part of current national policy guidelines or not. Where an intervention is part of a national policy guideline it is not ethical to introduce a control group who are denied the intervention, or arguably to test different delivery systems where it could be reasonably argued that one would be expected to be more effective than another.

A small proportion of the households who reported receiving a net at a public sector outlet in both regions, said that they used a voucher to buy the net. If these reports are accurate, there are two possible explanations. The first possibility is that nurses in the health facilities are not just supplying the voucher, but also selling the voucher scheme nets. Some of the nurses had been selling ITNs in the health facilities before the introduction of the voucher scheme and they may have 'adapted' the voucher scheme in order to continue to do this. The other possibility is misunderstanding of the response categories by either the respondent or the interviewer. In both regions one of the voucher scheme commercial partners established a system of selling voucher scheme ITNs from a table-top under a marketing umbrella. These 'umbrellas' were situated immediately outside some of the larger health facilities and hospitals in both regions and may have been interpreted by some respondents as being

within the health facility. This would cause an underestimation of the impact of the voucher scheme.

The voucher scheme may have impacted on direct (non-voucher) sales of mosquito nets through the formal private sector by improving availability to non-target groups in the retail outlets. This non-subsidy sale of ITNs through formal retail sector outlets is the long-term vision of the voucher scheme. However, attribution of these sales to the voucher scheme cannot be achieved using the methods employed here.

Attribution of nets to delivery systems was achieved in this study through the simple addition of three questions on the cross sectional household surveys. This study design allows relatively simple assessment of the effectiveness of a delivery system relative to other delivery systems within a given context. For complex interventions such as the ITN voucher scheme described here, and particularly for interventions that are delivered through several alternative delivery systems, a comprehensive assessment of delivery systems should be undertaken within the geographic area of implementation.

The steps in conducting an observational study with non-randomised controls for evaluating delivery systems of ITNs would apply to delivery of other public health products such as drugs. The conceptual framework could be further developed for application to the delivery of information through communications interventions. Additionally, this model can enable comparison of delivery system strategies. For example, the effect of applying different pricing strategies, different products, or different communication messages, to an intervention delivered through a specific delivery channel could be evaluated using this approach.

The novel methodological approach is attribution of coverage to a specific delivery system and the use of internal controls to enable a plausible inference that the coverage outcomes were due to a specific delivery intervention. This method is based upon the relationship between the delivery system and coverage outcome which is the endpoint of a delivery system evaluation. In contrast, where an intervention itself is under evaluation the outcome

that must be assessed is that of health impact. Although the effectiveness of a delivery system contributes substantially to the effectiveness, or health outcome of an intervention, other factors such as consistency of use or adherence to dosing schedules may also contribute. The presence of these factors and others that confound the relationship between coverage and health outcome, invalidate the use of this method for evaluation of interventions. It would not be possible to infer that the health outcomes were due to the intervention over and above the impact of confounding factors. However, a substantial number of external influences on intervention effectiveness are in fact delivery system factors.

This cross sectional observational study design provides a relatively simple method for assessing the effectiveness, and contributing to assessment of the cost effectiveness of delivery systems for public health interventions. Recognizing that more than one delivery system is needed to reach all target groups [197], this method is able to assess the relative contributions of a number of delivery systems to a single outcome.

In one region (Volta Region) it was shown that the increase in household ownership of nets could plausibly be attributed to the voucher scheme; and in the other region (Eastern Region) it was shown that it was implausible that the increase in ownership of nets was due to the voucher scheme. However, differences in contextual factors between the two regions should be taken into account in interpreting this plausibility statement. Particularly where it is possible that contextual factors (for example, alternative delivery systems) may confound the relationship between the voucher scheme and the outcome.

Using the proportion of non-standard nets reported as sourced from the public sector as our indicator, our findings suggest that relying on reported source of nets results in only minimal (1.4%) misclassification of the delivery system through which the net reached the household. The extrapolation of this measure of misclassification assumes that there is no differential misclassification of standard and non-standard nets to public and private sector delivery points (source of net). Several measures such as rigorous training of interviewers and visual

aides (labelled swatches) were used to minimise the misclassification errors by interviewers. However, some of the misclassification error may have been due to the incorrect identification of standard and non-standard nets, rather than the reported source being incorrect.

Bias would be introduced into the analysis if there was differential misclassification between: nets delivered via the different systems, whether or not a voucher was used in the purchase of the net, and respondents in particular geographic areas, or socio-economic groups. These same factors would introduce a bias into the outcomes of the analysis if they differed within the uncategorised responses on source of net.

4.5 Conclusions

This study highlights that a cross sectional observational study design conducted pre and post implementation of a new delivery system for insecticide treated nets without an external control can provide a strong plausibility inference on the effectiveness of the delivery system. This is achieved by attributing coverage outcomes to the delivery system through which the intervention reached the household. In the absence of this attribution, the effectiveness of the new delivery system would have been overestimated. It is plausible that the increase in household ownership during the period of the voucher scheme in Volta Region was attributable to the vouchers scheme. In Eastern Region, it was found to be implausible that the increase in household ownership was due to the voucher scheme. The increase was mainly due to direct delivery of mosquito nets through the public sector that is, through ANC.

Chapter 5: process evaluation of delivery of ITNs

5.1 Introduction

The outcome evaluation of the ITN voucher scheme showed an increase in the proportion of households with at least one net from 38.3% to 45.4% and 15.0% to 26.0% in Volta and Eastern Regions, respectively. The analyses also showed that it was plausible that the increase in the proportion of households with at least one mosquito net was due to the voucher scheme in Volta Region and implausible that the increase was due to the voucher scheme in Eastern Region.

With ANC coverage of 90.4% and 96% in Volta and Eastern Region respectively [167] it is clear that not all pregnant women who access ANC benefitted from the voucher scheme. The ITN voucher scheme design was such that every ANC registrant should receive a discount voucher on her first attendance at ANC, she should use the voucher to purchase an ITN from a voucher scheme accredited retail outlet, and sleep under the ITN during her pregnancy and with her baby after delivery to realise the full benefits of this scheme. Thus if all pregnant women attended ANC and all of the processes in the implementation pathway of the voucher scheme were 100% effective, then 100% of pregnant women would be reported as sleeping under ITNs.

It was clear from the outcome evaluation findings that one or all of the processes within the voucher scheme were not effective. Further process evaluation was undertaken to identify the stages in the ITN the voucher scheme at which problems occurred, resulting in inadequate effectiveness of the delivery system, and whether there were geographic and socio-economic disparities in stages of loss of delivery effectiveness. The voucher scheme process evaluation was conducted within the context of a wide range of approaches to process evaluations reported in the literature but little guidance on what types of process

evaluation would be most appropriate for different types of intervention and none on how to undertake a process evaluation of delivery systems for health interventions[9].

5.2 Methods

5.2.1 The voucher scheme processes

A detailed description of the introduction of the voucher scheme in Volta and Eastern Regions was presented in Chapter 3. In summary, the voucher scheme involved delivery of a subsidy, the voucher, through the public sector, and delivery of the ITN through the private sector. In Volta Region in the original programme design, vouchers were delivered directly to the health facilities by a Management Agent. Pregnant women were eligible for a voucher on their first visit to ANC. The need to include the cohort of currently pregnant women in the scheme who had already attended ANC at least once was recognised, and these women were to be offered a discount voucher on their next visit to ANC. Retail outlets were invited to join the voucher scheme by 'ITN distributors', and were supplied with ITNs by these same distributors. Pregnant women (or their representative) were to be given a discount on presentation of the voucher in a retail outlet in exchange for an ITN.

The framework for the flow of vouchers and ITNs (Figure 5.1) outlines the complexity of the delivery processes. The health facility (delivery point) is the major focal point for delivery of the subsidy. In order for pregnant women to receive the subsidy, they must 1) attend an ANC that has been included in the voucher scheme, 2) the eligible attendee must be offered a voucher by the health staff, and 3) they must accept the voucher when offered. In order for the voucher subsidy to be utilised, it must be 4) taken to a retail outlet where ITNs are available, and exchanged for an ITN. This ITN should then 5) be used by the pregnant woman. The effectiveness of delivery was assessed at each of these 5 individual steps and the

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[9] [9] Elements of this chapter have been published as: Webster, J., Kweku, M., Dedzo, M., Tinkorang, K., Bruce, J., Lines, J., Chandramohan, D., Hanson, K. (2010) Evaluating delivery systems: complex evaluations and plausibility inference (2010) *American Journal of Tropical Medicine and Hygiene* 82(4):672-7.

contribution of any loss in effectiveness at each step to overall reduction in effectiveness of the system.

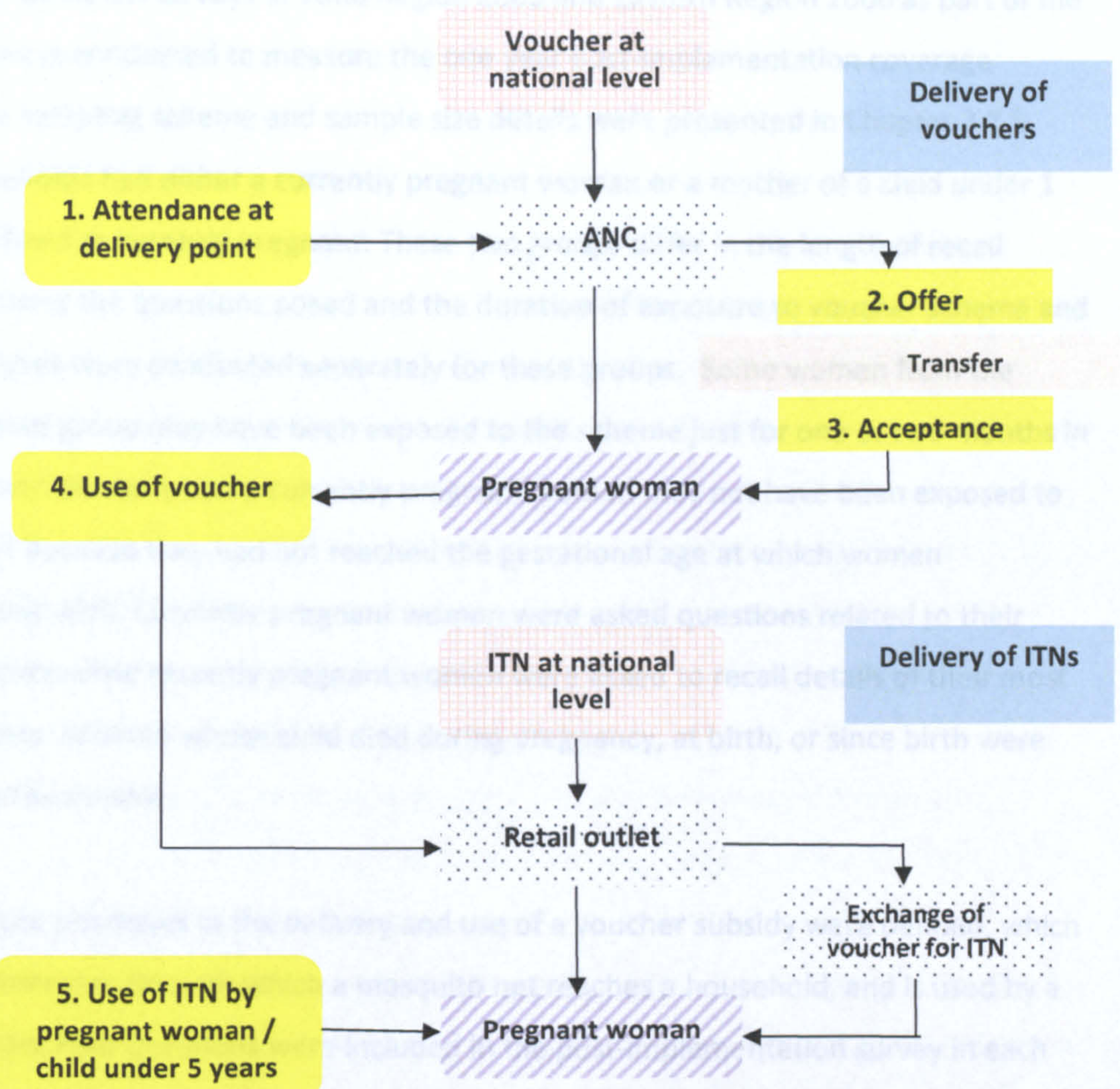

Figure 5.1: framework of critical points in the delivery of ITNs via the voucher scheme

The findings of the outcome evaluation show that there were both geographic and socio-economic disparities in the effectiveness of the voucher scheme within the two regions. Assessment of the effectiveness of the processes of the voucher scheme across these strata would further illuminate the steps of the processes where these disparities arise.

5.2.2 Household surveys

The delivery process effectiveness evaluation was conducted through the post- voucher scheme implementation surveys in Volta Region 2005 and Eastern Region 2006 as part of the household surveys conducted to measure the one year post-implementation coverage outcomes. The sampling scheme and sample size details were presented in Chapter 3.7.5. Sampled households had either a currently pregnant woman or a mother of a child under 1 year of age defined as recently pregnant. These two groups differ in the length of recall required to answer the questions posed and the duration of exposure to voucher scheme and therefore analyses were conducted separately for these groups. Some women from the recently pregnant group may have been exposed to the scheme just for one or two months in the last trimester. Similarly some currently pregnant women may not have been exposed to the scheme yet because they had not reached the gestational age at which women commonly attend ANC. Currently pregnant women were asked questions related to their current pregnancy while recently pregnant women were asked to recall details of their most recent pregnancy. Women whose child died during pregnancy, at birth, or since birth were excluded from the sample.

Five intermediate processes in the delivery and use of a voucher subsidy were defined, which describe the processes through which a mosquito net reaches a household, and is used by a pregnant woman. Four questions were included in the post-implementation survey in each region to assess the first four of these processes which were: 1) whether the pregnant woman or mother of a child under 1 year of age had attended ANC during her current/last pregnancy; 2) whether she was offered a voucher for a mosquito net during this visit; 3) whether she accepted the voucher; 4) whether she had used the voucher to purchase a net. Use of a net by a pregnant woman was based upon a combination of questions on the number and type of nets in the household and the identification of which household member slept under each specific net the night previous to the survey, as reported by the pregnant woman.

5.2.3 Data analyses

Proportions of pregnant women progressing through each step in the delivery process were quantified and stratified by geographic zone of the region, and by socio-economic quintile. This analysis was conducted for recently pregnant women and for currently pregnant women separately. Pearson's design based F test was used to test the statistical significance of the differences in proportions across geographic zones, socio-economic quintiles, and between currently and recently pregnant women.

Two assessments of the delivery process were conducted: 1) the effectiveness of each individual process, and 2) the overall effectiveness of the combination of all processes. In the assessment of effectiveness of individual processes, the proportion of recently and currently pregnant women moving from Process 1 through to Process 5 of the voucher scheme in each of the regions as defined in Figure 5.1 was calculated. The effectiveness of each individual process was defined as the proportion of those having reached a given process (that is successful in the previous process) that proceeded through to the next process. Only those who entered Process 1 are able to move to Process 2, and so on through to Process 5, therefore the denominator decreases correspondingly at each step. In the assessment of the overall effectiveness of the combination of processes, the denominator is the target population, which is the total number of respondents. The numerator is the total number of women who successful pass through each of the 5 processes, the overall effectiveness of the system being the proportion of respondents who pass through the processes and sleep under a net that they obtained using a voucher that they got at ANC.

Socio-economic disparities in the effectiveness of delivery at each step were assessed using the concentration index (Chapter 3.7.8).

5.3 Results

5.3.1 Distribution and characteristics of households and respondents

Total households sampled in Volta Region were 1,254, and in Eastern Region 1,226 (Table 5.1). Thirty clusters were selected in each of the three zones of the regions (zones were based upon the ecological zones of each district, see Chapter 3) with two districts selected as representative of each zone. Clusters were selected proportional to population size of the districts, and therefore numbers of households selected varied across the two districts within each zone.

Table 5.1: Distribution of sample households in Volta Region and Eastern Region

Zone	*Volta Region*		*Eastern Region*	
	District		**District**	
Northern	Krachi	204	Kwahu South	245
	Kpando	168	Manya Krobo	166
Central	Jasikan	211	East Akim	251
	Hohoe	251	Suhum Kraboa Coaltar	168
Southern	Ketu	309	Akwapim South	149
	South Tongu	111	Birim South	247
Total		1,254		1,226

The total number of individuals in sampled households was 4,659 in Volta Region, and 5,499 in Eastern Region (Table 5.2). Numbers of currently pregnant women sampled in the two regions were quite comparable, 635 in Volta Region and 619 in Eastern Region. More than 1,200 children were members of the households sampled for each survey (from 1,259 in the Volta Region survey and 1,346 in the Eastern Region survey).

Table 5.2: Characteristics of sampled households

Characteristic	Zone	Volta Region	Eastern Region
Total individuals	Northern	1,625	1,744
	Central	1,594	1,892
	Southern	1,440	1,863
	Total	**4,659**	**5,499**
Currently pregnant women	Northern	203	201
	Central	213	210
	Southern	219	208
	Total	**635**	**619**
Recently pregnant women	Northern	211	211
	Central	208	211
	Southern	209	204
	Total	**628**	**626**
Children <5	Northern	455	443
	Central	403	445
	Southern	401	458
	Total	1,259	1,346

Amongst recently pregnant women, the majority of respondents were between 20 and 39 years of age, with 20 to 29 representing the largest age band across the surveys in both regions (Table 5.3). Nearly a fifth of respondents in Volta Region had no formal education, whilst in Eastern Region there were slightly less women in this category (15.5%). Differences in educational level across regions were statistically significant (p=0.03). Approximately a third of women had just one child, and therefore had been primigravidae at the time of their visit to ANC. Amongst ANC attendees, over 60% in both regions had 4 or more visits to ANC during their most recent pregnancy.

Table 5.3: characteristics of respondents

	Volta Region		Eastern Region		p
	n	%	n	%	
		Recently pregnant women			
Regional total	628		630		
Age					
14 – 19	37	5.9 (4.2 – 8.2)	53	8.5 (6.5 – 10.9)	
20 – 29	391	62.3 (58.3 – 66.0)	377	60.2 (55.6 – 64.6)	
30 – 39	166	26.4 (23.1 – 30.1)	172	27.5 (23.7 – 31.7)	
40 – 49	34	5.4 (3.7 – 7.8)	24	3.8 (2.6 – 5.6)	0.2
Education					
None	126	20.1 (16.5 – 24.1)	97	15.5 (12.2 – 24.1)	
Primary	138	22.0 (18.8 – 25.5)	159	25.4 (21.8 – 29.4)	
Middle	306	48.7 (43.5 – 54.0)	331	52.9 (48.3 – 57.5)	
Secondary	58	9.2 (7.0 – 12.0)	34	5.4 (3.6 – 8.2)	
Tertiary	0	0	5	0.8 (0.2 – 2.6)	0.03
Parity					
Primagravidae / 1 child	213	34.1 (29.8 – 38.7)	205	33.8	0.4
Attend ANC ≥1					
	592	94.7 (92.1 – 96.5)	569	93.7 (91.2 – 95.6)	0.5
No. ANC visits					
1	27	4.6 (3.3 – 6.3)	30	5.3 (3.5 – 7.9)	
2	69	11.7 (9.2 – 14.7)	65	11.5 (8.9 – 14.7)	
3	118	19.9 (16.7 – 23.6)	99	17.5 (14.0 – 21.5)	
≥ 4	378	63.9 (58.8 – 68.6)	373	65.8 (60.3 – 70.8)	0.7
		Currently pregnant women			
Regional total	628		630		
Age					
14 – 19	42	6.7 (4.7 – 9.7)	80	13.4 (10.9 – 16.3)	
20 – 29	396	63.6 (59.4 – 67.5)	355	59.3 (55.2 – 63.2)	
30 – 39	159	25.5 (22.2 – 29.1)	144	24.0 (20.5 – 28.0)	
40 – 49	26	4.2 (2.7 – 6.3)	20	3.3 (2.0 – 5.4)	0.06
Education					
None	124	19.9 (16.1 – 24.2)	110	18.4 (15.0 – 22.3)	
Primary	143	23.0 (19.9 – 26.3)	153	25.5 (21.9 – 29.6)	
Middle	294	47.2 (42.2 – 52.3)	294	49.1 (44.7 – 53.5)	
Secondary	59	9.5 (7.2 – 12.3)	39	6.5 (4.5 – 9.4)	
Tertiary	3	0.5 (0.2 – 1.4)	3	0.5 (0.1 – 2.2)	0.4
Parity					
Primagravidae / 1 child	208	33.4 (29.8 – 37.2)	211	35.2 (31.1 – 39.6)	0.5
Trimester*					
1st	46	7.4 (5.0 – 9.2)	39	6.6 (4.7 – 7.9)	
2nd	216	34.7 (32.2 – 36.7)	219	37.1 (34.2 – 39.1)	
3rd	361	58.0 (55.2 – 60.1)	333	56.4 (53.3 – 57.8)	0.6
Attend ANC ≥1					
	534	85.9 (82.7 – 88.5)	471	79.7 (76.0 – 83.0)	0.009
No. ANC visits					
1	99	18.5 (15.9 – 21.5)	96	20.3 (16.9 – 24.3)	
2	142	26.6 (23.2 – 30.3)	125	26.5 (22.8 – 30.6)	
3	92	17.2 (14.7 – 20.1)	95	20.1 (16.7 – 24.1)	
≥ 4	201	37.6 (33.5 – 41.9)	156	33.1 (27.9 – 38.6)	0.4

Amongst currently pregnant women there were a greater proportion of teenagers amongst respondents in Eastern Region; 6.7% of the pregnant women in Volta Region and 13.4% in Eastern Region were between 14 to 19 years of age. This difference in the age group of women between the two regions was of borderline statistical significance (p=0.06). Unlike in recently pregnant women, there were no statistically significant differences in the level of education amongst the currently pregnant women. The proportion of currently pregnant women who had attended ANC at least once during their current pregnancy was higher in Volta Region that in Eastern Region (85.9% versus 79.7%; p=0.009). More than half of currently pregnant respondents were in the 3rd trimester of their pregnancies, and less than 10% in the first trimester.

The proportion of recently pregnant women having attended ANC 4 or more times during their pregnancy was approximately twice that of currently pregnant women, in both regions.

5.3.2 Attendance at ANC

5.3.2.1 Recently pregnant women

In Volta Region, a slightly higher proportion of recently pregnant women had attended ANC in the central zone compared to the northern and southern zones and this was of borderline significance (p=0.08) (Table 5.4). Amongst socio-economic groups in Volta Region women in the least poor households were more likely to attend ANC compared to the poorest households (98.3% versus 88.8%; p=0.02). Conversely in Eastern Region there was no difference in the proportion of recently pregnant women who attended ANC at least once across geographic zones or socio-economic groups.

The proportion of recently pregnant women who attended ANC at least once was similar in Volta and Eastern Regions (94.7% versus 93.7%, respectively; p=0.5) There were no differences between the regions in the proportion of recently pregnant women who attended ANC across geographic or socio-economic groups.

Table 5.4: proportion of currently and recently pregnant women attended ANC by geographic zone and socio-economic quintile

	Volta Region		*Eastern Region*		*p*
	n	**% (95% CI)**	**n**	**% (95% CI)**	
Recently pregnant					
Regional total	592	94.7	577	93.7	0.5
Northern zone	199	95.7 (91.0 – 98.0)	194	92.4 (86.4 – 95.9)	0.2
Central zone	202	97.1 (94.0 – 98.8)	202	96.2 (92.4 – 98.1)	0.6
Southern zone	191	91.4 (84.8 – 95.3) p=0.08	173	92.5 (88.4 – 95.3) p=0.2	0.8
Poorest	111	88.8 (81.0 – 93.7)	110	94.0 (88.2 – 97.1)	0.2
Very poor	107	93.9 (84.1 – 97.8)	110	94.8 (89.2 – 97.6)	0.9
Poor	129	95.6 (90.7 – 97.9)	103	90.4 (83.3 – 94.6)	0.1
Less poor	130	97.0 (92.2 – 98.9)	113	91.9 (85.1 – 95.7)	0.08
Least poor	115	98.3 (92.7 -99.6) p=0.02	127	97.0 (90.6 – 99.1) p=0.3	0.6
Currently pregnant					
Regional total	534	85.7	487	79.8	0.01
Northern zone	179	88.6 (82.3 – 92.9)	170	85.0 (78.7 – 89.7)	0.3
Central zone	178	84.4 (78.4 – 88.9)	164	78.9 (71.9 – 84.4)	0.2
Southern zone	177	84.7 (79.2 – 88.9) p=0.4	149	76.0 (69.7 – 81.4) p=0.1	0.01
Poorest	84	75.7 (64.0 – 84.5)	73	70.2 (60.3 – 78.5)	0.5
Very poor	104	81.9 (74.1 – 87.8)	91	81.3 (73.3 – 87.3)	0.7
Poor	106	82.2 (74.4 – 88.0)	94	77.1 (67.8 – 84.2)	0.3
Less poor	109	91.6 (84.6 – 95.6)	121	83.5 (76.0 – 88.9)	0.08
Least poor	131	96.3 (91.6 – 98.4) p=0.0002	101	85.6 (79.0 – 90.4) p=0.04	0.001

5.3.2.2 Currently pregnant women

In Volta Region there was no difference between the geographic zones in the proportion of currently pregnant women who had attended ANC at least once. However, those in the least poor households were more likely to have attended ANC compared to those from the poorest households (96.3% versus 75.7%; p=0.0002). A similar pattern was seen with currently pregnant women in Eastern Region, that is, no geographic disparities, but there were socio-economic disparities in ANC attendance; a high proportion of currently pregnant women from the least poor households attended ANC compared to those from the poorest households (85.6% versus 70.2%; p=0.04).

A greater proportion of currently pregnant women in Volta Region than in Eastern Region had attended ANC at least once (85.7% versus 79.8%; p=0.01). And these differences were also present between those in the southern zones of the regions and between those from least poor households.

5.3.3 Offered voucher at ANC

5.3.3.1 Recently pregnant women

In Volta Region, only 42.7% of recently pregnant women who attended ANC were offered a voucher for an ITN (Table 5.5). The proportion of recently pregnant women offered vouchers varied from 33.2% in the northern zone, through 41.6% in the southern zone to 53.2% in the central zone of the region (p=0.006). There were also socio-economic disparities with 30.6% of women from the poorest households, to 54.8% of women from the least poor households (p=0.007) being offered a voucher. In Eastern Region there was no significant difference in the proportion of recently pregnant women offered vouchers across the geographic zones of the region, or across socio-economic groups.

There were marked differences overall between the regions in being offered a voucher (42.7% versus 21.9%; p=<0.0001), between geographic zones and between socio-economic groups. The proportion of recently pregnant women offered a voucher upon attending ANC in Volta Region was approximately twice the proportion of recently pregnant women in Eastern Region.

Table 5.5: proportion of currently and recently pregnant women offered a voucher at ANC by geographic zone and socio-economic quintile

	Volta Region		*Eastern Region*		p
	n	% (95% CI)	n	% (95% CI)	
Recently pregnant					
Regional total	252	42.7	124	21.9	<0.0001
Northern zone	66	33.2 (24.1 – 43.6)	34	17.5 (12.0 – 24.8)	0.01
Central zone	107	53.2 (44.8 – 61.5)	54	26.7 (17.9 – 37.9)	0.0005
Southern zone	79	41.6 (33.2 – 50.5) p=0.006	36	21.1 (14.4 – 29.7) p=0.3	0.001
Poorest	34	30.6 (20.9 – 42.5)	19	17.6 (10.8 – 27.3)	0.1
Very poor	46	43.8 (34.2 – 53.9)	22	20.0 (12.5 – 30.4)	0.002
Poor	56	43.4 (35.6 – 51.6)	26	25.2 (17.3 – 35.3)	0.004
Less poor	53	40.8 (32.8 – 49.2)	22	19.5 (12.4 – 29.2)	0.003
Least poor	63	54.8 (45.0 – 64.2) p=0.007	33	26.0 (18.6 – 35.0) p=0.5	<0.0001
Currently pregnant					
Regional total	205	38.5	96	20.0	<0.0001
Northern zone	71	39.9 (30.6 – 50.0)	22	13.0 (8.0 – 20.5)	<0.0001
Central zone	74	41.8 (33.1 – 51.0)	53	32.5 (23.5 – 43.1)	0.07
Southern zone	60	33.9 (25.4 – 43.6) p=0.4	21	15.1 (7.3– 28.6) p=0.006	0.01
Poorest	21	25.6 (14.7 – 40.7)	12	16.9 (8.5 – 30.9)	0.3
Very poor	38	36.5 (24.9 – 50.0)	19	21.8 (13.9 – 32.5)	0.06
Poor	39	36.8 (28.6 – 45.8)	12	13.0 (7.2 – 22.6)	0.0001
Less poor	49	45.0 (33.0 – 57.5)	22	18.5 (11.8 – 27.9)	<0.0001
Least poor	58	44.3 (33.7 – 55.4) p=0.1	30	30.3 (18.3 – 45.8) p=0.1	0.05

5.3.3.2 Currently pregnant women

The proportion of currently pregnant women offered a voucher on attendance at ANC in Volta Region did not vary across geographic zones of socio-economic groups. In Eastern Region currently pregnant women from the central zone were more likely to be offered a voucher than those in the northern or southern zones (32.5% central zone, 15.1% southern zone and 13.0% northern zone; p=0.006).

Again there were marked differences overall between the regions in being offered a voucher overall (38.5%% versus 20.0%; p=<0.0001), between geographic zones and between socio-economic groups.

5.3.4 Accepted voucher at ANC

5.3.4.1 Recently and currently pregnant women

The majority of those offered a voucher at ANC accepted it. Within the regions there were no significant differences in the proportion of currently or recently pregnant women who accepted a voucher when offered, across zones of the region or across socio-economic quintiles (Table 5.6).

Table 5.6: accepted voucher at ANC by pregnant women and mothers of children under 1 year of age by zone and socio-economic quintile in Volta and Eastern Regions

	Volta Region		*Eastern Region*		p
	n	% (95% CI)	n	% (95% CI)	
Recently pregnant					
Regional total	233	92.8	106	86.2	0.2
Northern zone	65	98.5 (89.4 – 99.8)	28	82.4 (64.2 – 92.4)	0.008
Central zone	98	92.5 (82.4 – 97.0)	45	83.3 (67.5 – 92.3)	0.4
Southern zone	70	88.6 (80.1 – 93.8)	33	94.3 (78.8 – 98.7)	0.3
		p=0.1		p=0.3	
Poorest	32	94.1 (80.8 – 98.4)	17	94.4 (67.4 – 99.3)	1.0
Very poor	41	91.1 (74.3 – 97.3)	17	77.3 (54.3 – 90.7)	0.1
Poor	53	94.6 (84.7 – 98.3)	20	76.9 (57.5 – 89.1)	0.04
Less poor	49	92.5 (80.9 – 97.3)	21	95.5 (72.1 – 99.4)	0.5
Least poor	58	92.1 (82.7 – 96.6)	29	87.9 (68.1 – 96.1)	0.7
		p=0.9		p=0.2	
Currently pregnant					
Regional total	192	94.1	86	91.5	0.6
Northern zone	67	94.4 (85.1 – 98.0)	18	81.8 (54.7 – 94.4)	0.1
Central zone	71	97.3 (89.4 – 99.3)	49	94.2 (83.6 – 98.1)	0.9
Southern zone	54	90.0 (79.1 – 95.5)	19	95.0 (69.7 – 99.4)	0.5
		p=0.2		p=0.2	
Poorest	18	85.7 (65.3 – 95.0)	12	100	0.6
Very poor	34	91.9 (75.1 – 97.7)	17	89.5 (64.0 – 97.6)	0.8
Poor	36	92.3 (80.1 – 97.3)	10	83.3 (50.2 – 96.1)	0.4
Less poor	46	93.9 (82.5 – 98.0)	19	95.0 (72.0 – 99.3)	0.9
Least poor	58	100	27	90.0 (70.4 – 97.2)	0.1
		p=0.2		p=0.6	

Acceptance of a voucher when offered did not vary between Volta and Eastern Region in those recently pregnant (92.8% in Volta Region versus 86.2% in Eastern Region; p=0.2) or those currently pregnant (94.1% in Volta Region versus 91.5% in Eastern Region; p=0.6).

When comparing the proportion of pregnant women who accepted a voucher when offered,

recently pregnant women in the northern zone of Volta Region were more likely to accept than recently pregnant women in the northern zone of Eastern Region (98.5% in Volta Region versus 82.4% in Eastern Region; p=0.008).

5.3.5 Used voucher to purchase an ITN

5.3.5.1 Recently pregnant women

In Volta Region just under half (44.6%) of all recently pregnant women who accepted a voucher at ANC used it to purchase an ITN (Table 5.7). The proportion of recently pregnant women who used their voucher to purchase an ITN varied from 23.1% in the northern zone, to 50.0% in the central and 57.1% in the southern zones (p=0.003). More than double the recently pregnant women in the least poor socio-economic households used their voucher to purchase an ITN compared to those in the poorest households (28.1% in the poorest and 65.5% in the least poor households; p=0.004). In Eastern Region just under a third (29.8%) of recently pregnant women who accepted a voucher on visiting ANC used it to purchase an ITN, and there were no statistically significant disparities across the geographic zones or socio-economic groups.

Recently pregnant women in Volta Region who received a voucher were more likely to use it to purchase an ITN than recently pregnant women in Eastern Region (44.6% versus 29.8%; p=0.01. This difference was pronounced between the central and southern zones of the two regions but not between socio-economic groups.

5.3.5.2 Currently pregnant women

The difference in proportions of currently pregnant women using their voucher to purchase an ITN across geographic zones of Volta Region was not statistically significant. Amongst socio-economic groups, just 11.1% of currently pregnant women from the poorest households used their voucher to purchase an ITN compared to 36.2% in the least poor households. This was of borderline significance due to the small numbers of women in the analysis, particularly in the poorer socio-economic quintiles.

Table 5.7: use voucher by pregnant women and mothers of children under 1 year of age by zone and socio-economic quintile in Volta and Eastern Regions

	Volta Region		*Eastern Region*		p
	n	% (95% CI)	n	% (95% CI)	
Recently pregnant					
Regional total	104	44.6	31	29.8	0.01
Northern zone	15	23.1 (14.9 – 34.0)	7	25.9 (14.0 – 43.0)	0.8
Central zone	49	50.0 (38.8 – 61.2)	12	27.3 (15.2 – 44.0)	0.02
Southern zone	40	57.1 (40.8 – 72.1) p=0.003	12	36.4 (19.9 – 56.8) p=0.6	0.08
Poorest	9	28.1 (15.4 – 45.7)	3	17.7 (5.3 – 45.3)	0.4
Very poor	13	31.7 (19.7 – 46.8)	3	17.7 (3.9 – 52.9)	0.3
Poor	26	49.1 (36.5 – 61.7)	5	26.3 (10.6 – 51.7)	0.1
Less poor	18	36.7 (21.1 – 51.6)	5	25.0 (8.7 – 53.8)	0.3
Least poor	38	65.5 (48.9 – 79.0) p=0.004	14	48.3 (31.0– 66.0) p=0.2	0.2
Currently pregnant					
Regional total	49	25.5	27	32.1	0.2
Northern zone	19	28.4 (18.5 – 40.8)	9	52.9 (35.1 – 70.0)	0.01
Central zone	13	18.3 (12.0 – 26.9)	10	20.4 (10.3 – 36.4)	0.6
Southern zone	17	31.5 (19.0 – 47.4) p=0.2	8	44.4 (10.0 – 85.3) p=0.2	0.3
Poorest	2	11.1 (2.5 – 37.9)	0	0	0.8
Very poor	5	14.7 (6.8 – 28.9)	4	23.5 (8.6 – 50.1)	0.4
Poor	10	27.8 (16.2 – 43.4)	1	11.1 (1.4 – 52.8)	0.6
Less poor	11	23.9 (13.2 – 39.4)	5	26.3 (10.3 – 52.7)	0.8
Least poor	21	36.2 (24.9 – 49.3) p=0.08	17	65.4 (37.6 – 85.5) p=0.003	0.02

Although the proportion of currently pregnant women using their voucher for an ITN varied from 20.4% in the central zone of the region to 52.9% in the northern zone, this difference in proportions was not significant. Amongst currently pregnant women, those from the relatively socio-economically advantaged households were more likely to use their voucher to purchase an ITN than those from the less advantaged households (p=0.003).

There were statistically significant differences in the proportion of currently pregnant women who used their voucher to purchase an ITN between the northern zones of the two regions and between the least poor households. In each case the proportions of women were higher in the Eastern than Volta Region.

5.3.6 Sleep under ITN purchased with a voucher

5.3.6.1 Recently and currently pregnant women

Approximately two thirds (64.4%) of recently pregnant women who purchased an ITN with a voucher in Volta Region and just over half in Eastern Region (54.8%) slept under the ITN the night before the survey (Table 5.8). Despite small numbers of pregnant women remaining in the evaluable sample at this point of the analysis, recently pregnant women in the southern zone of Volta Region (90.0%) were more likely to sleep under the net that they purchased with their voucher than those in the other zones of the region (p=0.0003). No other intra-regional differences were observed in either region for recently or currently pregnant women.

Table 5.8: use ITN by pregnant women in Volta and Eastern Regions

	Volta Region		*Eastern Region*		p
	n	% (95% CI)	n	% (95% CI)	
Recently pregnant					
Regional total	67	64.4	17	54.8	0.4
Northern zone	6	40.0 (15.8 – 70.4)	3	42.9 (16.0 – 74.7)	0.8
Central zone	25	51.0 (33.7 – 68.1)	8	66.7 (30.9 – 90.0)	0.4
Southern zone	36	90.0 (76.8 – 96.1) p=0.0003	6	50.0 (19.6 – 80.4) p=0.6	0.008
Poorest	7	77.8 (39.6 – 94.9)	2	66.7 (13.0 – 96.4)	0.7
Very poor	7	53.9 (22.4 – 82.5)	3	100.0	0.2
Poor	15	57.7 (35.7 – 77.0)	2	40.0 (7.0 – 85.5)	0.5
Less poor	14	77.8 (47.0 – 93.2)	3	60.0 (25.1 – 87.0)	0.4
Least poor	24	63.2 (49.3 – 75.1) p=0.6	6	42.9 (17.8 – 72.2) p=0.5	0.2
Currently pregnant					
Regional total	24	49.0	13	42.0	0.6
Northern zone	9	47.4 (26.0 – 69.7)	5	50.0 (20.3 – 79.7)	0.9
Central zone	6	46.2 (22.1 – 72.1)	5	45.5 (20.3 – 73.2)	1.0
Southern zone	9	52.9 (21.0 – 82.6) p=0.6	3	30.0 (3.3 – 84.5) p=0.3	0.5
Poorest	1	50.0 (0.1 – 99.9)	1	100.0	0.5
Very poor	3	60.0 (20.1 – 90.0)	2	50.0 (7.4 – 92.6)	0.8
Poor	5	50.0 (7.0 – 85.5)	0	0	0.2
Less poor	6	54.6 (26.0 – 80.4)	2	40.0 (7.9 – 83.8)	0.6
Least poor	9	42.9 (20.8 – 68.1) p=0.5	8	42.1 (12.7 – 78.4) p=0.9	1.0

Less than half of currently pregnant women in both regions used their voucher to purchase an ITN. There were no statistically significant intra- or inter-regional differences across geographic zones or socio-economic groups.

5.3.7 Delivery process effectiveness

5.3.7.1 Recently pregnant women

In order to benefit from the ITN voucher scheme, women needed to attend ANC. Attendance at ANC at least once was high for recently pregnant women in both regions, 94.7% in Volta Region (Table 5.9), and 93.7% in Eastern Region (Table 5.10). However, only 16.6% of respondents in Volta Region and 5.0% of respondents in Eastern Region said that they had used a voucher to buy a net. Examination of the intermediate steps in the delivery process shows that there were two processes where delivery of nets via the voucher subsidy, were ineffective. These delivery disorders arose in the process of offering a voucher to eligible ANC attendees (only 42.7% and 21.9% in Volta and Eastern Regions, respectively), and in the process of using a voucher in exchange for a mosquito net (44.6% and 29.8% in Volta and Eastern Regions, respectively).

In Volta Region the delivery process effectiveness across socio-economic groups as assessed by the concentration index shows that two intermediate processes were significantly more effective amongst women in higher socio-economic households than those in the lower. These two processes were attending ANC (concentration index 0.018; 95% CI 0.005, 0.031) and using a voucher in exchange for a net (concentration index 0.139; 95% CI 0.048, 0.230). In Eastern Region, there were no disparities in attendance at ANC across socio-economic groups. As in Volta Region using a voucher to purchase a net was more effective in recently pregnant women from households in the higher socio-economic groups (concentration index 0.146; 95% CI 0.056, 0.236) as was being offered a voucher in ANC (concentration index 0.061; 95% CI 0.002, 0.119). In Eastern Region, recently pregnant women from the poorer households were more likely to use a net that they had purchased with a voucher than those in relatively rich households (concentration index -0.140; 95% CI -0.235, -0.046).

Table 5.9: voucher scheme delivery process evaluation for recently pregnant women in Volta Region

Delivery Step	*n*	*Delivery step*			*Delivery cumulative effectiveness*
		Effectiveness %	**Concentration index**	**Concentration index 95% CI**	
1. Attend ANC	592	94.7	0.018	0.005, 0.031	94.7
2. Offer voucher	252	42.7	0.078	-0.002, 0.158	40.1
3. Accept voucher	233	92.8	-0.002	-0.009, 0.004	37.1
4. Use voucher	104	44.6	0.139	0.048 , 0.230	16.6
5. Use ITN	67	64.4	-0.001	-0.072, 0.071	10.7

Table 5.10: voucher scheme delivery process evaluation for recently pregnant women in Eastern Region

Delivery Step	*n*	*Delivery step*			*Delivery cumulative effectiveness*
		Effectiveness	**Concentration index**	**Concentration index 95% CI**	
1. Attend ANC	577	93.7	0.004	-0.010 – 0.017	93.7
2. Offer voucher	124	21.9	0.061	0.002 – 0.119	20.1
3. Accept voucher	106	86.2	0.008	-0.036 – 0.052	17.2
4. Use voucher	31	29.8	0.146	0.056 – 0.236	5.0
5. Use ITN	17	54.8	-0.140	-0.235 - -0.046	2.8

5.3.7.2 Currently pregnant women

In Volta Region 85.7% of currently pregnant women attended ANC at least once (Table 5.11) and in Eastern Region 79.8% (Table 5.12). Just 7.9% of currently pregnant respondents in Volta Region, and 4.4% in Eastern Region said that they had used a voucher to buy a net. As with recently pregnant women there were two intermediate processes which were particularly ineffective and these were being offered a voucher in ANC (38.5% and 20.0% in Volta and Eastern Regions, respectively) and using the voucher to purchase a net in the retail sector (25.5% and 32.1% in Volta and Eastern Regions, respectively).

Amongst currently pregnant women in Volta Region, all voucher scheme intermediate processes were significantly more effective in women from relatively rich households compared to poorer households, with the exception of using a net purchased with a voucher. Women in poorer households were significantly more likely to use a net they have purchased with a voucher than currently pregnant women from richer households (concentration index -0.0534; 95% CI -0.0976, -0.0092). In Eastern Region, three intermediate processes were more effective in currently pregnant women from richer households, which were attending ANC, being offered a voucher at ANC, and using a voucher to purchase a net.

Table 5.11: voucher scheme delivery process evaluation for currently pregnant women in Volta Region

Delivery Step	*n*	*Delivery step*			*Delivery cumulative effectiveness*
		Effectiveness	**Concentration index**	**Concentration index 95% CI**	
1. Attend ANC	534	85.7	0.0472	0.0296, 0.0648	85.7
2. Offer voucher	205	38.5	0.0748	0.0036, 0.146	32.9
3. Accept voucher	192	94.1	0.0243	0.008, 0.0401	30.8
4. Use voucher	49	25.5	0.1359	0.0129, 0.2589	7.9
5. Use ITN	24	49.0	-0.0534	-0.0976, -0.0092	3.9

Table 5.12: voucher scheme delivery process evaluation for currently pregnant women in Eastern Region

Delivery Step	*n*	*Delivery step*			*Delivery cumulative effectiveness*
		Effectiveness	**Concentration index**	**Concentration index 95% CI**	
1. Attend ANC	487	79.8	0.0302	0.0022, 0.0582	79.8
2. Offer voucher	96	20.0	0.1145	0.0285, 0.2005	15.7
3. Accept voucher	86	91.5	-0.0092	-0.0368, 0.0184	14.1
4. Use voucher	27	32.1	0.1972	0.0226, 0.3718	4.4
5. Use ITN	13	42.0	-0.1024	-0.3088, 0.104	2.1

Analyses were stratified by recently pregnant and currently pregnant women in the two regions in consideration of the fact that currently pregnant women had not yet completed their exposure to the voucher scheme processes. The cumulative delivery system effectiveness in Volta Region was 10.7% in recently pregnant women and just 3.9% in currently pregnant women. In Eastern Region however, there was little difference in the cumulative delivery system effectiveness of recently and currently pregnant women (2.8% and 2.1%, respectively).

5.4 Discussion

Five processes were defined in the delivery of an ITN to a pregnant woman via the voucher scheme. The first, fourth and fifth steps concern the behaviour of the pregnant woman in attending ANC, taking a voucher to a retail outlet to exchange it for an ITN together with a 'top-up' payment, and sleeping under the ITN when they have it. The second and third steps concern decisions made by the health worker, and the interaction between the health worker

and the pregnant woman. The fourth step involves a range of different types of stakeholders in the private sector in ensuring that there are ITNs in retail outlets close to ANC in the two Regions.

5.4.1 Geographic and socio-economic disparities in delivery

The first aim of the current analysis was to assess each of these steps in delivery for disparity in effectiveness across geographic zones of each region and across socio-economic groups of the households from which the pregnant women came. The presence of disparities across geographic zones within the regions, and across women from socio-economic groups varied between the individual delivery processes, between currently and recently pregnant women, and between the two regions. In Volta Region, recently pregnant women were more likely to attend ANC if they were from the least poor households; be offered a voucher if they were from the central zone or the least poor households; use their voucher to buy an ITN if they were from the central or southern zones or the least poor households; and sleep under their ITN that they purchased with a voucher subsidy if they were from the southern zone of the region. In Eastern Region there were no disparities across geographic zones or socio-economic groups in the effectiveness of the intermediate process of the voucher scheme for recently pregnant women.

Currently pregnant women from Volta Region were more likely to attend ANC if they were from less poor households. In Eastern Region, more currently pregnant women attended ANC from the least poor households; were offered a voucher if from the central zone of the region; and used their voucher to purchase an ITN from the least poor households. Process effectiveness findings for currently pregnant women will have been influenced by their gestational age that is, how far along in their pregnancy they were. However, the majority of currently pregnant women in both regions were in the second or third trimester and the distribution across trimesters did not differ by region. Also, the pattern of number of attendances during pregnancy was similar for those recently and currently pregnant across the two regions.

It is plausible that the disparities across geographic zones and socio-economic groups would differ between the five steps in the delivery process of the ITN voucher scheme. Attendance at ANC will be influenced by a myriad of cultural and demographic factors, but also by distance of the household from the health facility [198]. Socio-economic disparities in health seeking at health facilities, and receipt of other preventive interventions such as the EPI vaccines have been reported [30, 199]. Once having accessed ANC there will be a more direct influence of health system factors on the delivery process. There should be no reason that geographic zone or socio-economic group of the woman should affect the offer of a voucher by a health provider to an ANC attendee.

This was however, the case in Volta Region for both geographic zone and socio-economic group for recently pregnant women, and for geographic zone for currently pregnant women in Eastern Region. This suggests that the voucher scheme was not being fully implemented in all zones of the two regions, that the health workers were not offering vouchers to all women. Geographic disparities in offer may be due to poor supply of vouchers. Problems in supply of vouchers in Volta Region have been reported [200].

The socioeconomic disparity in offer of a voucher is perhaps more worrying as we would expect that once an eligible pregnant woman entered an ANC there would be no disparity in what she was offered. Monitoring activities identified rationing of vouchers by midwives early in the voucher scheme, with vouchers only offered to women who the midwives perceived could afford the top-up [200], and similar findings have been reported from Tanzania [201]. The finding that socio-economic group affected the offer of vouchers in recently but not currently pregnant women suggests that the measures taken to reiterate the guidelines that vouchers should be offered to all first attendees, were successful and the problem was resolved.

The majority of pregnant women who were offered a voucher, accepted it. However, it was interesting to find that not all women accepted the voucher. These women may have been

those who did not perceive that an ITN was valuable to them and the messages delivered by the ANC staff were not sufficient to convince them otherwise, and therefore would not be prepared to pay the monetary top-up required. Alternatively, they may have been women who already had sufficient ITNs within the household and did not perceive the need for another one.

In order for a woman with an ITN voucher to exchange the voucher for an ITN, she must have access to a voucher scheme accredited retail outlet, she must go to the outlet when they have ITNs in stock, and she must have the top-up payment required to purchase the ITN. Supply of ITNs to different geographic zones of the regions and the socio-economic status of the pregnant woman's household are therefore likely to influence exchange of a voucher for an ITN. Once owned by the household, use of an ITN by the pregnant woman was higher in the southern zone of the Volta Region. The southern zone of Volta Region had very high ownership and relatively high use of ITNs pre implementation of the voucher scheme (Chapter 4.3.1). This finding suggests that households with a habit of use of mosquito nets are more likely to use ITNs than those without the habit.

Differences in effectiveness of delivery between currently and recently pregnant women may also be due to the different timeframes to which they are relevant. For example, if there was a stock out of vouchers across the regions between two and three months prior to implementation of the survey, then this factor would impact of the proportion of currently pregnant women offered a voucher, but not on recently pregnant women.

5.4.2 Delivery process effectiveness

In order to achieve the coverage goals for pregnant women sleeping under an ITN via the ITN voucher scheme, it was essential that the majority of women moved effectively from one step of the delivery process to the next. Although there was room for improvement in the proportion of pregnant women attending ANC in both districts, attendance was quite high. There were two major non-effective steps within the delivery process, which were the offer of a voucher from the health provider to the pregnant woman, and the use of the voucher to

purchase an ITN by the pregnant woman. The use of the ITNs by pregnant women was not optimal, but the effectiveness was higher than the offer of a voucher and its use.

For recently pregnant women, the effectiveness of each individual step in the delivery process was lower in Eastern Region than in Volta Region. Offer of a voucher was the step where the biggest difference was seen between the regions, with only 21.9% of eligible women being offered a voucher in Eastern Region, compared with 42.7% in Volta Region. The resulting overall effectiveness of the delivery system was just 10.7% in Volta Region and 2.8% in Eastern Region. The ITN voucher scheme was clearly ineffective in both regions. In Tanzania by comparison, cumulative effectiveness of a voucher scheme was found to be 30.0%, [201] and this was despite additional losses due to the need to treat voucher scheme nets which were untreated at purchase and packaged with an insecticide treatment kit [201].

The aim of the delivery process evaluation was to assess how well the individual processes and overall system was working and to use the information to improve the system. The problems identified in this system related to steps involving actions by the pregnant woman, the health worker, and the private sector distributors and retailers. Perhaps the step that should be most in control of the public sector is to ensure that all women who attend ANC are offered a voucher. However the failure of the voucher scheme in achieving its objective appears to have started at this step. Probably this step of ANC staff offering vouchers to pregnant women could be addressed with robust training and supervision of the health workers involved. Results of this delivery process analysis are useful to highlight the failure of the delivery system and to initiate discussions of steps to be taken in order to fix the problems identified. Nevertheless, using the example from the voucher scheme in the two regions with recently pregnant women, if 100% of ANC attendees were offered a voucher in both regions, then the overall delivery system effectiveness would still only reach 25.1% and 13.1% in Volta and Eastern Regions, respectively because the effectiveness of the next critical step of exchanging the voucher for an ITN is low in the two regions. Addressing problems at this step is complex because it involves behaviour change of several stakeholders and a multifaceted supply chain system. This shows that where a delivery system is comprised of

several intermediate processes that are of moderate effectiveness, the overall effectiveness of the system as a whole will be very low because the reduction in effectiveness is cumulative.

Using the concentration index to assess the effectiveness of delivery across socio-economic groups suggests that delivery was more effective amongst the less poor households in both regions for all steps in the delivery process with the exception of the use of ITNs. The use of voucher scheme ITNs was biased towards women from the poorer households in both regions, and this bias was statistically significant in Eastern Region. This suggests that whilst pregnant women from the least poor households are more likely to benefit from the voucher scheme in terms of the delivery system, those from the poorest households are more likely to use the net if they manage to get one. Voucher scheme nets were not free and therefore women who have exchanged their voucher for a net have made a financial commitment together with a commitment in terms of the time they have taken to travel from the clinic to a voucher scheme outlet. Possible reasons they may not use the net are that they have given it for use by someone else in the household, they already have a net and are saving the net until the old one needs replacing, or they are saving the net until the baby is born [202]. Possible reasons why those in the poorest households would use a net if they have purchased one are that the financial commitment of providing the top-up money to the voucher in order to purchase the net presents a more substantial commitment to the poorer households and therefore this commitment is only made if they intend to use the net. Pregnant women in poorer households may be more at risk of nuisance biting by non-anopheline mosquitoes due to less protected housing where air conditioners and fans are not available. The missed opportunity of providing a voucher and subsequently a net, to pregnant women in the poorer households is a major downfall of the voucher scheme.

5.4.3 Limitations

In this study the wider determinants of the effectiveness of delivery at each stage of the process were not assessed. This means that we cannot rule out the presence and impact of confounding factors on the relationship between geographic zone and socio-economic status

and delivery of ITNs through the voucher scheme. For example, if there were differences in gestational age of pregnant women in attending ANC across geographic zones or socio-economic quintiles this would influence the relationship between geographic zone, socio-economic status and the intermediate outcomes assessed.

Standard methods of sample size calculation were used for the household surveys, where the aim was to achieve a 6% precision in the outcome estimate of use of an ITN with a power of 80% [174]. However, when evaluating the effectiveness of successive steps in the delivery process, the evaluable sample decreased at each step such that the sample size for analysis in the final step was very small thereby reducing power to detect significant differences in the subgroup analyses.

There are limitations to assessing delivery process effectiveness in currently pregnant women as they have not yet had their full potential exposure to the voucher scheme. In Eastern region the cumulative effectiveness of the voucher scheme when compared between recently and currently pregnant women was quite similar. However the voucher scheme was overall less effective when assessed in currently pregnant women as compared to recently pregnant women. This may be due to the fact that currently pregnant women have not had their full exposure time and could still attend ANC, be offered and accept a voucher, and exchange it for a net in the private sector. Alternatively, there could be other factors associated with changes in the nature and effectiveness of the voucher scheme itself, over time, as currently pregnant women as a cohort were exposed to the voucher scheme at a later date than recently pregnant women.

5.5 Conclusion

Assessment of the delivery processes provided additional evidence that it was not plausible that the increase in ITN coverage in Eastern Region was due to the voucher scheme because only 2.8% of recently pregnant respondents in sampled households reached the endpoint of the delivery system by using a voucher to purchase a mosquito net. This delivery process evaluation also identified the points at which there were 'disorders' in the delivery system

impeding its effective operation. The ITN voucher scheme was an ineffective delivery system for ITNs in both Volta and Eastern Regions. With the exception of attendance at ANC in Volta Region, and acceptance of a voucher in both regions, all steps in the delivery process were below 90% effective. All intermediate processes were significantly less effective in Eastern Region than in Volta Region. The offering of a voucher by health workers to pregnant women and the use of the voucher to purchase an ITN by pregnant women were the most ineffective steps in delivery, followed by use of the ITN by the pregnant woman. Increasing the effectiveness of the voucher scheme would require multi-pronged approaches that increase the effectiveness of at least 3 of the critical delivery processes. In order to determine the nature of possible interventions more research is needed to identify the reasons for the ineffectiveness of each of the steps in the delivery process.

Chapter 6: Qualitative process and delivery system context evaluation

6.1 Introduction

The ITN voucher scheme outcome evaluation found that in Volta Region, there was a relatively small increase in the proportion of households with a recently or currently pregnant woman that owned at least one mosquito net pre- and post-implementation of the scheme, and that this increase was due to the voucher scheme. In Eastern Region increases in household ownership of mosquito nets were higher than in Volta Region, but were not due to the voucher scheme. The ITN voucher scheme was therefore not sufficiently effective in achieving increases in household ownership of mosquito nets in Volta Region and was ineffective in Eastern Region. The increase in household ownership of mosquito nets during the time of implementation of the voucher scheme in Eastern Region was due to the direct delivery of mosquito nets through the public sector that is, through ANC. This increased delivery of mosquito nets through the public sector was unexpected as prior to the implementation of the voucher scheme, the RHDs and NMCP had agreed that no ITNs would be distributed to health facilities in the regions during implementation of the voucher scheme.

In the last chapter the effectiveness of individual processes in the voucher scheme was assessed to identify critical processes in the delivery of the voucher and the ITN where implementation was sub-optimal. There was loss of effectiveness at all stages of the delivery processes with the offer of a voucher to a pregnant woman by a health worker at ANC, and the use of a voucher in exchange for an ITN by the pregnant woman in the retail sector being the two least effective processes.

Given the above findings and conclusions, qualitative studies were required for two main reasons. The first of these was to illuminate the context in which the ITN voucher scheme was being implemented. Of particular relevance are the context with respect to other mosquito net delivery systems and changes in these systems that occurred during the period of

implementation of the voucher scheme. The second reason was to provide explanations for the sub-optimal effectiveness of the voucher scheme processes. Whereas quantitative methods can provide information on large scale distribution of programme and delivery system outcomes, qualitative methods are much more useful in enabling rich descriptions of complex phenomena such as the voucher scheme processes, the context and its influence on the voucher scheme and other delivery systems [186, 203-206]. Events may also be tracked and interpreted by a range of stakeholders. In order to deliver ITNs effectively the voucher scheme needed to be successfully implemented by the public and private sectors both at the institutional level and by individuals within these sectors.

The qualitative studies were undertaken from the perspective of the providers involved and did not include the perspectives of pregnant women. This was due firstly to resource constraints. The decision was taken that the provider perspective would be investigated first. The pregnant woman perspective would be investigated if 1) further resources could be identified and 2) the provider perspective had left many unanswered explanations of why delivery processes had been ineffective. In order to deliver ITNs effectively the voucher scheme needed to be successfully implemented by the public and private sectors both at the institutional level and by individuals within these sectors.

This study was undertaken from the point of introduction of the voucher scheme into the public and private sectors, involving the adoption of the scheme as a whole and assimilation of the intermediate processes with the aim of facilitating the 'routinisation' of the scheme. The presence of alternative delivery systems for ITNs is likely to have posed an extra challenge to adoption and assimilation of the voucher scheme.

In this chapter the context of delivery systems for mosquito nets over the period in which the outcome evaluation of the voucher scheme was conducted in Volta and Eastern Regions is described. The reasons for the changing delivery systems context and the low effectiveness of the voucher scheme delivery processes within the changing delivery systems context are explored from the perspective of stakeholders.

6.2 Methods

Methods for sample selection, interviews and transcription were presented in Chapter 3.7.9. The transcriptions were read and reread manually in order to gain an overall feel for the data before beginning data reduction through coding [187]. Transcripts were then entered into N-Vivo version 8 for management and coding.

Data coding and analysis was undertaken in two stages. This two stage process was adopted in order to fully understand the voucher scheme, alternative delivery systems and the way in which the voucher scheme changed over the period of its implementation.

6.2.1 Data coding and analysis: stage 1

The first stage of coding and analysis used open coding and progressive categorisation of themes addressing descriptions of the delivery systems context and changes that had occurred to this during the period of implementation of the voucher scheme. The delivery systems context before and during the voucher scheme was described at this stage, and events triggering changes in this context were mapped against timing of evaluation activities.

6.2.2 Data coding and analysis: stage 2

The second stage of the analysis aimed to address factors influencing loss of effectiveness of the voucher scheme delivery processes. I felt that a theoretical basis for understanding the interaction between the changing delivery systems context and the voucher scheme delivery process effectiveness would strengthen this stage of the analysis. Three frameworks within the field of adoption and integration of innovations into health systems were reviewed to provide a theoretical base for the analysis. These three frameworks were the characteristics of the innovation that are determinants of successful adoption and diffusion [62], an extension of this original diffusion of innovations framework to those of complex processes in service organisations [63], and a framework for the integration of targeted interventions into health systems [64] (Chapter 1.2).

According to Rogers' framework [62] there are several attributes of an intervention that influence its adoption and the rate of its adoption including: relative advantage, compatibility, trialability, observability and complexity. The relative advantage of an innovation is the degree to which it is perceived as better than that which it precedes. To be successful the voucher scheme needed to be accepted by both the public and private sectors and therefore to be perceived as having a relative advantage over the direct delivery of ITNs in the public sector by stakeholders within the public sector, and over the continued unsubsidised sales in the formal commercial sector by commercial sector stakeholders. Compatibility asks whether the voucher scheme and other existing delivery systems fit with the existing values, past experiences and needs of the adopters. Experimentation with the voucher scheme by its adopters is a mark of its triability. Observability refers to the extent to which the achievements of the voucher scheme were seen. And complexity is the degree to which the voucher scheme was considered as complex and difficult to use by its adopters. The perceptions of stakeholders on the voucher scheme and other delivery systems for mosquito nets are assessed within this framework of innovation attributes.

Whereas Roger's framework has a major focus on the nature of the innovation itself, this framework was expanded by Greenhalgh *et al* [63] to consider the diffusion of innovations within service organisations. This included consideration of the adopters, the assimilation process and diffusion and dissemination, where pure diffusion is the unaided spread of an innovation and dissemination involves the employment of techniques such as mass media to help the spread of use of an innovation. Atun *et al* [64] take a similar stand also incorporating Roger's nature of the innovation, in their framework for integration of targeted interventions into health systems. In addition, they take account of the adoption system as distinguished from the health system characteristics, and on the nature of the problem that the innovation is addressing.

There were two major elements of the context of this study requiring a focus which was not specifically provided by any of these frameworks. The first was the context of multiple delivery systems (multiple innovations) and therefore the possibility of competition between

innovations; and the second was that the primary innovation under study was dependent upon effective implementation across two sectors, the public and private sectors. Given the diversifications of the voucher scheme and other delivery systems for ITNs during the period of implementation of the study, it was necessary that the reasons for loss of effectiveness of the voucher scheme processes were assessed within the context of the shifting nature of these systems as a whole.

As Roger's elements of the nature of the innovation were common to all three frameworks, and given the importance of context in this study, I focussed primarily on Roger's framework as a theoretical base for my analysis with the aim of developing a broader framework for application in the context of multiple delivery systems and multiple delivery sectors. First I conducted open coding of the data in which themes were developed inductively, and then a second round of analysis was used to fit the themes within the theoretical framework.

Perceptions of public and private sector providers of ITNs towards the voucher scheme within the context of the other delivery systems for ITNs, and the diversifications noted above were analysed. Pregnant women were not included in the study for reasons of resource limitations (Chapter 6.1). As there were substantial changes in the delivery system context during implementation of the voucher scheme, as presented above, perceptions of providers relating to the initial design of the voucher scheme and alternative delivery systems and to the systems after diversification are reported. Public sector perceptions of private sector systems and actions and private sector perception of public sector systems and actions were included. Where appropriate, responses of stakeholders were related to the processes identified in the delivery of ITNs through the voucher scheme, particularly those where the major loss of effectiveness was identified.

In order to preserve anonymity in the use of quotes, the stakeholders were given a number and their sector identified (public or private). Their specific role is not distinguished as this would lead to the possibility of identifying a specific person. Objectivity was increased

through a commitment to reflexivity in accounting for the possible effects of the author's role [188] in the voucher scheme and with partners.

I had a technical role in the voucher scheme in Volta and Eastern Regions as the person contracted, on a consultancy basis, by the funder DfID to direct the monitoring and evaluation in the two regions. Pre-design and development of the voucher scheme I had also performed an assessment of support needed to the ITN Partnership in Ghana for this same funder, where my colleague and I, in discussion with the DfID health advisor had suggested that a voucher scheme may be a useful approach to delivery of ITNs in the country. I was known therefore amongst the national and regional level stakeholders (both public and private sector) as being associated with the voucher scheme and with the funder. This may have affected their responses to my questions in the interviews. At the facility and retail level, responses to my questions may have been influenced by people's perceptions of me as an outsider, a white European researcher.

From my own perspective, I tried throughout the evaluation period to keep an open mind about the voucher scheme and the various stakeholder's involvement and actions. During this period whilst never being involved in implementation, I was however, privy to multiple anecdotal observations and discussions with many of the stakeholders. It is possible that some of these observations and discussions may have influenced my analysis of the interview data.

6.3 Results

6.3.1 Stage 1: the delivery systems context

6.3.1.1 The diversification of ITN delivery systems in Volta and Eastern Regions

There were four delivery systems for mosquito nets in Volta and Eastern Regions pre introduction of the voucher scheme. These were within the public sector, the formal private sector, the informal private sector and the community. During the period of implementation of the pilot ITN voucher scheme in the two regions there were changes or diversifications in the voucher scheme and in the public sector and formal commercial sector delivery models

involving divergence of systems, and convergence of one system with another. Here, the term divergence is used to describe a situation in which a delivery system develops off-shoots where the delivery channel itself may diversify, or the strategies within it may also diversify. Convergence describes the situation where there are two or more systems, channels or strategies which come together at one or more points. A delivery system therefore may diverge from its prescribed or previous structure and converge with other systems, or may diverge without converging with other systems.

A schematic representation of the alternative delivery systems for ITNs in the two regions during implementation of the voucher scheme is presented in Figure 6.1. Community based delivery and informal sector delivery is presented for completeness. However, as can be seen in the figure, there were no linkages between these sectors and the public and formal commercial sectors through which the voucher scheme was implemented. Therefore the remainder of the chapter and analysis focuses on the public and formal commercial sectors.

In addition to delivery systems within the two regions where the voucher scheme took place, it is important to bear in mind that systems in other regions may also have an impact in terms of both the providers and users, or supply and demand. For example, there has been much anecdotal evidence of cross district, region and national border demand for ITNs delivered through campaigns. Such demand may have played a role here, as the first national scale integrated ITN campaign was undertaken in Togo during December 2004 and Volta Region shares a border with Togo.

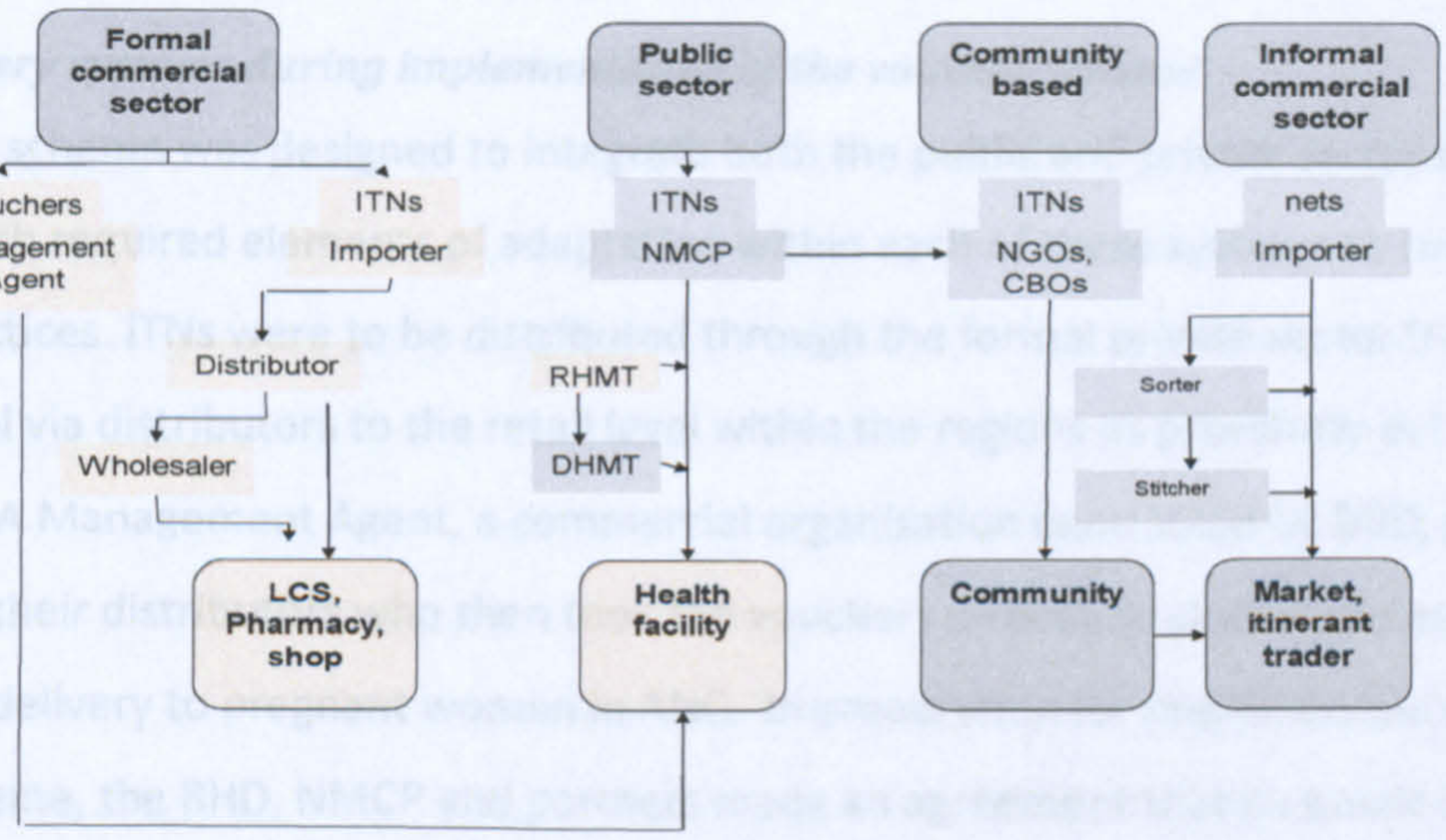

Figure 6.1: mosquito net delivery systems pre-ITN voucher scheme in Volta and Eastern Regions

6.3.1.2 Delivery systems pre-voucher scheme

Pre-voucher scheme, public sector mosquito nets, ITNs and insecticide were imported mainly through partners of the NMCP such as the WHO and UNICEF. These nets were kept in the Central Medical Stores in a location close to the capital with regions and districts to which they were assigned being responsible for collecting them from the centrally located stores. The nets were then transported from the region to the district or directly from the district to health facilities where they were sold for USD2.2 to pregnant women and children under 5 years of age.

ITNs for sale within the formal commercial sector, prior to the voucher scheme, were imported by a small number of commercial organisations including international ITN manufacturers, international insecticide companies and local agricultural product distributors. For all of these companies, but particularly for the smaller ones, the complexity and cost of importation was prohibitive. Prior to the voucher scheme there were just two main distributors of ITNs, one of whom was also an importer. These companies distributed

mosquito nets and ITNs either directly to commercial outlets such as LCS, pharmacies and shops, or via wholesalers to the same range of outlets.

6.3.1.3 Delivery systems during implementation of the voucher scheme

The voucher scheme was designed to integrate both the public and private sector delivery systems which required elements of adaptation within each of these systems to current working practices. ITNs were to be distributed through the formal private sector from the national level via distributors to the retail level within the regions as previously but on a larger scale. A Management Agent, a commercial organisation contracted by DfID, gave the vouchers to their distributors who then took the vouchers directly to staff of the health facilities for delivery to pregnant women in ANC. In preparation for implementation of the voucher scheme, the RHD, NMCP and partners made an agreement that no public sector nets would be sent to districts in Volta and Eastern Regions during the period of the voucher scheme pilot. However, it was acknowledged that some health facilities within the regions might have stock of ITNs remaining from previous distributions.

Based upon the interviews with stakeholders in both regions and at the national level, diversification of the public sector delivery systems and divergence of the voucher scheme from its original design occurred at four points (Figure 6.2). The first diversification was precipitated by the receipt of funding for ITNs from the Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) by the NMCP, who sought assistance from an international ITN manufacturer to import the ITNs. This international ITN manufacturer established a warehouse in Accra (the capital city), to supply their market in both Ghana and other countries of West Africa, and to reduce lead times on supply of nets into these countries. This was a diversification of the public sector delivery of ITNs involving a convergence with the formal commercial sector at the level of importation. The establishment of the warehouse in Accra was positively viewed by the ITN distributors

".....because they have a warehouse in Accra that serves the whole of West Africa, things are quite easy with us, they import into their warehouse and we 'pay and pick'"

(Private sector 2)

A similar and linked diversification of the public sector delivery of ITNs was again facilitated by increased funding and the recognition by the NMCP of the difficulties faced by the regions and districts in transporting mosquito nets from the central medical stores (CMS). A distributor was contracted to deliver mosquito nets from the CMS to the regions. The distributor who won the contract was also a distributor of ITNs for the international ITN manufacturer through the formal commercial sector, including within the voucher scheme. This diversification of the public sector, again involved convergence with the formal commercial sector and with the voucher scheme at the level of distribution.

During the voucher scheme distributors established a new delivery point for ITNs, which was a structure under the management of the distributors. This took the form of one salesperson sitting under a branded 'umbrella' redeeming vouchers but also sold nets commercially, immediately outside health facilities. Vouchers plus the top-up charge were also exchanged for ITNs at these sales points. This third example of diversification of ITN delivery systems remained within the formal commercial sector alone and involved diversification of sales points.

The fourth point of diversification of systems involved a divergence of formal commercial sector delivery points to include health facilities and a convergence of the formal commercial sector delivery system with that of the public sector. Distributors took ITNs to midwives for them to sell, including redemption of vouchers, and possibly at full commercial price. These distributors were amongst those who were distributing ITNs to the formal commercial sector for the voucher scheme.

The first and second diversifications were only to a small degree linked to the introduction of the voucher scheme, whereas the third and fourth were direct products of the momentum

built around and contextual interplay of processes of the voucher scheme in Volta, Eastern and Greater Accra regions (see below). During implementation of the voucher scheme, and despite the initial agreement between the RHDs, NMCP and partners that no public sector nets would be distributed to health facilities, public sector nets continued to be distributed to the health facilities in both regions. According to the stakeholder interviews, the precipitating factor for this reneging on policy commitments was the implementation of a short term voucher scheme organised by Exxon Mobil (a large American oil company) in the commercial capital of the country, Greater Accra, just two months after the start of implementation of the Volta Region voucher scheme. Higher than anticipated uptake of the voucher scheme in Greater Accra and subsequently in Ashanti Region (the second largest commercial centre) resulted in an insufficient quantity of ITNs in the country, and little possibility of immediate importation. The distributors involved in the voucher scheme and in the formal private sector had limited resources and therefore limited capacity to buy ITNs in bulk. With the long lead times on bringing nets into the country, the market was not able to respond sufficiently to the increased demand. This resulted in withdrawal of ITNs from the Volta Region retail outlets where sales were slow, to meet the increased demand in the two largest commercial centres in the country.

"When the first Volta was running and then there was Mobil Exxon in Accra for a short period. .....And Accra is a big place everyone can afford it. And the man here's boom so he sends all his nets in the warehouse to Accra and they start running out fast they say no let me go to the Volta region. So he sends his salesman back with an empty van and picks up all the nets in all the various places".

(Private sector 4)

" so when the Exxon Mobil started all the nets that they promised that were for the voucher scheme got vanished. They move them all to Accra because they were able to sell them all in one month...."

(Public sector 9)

The withdrawal of ITNs from retail sector outlets in Volta Region precipitated complaints from the health facilities involved in the voucher scheme that there were no ITNs available in the retail sector therefore the voucher scheme could not function. Due to pressure from facilities on DHMTs, and DHMTs on the RHD, the RHDasked for the assistance of the NMCP in the form of public sector nets to send to the health facilities. The result was the supply of ITNs to health facilities that were part of the voucher scheme and a loss of trust by the public sector in the private sector's commitment to the voucher scheme.

"you move them to Accra, you sold them, they were not there for the voucher so the district directors do not sit down [do nothing] *that we are waiting for the voucher."*

(Public sector 9)

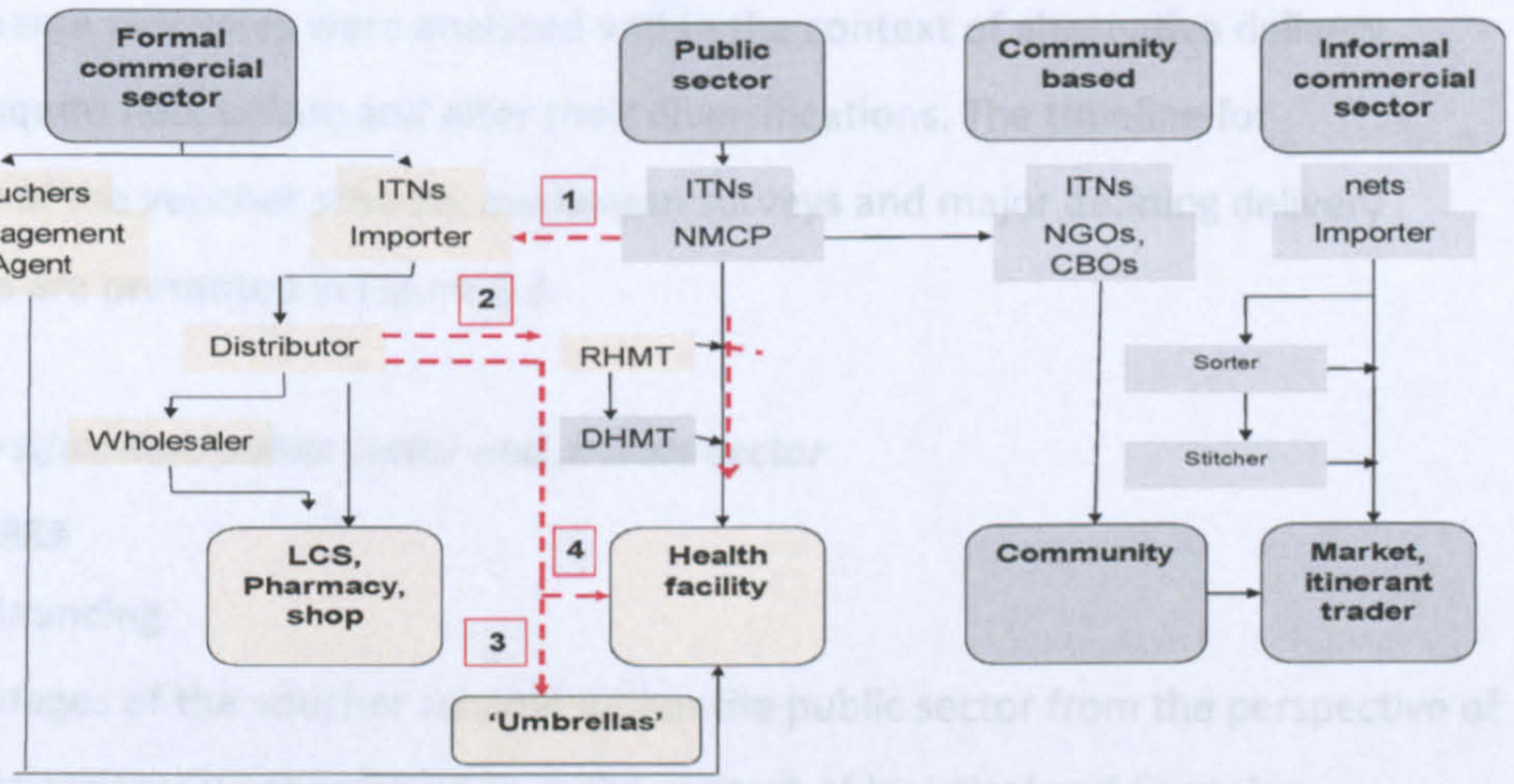

Figure 6.2: diversification of mosquito net delivery systems during implementation of the ITN voucher scheme in Volta and Eastern Regions

Immediately striking from examining the figure (Figure 6.2) of diversified delivery systems is the relatively small role played by the public sector in comparison to the private sector, and particularly that of the distributors. The role played by the RHD and DHMTs in the voucher scheme was minimal and this was particularly true for the DHMT. All four diversifications increased the role of the private sector distributors in both public and voucher scheme

delivery of ITNs. In the public sector, distributors transported mosquito nets from the national to the regional level and began to take retail sector mosquito nets into the public sector health facilities. In the private sector the role of delivery of mosquito nets to LCS, pharmacies and other retail outlets remained with the distributors, however, the establishment by the distributors of 'umbrellas' directly outside health facilities may have changed the market for the retailers. The only part of the system that the ITN distributors did not have a part in was that of the delivery of vouchers to the health facilities.

More detailed descriptions of these diversifications in the mix of delivery systems are presented in the next section, and their impact on the implementation of the voucher scheme is explored from the perceptions of public and private sector stakeholders.

6.3.2 Stage 2: perceptions of public and private providers

The voucher scheme processes were analysed within the context of alternative delivery systems for mosquito nets before and after their diversifications. The timeline for implementation of the voucher scheme, evaluation surveys and major defining delivery systems changes are presented in Figure 6.3.

6.3.2.1 Pre-diversification: public sector and private sector

Relative advantage

Transport and financing

Perceived advantages of the voucher scheme within the public sector from the perspective of public sector respondents were referred to in the context of logistical and financing disadvantages of the direct delivery of ITNs through health facilities. Transport of mosquito nets from the central level to the regions, districts and on to the health facilities was seen as a disadvantage of the delivery of mosquito nets through the public sector and an advantage of the voucher scheme. Direct delivery depended upon the districts having transport to pick-up the nets from the CMS.

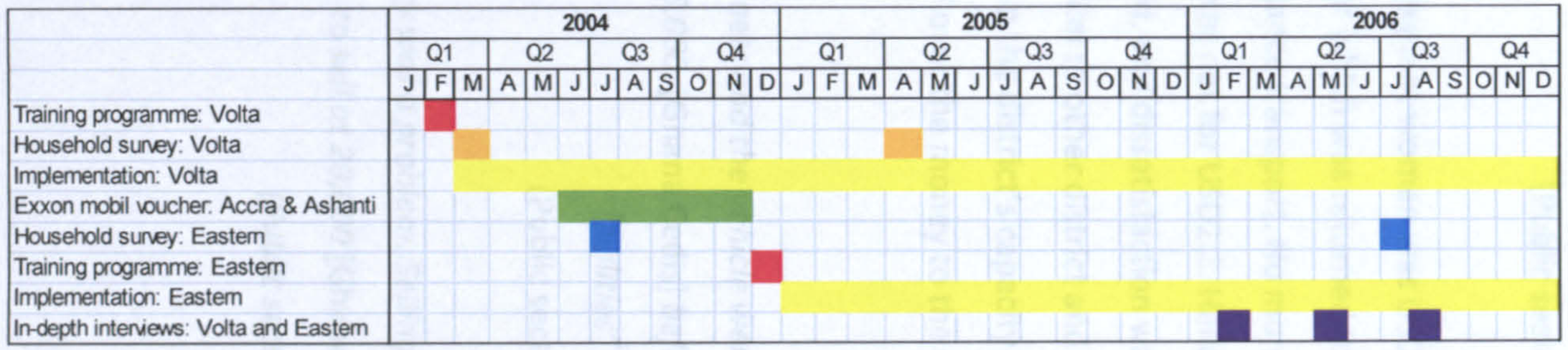

Figure 6.3: voucher scheme implementation and evaluation time

".....and they have to go to the central medical stores to go and collect the nets and sometimes delays – they may not have the transport – and the nets will just be piled up there sitting for a long time. But at least with the voucher – you get the coupon, the pregnant woman must know where to go – so managerially its smoother."

(Public sector 10)

"the first consignment that we had the one we receive from the medical store it was too much so we had to go two times the vehicle was too small"

(Public sector 23)

The cost of the net to the pregnant woman was USD2.2 which at that time translated to 20,000 Cedis, 15,000 Cedis of which was returned to the NMCP, and 5,000 Ghana Cedis retained at the district to finance transport. No money was retained at the health facility from the sale of a public sector net for USD2.2. Handling of money was therefore required at all levels in the health system, and dissatisfaction was expressed at all levels. The ITN financing system ran in parallel to other district and national level financing systems. Its management depended upon the district's capacity to retrieve the money from the facilities, and for the facilities to hand over the money to the district. The same applied for the district and national levels.

"If they give you 1,700 nets and the vehicle went two times, already going to convey the nets alone has taken the 5,000 [Ghana Cedis] *before now you have to move to the health facilities"*

(Public sector 9).

"...retrieving the money was a problem. Selling at a fixed price was also a problem. You give the net to them to sell at 20,000 [Ghana Cedis]*, they sell it at 35,000....."*

(Public sector 9)

At the facility level, a major advantage of the voucher scheme was felt to be that there was no need for midwives to handle money for ITNs:

"We prefer not to be involved in physical money .....So for us to get away from handling physical money..... The voucher can still be...."

(Public sector 6)

Within the voucher scheme the public sector had no responsibility for either distribution of mosquito nets to the health facilities, or their delivery to the target group within the facilities.

The aim of the voucher scheme was to prime the private sector in order to increase coverage of pregnant women with ITNs. The Ghana Health Service has a strong history of including the private sector within the health system. The role of distribution of ITNs by the private sector was generally supported by stakeholders in the public sector:

"Let us leave the distribution of nets to the private sector. We always advocated in the health sector health is not only the duty of the ministry of health so why not raise the opportunity to provide an inroad for other players"

(Public sector 2)

Although the private sector role in distribution and delivery of mosquito nets was well developed in some areas of the country through the informal retail sector, the market for ITNs was not well developed. This ITN market was only in evidence in the major commercial centres. It was hoped that the voucher scheme would be the catalyst to raise more interest from the private sector to help to build the commercial market. The voucher scheme and the relative security this offered, through assured demand, was the reason for the two new distributors to enter the market.

Use of the ITN

Although with the voucher scheme the midwives were able to discuss the utility of the voucher in providing a discount on an ITN, they did not feel that they were adequately connected to the ITN sale to be able to convince women. They also felt that shopkeepers were more interested in the sale than what the woman did with the ITN after the sale:

".....we convince better than the people in the shops, because shops just give it out without explanation."

(Public sector 5)

Compatibility

Health system: focussed ANC

The Reproductive Health Programme in Ghana has adopted the policy of focussed ANC (fANC) which is a goal oriented form of antenatal care with a reduced number of visits [207]. WHO recommends that pregnant women should receive care from a trained healthcare practitioner at least four times during the course of their pregnancies as part of fANC. This recommendation was based upon evidence showing that health outcomes with this new approach were comparable with the standard approach including several ANC visits [207-208], but is currently under review due to recent evidence of increased perinatal mortality with goal oriented and reduced visit models of ANC [209-210]. FANC aims to ensure that pregnant women pass through minimal stages in the ANC process whilst receiving all of the required care, the aim is 'one-to-one' care. FANC services are free of charge. Delivering a net directly is seen as more compatible with the one to one idea of focussed antenatal care than is giving a voucher which then needs to be exchanged at a retail outlet:

"If you have one midwife dealing with focus antenatal then in that instance having nets with them and giving it out would be better than leaving it at the chemical shop because immediately they come to the ante natal they would be seen on a one to one basis, do you have money for your net yes immediately they take it and go."

(Public sector 8)

Health system: payment in ANC

Neither the public sector sale of mosquito nets nor the voucher scheme, with the financing systems as designed, are compatible with the financing of fANC. According to national policy fANC is free of cost to the pregnant woman. It could be argued that under the voucher scheme design this was more compatible with fANC as no money needed to change hands in ANC, as the payment for the ITN was conducted with the exchange of the voucher in the private sector.

"antenatal clinics are free we don't collect money so when they are coming for their health they know it is free so most of them don;t bring money"

(Public sector 13)

"the antenatal is free. Everything else is free. Maybe they want it [ITN] free..."

(Public sector 4)

"It may deter some women from even coming to antenatal because when you come the first day have you got money, no, the second time have you got money, no, the third time oh I don't have money."

(Public sector 8)

Health system: health education

On a similar note there was a fine balance between health education that is routinely delivered in ANC and private sector brand promotion. From the public sector perspective the private sector were seen to over step their role when invited into the health facilities to promote the uptake and use of ITNs. Competition between private sector partners then entered the health facilities; such competitive marketing was frowned upon by the public sector and was felt to be incompatible with their mission.

"Some of the commercial partners came and took over the health talk and start promoting ITNs.....just coming to say Brand X is the best" "When they saw that we have ITNs

from other distributors [hanging in the clinic] *they were all very aggressive with the ante natal and the clinics and before we realised they had given nets* [to sell] *to the midwives".*

(Public sector 9).

Voucher scheme ITN delivery point

Doubts were expressed on the compatibility of the chosen voucher exchange point that is the LCS with the behaviour of pregnant women once they have been to ANC. Once a woman has been to ANC she does not necessarily need to visit a chemical seller, she only goes to the chemical seller when she is ill. Whereas if the ITNs could be held in places she is likely to visit anyway (such as the market) then she is more likely to use the voucher in exchange for an ITN.

"for the chemical shops its only when you are sick when you go there but the reason why they started with the chemical shops is that you can't just go and give nets to market women who you don;t know".

(Public sector 8)

The voucher scheme is compatible with the commercial market as it targets pregnant women who are one of the vulnerable groups. The vision was that where retail outlets stocked ITNs for the voucher scheme, they would also stock ITNs for sale to the non-target population of the voucher scheme. In this way the commercial market would grow and expand.

Trialability

The voucher scheme began as a 1 year pilot in Volta Region. However, before implementation began in Volta Region, discussions were already progressing on introducing Eastern Region into the pilot. The motivation for this was that partners were eager to see whether the voucher scheme could work in more than one region, and the funds were available. The public sector management were not sufficiently in control of the scheme to have any room for trial in any element of the voucher scheme. The public sector at the point of delivery of the voucher did make local adaptations to the design of the scheme. These

adaptations included reserving the voucher for those who could show that they had money for the top-up because they were afraid of wasting the voucher. They also pinned the voucher to the ANC card so that they would know on the woman's subsequent visit whether the voucher had been used. Each of these adaptations related to elements of the voucher scheme where the midwives felt that they had little control over the system.

During implementation of the voucher scheme a stock advance model was trialled in order to try to push private sector nets further into rural areas. The voucher scheme design required the private sector partners to stock ITNs, exchange the ITNs for the voucher plus top-up, and then replace the ITNs with more stock in exchange for the voucher. In recognition that the partners did not have the financial capacity to lay out money for this stock, NetMark provided stock advances. The hope was that because as the partners would have more stock they would be more adventurous and reach to wider geographic areas. A requirement of the stock advance was that the partners would self finance matching stock themselves, to that they took in advance. The idea was that having lots of stock would enable them to 'sacrifice' and take stock to areas where it will stay in the system for longer. This was in response to the observation that when they don't have adequate resources they go where turnover is fastest.

> *"It's only when they have adequate stock that they can sacrifice and go and spread their stock around. When they don't have adequate stock they go to the fastest* [selling outlets], *because if you have adequate stock and you keep them in your warehouse it is of no advantage....."*
>
> (Private sector 1)

After the cost sharing by NetMark, each of the 4 distributor partners was advanced USD100,000 to stock ITNs, then when the vouchers were returned this was ticked off against the USD100,000 stock that was advanced to them. The money for the stock advance actually went to the supplier that is, the importer. The reason for this was so that the distributor could not use the money for any other purpose.

Observability

A problem cited by many health providers was that when you give a net, you know that the woman has received it, even if you don't know that she will use it. If you give a voucher then you don't' know that she will ever exchange the voucher for the ITN. In reaction to this lack of observability as to whether the voucher was in fact used by the recipients, midwives reported pinning the voucher to the ANC card. If it was there on the next visit they could again advise the woman to exchange it for an ITN.

"When you give it to them they will put it in their ante natal card and it will be there next time they come. We ask them why they are putting it there and they say they don't have the money to buy but they will buy it. Some people they will deliver before they buy it..... But when they deliver they may want to decorate the room....."

(Public sector 4)

".....if they are buying it we collect the coupon over there. If you didn't buy the net the coupon will still be there and we always put the voucher number on the antenatal card so that when you buy it they will say you have bought it if not we will know.....

(Public sector 5)

Complexity

Delivery point: voucher offer

Primary reasons for lack of access to ITNs through the voucher scheme related to the action of midwives not offering a voucher. In the absence of ITNs for direct sale in the health facilities, there were several reasons why midwives did not offer a voucher to eligible pregnant women. Initially in Volta Region, in particular, the numbers of vouchers distributed to some facilities was insufficient and therefore vouchers were perceived by the midwives to be scarce. This perceived scarcity was one of the major drivers of vouchers not being 'wasted' by being offered to pregnant women who could not show that they were 'ready with money' to pay the top-up price to buy an ITN, or were perceived by the midwives as being unable to afford the ITNs. This is in-line with quantitative data which shows that there were socio-

economic disparities in the proportion of eligible pregnant women who were offered a voucher: 28.5% of pregnant women from the poorest households and 49.2% from the least poor households were offered a voucher in Volta Region whilst in Eastern Region 16.8% and 28.0% of pregnant women from the poorest and least poor households, respectively, were offered a voucher (Chapter 5.3.3).

One of the reasons that respondents gave for not offering a voucher was when they did not know where to send pregnant women to exchange their voucher for an ITN, or when they perceived that there were no ITNs in stock in the outlets that they knew about, they withheld the offer of a voucher:

".....now we have the vouchers but the nets are not with the commercial service so we can't just issue the voucher to the pregnant women because when they go there they cannot get the nets to buy"

(Public sector 23)

This was not in line with their training in which they were told to offer vouchers to all eligible pregnant women upon attendance at ANC.

"..... we told them over and over give to everybody who comes to the ANC the person may not buy it now. He may leave it lying around in 2 weeks 3 weeks their kid, the cousin, their brother may come and buy it for them. But I don't know."

(Private sector 4)

Another problem due to the complexity of the voucher scheme was that some health facility staff misunderstood their role. Their perception was that they would receive both vouchers and nets and they would then be responsible for putting or advising on where to put the nets in outlets in the town.

" It's not working here because the main problem is they were going to bring in nets .....when they come we will give the nets to people in town and then the authorities will deal with that. These are the vouchers we were given. Those who promised they were going to bring this system here didn't come here again."

(Public sector 15)

As reported above, some midwives withheld vouchers from pregnant women who they perceived not to have money for the top-up to exchange the voucher for a net. However, the reason for this was also misunderstanding on their part about the role of the voucher.

"our nurses have said that the vouchers are not very clear to them that is where they have these mixed feelings.....initially some did not give out a coupon if the person didn't have money"

(Public sector 1)

Exchange of voucher for ITN

The midwives felt that the majority of pregnant women who were given a voucher did not use it to buy an ITN.

"We give the vouchers, but since they don't purchase the nets with the vouchers. I feel if we are to sell them to the mothers it will be better."

(Public sector 3)

The most common reason mentioned by the midwives for a pregnant woman not using her voucher for an ITN was the bother of having to go somewhere else with the voucher, which required an extra effort. They felt that the distance a pregnant woman would have to travel was a significant influence on whether she would make the effort and that the ITNs were likely to be far from the health facilities. They perceive pregnant women as a target group that often do not feel like making extra effort:

"Pregnant women are the sort of people that anything that will give them an extra mile they will refuse to do it. One they are weak, and then you know that most of them are coming from around town [out of town] *so from the hospital they will join the* [bus]*station, they will not bother passing through town buying the net if there is no one at the station area selling."*

(Public sector 5)

" You see the inconvenience for the pregnant woman and you find out that maybe in some few districts from where the hospital [and/or] *the clinic is located and where the outlet is, some places you may find that these are quite a distance but if you have the nets in front of the midwife then its straight forward you give it and go."*

(Public sector 11)

" the nets should not be far from the facility. It should be within the facility so that it can be easily purchased."

(Public sector 6)

For the LCS, those that had sold nets before the introduction of the voucher scheme had sold mainly to the student market. The size of the ITNs that are sold to students (single) differs from that sold to pregnant women (double and above), and therefore decisions were made at the time of purchasing stock about what size to buy. When approached by distributors, retailers were generally happy to take a few voucher scheme ITNs, however, they were then dependent upon the demand for these nets, and when pregnant women did not come to exchange their vouchers for nets, the retailers did not restock.

What I took was the student types most of the time. The pregnant women.... only took a little because the market was very slow. Then the prescriptions [vouchers] *were not coming – only a few that came. Then after that.....we also didn't ask for, we should have asked for more if the demand was ongoing."*

(Private sector 8)

Their perceptions of the possibility of selling nets via the voucher scheme was that it depended very much on how close they were to the hospital or health centre:

"I believe that might be the cause me not receiving the voucher from the hospital. There are 6 other drug stores on the way to my place [from the hospital]. *When they get it at the nearest location they take it because the same is the same."*

(Private sector 8)

The voucher scheme to a large extent did not pose a relative advantage over the pure commercial sector for the distributors to reach further geographically.

"...the poor infrastructure in the hard to reach areas poses a challenge and in addition to that is the low turnover of stock in some of those hard to reach areas"

(Private sector 1)

The voucher scheme had 4 distributors, two of whom supplied PermaNet and two of whom supplied other brands of net, some of which were LLINs, ITNs and bundled nets. These nets were available in the different sizes, shapes and colours and attracted different retail prices and therefore the amount of top-up payment required from a pregnant woman with the voucher discount also varied. The vision within the voucher scheme was that this diversity of types of nets would enable customer choice in the type of net that they preferred and in the amount of money they were willing to or could afford to pay. In reality the increased customer choice did not happen as envisaged because the distributors preferred to avoid competition in what they perceived to be a small market.

"not all of them are in all the areas – I think they decided to take portions, like Transcol will take this part, Reiss and Co goes here.....so the blend of nets we want to have at the place is not very common"

(Public sector 1)

6.3.2.2 Post diversification: public sector and private sector

Two major diversifications of the mix of delivery systems were seen to affect the public sector role in the voucher scheme. These were the presence of public sector 'Global Fund' ITNs in the ANCs, and the presence of private sector ITNs in the ANCs. During the period of the voucher scheme, some health facilities had small numbers of mosquito nets remaining from previous distributions from the NMCP and from purchases made by the DHMT. In November 2004 due to reported lack of ITNs in the private sector and requests from the RHD and DHMTs, the NMCP sent a supply of ITNs to all districts in the Volta Region for delivery through their health facilities. Then in January 2006 a supply of ITNs from GFATM meant that the NMCP were able to send a supply of ITNs to all districts in the country, again for delivery through health facilities. This was a much larger distribution than any that had previously been undertaken, as in the past due to lower numbers of ITNs, only a limited number of districts (10 and then 20) had been targeted for distribution. Some districts, therefore, had not previously received mosquito nets from the NMCP. Adding to the complexity of the context of mosquito net delivery in the Regions, the private sector directly approached midwives in health facilities with a supply of ITNs.

Relative advantage

Voucher offer

Public sector nets in ANC

The distribution of mosquito nets to health facilities meant that the midwives now had both vouchers and ITNs from the NMCP, via the districts which were provided with nets through the Global Fund grant. The midwives were more confident that the pregnant woman would get a net if they sold her one directly, than if they gave her a voucher and then she had to purchase the net. There was some suggestion that the vouchers were being used in exchange for ITNs within the clinics.

"the voucher scheme is not going well. First you issue the voucher and then they choose the time they want to come and buy the net and at times they don't come. But when they are

holding the money the net is here we sell it to them right away. I think that is much better.

(Public sector 5)

"They get the vouchers, we issue them to pregnant women, they go to the drugstore....to buy. But during the latter part of last year they brought the nets – treated nets to us so we issued the voucher then when they bring the money we give it to them and then we get the voucher back. People have been coming from Accra to collect the vouchers"

(Public sector 4)

"The voucher is better but the nets should be kept at the facility not to other outlets.

(Public sector 6)

The 'Global Fund' nets as they were referred to by many of the midwives, were to be sold to pregnant women through ANC and to children under 5 years through CWC at the price set by the NMCP of USD2.2 (20,000 Cedis). Although the voucher provided a discount of USD4.4 (40,000 Cedis), price variation of ITNs in the retail outlets meant that the cost of the top-up value of nets varied by brand, form of insecticide treatment (LLIN, pre-treated, or bundled with insecticide), size and shape. The 'Global Fund' mosquito nets were PermaNet LLINs. The top up cost of a PermaNet with a discount voucher in the retail sector was between 30,000 Cedis and 55,000 Cedis depending upon size.

"what will happen even then telling the woman I have a Permanet here at 20,000 and advising the pregnant woman to go and buy a Permanet at 55,000"

(Public sector 9)

There was a clear financial disadvantage to using a voucher to purchase a PermaNet in particular from the private sector in comparison with buying an ITN directly in the health facility.

Private sector nets in ANC

The positioning of the umbrellas outside of the hospitals was seen as creating direct competition and as a reason that people did not access nets through the voucher scheme in pharmacies and LCS. According to the perceptions of a retailer in the Volta Region the selling of ITNs at umbrellas based outside of the wards was one of the main reasons that demand for his ITNs decreased drastically. ITNs were taken away from his pharmacy by the voucher scheme supplier in December 2004/January 2005

"I saw somebody with an umbrella at the opening of the wards.....so they were no longer coming to me and my supplier didn't find it attractive to leave so many nets with me when I didn't have the opportunity to give them out."

(Private sector 9)

Compatibility

In two districts of Eastern Region, Kwahu South and Kwaebirim, the voucher scheme ran alongside the selling of global fund nets in the facilities. The vouchers were for pregnant women and the global fund nets for children under 5 years:

"so it's not bad bringing the global fund in if you give clear instructions"

(Public sector 1)

The use of the umbrellas outside of the clinics was seen as compatible with the required systems by the public sector in that the midwives were then not dealing with money, and the private sector were not entering the facilities

"if it's in the chemical shop most of them will not turn up there, but if just after leaving the clinic it is there that you can buy then it's a better strategy"

(Public sector 8)

However, the delivery of ITNs through health facilities was perceived to be incompatible with the voucher scheme and worries were expressed by both public and private sector stakeholders. When the private sector approached the health facilities with their mosquito nets, the complexity of the situation increased. Some facilities had vouchers, public sector ITNs and private sector ITNs, whilst others had mixes of two, one or none at any particular time. For the public sector the entry of the private sector distributors directly into the health facilities with no adherence to the public sector managerial structures and lines of responsibility was unacceptable.

"if you [private sector] *think it is the midwife who should sell the nets then we can provide her because she's our employee and not yours and she can't serve two masters at the same time"*

(Public sector 9)

"you know the health system has its structures and so it's like the drugs how do we get drugs to the health facilities? How do we get our logistics to the health facilities? There is a system from the regional level and you are not allowed to go outside of that system and just go and buy from any commercial partner and come and serve"

(Public sector 9)

There were suggestions that the midwives were given a commission from the private sector for selling their ITNs.

"the number of nurses selling the nets they were getting commission too.....we were advising that someone can sit in the facility and sell the net but the nurse or any health worker shouldn't sell the nets within the facility. That is where the problem is coming from because of the commission".

(Public sector 23)

"The first batch that was left with the chemical sellers they realise that not much has been bought so they decided to leave it with the midwives. They were given t-shirts and they were satisfied with that".

(Public sector 8)

The complex system that developed of midwives sometimes writing vouchers for ITNs that they were selling made district level monitoring impossible.

"let's say this is the voucher and you are pregnant so when you come to my facility I see you and I write a voucher for you and say take it to the outlet down there and collect it.....and you meet the health centre outlet then the same midwife is going to write the voucher for you put it somewhere record it in another book and give you a net, which is not supposed to be the right thing. This is like you have to play a double role which you are not supposed to do that. Then that would be a problem with the monitoring.....I don;t know at this point whether they are all [global fund nets] used with the voucher in the facilities"

(Public sector 11).

Views were expressed by private sector providers however, that the incompatibility was due to the different prices of the nets through the voucher and public sector systems, and if these were addressed then the strategies would be complementary:

"...and if you look at it critically if you implement the delivery [of LLINs] by the health system you are virtually killing the voucher scheme. The voucher scheme nets are going to be more expensive than the other ones"

(Public sector2)

"My main worry is the global fund nets because we like to get big redemptions and anything that will mitigate the number of redemptions is really not very comfortable"

(Private sector 4)

.....and the voucher scheme is a global fund project and then this distribution is also a global fund project.....But what is going to happen is that it is really going to slow down the voucher scheme"

(Private sector 5)

"Now the only issue that comes to the commercial side is that their nets are still expensive so that is where the competition is. But in terms of policy direction it is complementary..... Just to get the volumes in there through this scheme and that scheme"."

(Private sector 5)

Trialability

Adaptations were made to the voucher scheme sometimes pushed by the public sector and at other times by the private sector. The result was that the private sector took their nets directly to the clinics:

"At first the nets were not with us, they were with the chemical sellers ...so we told those who are supplying us with the coupon .....that we issue the coupon but they don't go to the chemical shop to buy so they decided to bring some here to us. They were brought to us here."

(Public sector 5)

Although there were suggestions that the LCS were maybe not the most appropriate outlet for reaching everyone, the LCS model was perceived as a model which could be tried

"The reason why they started with the chemical shops is that you can't just go and pilot and you go and give nets to market women who you don't know. At least let's look at a well organised people."

(Public Sector 8)

Complexity

Before the delivery systems began to diversify there was poor understanding by some of the health workers of how the voucher exchange for an ITN should work and where it should be conducted. With the distribution of public sector nets to the health facilities and then also the private sector entering the health facilities with their nets, the situation became very complex. In some health facilities the practice became to issue vouchers and exchange them for nets within the facilities. The timing of these events varied with voucher and ITN exchange being simultaneous, or with a gap between the two events:

" So when they bring the money we issue the voucher and given them the nets"

(Public sector 4)

" We tell them to go to the drugstore to buy. But during the latter part of this year they brought the nets – treated nets to us so we issued the voucher then when they bring the money we give it to them and then we get the voucher back. People have been coming from Accra to collect the vouchers."

(Public sector 4)

Although the midwives themselves seemed to be quite clear on which nets were from the district and therefore did not involve the issue of a voucher, they did not understand the different partners who were bringing nets to the clinics.

" this year global fund came in with the Permanets , last year other NGOs have been bringing nets to the facilities we don't know anything about those ones. They will go to the facilities and just give to any nurse or orderly to sell."

(Public sector 6)

When asked whether these were the voucher scheme distributors:

"..one who is issuing the voucher and one who is issuing the nets we know them, but the others we don't know. So as for them they don't use the voucher. They say they will be selling them from the facilities. That's why we don't have any control".

(Public sector 6)

The retailers were supposed to take a sticker from the net packaging and put it on the voucher presented to them by the client. They then pass this voucher with a sticker as proof of purchase back to the distributor for redemption to the management agent. The policy was that money would not be given to the distributors for vouchers returned without a net packaging sticker. This system presented problem:

"Some people don't understand the programme very well. Some people can leave their shop to their daughter for a second and when somebody comes to buy the person selling may not understand the programme and just takes the net and gives to the person" [without removing the sticker from the packaging].

(Private sector 4)

Adopters

Public sector

To some extent the regional level could be said to have been more involved in the voucher scheme in Volta and Eastern Regions, than the district level. Although the district directors were involved in the trainings initially, from their perspective they were not sufficiently involved afterwards.

"The district directors always complain that the commercial partners come they don't know what they are doing with the midwives.....They are not being involved and if the head says I don't know anything about it, that's the end of the programme...The district directors consider that it's not our duty. We don't know anything about that. Let's get the global fund net and put it there as we were doing in the past."

(Public sector 9)

The district director and the public health nurse, with their monitoring roles over the midwives, were key to the success of the voucher scheme, but they did not feel that they were involved. With the voucher scheme the distribution of vouchers was directly via the Management Agent as was the monitoring of voucher delivery in the health facilities. This was not compatible with the role of the District in monitoring of their programmes and led to a feeling of detachment and non-ownership. As in fact the districts had no ownership of the voucher scheme.

"We were monitoring the global fund one we are the administration here but the voucher scheme one when it came to the distribution was done without our knowledge we also could not monitor.....so you find it difficult to know exactly how many nets you have at one particular outlet"

(Public sector 11)

"The major problem is with the monitoring. If they want to monitor from Accra, fine let them come here frequently to do that

(Public sector 15)

The ANC staff had a clear preference for the direct delivery of an ITN relative to the issuing of a voucher. The main problem with the voucher scheme from the perspective of the ANC staff was that they could not know for sure whether the pregnant woman ever exchanged the voucher for a net, and they did not generally believe that many women did so.

"They all don't take time. They are the same to me. I don't have any difficulty with issuing the vouchers. The people's purchase is my problem but issuing vouchers is not a problem".

(Public sector 3)

Private sector

At inception of the voucher scheme there was one international ITN importer, 2 distributors and a few retailers. The aim initially was to increase the number of both distributors and retailers. This did happen initially, with two more distributors entering the market and all distributors increasing the retailers to whom they distributed ITNs for the voucher scheme and for unsubsidised sales. The establishment of sales points directly outside of hospitals and other large health facilities in urban centres effectively blocked trade for the LCS and pharmacies that were a greater distance from the hospitals and health facilities. Availability of ITNs closer to the health facilities was felt to be important:

> *"If it's in the chemical shop most of them will not turn up there, but if just after leaving the clinic it is there that you can buy then it's a better strategy."*
>
> (Public sector 8)

The role of the distributors in the voucher scheme became very prominent, and that of the retailers less important as the urban centres were dominated by the 'umbrella' sales points.

6.4 Discussion

During the period of implementation of the voucher scheme significant contextual changes occurred in the mix of delivery systems for mosquito nets in the two regions. The distribution of public sector nets to health facilities, precipitated by the removal of nets from retail outlets in Volta Region with the introduction of a voucher scheme in Greater Accra, changed the course of the voucher scheme in Volta and Eastern Regions. Volta Region was hit by stock outs of ITNs in the retail outlets throughout the region within the first few months of implementation of the voucher scheme. The sending of public sector ITNs to the health facilities meant that the midwives had a choice of selling an ITN or giving a voucher. Selling the ITN was a clear best option for the midwives: it overcame their worries about women having to travel to get the ITN and their perceptions that few of them would do this, they could see that the woman actually received a net and they also felt more in control of

educating the woman on how to use the net. Added to these factors was that of cost. Women would need to pay more for an identical ITN if they got it through the private sector, even with the voucher discount, than if they bought the ITN from the midwives.

Whilst there were clear disadvantages of the voucher scheme at the point of delivery of the voucher, advantages were perceived at the level of logistics and financing. Perceived relative advantages of the voucher scheme over the direct delivery of ITNs in the public sector were managerial and logistic in terms of the financial systems to handle the money from net sales and the logistical problems of transporting nets. One of the diversifications of the public sector system resolved the transport problem by contracting this out to a distributor. This contracting to the private sector facilitated transport to the districts, but not to the health facilities. Any advantage of the voucher scheme over the direct delivery of ITNs at the delivery level was overridden at the district level by lack of involvement in the voucher scheme. The vouchers were delivered by the Management Agent who also conducted the monitoring of voucher issue. The district had a system of monitoring ITN distributions, but the mix of voucher, public and private nets in the facilities resulted in confusion and consequent lack of control at both the health facility and district levels. The districts felt excluded and therefore did not consider the voucher scheme as part of the district health system.

Findings of the study provided an insight into the reasons for loss of effectiveness of the voucher scheme processes. The nature of the reasons for the loss in effectiveness varied with the changing delivery system context (Figure 6.4). Initially, misunderstandings about the programme and the nature of the vouchers led to rationing of vouchers by the health workers sometimes because they were worried about running out of vouchers and other times because they did not want to waste the voucher on a woman who they perceived would not use the voucher in exchange for an ITN because she did not have the money required for the top-up payment. Access to ITNs in the retail sector was sub-optimal. Penetration was limited, and although efforts were made by partners to reach further into rural areas, the slow turnover of sales and wear and tear on vehicles made this a non-viable

option for the distributors. The advent of a time-limited voucher scheme in the national commercial capital drew the spotlight away from the Volta Region, meaning that stocks were not replenished at the same rate as previously and there was also evidence of nets being withdrawn from the retail outlets in this region and transported back to Accra. This quickly resulted in stock-outs of ITNs in Volta Region. And finally, when the option of offering a voucher or offering an ITN was available, the health workers preferred to offer an ITN.

Reasons suggested by health workers to explain why women with vouchers did not exchange them for an ITN were mainly that it was an extra effort for a pregnant woman to travel to an LCS to make the exchange. Pregnant women were seen as a group for whom extra effort was less likely to be undertaken. The use of LCS as the retail outlet of choice for ITNs targeted at pregnant women was questioned as people only go to LCS when they are ill. Pregnant women going to ANC are not necessarily ill and therefore there is no reason that they would need to go to an LCS. It was suggested that it would have been better to locate the voucher scheme ITNs somewhere that pregnant women generally go, which is ANC and markets.

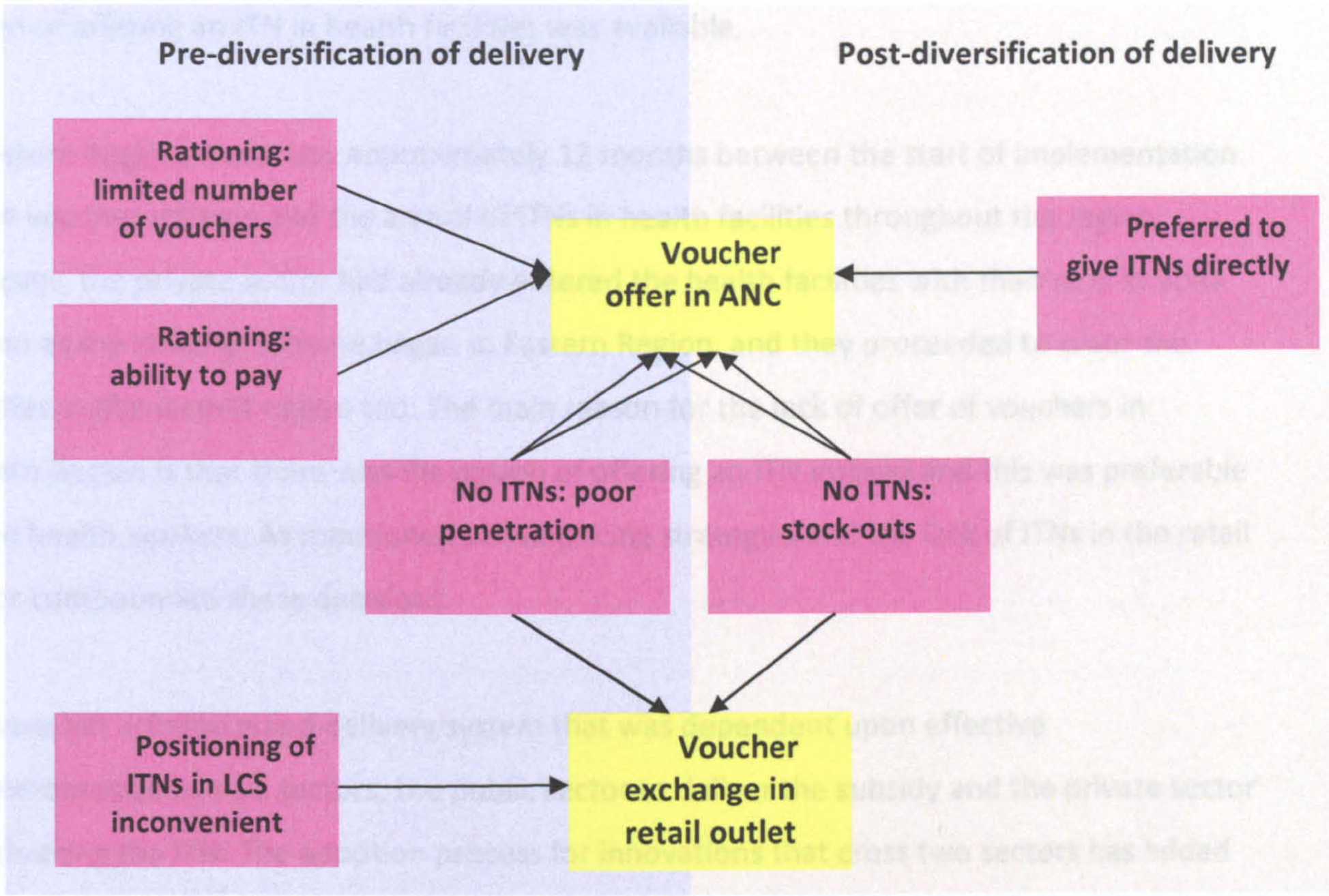

Figure 6.4: perceptions of public and private stakeholders for loss of delivery process effectiveness

Diversifying the voucher scheme to place ITNs immediately outside the ANC in urban centres seemed to be a viable option, although there is no quantitative data to back this statement. This caused a considerable shift in the momentum of the voucher scheme of LCS retail outlets who found that few pregnant women were presenting with vouchers. This change effectively cut out the LCS in urban centres.

The reaction by the RHDs and NMCP of sending ITNs to the health facilities was undertaken in the context of the private sector failing in their promise to stock retail outlets with ITNs, and a national and international policy arena of scaling-up of coverage with ITNs. Given the low but statistically significant increase in the proportion of households with an ITN that was attributable to the voucher scheme in Volta Region, it is likely that this expansion in coverage occurred early in the scheme. At voucher scheme inception momentum was at its highest,

before the private sector were distracted by an alternative faster market, and before the option of offering an ITN in health facilities was available.

In Eastern Region, there was approximately 12 months between the start of implementation of the voucher scheme and the arrival of ITNs in health facilities throughout the region. However, the private sector had already entered the health facilities with their nets in Volta Region as the voucher scheme began in Eastern Region, and they proceeded to enter the facilities in this second region too. The main reason for the lack of offer of vouchers in Eastern Region is that there was the option of offering an ITN instead and this was preferable to the health workers. As mentioned above pricing strategies and the lack of ITNs in the retail sector compounded these decisions.

The voucher scheme was a delivery system that was dependent upon effective implementation by two sectors, the public sector to deliver the subsidy and the private sector in delivering the ITN. The adoption process for innovations that cross two sectors has added complexity, and the rate of adoption needs to be the same or sufficiently overlapping that the system as a whole may function. The complementary timings required by either or both of the sectors may not be achievable. Initially the adoption process in the two sectors was in line, but when the private sector was distracted, the voucher scheme failed in both sectors. By the time the attention of the private sector returned and they brought in new stocks of nets, the public sector had adopted an alternative option of direct delivery of ITNs. Action by one sector dramatically changed the context for the other sector.

The theoretical framework used in supporting the analysis was primarily that of Roger's diffusion of innovations [62]. Relative advantage was found to be an important determinant of the effectiveness of the voucher scheme in the context of a choice between the voucher scheme and the direct delivery of ITNs as competing innovations. The offer of a voucher to a pregnant woman on attending ANC was found to be the most critical step in the success or failure of the voucher scheme in this context. There were problems in compatibility of both the voucher and direct delivery systems in terms of fANC, and district level monitoring.

Compatibility, however to a large extent, took second place to the problem of lack of observability of the effect of giving a voucher and of whether the pregnant woman ever used this voucher to access an ITN. The importance of observability has been shown in other studies for example tuberculosis treatment in Russia, where doctors preferred prolonged periods of hospitalisation so that they knew that the patient would be given the right treatment. They did not believe that treatment regimes would be adhered to at the community level [211].The voucher scheme was relatively complex and there were misunderstandings about the role of the voucher which were likely to have stemmed from fidelity of implementation of the training pre-implementation of the scheme. In the early days where there was relatively little interference from ITNs in health facilities, complexity was the major driver of the lack of offering an ITN to eligible pregnant women on attendance at ANC. The innovation attributes were also found to overlap with the adopters to a large extent, possibly this was exacerbated as the innovation attributes were assessed based upon the perceptions of the adopters.

The theoretical framework was insufficient in major respects, the first being that it didn't adequately reflect that the innovation was a delivery system in the context of other delivery systems, rather than an intervention *per se* such as a new drug, or a health education programme. A delivery system is an integral part of the health system so the linkages are much tighter than when considering other kinds of innovations. The second limitation was the lack of scope for the changing context in terms of the mix of delivery systems. A revised conceptual framework was therefore developed of the adoption of the voucher scheme and its integration into the public and private sectors (Figure 6.5). This framework hypothesises that as the voucher scheme was implemented adaptations were made by the implementers. Increase in the ownership of mosquito nets in Eastern Region through the public sector suggested that there was a change in the delivery system context of mosquito nets in the region(s). Direct public sector delivery of mosquito nets through ANC meant that both vouchers and mosquito nets were available in the health facilities.

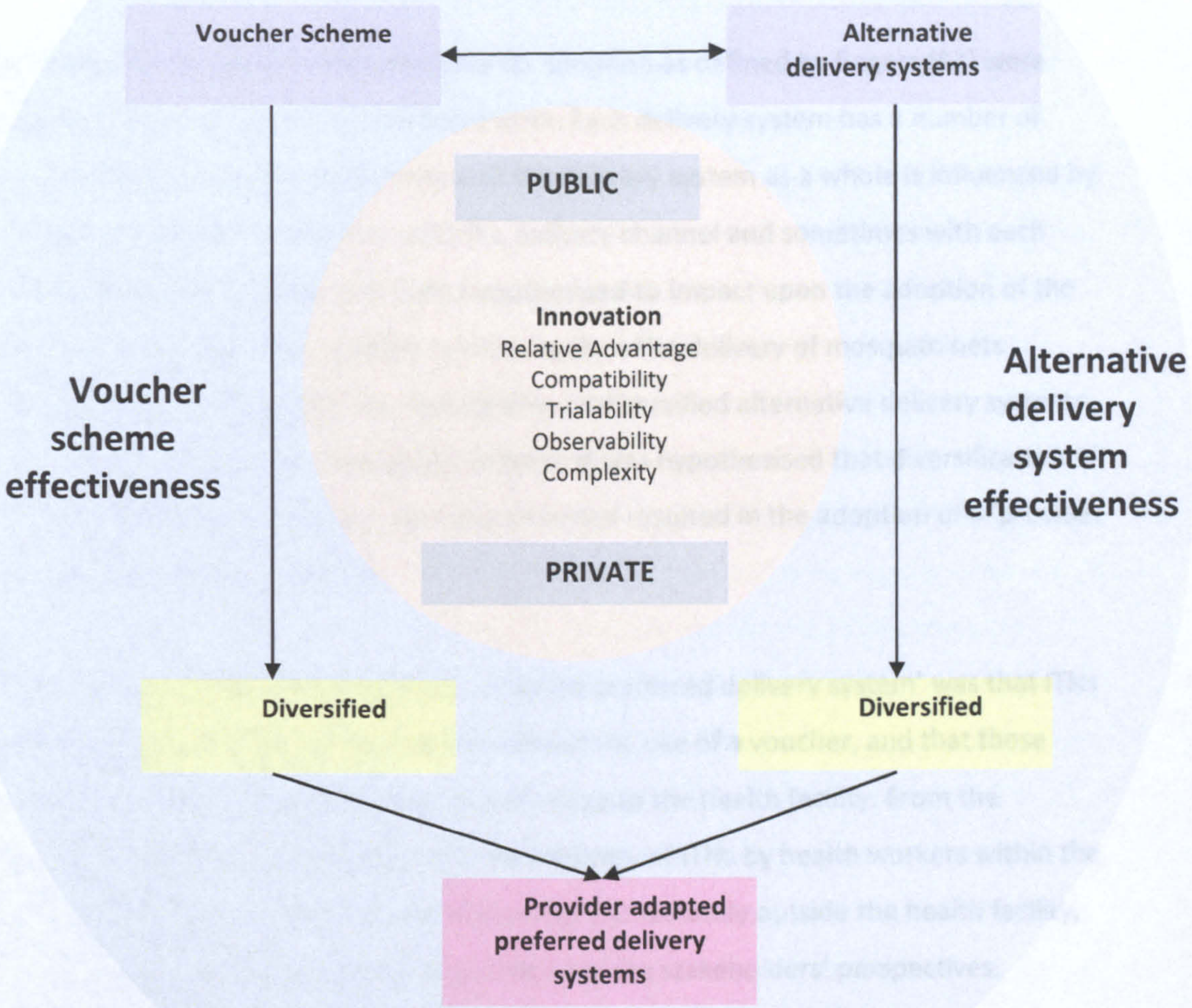

Figure 6.5: conceptual framework of the context of effectiveness of voucher scheme processes

It was likely therefore, that the presence of the public sector mosquito nets in the health facilities would influence the effectiveness of the voucher scheme and *vice versa*. It was also hypothesised that the presence of the voucher scheme influenced the public sector delivery of nets.

The elements of an innovation that influence its adoption as defined by Rogers [62] were placed at the centre of the theoretical framework. Each delivery system has a number of providers (adopters), and the effectiveness of the delivery system as a whole is influenced by these adopters, and their interaction with the delivery channel and sometimes with each other. Here innovations and adopters are hypothesised to impact upon the adoption of the voucher scheme or alternative delivery systems such as the delivery of mosquito nets through ANC, and the diversified voucher scheme or diversified alternative delivery systems within the health system and wider policy context. It was hypothesised that diversification of the mix of delivery systems as they were implemented resulted in the adoption of a 'provider adapted-preferred delivery system'.

In Volta and Eastern Regions, the 'provider-adapted preferred delivery system' was that ITNs were delivered directly to pregnant women without the use of a voucher, and that these were delivered within the health facility, or very close to the health facility. From the perspective of the delivery point either the free delivery of ITNs by health workers within the facility, or the delivery of ITNs via the private sector immediately outside the health facility, as with the example of the 'umbrellas' would fit from the stakeholders' perspectives. However, private sector stakeholders did not feel that it would be possible to sustain this kind of input (e.g. the "umbrellas") in rural areas. A possible strategy would be the use of the 'umbrellas' outside hospitals and busy urban clinics and the distribution of ITNs to DHMTs via the private sector distributors, with delivery to health facilities and to pregnant women in rural areas via the health facilities. The findings did not support that the context was conducive to the feasibility of effective implementation of the voucher scheme.

The contextual framework developed through this study is applicable to new delivery systems introduced into a context where the intervention to be delivered is already being delivered through other systems. For example anti-malarials, delivered through the public and private sectors. The special case encountered in the voucher scheme was that there was direct competition between two or three delivery systems (voucher scheme, direct delivery of NMCP nets, and direct delivery of private sector nets) within ANC such, that is at the same delivery point and the choice was determined by the health worker.

The objectives of the study were to describe the delivery systems context in the two regions during implementation of the voucher scheme, and to determine the reasons for the loss of effectiveness in the voucher scheme processes. There were several limitations of this qualitative study that should be noted. The sampling was purposive and included stakeholders from the various levels of the public sector, and stakeholders from all the major private sector groups, involved in the voucher scheme. No attempt was made to stratify interviews amongst adopters and non-adopters in the public and private sectors, or to stratify the sampling and therefore findings by region. However, because of the strength of the changed context on the effectiveness of the voucher scheme, in this instance, such stratification is not likely to have added much depth to the findings of the study. In retrospect the most useful stratification would have been over time, in line with the changing context. Because there were such a variety of stakeholders involved in the voucher scheme, the repeating of the interviews overtime would have been prohibitively resource consuming. However, time is a factor which should be considered in the future in evaluations that aim to describe a changing context.

All interviews were conducted by me, and all stakeholders were aware that my aim was to understand how well the voucher scheme was working and what were its positives and negatives. I was therefore seen as associated with the voucher scheme and this could have influenced responses (Chapter 6.1).

In this chapter together with Chapter 3 the delivery system context for ITNs in the two regions has been described and investigated from the perspectives of a range of stakeholders. The data generated provided an insight into the complexity of factors that contributed to the outcomes of the voucher scheme in the two regions. It was clear that the findings were greatly influenced by the context and therefore may not be transferrable to different contexts. However, I would argue that the conceptual framework of the context of effectiveness of the voucher scheme processes may be applied to other examples of the delivery of ITNs and other malaria control interventions where an intervention is delivered through a new delivery system where the same intervention is already being delivered by alternate delivery systems. The framework is therefore about the nature of the new delivery system in comparison with the alternatives, whether one is adopted in preference to the others, or whether each is adapted to ensure the best fit with the system into which they are integrating.

In Tanzania, the ITN voucher scheme was effective [212] and there have been a variety of delivery systems for ITNs besides the ITN voucher scheme. However none of these alternative delivery systems have been directly competitive with the voucher scheme, as was the direct delivery of ITNs through ANC in Ghana. Both social marketing and private sector delivery, which have been implemented at the national scale in Tanzania may be seen as complementary and have the capacity to augment the success of the voucher scheme.

As mentioned previously, lack of resources with which to include pregnant women in the qualitative study is a limitation. The impact of this is that of not knowing how pregnant women perceived the voucher scheme and particularly in comparison to the direct delivery of ITNs through ANC. The health workers expressed their opinion on how pregnant women viewed the alternative delivery systems and these were noted, however, these are not the views of the pregnant women as stated themselves, and may therefore differ.

6.5 Conclusions

The advent of a short-term ITN voucher scheme in the two largest commercial centres of the country deflected limited resources in terms of ITNs, from the Volta Region. This triggered factors resulting in NMCP ITNs in ANC which also had ITN vouchers, and subsequently also private sector ITNs in the same ANCs. The voucher scheme and the direct delivery of ITNs in ANC were competitive delivery systems and the direct delivery through ANC was the preferred one. Careful analysis of context and delivery system process pathways is required to highlight any potential conflict between current and proposed systems.

Chapter 7: A methodology for the evaluation of delivery systems

7.1 Introduction

The term "evaluation" encompasses several methodologies that vary depending upon what is being evaluated. Programme evaluation and impact evaluation each provided useful starting points for the methodology of delivery systems evaluation that is developed in this thesis.

The essential element common to this delivery systems evaluation methodology and impact evaluation is that of attribution. In impact evaluation attribution refers to programme or health outcomes and is also used to assess what would be the level of the outcome of interest if the intervention had not been implemented (Chapter 1.2). In delivery systems evaluation however, we are interested in delivery attribution, that is, attribution of coverage outcomes. I used this concept of attribution for the purpose of assessing relative contribution of alternative delivery systems to the coverage outcome. In delivery systems evaluation attribution is used to strengthen the evaluation inference from adequacy to plausibility, as defined in the programme evaluation literature. Plausibility inference is relatively achievable in delivery systems evaluation as compared to intervention and programme evaluation.

Both intervention and delivery system evaluation may be considered as components of programme evaluation, but due to the different nature and functions of interventions and delivery systems there are differences in the methodologies required for each. The previous chapters have explored the use of a mixed methods approach to delivery systems evaluation based upon programme evaluation and impact evaluation methodologies.

Based upon the Ghana voucher scheme evaluation experience, I recommend that delivery systems evaluation should include: 1) an assessment of the primary outcome; 2) an assessment of the proportion of the outcome attributed to each system through which the intervention is delivered; 3) a description of the delivery processes; 4) quantitative assessment of the effectiveness of each of the delivery processes; 5) a qualitative study of the effectiveness of each of the delivery processes; 6) a study of the context within which the delivery system under study is implemented, including that of other delivery systems for the

intervention. In this chapter the methodology that has been developed through the thesis research is presented, summarised and broadened to show how it may be used for the evaluation of other malaria control interventions. Delivery systems contexts where this approach is recommended are discussed.

7.2 Design features of the methodology of delivery system evaluation

7.2.1 Determine the purpose and objectives of the evaluation

The first step in designing a delivery system evaluation is to define the purpose and objectives of the evaluation (Table 7.1). Generally the purpose will be to determine the effectiveness of a delivery system in achieving the highest effective coverage of the target population with a specified intervention. Where there is more than one delivery system for the intervention, either new or existing, then objectives may be to assess the effective coverage of all delivery systems combined, or to measure the proportion of effective coverage achieved attributable to each individual delivery system.

As in the example of the evaluation presented in this thesis, delivery system evaluations often have objectives of measuring coverage outcomes across geographic areas, and in different sub-groups, such as socio-economic groups. Such stratifications of coverage require that the sampling scheme is designed to enable geographic stratification, and that questions on household assets are included within household surveys.

Evaluations may additionally have an objective of assessing the effectiveness of each of the intermediate processes in delivery in order to inform remedial actions, or to reach judgements about the effectiveness of a particular delivery system. This has been done for ITNs delivered through voucher schemes [163, 201] and through a targeted mass campaign [213].

Table 7.1: Steps in designing a delivery system evaluation

	Examples	Comments
Determine the purpose and objectives of the evaluation	- To evaluate a new delivery system for ITNs - To evaluate a new delivery system for artemisinin combination therapies (ACTs) - To evaluate an existing delivery system for IPTp	Evaluation of a new delivery system for an existing intervention will usually require attribution of outcomes to a specific delivery system, that is the new deliver y system and the existing one A process analysis is required to assess the effectiveness of each intermediate step in delivery
Select the outcomes and their indicators	- the proportion of children under 5years using an ITN - the proportion of children under 5 years with malaria given effective treatment with an ACT - the proportion of pregnant women who attend ANC and receive at least two doses of IPTp	The primary outcome indicator may be a distal or proximal indicator
Select the evaluation method including attribution	- cross sectional pre-post survey with attribution of outcomes by source of intervention - cross sectional post intervention survey with attribution of outcomes by source of intervention - cross sectional post-intervention survey with no control	For evaluation of a new delivery system for an existing intervention a pre-post survey with attribution of outcomes by source would provide causal inference for proximal indicators and plausibility inference for distal indicators.
Define and assess the effectiveness of the delivery processes	- include several proximal and more than one distal process - includes several proximal and one distal process - the evaluation terminates at proximal process	The number of processes varies with interventions and with delivery systems. Many process pathways are linear Not all process pathways are linear
Characterise the contextual factors	- malaria transmission levels - structure and strength of the health system - socio-demographics of the population - alternative delivery systems - policy context	Disaggregate outcomes by contextual factors Describe contextual factors Describe the influence of each alternative delivery system on the system under study Describe adaptations to each delivery system and whether there is divergence and/or convergence of systems

7.2.2. Select the outcomes and their indicators

The primary outcome measure in a delivery system evaluation is coverage of the intervention achieved through the specific delivery system(s) (Figure 7.1). Secondary outcomes can include geographic coverage, equity (the socio-economic distribution of coverage achieved), cost and/or cost-effectiveness, tempo (how quickly a system can reach high coverage), and others.

Primary outcome measures are classified further into proximal and distal outcomes (Table 7.2). Proximal outcomes are those intrinsically linked to the delivery channel such as ownership of an ITN, and delivery of an ACT and therefore measure the effectiveness of the processes or intermediate steps within the delivery system. Distal outcomes relate to use of the intervention once it has been delivered, such as use of an ITN by the target group, delivery of a dose of IPTp, and adherence to an ACT regimen, all of which may be mediated by factors other than the delivery channel (e.g. the delivery strategies but also other factors).

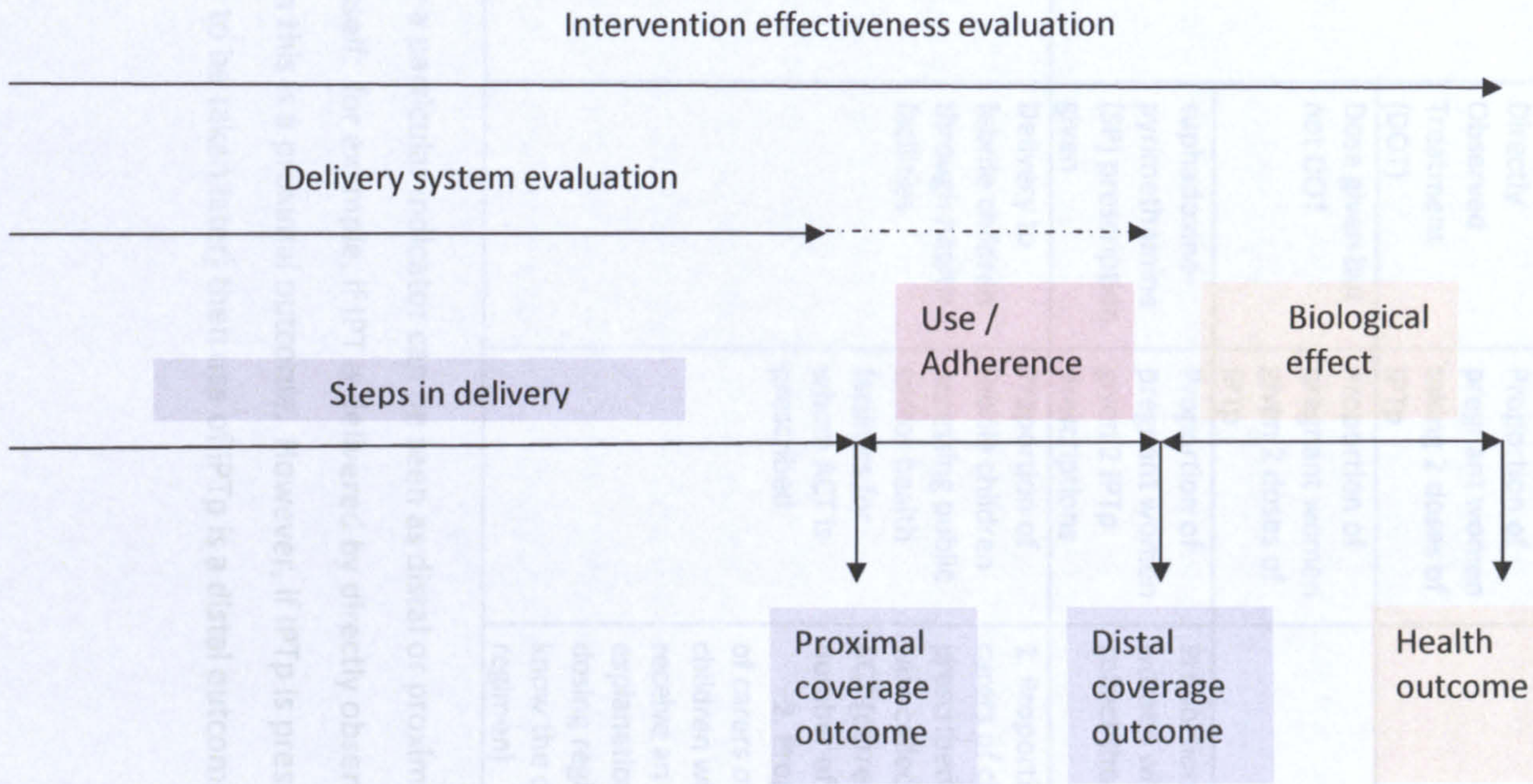

Figure 7.1: Intervention delivery system evaluation versus effectiveness evaluation

Table 7.2: examples of proximal and distal coverage outcomes for three malaria control interventions

Intervention	Delivery details	1st level of proximal coverage outcome	Subsequent proximal coverage outcomes	Distal coverage outcome
ITNs	Direct delivery through ANC	Proportion of households owning at least one ITN delivered through ANC		Proportion of the target group who slept under an ITN delivered through ANC
IPTp	Directly Observed Treatment (DOT)	Proportion of pregnant women taking 2 doses of IPTp		None
	Dose given but not DOT	Proportion of pregnant women given 2 doses of IPTp		Proportion of pregnant women who take 2 doses of IPTp
	suphadoxine-pyrimethamine (SP) prescription given	Proportion of pregnant women given 2 IPTp prescriptions	Proportion of women who collect the SP	Proportion of pregnant women who take 2 doses of IPTp
ACTs	Delivery to febrile children through health facilities	Proportion of febrile children accessing public sector health facilities for whom ACT is prescribed	1. Proportion of carers of children prescribed ACTs who collect the ACT (correct number of tablets) 2. Proportion of carers of children who receive an explanation of the dosing regimen (or know the dosing regimen)	Proportion of children given ACTs who take the correct dosing regimen (number of tablets each time, number of times each day, number of days)

Whether a particular indicator can be seen as distal or proximal may depend on the delivery system itself: for example, if IPT is delivered by directly observed therapy (DOT) within the ANC then this is a proximal outcome. However, if IPTp is prescribed rather than given by DOT (or given to be taken later) then use of IPTp is a distal outcome for that particular delivery

system. Thus the distal outcomes evaluate the processes that are not entirely within the control of the delivery system. Measuring health outcomes (impact) is not essential unless there is a plausible reason that identical coverage of the intervention achieved via different delivery systems would result in different health impacts.

It is plausible that the relationship between the proximal coverage outcome and the distal coverage outcome would depend upon the system through which the intervention is delivered. For example, pregnant women and children under 5 years receiving free ITNs delivered through ANC may be more, or less, likely to use the ITNs than those mothers and children obtaining ITNs delivered through social marketing in the retail sector, or from the informal private sector. Children may be more or less likely to be given a full dose of ACT (correct number of tablets each time, correct number of times per day, correct number of days) if their carers get the drug from the public sector than from the private retail sector. Assessing both proximal and distal outcomes through measuring indicators of each intermediate process will enable such relationships to be characterised.

The relationship between distal outcomes and health outcome is dependent upon the intervention itself and upon the context. Similar distal coverage outcomes of an intervention could result in different health impacts among different population groups including different age groups, those living in different transmission intensity areas, and different socio-economic groups. However, it is unlikely that this difference in health impact is due to the system through which the intervention was delivered. For example, if the population of one district all use an ITN (distal coverage outcome) on the same nights for the same number of hours during a one year period the health impact may differ between children 0 to 2 years of age, children 3-5 years of age, older children, and adults, but this difference in health impact will be due to biological and behavioural factors, and not related to the system through which the ITN was delivered. In terms of the processes of the intervention, the relationship between health impacts at a given level of use is not directly linked to the delivery system, whose impact is exerted upon proximal outcomes.

7.2.3. Select the study design including approach to attribution

Cross-sectional observational studies offer a method of evaluating the outcomes of delivery of an intervention and the potential for adaptation to accommodate evaluation of a single system or multiple systems. Three factors contribute to the level of inference that can be applied to the relationship between a specific delivery system and the coverage outcome: whether the evaluation is a pre-post intervention design or post only, whether or not the design includes a control group, and what kind of control group is included.

7.2.3.1 Attribution of coverage outcomes to a specific delivery system

If an intervention is delivered through a single system, then coverage outcomes can be directly attributed to this specific delivery system. For example, Intermittent Preventive Treatment for Infants (IPTi) is only delivered through the EPI. Where an intervention is delivered through more than one system, then more complex methods are needed to attribute the coverage achieved by each system. This has been done for mosquito nets based on whether the net was treated or not [30], the source or delivery point of the net [29] and whether a voucher was used in the purchase of the net [31, 148]. Where such a distinguishing feature of a delivery system can be identified, a single cross sectional survey may be used to assess the relative proportion of coverage of an intervention that is due to one specific delivery system, or to all known delivery systems. A new delivery system which is introduced within existing, multiple systems, can be evaluated by attributing the proportion of coverage to each delivery system pre and post implementation of the new delivery system.

Attribution to specific delivery systems requires a simple way of linking the coverage achieved to the system through which it was achieved. All malaria control interventions have a point at which they are delivered to the users, and therefore the coverage of an intervention can be matched to a specific delivery system by identifying the delivery point from which the recipient received the intervention. This can be done by adding a few questions to cross sectional surveys. For example "where did you get this net" or "where did

you get these medicines for your child"? This method assumes that the alternative delivery systems in operation for an intervention do not share the delivery point of the system that is being evaluated. However, if there are instances where two delivery systems share a delivery point (for example a voucher system for ITNs, and subsidised delivery of ITNs through ANC clinics, as in the Ghana example in this thesis) then further questions will be needed to distinguish the two.

7.2.3.2 Assessing proximal coverage outcomes

Evaluations should consider the simplest way of achieving their objectives whilst maintaining internal validity of the methods used, and the external validity of the findings.

Internal validity: An internally valid evaluation minimises random and systematic errors due to chance, bias, and confounding [214]. Data collection methods for delivery system evaluation should be internally valid and should apply statistical methods in the analysis to assess random errors and adjust for any potential confounding effects. Well designed RCTs have strong internal validity as they minimise both random and systematic errors. However, assessment of a number of delivery systems using an RCT would be prohibitively complex and expensive, and potentially infeasible. Cross sectional observational studies are generally of weaker internal validity than are RCTs. However, using structured random sampling techniques to select an adequate number of appropriate units can reduce selection bias and random errors, and data on potential, confounding factors can be collected and accounted for in the analysis.

Inference: Where an intervention is delivered through a single system, then the proximal coverage outcomes can be directly attributed to this delivery system and it is appropriate to infer that the delivery system had a causal relationship to the proximal coverage outcome. However, unless the intervention is new, then it cannot be assumed that it is delivered through only one system. In this situation either formative work must be undertaken to ensure that there is only one delivery system in operation, or a question on source of the intervention should be included in the evaluation. Where a new delivery system is evaluated

within the context of multiple existing delivery systems, if the relative share of the proximal coverage outcome is attributed to each of the delivery systems, then a plausibility statement can be made on what proportion of the outcome was due to the new delivery system. In this type of evaluation, the existing delivery systems are acting as internal controls and thus it is possible to infer that the changes in coverage were due to the new delivery system, above and beyond the influence of other external factors.

External validity The findings of an RCT may have limited external validity even with respect to the population in the area in which the trial was conducted. Well conducted cross sectional observational studies will have good generalisability to the population from which they were sampled. Therefore if a survey is undertaken at the national level, then the findings are generalisable at the national level. Characterisation of the contextual factors such as transmission intensity, socio-economic status of the population, urban rural distribution of the population, that are present will help to inform a judgement as to the other geographic areas to which the findings may be generalised.

7.2.3.3 Assessing distal coverage outcomes

Distal coverage outcomes measure the use of an intervention by the target population, and they are the primary link between intervention coverage and health impact.

Internal validity: Distal coverage outcomes are measured in the same way as proximal coverage outcomes through RCTs or cross sectional observational studies. The methodological issues in the internal validity of proximal coverage outcomes mentioned above would therefore apply to that of distal coverage outcomes.

Inference: Factors that impact upon the delivery system are termed implementation related factors, and they function as effect modifiers in the relationship between delivery system and outcome. The effect of implementation related factors on distal coverage outcomes may vary depending on the way the intervention was delivered, for example the intensity of communication messages at the point of receipt by the end user, on the reasons for sleeping

under an ITN. External factors such as temperature may also modify distal coverage outcomes, such as not sleeping under an ITN when temperatures are high. The effect of implementation related factors on the distal coverage outcome may be assessed by measuring the relative dose-response relationship (although care must be taken to assess any selection biases in the dose received) [39, 214]. For example the effect of exposure to communication messages on the relationship between ownership and use of ITNs can be measured. External factors are more difficult to define and to assess. For example, the proportion of those owning an ITN who use it may depend upon factors such as season (temperature), levels of biting nuisance, or housing characteristics, irrespective of the system through which they received the ITN. If use of ITNs amongst those owning them is attributed to specific delivery systems then the other delivery systems act as internal controls for external factors. For example, use of an ITN delivered through ANC and use of an ITN delivered through the private retail sector would be equally influenced by external factors such as season (temperature), levels of biting nuisance, or housing characteristics. This would enable a plausibility inference as to the observed association between ITN use and a specific delivery system.

External validity: There are factors additional to those confounding proximal coverage outcomes that may confound the relationship between the delivery system and the distal coverage outcomes. As in the case of proximal coverage outcomes, the findings of an RCT for distal coverage outcomes may have very limited external validity. Again the external validity of cross sectional observational studies depends upon a population level representative sampling scheme and upon characterisation of the implementation context.

7.2.3.4 Other factors influencing selection of method

Policy status: Depending upon the policy status of the intervention to be delivered, it may not be possible to include control groups to whom the intervention will not be delivered. Where an intervention is part of the national policy it is unethical and likely to be politically impossible to systematically exclude sub groups of the population from a particular delivery system. In this situation, delivery system evaluations would therefore need to compare

outcomes among those receiving the intervention through one delivery system compared to an alternative system, or through a combination of the two.

Cross sectional observational studies are not limited by whether an intervention is policy or not. As they are able to use internal control groups, cross sectional observational studies are applicable to evaluating the role of alternative delivery systems in operational contexts, and to evaluating proximal and distal outcomes of interventions. For example, evaluation of the delivery of ITNs through ANC in an area with ongoing delivery of ITNs through social marketing would assess the relative proportion of the coverage due to delivery through ANC compared with that achieved through social marketing, together with the effects of any other systems in operation such as the formal and informal private sectors.

Scale: RCTs with a high level of control are not usually conducted at scale because they are very expensive, and prohibitively difficult. It may be possible to implement and intervention on a large scale and randomly allocate intervention and control groups, although this may sometimes be difficult. However, it would be unusual to have a strictly controlled trial on a large scale due to the considerable resources required to achieve this [214].

Where a delivery system is in operation at the national level, pre and post implementation cross sectional observational studies can be undertaken using standard sampling techniques to provide coverage estimates attributable to the delivery system being evaluated that are representative at the national level.

7.2.4. Define and assess the effectiveness of the delivery processes

In an effective delivery system, the intervention will progress through each intermediate process with minimal loss, for example, all febrile children prescribed an ACT will receive the correct number of tablets. It is likely in practice however, that there will be some loss of coverage at each intermediate delivery process within the system of delivery. For example, some febrile children prescribed an ACT will be given insufficient tablets to complete effective treatment, or may be given artesunate monotherapy. In order to assess the

intermediate processes in the pathway of delivery of an intervention it is necessary to define and describe these processes. The evaluation can then be designed to assess the proportion of the population that progress successfully through each process. Often during implementation, variations or adaptations to the defined intermediate processes will be introduced. These may be due to intermittent problems such as interruption in drug supply, or they may be ways in which health workers try to adapt guidelines to their routine working systems. For example, strategies for coping with drug stock-outs include writing a prescription and sending the child to another health facility or the private market. These adaptations need to be included within the evaluation otherwise outcomes may be under (or over) estimated.

Where important blockages in the processes required for effective delivery of an intervention are identified, for example where those eligible for an intervention not being offered it as in the Ghana voucher scheme evaluation described in this thesis, then further research is needed to identify the reasons why the problems occur. Such research requires qualitative methods such as in-depth interviews and focus group discussions to investigate issues and events from the perspective and interpretation of a range of stakeholders. Once the problems have been identified steps may be taken to prevent them reoccurring. Purposive selection of participants for in-depth interviews should ensure that those linked with the delivery system at all levels are included, those at the policy level, down to those who at the front-line in delivering the intervention to the target population. Stratifications of the responses of advocates and opponents of the delivery system, or adopters and non-adopters may provide richer insights into process effectiveness. Where possible it may be advantageous to plan a timeline for repeated interviews to gauge any trends in perceptions and opinions of stakeholders over time.

7.2.5. Characterise the contextual factors

Contextual factors can have two different effects. They may be confounders of the relationship between outcome and delivery system including any of the intermediate processes of the system. Or they may act as implementation related effect modifiers where

they lie upon the causal pathway of the intervention and its outcome. Where there is more than one delivery system for the intervention under study, then the alternate delivery systems may act as confounders and/or as implementation related effect modifiers. These factors may be investigated using in-depth interviews alongside those aimed at examining the delivery system processes. As for the delivery system processes qualitative study, conducting the study over a period of time is advantageous as changes in the context may then be assessed.

7.3 Application of the methodology to other malaria control interventions

The likelihood that there will be more than one delivery system varies across malaria control interventions. It is clear from the previous chapters of this thesis that for ITNs it is likely that there will be more than one delivery system in operation at one time. ACTs may also be delivered through more than one delivery system including public health facilities, private health facilities, pharmacies, and the retail sector [215-216]. For IPTp however, with the exception of a few studies of delivery through community based systems [217-219], this intervention is primarily delivered through ANC in public, private and mission health facilities [220]. For most evaluations of the delivery of IPTp then, attribution is not required. Both IPTi and Intermittent Preventive Treatment for children under 5 years of age (IPTc) are new interventions and therefore in the first phase of evaluating delivery systems for these new interventions and during the primary stages of their implementation it can be safely assumed that they are only delivered through the system/s under study, and therefore including attribution in the evaluation is not necessary. Whilst IPTi was developed with EPI as its designated delivery channel [221] and its effectiveness and equity challenged [222], evaluations of different delivery systems for IPTc have been undertaken [223-224].

Evaluation of the effectiveness of intermediate processes in delivery is potentially important for all malaria control interventions, whether they are new or existing interventions and whatever system they are delivered through. There are examples of intermediate process analyses in evaluations of the delivery of IPTp and effective case management for malaria. A slightly adapted approach was taken by Gross *et al* who looked at loss in effectiveness of

delivery of IPTp where the intermediate processes included in the analysis were individual, facility and policy factors [225]. Intermediate processes for delivery of prompt and effective treatment of malaria through a combination of systems including health facilities, drug stores, general shops, and from within the home have been evaluated in Tanzania [164]. The objective of this evaluation was to identify barriers to prompt and effective treatment from all sources rather than to identify problems through specific delivery systems. However, where an intervention is delivered through more than one delivery system, then ideally the effectiveness of intermediate delivery processes should be measured for each system.

7.4 Evaluation contexts within which this methodology is applicable

This methodology is applicable when the objective is to evaluate the effectiveness of a delivery system for an intervention. It is not appropriate if the objective includes an assessment of the effectiveness of the intervention itself. This would require an intervention effectiveness evaluation.

The delivery systems context, together with resources available, would dictate whether all elements of the methodology presented above would be included in the evaluation. The most important question here is whether to include attribution. The relevance of attribution has been discussed above and relates to contexts where there is more than one delivery system for the intervention.

7.5 Discussion

7.5.1 The delivery systems evaluation methodology

A general approach to delivery systems evaluation was developed using the specific case of evaluation of delivery systems for ITNs. This methodology was designed to allow attribution of outcomes to the system through which they were delivered, enabling a causal inference that proximal outcomes were due to the system through which they were delivered, and a plausible inference for distal outcomes. Each delivery system functions as an internal control for the other systems and as such is affected by existing external contextual factors. Implementation effect modifiers are internal to each specific delivery system. The processes

of the delivery system were defined so that proximal outcome indicators at each step could be determined and assessed.

Use or adherence to the intervention by the population, are distal indicators that provide the link between delivery system effectiveness and health outcomes. The gap between ITN delivery system proximal and distal outcomes, that is between household ownership and use is a major cause for concern [202] and is influenced by a variety of factors [226-227]. Assessment of health outcomes is not required for delivery system evaluations. If a need to measure health outcomes is identified, then an evaluation of the intervention itself is required, rather than an evaluation of delivery system effectiveness.

This methodology was developed with a primary focus on delivery systems for ITNs. ITNs are appropriate for this role as they have probably been delivered through a greater range of delivery channels, delivery strategies, and delivery systems than any other public health intervention. This diversity in delivery systems means that ITNs provide insights into evaluation requirements to address a range of mixes of delivery systems in some quite different contexts.

An important limitation of the primary focus on ITNs in the development of this methodology, however, in terms of its applicability to other malaria control interventions is that for ITNs delivery processes are relatively simple, particularly those within the public sector. Delivery of ITNs in the public sector requires the provider to offer an ITN or a voucher to a pregnant woman on her first visit to ANC. Delivery of IPTp involves more complex delivery guidelines that may be misinterpreted by health workers [225], and a greater number of processes that may be conducted differently or not conducted at all. Delivery of IPTp requires that the pregnant woman is of the required gestation and/or 'quickening' (movement of the baby) has occurred before she is offered IPTp. IPTp should be given by DOT. Delivery of effective case management involves multiple intermediate processes, including diagnosis of disease. The relevance of these differences for evaluation is that that whilst household surveys were an appropriate method for evaluating the effectiveness of

intermediate delivery of ITNs, they are less appropriate where the intervention involves complex processes and possibly clinical decisions in health facilities.

In order to evaluate the effectiveness of intermediate processes for delivery of interventions involving complex processes, especially laboratory or clinical diagnosis in the public sector, other methods are needed which are health facility based. There is a dearth of quantitative health facility data on the processes of delivery of ITNs and vouchers through health facilities, but in-depth interviews have been held with MCH staff on use and misuse of vouchers [97, 228]. Quantitative methods for evaluating the effectiveness of delivery of IPTp through ANC have involved household surveys [229-230], structured interviews with staff and observations of ANC consultation[231], and exit interviews with pregnant women as they are leaving the facility [225]. Evaluation of the effectiveness of delivery of case management for malaria has involved health worker interviews, exit interviews [232-235], structured observations [232] and in-depth interviews with health workers [236]. If we are to improve the effectiveness of delivery of malaria control interventions, there is a need to increase the use of health facility surveys which are currently not frequently used. For example, although most countries of sub-Saharan Africa implement DHS surveys every 3 to 5 years, only 12 Service Provision Assessments (SPAs) that is health facility surveys were implemented in the 10 year period 2000 to 2010.

The methods used in this study of delivery processes were household surveys amongst currently and recently pregnant women in two regions of Ghana. The analysis and interpretation of the data therefore rely upon the validity of the responses given by the women in the survey. Any biases in these responses would reduce the internal validity of the study. For example, if women were not able to correctly recall or understand being offered a voucher, then they would be misclassified to offered or not offered and the effectiveness of that individual step and the overall delivery would be under or over estimated depending upon these misclassifications. If women in a particular geographic zone or socio-economic group were more likely to have problems in this recall or understanding, then this would introduce a bias. There is however, no credible reason why a woman from a particular

geographic zone or from a particular socio-economic group would have more difficulty in recalling being offered a voucher, or any other steps in the delivery process that she was asked about in this study. The sampled target population had differing duration and intensity of exposure to the intervention and this has not been fully accounted for in the study design. Analyses of process effectiveness were stratified by recently and currently pregnant women, but intensity of implementation of the voucher scheme and therefore intensity of exposure has not been assessed or accounted for.

7.5.2 Application of the methodology to other malaria control interventions

Approaches that have been taken to evaluation of delivery systems for ITNs were reviewed and discussed in chapter 2: Literature review. The approaches that have been taken to evaluating the delivery of IPTp and effective case management have varied from those taken to evaluation of ITN delivery. The nature of the interventions themselves seems to have influenced the approach to evaluation that is adopted. Mosquito nets to which insecticide treatment is added to produce an ITN have been household goods in most of Africa, but particularly in West Africa, for many years. They have therefore been delivered through a variety of systems, and there is no innately obvious appropriate system through which they should be delivered to reach the whole target population. Consequently, evaluations have covered a range of delivery systems, and evaluation methods have generally been aimed at assessing the relative coverage attributable to existing delivery systems, or to new ones within the context of those existing, and to the population groups targeted.

IPTp and effective case management, however, is drug based, and national policy usually dictates that they should be delivered through public sector health facilities, and often in combination with other delivery systems. For example policies in many countries now allow delivery of ACTs through the private sector. With a target group of pregnant women, ANC is the obvious delivery system for IPTp. Alternative delivery systems would be required if the target population were not being reached through ANC.

New delivery systems for IPTp have been community based approaches and these have been evaluated using non-randomised intervention studies with external geographic controls [217-219]. The disadvantage of this approach is that non-randomized external geographic control groups may be subject to a myriad of confounders which influence the relationship between the delivery system and the outcomes. Studies of the delivery of IPTp through ANC have been cross sectional observational studies with no control [229, 237-238]. As discussed for the delivery of ITNs, where doses of IPTp are attributed to specific delivery systems, external controls are unnecessary.

There have been few evaluations of new systems for delivering effective case management to febrile children and there has been no common methodological approach. Study designs are complicated by inclusion or exclusion of diagnosis for the presence of malaria parasites. The evaluations that have taken place have used RCTs [239] and observational cross sectional studies [240-242] with external geographic controls and no controls. The primary outcomes have been diverse, encompassing proximal indicators receiving an ACT [240], and receiving treatment according to protocol [241], and distal indicators including treatment incidence density per year [239]. Evaluations of existing delivery systems for malaria case management have had diverse objectives and have included evaluations of quality of case management after a policy change to studies on adherence. However, the majority of the evaluations used cross sectional observational surveys either at health facilities or the household, and did not use controls.

Few studies have described in sufficient detail the structure of the delivery systems being evaluated, and only in a minority have the processes been described [104, 164] and several proximal outcomes assessed [31, 74-75, 148]. Only by describing the delivery processes is it possible to identify the implementation effect modifiers and to ensure that these are included in the evaluation. There is perhaps a greater tendency towards assessment of health outcomes (that is evaluation of the effectiveness of the intervention) than to greater exploration of the delivery system and its enabling and disabling factors.

The practical implications of this evaluation framework are that observational cross sectional surveys can be implemented on a large scale, and applied easily to the evaluation of new delivery systems, natural experiments in which new delivery systems are introduced, or to evaluation of the current situation. The addition of a small number of questions per intervention to national surveys such as the Demographic and Health Surveys would enable such evaluations to be undertaken at little or no extra cost.

7.6 Conclusion

This chapter drew upon experiences of exploring and testing evaluation concepts and methods during the evaluation of a new delivery system for ITNs in two regions of Ghana. A 5-step methodology was developed and presented from this experience. The methodology draws upon quantitative and qualitative methods and is rooted within epidemiological principles. A methodology for evaluating delivery systems for malaria control interventions has not been previously defined. The methodology presented may be applied to other malaria control interventions and to a wider range of public health interventions beyond those for malaria control.

Chapter 8: Discussion

In this thesis an evaluation of a new delivery system for ITNs in two regions of Ghana that was conducted using a mixed methods approach broadly based upon programme evaluation and impact evaluation methodologies was presented in Chapters 4, 5, and 6. The methodology developed through this experience was presented and discussed in the previous chapter (Chapter 7: A methodology for the evaluation of delivery systems). In this chapter reflections focus around two main themes which are 1) the findings of the evaluation in relation to the voucher scheme, and more broadly the delivery of ITNs in Volta and Eastern Regions and 2) the conceptual framework for the influence of contextual factors on delivery systems and their evaluation.

8.1 Reflections on the findings of the evaluation

The outcome analysis suggested that the voucher scheme increased ownership of mosquito nets/ ITNs among the target group in Volta Region, but this increase was modest, whilst in Eastern Region the voucher scheme did not increase ownership of mosquito nets/ITNs. The quantitative process analysis identified losses in effectiveness of all processes in the voucher scheme, but there were two processes which were particularly ineffective. The qualitative process and contextual analysis provided a rich explanation for the loss of effectiveness of the voucher scheme processes. Triangulation across these three evaluation elements therefore increased the understanding of the multiple reasons for the loss of effectiveness of the intermediate processes and the low overall coverage outcomes.

The voucher scheme was implemented during a period in which there was increasing political pressure for countries to scale-up coverage with ITNs. The heads of African countries had recently signed the Abuja declaration with a view to scaling-up coverage with malaria control interventions. The aim of the declaration was to achieve the Abuja Targets by April 2005. The influx of funding to facilitate this scale-up, which has characterised the last five years of massive scale-up of ITNs in sub-Saharan Africa, had not yet occurred. In Ghana, the main delivery system for mosquito nets had been the informal private sector, with a relatively

weak and under-developed formal private sector. In the public sector delivery of ITNs had been initiated through ANC and CWCs in a limited number of districts. The number of districts was limited because the ITNs available were insufficient to cover all districts. Within this context of political pressure and limited resources, new ideas of ways in which to increase coverage that were backed by resources were welcomed. The support of the retail sector in the delivery of public health interventions has been welcomed for many years in Ghana. An example of this was the partnership between the public sector, GSMF and the private sector for the social marketing of ITNs in 1998 Chapter 3.6.4). Therefore the concept of a true partnership between the public and retail sectors in scaling-up ITNs was welcomed by many stakeholders.

The voucher scheme was operating within a complex public and private sector system, and there were several factors that contributed to the ineffectiveness of the voucher scheme and its displacement by competition from the direct delivery of ITNs through ANC. The limited capacity of the private sector and their inability to respond quickly to increased demand was not adequately considered when a short term voucher scheme was implemented in the commercial capital of the country. Planning and forecasting was inadequate for the combination of the Accra scheme together with the Volta and Eastern Region schemes. When the private sector's attention was distracted from the Volta Region, this triggered a cascade of events that precipitated the failure of the voucher scheme. Although the trigger point is clear, it is not clear whether some or all of the events that led to the failure would have eventually occurred in the absence of the competing voucher scheme in Greater Accra. Factors contributing to the failure were many and included lack of clarity around the scheme in the public sector, nurses not being able to observe whether the woman used her voucher to buy an ITN and disbelief that she would do so, preferences for giving an ITN in ANC, and lack of penetration of the private sector into rural areas.

Conversely, a voucher scheme for delivery of ITNs has been relatively successful in Tanzania. During implementation between 2005 and 2007, household ownership of at least one mosquito net increased from 44% to 65% ($p<0.001$) and the proportion of mosquito nets in

households with a child under 1 year that had been bought with a voucher from 7% to 50% ($p<0.001$) during the same time period [31]. The voucher scheme in Tanzania was scaled-up to national level over a period of 18 months, whereas the scheme in Ghana was in just two regions and was never seen as a strategy that would be implemented in all regions of the country. A strong base in social marketing from two projects, the KINET and the Social Marketing for ITNs project (SMITN) provided momentum for scale-up of ITNs in Tanzania [107]. The KINET project provided experience against which some of the systems issues of a national voucher scheme could be foreseen and appropriate designs developed. The other markedly different context was the well developed private sector for ITNs in Tanzania in comparison to that in Ghana. There were at least 4 net manufacturers in Tanzania and approximately 20,000 net retailers across urban and rural areas [31, 107, 243]. A thorough analysis of the differences in the systems context, design and implementation of the voucher schemes in Ghana and Tanzania would provide valuable lessons for future strategic decision-making on appropriate delivery choices for ITNs based upon country context.

The findings of this delivery systems evaluation suggest that the delivery of ITNs through ANC was relatively effective in increasing household ownership with ITNs in Eastern Region. The effectiveness of this delivery mechanism had not been previously shown in Ghana. The probable reason for this is that the method of 'monitoring' household ownership and use of ITNs is through national surveys such as the DHS. These surveys are designed to be representative at the national and regional levels, but not at the district level. Due to limited resources and therefore delivery of ITNs through scattered districts in the country, any increases in ownership and use of ITNs through district level interventions were diluted in such surveys and the impact of an effective delivery system, unseen. The three to five year time-lag between surveys also makes the use of these surveys less appropriate for national level monitoring of the impact of interventions.

Delivery of ITNs through ANC has been conducted on a large scale in Malawi and Kenya in a partnership between the NMCPs and an NGO, PSI. In Kenya, this system has been shown to achieve similar use of ITNs by children under 5 years of age as a mass campaign. A household

survey in four sentinel districts representing the dominant malaria transmission contexts in Kenya, in 2006/7 found that 41.2% of children under 5 slept under a net that was obtained from health facilities, and 43.6% from a free mass distribution of ITNs [29]. However, socio-economic disparities in the households who received the ITNs decreased significantly when nets were delivered through mass campaigns compared with through ANC. There is little evidence however, on achievements in delivery through ANC without the support of an NGO for both logistics systems and monitoring, and evidence available was in the context of an intervention delivered through a research study [74, 111]. Although delivery of ITNs through ANC is supported by WHO and the RBM VCWG [244], there is little evidence on the proportion of pregnant woman going to ANCs with ITNs available, that are offered one. More evidence is needed on the effectiveness of ANC as a delivery system for ITNs. It would be possible to obtain this information with the addition of one question on DHS surveys asked of pregnant women who attended ANC "were you given an ITN on any visit to ANC for this/your last pregnancy?" More information on the timing of when they received the ITN through ANC if required could be gathered with the addition of further questions.

A limitation of the evaluation was that implementation fidelity or the degree to which the intervention was implemented as designed (Chapter 1.2) was not fully measured. Most of the implementation steps that is, the implementation process, were covered in the evaluation of the voucher scheme in Volta and Eastern Regions, but the training of health workers in the scheme was omitted, as was supply of vouchers in health facilities and ITNs in retail outlets. Cascade training was used, in which health workers who received formal training were expected to train their peers upon their return to the health facility. There are examples in the literature of the failure of cascade training [245]. The findings of the quantitative and qualitative process evaluations such as the one presented in this thesis could be used in any feedback mechanism to improve the performance of health workers in delivering ITN vouchers, and in encouraging women to use the voucher to buy ITNs and sleep under an ITN. Problems in the initial implementation period in Volta Region were based on misunderstandings about the nature of the vouchers and may have been due to lack of training. There was some indication that many of those trained in the scheme were not the

people who worked in ANC on a daily basis and therefore those who were delivering the voucher were not actually trained. In future evaluations, implementation fidelity needs to be addressed so that it is clear whether what is being assessed is an innovation adequately implemented or one which has not been adequately implemented. These two scenarios raise different research questions about the innovation.

8.2 The conceptual framework for delivery systems context

In Chapter 3.4 a broad based basic conceptual framework was presented for the action of confounders and effect modifiers in the evaluation of interventions. This framework was used as the basis for the evaluation of the ITN voucher scheme conducted in Volta and Eastern Regions. Based upon the findings of the evaluation, this framework was further developed to more specifically address delivery system evaluation (Figure 8.1). A major conceptual difference between intervention evaluation and delivery system evaluation is that of context.

Findings of this thesis provided insights into the way in which context needs to be taken into account in delivery systems evaluation, particularly where more than one delivery system for an intervention is available and functioning. The focus was predominantly on the influence of different kinds of contextual factors on the delivery systems, particularly a delivery system which crosses more than one delivery sector. The framework conceptualises the linkages between contextual factors and delivery sectors; and among contextual factors, the delivery system and the outcome of household ownership of a mosquito net. Where alternative delivery systems are available and functioning they act as contextual factors that may have, as presented in this thesis, a profound effect upon the effectiveness of the delivery system under study.

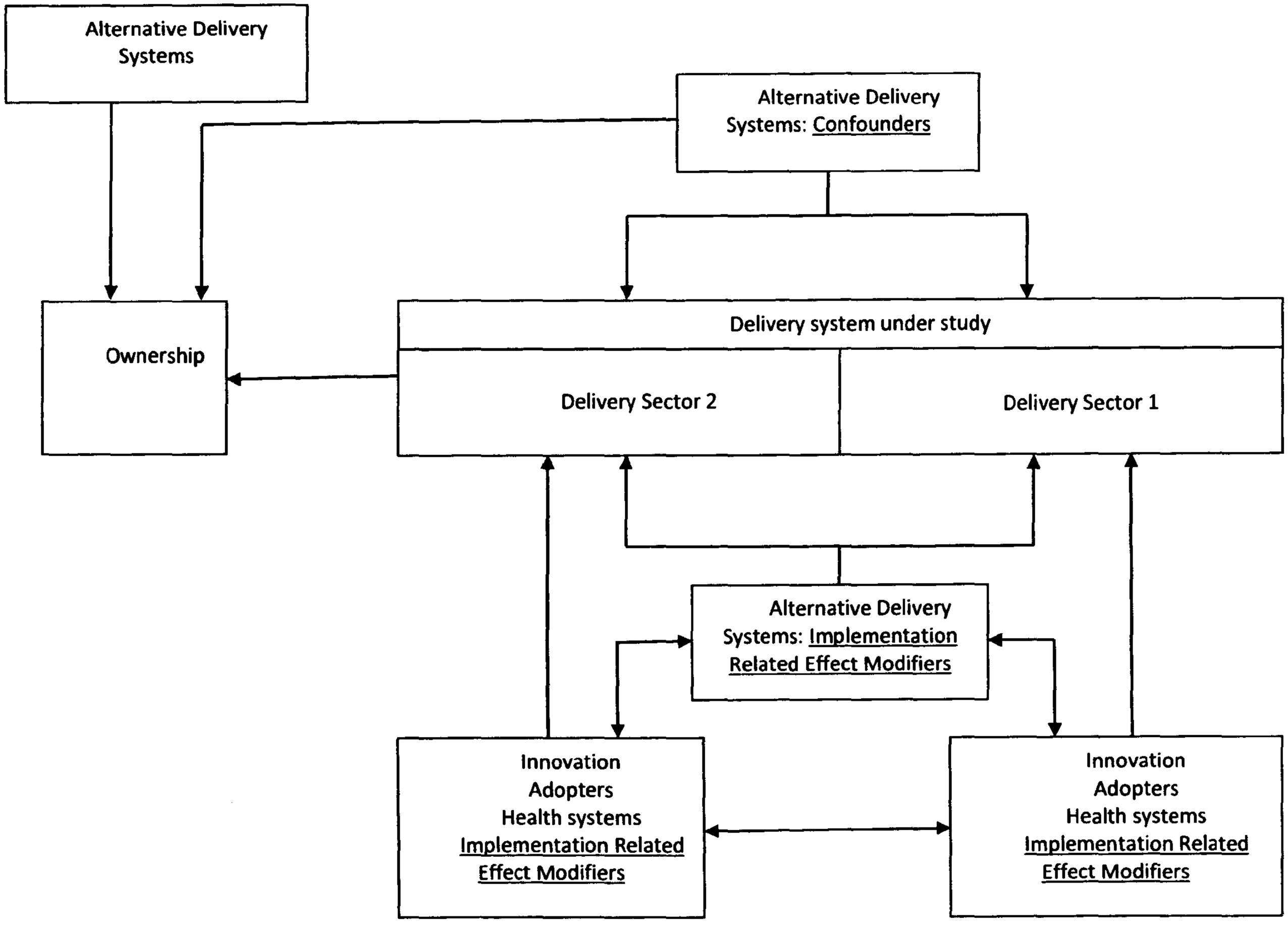

Figure 8.1: conceptual framework of the influence of contextual factors on delivery systems and their evaluation

Conceptualising alternative delivery systems as contextual factors provides important new insights and is the major addition to evaluation literature made by this thesis. Whilst providing a useful general evaluation background, none of the literatures used as a basis for development of this methodology had a major focus on delivery systems or their evaluation. Elements of programme evaluation, particularly study designs required to achieve a plausibility inference were used in the development of the methodology, together with the concept of attribution, drawn from the impact evaluation literature. The concept of diffusion of innovations and their assimilation into health systems has been expanded recently to include an institutional dimension, but still without a focus on the possible presence of multiple delivery systems and of adoption and diffusion of interventions and delivery systems across the public and private sectors.

The conceptual thinking upon which this methodology was developed, did not all take place before design, planning and implementation of the voucher scheme evaluation in the two regions of Ghana. Its development has been an ongoing process which has been aided by the voucher scheme evaluation experience. The effect of this is that the data that were collected and the design through which they were collected were not always adequate for proposed or prospective analyses. For example, classic sample size calculations were made in designing the household surveys that allowed acceptable level of precision on the final outcome estimates. However, for conducting quantitative process analyses, or systems effectiveness analyses, the evaluable sample reduces at each step in the process, meaning that processes a few steps down the causal chain in delivery system effectiveness have a reduced sample size and consequently generated wide confidence intervals and reduced precision. In future studies, this problem can be addressed by hypothesising the proportion of the evaluable sample likely to be lost at each intermediate process and increasing the initial sample size accordingly.

The qualitative study was severely under-resourced and therefore it was only possible to interview either providers or pregnant women. In retrospect, the choice of providers was the right decision and was the source of rich information about the delivery systems and their interactions. However, this did mean that any additional information from pregnant women was

missed. There may have been value in purposively selecting health workers for interview in health facilities where monitoring data suggested that the voucher scheme was doing relatively well and those where it was functioning particularly ineffectively, to enable comparison. It would also have been very valuable, in retrospect, to conduct qualitative interviews with a range of stakeholders over time, including during the first 3 months of the voucher scheme, after 6 months and after 1 year, in line with the changing context.

The evaluation approach taken in this thesis has shown that delivery systems may act as different types of contextual factors. They may impact upon the outcome measure alone without impacting upon the delivery system under study, for example purchasing a mosquito net from the informal sector would increase household ownership of mosquito nets (but not ITNs), and may not necessarily impact upon the receipt and use of a voucher for an ITN through the voucher scheme. Alternative delivery systems may act as confounders where they are independently associated with both the outcome and the intervention. For example, in the case of the formal retail sector, the household ownership of mosquito nets/ITNs may be increased through the formal private sector independently of the voucher scheme, and the level of development of retail sector is also independently associated with the relationship between the outcome of household ownership of ITNs and the voucher scheme. Where there are closer linkages between delivery systems, for example where they are delivered by the same providers and/or through the same delivery point, then the alternative delivery system may act as an implementation related effect modifier between the delivery system under study and the outcome. This was seen quite clearly with the relationship between the delivery of ITNs through the public sector and the voucher scheme in Volta and Eastern Regions. Here, the delivery of ITNs in the public sector lay on the causal pathway between the voucher scheme and the ownership of an ITN in the household, as there was direct competition between the two systems at the point of delivery within the public sector.

Delivery systems evaluations therefore need to be comprehensive enough to capture these factors and linkages where they exist, and versatile enough to be enable evaluation of single

delivery systems, involving single delivery sectors, single delivery systems involving multiple delivery sectors, and multiple delivery systems involving multiple sectors.

8.3 Conclusion

This study has: 1) shown that inclusion of questions on source of an ITN in a household survey can be used to attribute an ITN to a specific delivery system, to enable a plausibility inference on the effectiveness of a delivery system in the context of the presence of multiple delivery systems; 2) demonstrated that a mix of quantitative and qualitative process evaluations can provide evidence on the effectiveness of intermediate processes within the delivery system and reasons for loss of effectiveness in these processes. These findings contributed to defining a 5-step methodology for evaluation of delivery systems. The systems through which national policies are to be delivered are less often defined, leading to significant gaps between policies and their implementation. Strategic direction for delivery of public health interventions such as ITNs has the potential to increase the overall effectiveness of their delivery and increase coverage of interventions. Delivery systems for ITNs need to be presented as a national scale strategic direction by which the most effective combinations of delivery strategies are defined and behind which partners can align and harmonise depending upon their relative missions. Non-alignment may result in competitive strategies that reduce the effectiveness of the delivery systems, and therefore deprive populations of interventions that have known potential to significantly decrease the burden of morbidity and mortality due to malaria. The delivery systems evaluation methodology developed in this thesis has the potential to contribute to defining the most effective combinations of delivery strategies.

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Appendix 1: Household survey instruments

PAGE NUMBERING AS ORIGINAL

Household Survey Instrument: pre-implementation

Questionnaire for pregnant women/mothers of children <1 year

Interviewer ID Number [ ] Date of interview ___/___/___

District _____ District Code [ ]

Cluster number [ ]

Village name _____

Name of respondent _____ Age [ ]

Education background (highest level of education attended)

1) None [ ]
2) Primary [ ]
3) Middle/JSS [ ]
4) Secondary/SSS/Tech/Voc [ ]
5) Tertiary (polytechnic, university) [ ]

Q1	Members of the household (those who normally live and sleep in the household)											
	Ask respondent				Complete after interview is finished							
	First name	Age	Sex	Pregnant	Number of nets in the household [ ]							
					Net 1		Net 2		Net 3		Net 4	
					Slept under a net last night	Net treated	Slept under a net last night	Net treated	Slept under a net last night	Net treated	Slept under a net last night	Net treated
01												
02												
03												
04												
05												
06												
07												
08												
09												
10												
11												
12												

				Go to
Q2	Does your household have any mosquito nets that can be used while sleeping? [I am not talking about baby nets that just fit an infant or screening on windows and doors]	1= Yes		Q4
		2= No		Q3

			Go to
Q3	Why doesn't your household have any mosquito nets? Don't read responses. Allow multiple responses	A= Don't have any/enough money [ ]	
		B= Too expensive [ ]	
		C= Not available / don't know where to get them [ ]	
		D= Don't like them [ ]	
		E= Don't need them [ ]	
		F= There are no mosquitoes here [ ]	
		G= Nets won't fit on the sleeping place [ ]	
		H= Other (specify) [ ]	
		I= DK[1] [ ]	
			Q37/41

Q4	How many mosquito nets does your household have?	Number of nets [ ]				
						Go to
Q5	Ask respondent to show you the net(s) in the household [newest net = net 1, etc.]	Net 1 observed	Net 2 observed	Net 3 observed	Net 4 observed	
		1=Yes [ ]	1=Yes [ ]	1=Yes [ ]	1=Yes [ ]	Q6
		2=No [ ]	2=No [ ]	2=No [ ]	2=No [ ]	Q7

						Go to
Q6	What is the condition of the net. Interviewer's assessment. Do not ask the respondent.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		Q6a Holes in the body of the net that are larger than 1 finger but smaller than 1 fist (include those that have been repaired)				
		1= 0 holes [ ]	[ ]	[ ]	[ ]	
		2= 1 – 5 holes [ ]	[ ]	[ ]	[ ]	
		3= > 5 holes [ ]	[ ]	[ ]	[ ]	
		Q6b Holes in the body of the net that are larger than a fist (include those that have been repaired)				
		1= 0 holes [ ]	[ ]	[ ]	[ ]	
		2= 1 – 5 holes [ ]	[ ]	[ ]	[ ]	
		3= > 5 holes [ ]	[ ]	[ ]	[ ]	
		Q6c Are there any holes larger than a fist in the seams?				
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	

[1] DK = Don't know

						Go to
Q7	Did you get your net ready made, or did you buy the material and have it sewn into a net?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Ready made [ ]	[ ]	[ ]	[ ]	
		2= Bought material then sewn by someone [ ]	[ ]	[ ]	[ ]	
		3= DK [ ]	[ ]	[ ]	[ ]	
Q8	Observe the net. What type of fabric is the net made from? **[Check against fabric swatches provided]**[2] If the net not observed show the swatches to the respondent.	1= Standard netting [ ]	[ ]	[ ]	[ ]	
		Other fabrics				
		2= Patterned non-standard netting [ ]	[ ]	[ ]	[ ]	
		3= Plain non-standard netting [ ]	[ ]	[ ]	[ ]	
		4= Non-netting (including calico) [ ]	[ ]	[ ]	[ ]	
		5= Mixed (2 or more of the above) [ ]	[ ]	[ ]	[ ]	
Q9	What is the name on the label [Check label]	1= Permanet [ ]	[ ]	[ ]	[ ]	
		2= Siamdutch [ ]	[ ]	[ ]	[ ]	
		3= Vestergaard [ ]				
		4= Other (specify) [ ]	[ ]	[ ]	[ ]	
		5= No label [ ]	[ ]	[ ]	[ ]	
Q10	What brand is the net? Ask respondent.	1= Permanet [ ]	[ ]	[ ]	[ ]	
		2= Dawanet [ ]	[ ]	[ ]	[ ]	
		3= K-O Net [ ]	[ ]	[ ]	[ ]	
		4= Brand _____ [ ]	[ ]	[ ]	[ ]	
		5= Brand _____ [ ]	[ ]	[ ]	[ ]	
		6= Brand _____ [ ]	[ ]	[ ]	[ ]	
		7= Brand _____ [ ]	[ ]	[ ]	[ ]	
		8= Unbranded/DK [ ]	[ ]	[ ]	[ ]	

Q11	How long ago did you get the net? Do not prompt	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= 6 months or less [ ]	[ ]	[ ]	[ ]	
		2= 7-12 months [ ]	[ ]	[ ]	[ ]	
		3= 13-23 months [ ]	[ ]	[ ]	[ ]	
		4= 2-3 years [ ]	[ ]	[ ]	[ ]	
		5= >3 years (specify) [ ]	[ ]	[ ]	[ ]	
		6= DK [ ]	[ ]	[ ]	[ ]	

[2] The interviewer is provided with swatches of available varieties of fabric, categorised as netting and non-netting fabric

Q12	When you got your mosquito net did it come packaged with an insecticide?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	**Go to**
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q14
		3= DK [ ]	[ ]	[ ]	[ ]	Q14

Q13	Were the instructions clear to you? Do not prompt	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	
		3= Didn't read them [ ]	[ ]	[ ]	[ ]	
		4= Someone explained to me when I bought it [ ]	[ ]	[ ]	[ ]	
		4= DK [ ]	[ ]	[ ]	[ ]	

Q14	Since you got the net was it ever treated with an insecticide to repel mosquitoes or bugs? (This includes the time of buying it)	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q24
		3= DK [ ]	[ ]	[ ]	[ ]	Q24

Q15	How was it treated? Allow the respondent to describe – do not prompt.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Net dipped in insecticide solution [ ]	[ ]	[ ]	[ ]	Q16
		2= Aerosol spray or flit-gun [ ]	[ ]	[ ]	[ ]	Q24
		3= Bought already treated [ ]	[ ]	[ ]	[ ]	Q24
		4= Other (specify) [ ]	[ ]	[ ]	[ ]	Q24
		5= DK [ ]	[ ]	[ ]	[ ]	Q24

Q16	How many times has the net been soaked or dipped in a liquid to repel mosquitoes or bugs? (This includes the time of buying it)	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= 1 [ ]	[ ]	[ ]	[ ]	
		2= 2 [ ]	[ ]	[ ]	[ ]	
		3= 3 [ ]	[ ]	[ ]	[ ]	
		4= >3 [ ]	[ ]	[ ]	[ ]	

Q17	Did you soak or dip the net in insecticide yourself, or did you take it somewhere else to be soaked or dipped?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Treated it myself [ ]	[ ]	[ ]	[ ]	Q18
		2= Took it somewhere else to be treated [ ]	[ ]	[ ]	[ ]	Q19
		3= DK [ ]	[ ]	[ ]	[ ]	Q18

						Go to
Q18	Where did you get the insecticide? [Answer even if it was packaged with a net] Do not prompt One answer only per net.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= General shop [ ]	[ ]	[ ]	[ ]	
		2= Market [ ]	[ ]	[ ]	[ ]	
		3= Pharmacy [ ]	[ ]	[ ]	[ ]	
		4= Chemical seller [ ]	[ ]	[ ]	[ ]	
		5= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	
		6= Clinic / hospital [ ]	[ ]	[ ]	[ ]	
		7= Vaccination campaign [ ]	[ ]	[ ]	[ ]	
		8= School [ ]	[ ]	[ ]	[ ]	
		9= Gift – someone gave it to me [ ]	[ ]	[ ]	[ ]	
		10= Employer [ ]	[ ]	[ ]	[ ]	
		11= Other (specify) [ ]	[ ]	[ ]	[ ]	
		12= DK [ ]	[ ]	[ ]	[ ]	
						Go to
Q19	Where did you take the net to get it treated with insecticide? Do not prompt	**Net 1**	**Net 2**	**Net 3**	**Net 4**	**Q21**
		1= General shop [ ]	[ ]	[ ]	[ ]	
		2= Market [ ]	[ ]	[ ]	[ ]	
		3= Pharmacy [ ]	[ ]	[ ]	[ ]	
		4= Chemical seller [ ]	[ ]	[ ]	[ ]	
		5= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	
		6= Clinic / hospital [ ]	[ ]	[ ]	[ ]	Q20
		7= Outreach clinic [ ]	[ ]	[ ]	[ ]	Q20
		8= Community volunteer [ ]	[ ]	[ ]	[ ]	
		9= Vaccination campaign [ ]	[ ]	[ ]	[ ]	
		10= School [ ]	[ ]	[ ]	[ ]	
		11= Employer [ ]	[ ]	[ ]	[ ]	
		12= Other (specify) [ ]	[ ]	[ ]	[ ]	
		13= DK [ ]	[ ]	[ ]	[ ]	
Q20	Who in the clinic did the treatment	1= Clinic staff [ ]	[ ]	[ ]	[ ]	
		2= Community volunteer [ ]	[ ]	[ ]	[ ]	

						Go to
Q21	How long ago was the net soaked or dipped in a liquid to repel mosquitoes or bugs? I am not talking about treating with an aerosol spray or a flit-gun	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= 6 months or less [ ]	[ ]	[ ]	[ ]	
		2= 7-11 months [ ]	[ ]	[ ]	[ ]	
		3= 1-3 years [ ]	[ ]	[ ]	[ ]	
		4= > 3 years [ ]	[ ]	[ ]	[ ]	
		5= DK [ ]	[ ]	[ ]	[ ]	

Q22	Is the insecticide still working?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	
		3= It never worked [ ]	[ ]	[ ]	[ ]	
		4= Other (specify) [ ]	[ ]	[ ]	[ ]	

						Go to
Q23	What was the name of the product that was used to treat your net?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= K-O Tab [ ]	[ ]	[ ]	[ ]	
		2= Solfac [ ]	[ ]	[ ]	[ ]	
		3= IcoNet [ ]	[ ]	[ ]	[ ]	
		4= Deltamethrin [ ]	[ ]	[ ]	[ ]	
		5= Other (specify)[ ]	[ ]	[ ]	[ ]	
		6= DK [ ]	[ ]	[ ]	[ ]	

						Go to
Q24	Did anyone sleep under this mosquito net last night	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q26
		3= DK [ ]	[ ]	[ ]	[ ]	
Q25	Who slept under this mosquito net last night? [Use person code from Q1]	01 [ ]	[ ]	[ ]	[ ]	
		02 [ ]	[ ]	[ ]	[ ]	
		03 [ ]	[ ]	[ ]	[ ]	
		04 [ ]	[ ]	[ ]	[ ]	
		05 [ ]	[ ]	[ ]	[ ]	
		06 [ ]	[ ]	[ ]	[ ]	
		07 [ ]	[ ]	[ ]	[ ]	
		08 [ ]	[ ]	[ ]	[ ]	
		09 [ ]	[ ]	[ ]	[ ]	
		10 [ ]	[ ]	[ ]	[ ]	
		Other [ ]	[ ]	[ ]	[ ]	
		14= Visitor [ ]	[ ]	[ ]	[ ]	
		15= DK [ ]	[ ]	[ ]	[ ]	

			Go to
Q26	When in the year do people in your household use a mosquito net? Do not prompt	1= Throughout the year/all year [ ]	
		2= Rainy season [ ]	
		3= Dry season/harmattan [ ]	
		4= Other (specify) [ ]	
Q27	Every night or sometimes?	1= Every night [ ]	
		2= Sometimes [ ]	

Q28	How many months a year do people in your household use a mosquito net?	1= Months [ ]	
		2= DK [ ]	

						Go to
Q29	Where did you get the mosquito net? [Do not read responses. One answer only for each net]	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Market [ ]	[ ]	[ ]	[ ]	
		2= Local kiosk [ ]	[ ]	[ ]	[ ]	
		3= Street hawker [ ]	[ ]	[ ]	[ ]	
		4= Table top vendor [ ]	[ ]	[ ]	[ ]	
		5= Table top vendor close to clinic [ ]	[ ]	[ ]	[ ]	
		6= General shop [ ]	[ ]	[ ]	[ ]	
		7= Clothes/Fabric shop [ ]	[ ]	[ ]	[ ]	
		8= Wholesaler [ ]	[ ]	[ ]	[ ]	
		9= Pharmacy [ ]	[ ]	[ ]	[ ]	
		10= Chemical seller [ ]	[ ]	[ ]	[ ]	
		11= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	
		12= Clinic/hospital [ ]	[ ]	[ ]	[ ]	
		13= Outreach clinic [ ]	[ ]	[ ]	[ ]	
		14= School [ ]	[ ]	[ ]	[ ]	
		15= Gift/somebody bought t for me [ ]	[ ]	[ ]	[ ]	
		16= Employer [ ]	[ ]	[ ]	[ ]	
		17= Other (specify) [ ]	[ ]	[ ]	[ ]	
		18= DK / can't recall [ ]	[ ]	[ ]	[ ]	
Q30	In which town did you buy it?	Town [ ]	[ ]	[ ]	[ ]	
Q31	And which district	District [ ]	[ ]	[ ]	[ ]	
Q32	How long does it take to get to where you bought the net?	1= < 1 hour [ ]	[ ]	[ ]	[ ]	
		2= 1-2 hours [ ]	[ ]	[ ]	[ ]	
		3= > 2 hours [ ]	[ ]	[ ]	[ ]	
		4= DK [ ]	[ ]	[ ]	[ ]	
Q33	How much did you pay for the mosquito net?	Cedis [ ]	[ ]	[ ]	[ ]	
		CFA [ ]	[ ]	[ ]	[ ]	
		Nothing, it was free [ ] =8888	[ ]	[ ]	[ ]	
		3= DK / Can't remember [ ] =9999	[ ]	[ ]	[ ]	
Q34	How did you pay for the net?	1= Outright [ ]	[ ]	[ ]	[ ]	
		2 = In 2 instalments [ ]	[ ]	[ ]	[ ]	
		3 = In 3 instalments [ ]	[ ]	[ ]	[ ]	
		4 = In > 3 instalments [ ]	[ ]	[ ]	[ ]	
		5 = Other (specify) [ ]	[ ]	[ ]	[ ]	

			Go to
Q35	When you got your newest net, did you use it to replace an old net?	1= Yes [ ]	
		2= No [ ]	Q37
		3= This is my first net [ ]	Q37

Q35	Where is the old net now?	1= Still in the household [ ]	
		2=Thrown away [ ]	
		3= Given to another household [ ]	
		4= Other (specify) [ ]	
		5= DK [ ]	

	Question to pregnant women only	If not pregnant women Go To 41	Go to
Q37	Is this your first pregnancy?	1= Yes [ ]	
		2= No [ ]	
Q38	Have you visited an antenatal clinic since you have been pregnant this time?	1= Yes [ ]	
		2= No [ ]	
Q39	What is the name of the antenatal clinic. Please give names of all clinics visited since you got pregnant this time.	Name [ ]	
		Name [ ]	
		Name [ ]	
Q40	Were you asked to buy a mosquito net at the clinic?	1= Yes [ ]	
		2= No [ ]	

	Question to mothers of children <1 only	If not a mother of a child <1 Go To Q44	Go to
Q41	How many children do you have?	1= 1 [ ]	
		2= 2- 3 [ ]	
		3= 4 or more [ ]	
Q42	Did you visit an antenatal clinic whilst you were pregnant with your youngest child?	1= Yes [ ]	
		2= No [ ]	
Q43	Were you asked to buy a mosquito net at the ANC?	1= Yes [ ]	
		2= No [ ]	

Questions to all respondents

			Go to
Q44	If you wanted to get a net, where is the nearest place you could get one?	Name of village / town [ ]	
		Don't know [ ]	Q49

Q45	If you want to buy a net would you go and buy it yourself or would you send someone else?	1= Buy it myself [ ]	
		2= Get someone else to buy it for me [ ]	
		3= Other (specify) [ ]	
		4= DK [ ]	
Q46	How long does it take to get to this place?	1= Less than 1 hour [ ]	
		2= 1-2 hours [ ]	
		3= More than 2 hours [ ]	
		4= DK [ ]	
Q47	How often do you or someone from your household visit this place?	1= Every day [ ]	
		2= Every week [ ]	
		3= Every 2 weeks [ ]	
		4= Every month [ ]	
		5= Every 2-3 months [ ]	
		6= Less frequently than every 3 months [ ]	
		7= DK [ ]	
Q48	What type of place can you get the net from in [name of place quoted above]. Do not read responses First answer only.	1= Market [ ]	
		2= Local kiosk [ ]	
		3= Street hawker [ ]	
		4= Table top vendor close to clinic [ ]	
		5= General shop [ ]	
		6= Clothes/Fabric shop [ ]	
		7= Wholesaler [ ]	
		8= Pharmacy [ ]	
		9= Chemical seller [ ]	
		11= Project (e.g. NGO) [ ]	
		12= Clinic/hospital [ ]	
		13= Outreach clinic [ ]	
		14= School [ ]	
		15= Other (specify) [ ]	
		16= Don't know [ ]	

			Go to
Q49	Have you ever bought anything from a shop at a petrol station?	1= Yes [ ]	
		2= No [ ]	
Q50	Do you use anything else to stop mosquitoes biting you?	1= Yes [ ]	
		2= No [ ]	

Q51	What do you use? Ask all respondents (even when the answer to Q49 was no) Read responses. Multiple answers allowed	A = Coils [ ]	
		B = Sprays or flit-guns [ ]	
		C = Skin repellents [ ]	
		D = Screening on windows/doors [ ]	
		E = Have the house sprayed professionally [ ]	
		F = Other (specify) [ ]	
		G= Ceiling fan [ ]	
		H= Air conditioner [ ]	

			Go to
Q52	When in the year do mosquitoes bother or bite you most? Don't read responses	1= Rainy season [ ]	
		2= Dry season/harmattan [ ]	
		3= Through out the year [ ]	
		4= Other (specify) [ ]	
Q53	When in the day do mosquitoes bother or bite you the most **in the house**? One response only	1= Morning [ ]	
		2= Afternoon [ ]	
		3= Evening or night before sleeping [ ]	
		4= At night when you are sleeping [ ]	
		5= All day long [ ]	

			Go to
Q54	In the last 12 months have you seen or heard any information about insecticide treated mosquito nets/bednets and/or retreatment of mosquito nets?	1= Yes [ ]	
		2= No [ ]	Q56

Q55	Where did you see or hear this information Do not read responses Allow multiple answers	A= Radio [ ]	
		B= Television [ ]	
		C= Newspaper / magazine [ ]	
		D= Staff at shop / pharmacy / market [ ]	
		E= Health staff [ ]	
		F= Poster / notice at health facility [ ]	
		G= Church / mosque [ ]	
		H= School [ ]	
		I= Drama group / road show [ ]	
		J= Friends / neighbours / relatives [ ]	
		K= Billboards [ ]	
		L= Women's group(s) [ ]	
		M= Organisation (specify) [ ]	
		N= Other (specify) [ ]	
		O= Don't know / can't recall [ ]	

			Go to
Q56	What is the **main** source of **drinking** water for members of your household?	**Piped water**	
		1= Piped into house [ ]	Q58
		2= Piped into compound [ ]	Q58
		3= Piped into neighbours compound [ ]	
		3= Public tap [ ]	
		Water from open well	
		4= Open well in compound [ ]	Q58
		5= Open public well [ ]	
		Water from covered well or bore hole	
		6= Protected well in compound [ ]	Q58
		7= Protected public well [ ]	
		Surface water	
		8= Spring [ ]	
		9= River/Stream [ ]	
		10= Pond/Lake [ ]	
		11= Dam [ ]	
		12= Rainwater [ ]	
		13= Tanker truck [ ]	
		14= Bottled water [ ]	
		15= Sachets of water [ ]	
		16= Other (specify) [ ]	

Q57	How long does it take you to go there, get water and come back?	Minutes [ ]	
Q58	What kind of toilet facilities do you have **within your house or compound**?	1= Flush toilet [ ]	
		2= Pit latrine (traditional) [ ]	
		3= Pit latrine (KVIP) [ ]	
		4= None [ ]	
		5= Other (specify) [ ]	
Q59	Do you share these facilities with other households?	1= Yes [ ]	
		2= No [ ]	
Q60	Does your household own Read responses Tick if yes	Electricity [ ] (1= yes 2= No)[3]	
		Radio [ ] (1= yes 2= No)	
		Television [ ] (1= yes 2= No)	
		Video deck [ ] (1= yes 2= No)	
		Telephone : landline [ ] (1= yes 2= No)	
		Mobile telephone [ ] (1= yes 2= No)	
		Refrigerator [ ] (1= yes 2= No)	
		Deep freeze [ ] (1= yes 2= No)	

[3] For data entry only

			Go to
Q61	What type of fuel does your household **mainly** use for cooking? Not more than two answers.	1= Electricity [ ]	
		2= Gas [ ]	
		3= Kerosene [ ]	
		4= Straw [ ]	
		5= Charcoal [ ]	
		6= Firewood [ ]	
		7= Dung [ ]	
		8= Other (specify) [ ]	
Q62	Observe the main material of the floor One answer only	1= Earth/sand [ ]	
		2= Dung [ ]	
		3= Terazo [ ]	
		4= Wood planks [ ]	
		5= Parquet or polished wood [ ]	
		6= Ceramic tiles [ ]	
		7= Cement [ ]	
		8= Carpet [ ]	
		9= Linoleum [ ]	
		10= Other (specify) [ ]	

Q63	Does any member of your household own Read responses Allow multiple answers.	A= A bicycle [ ]	(1=yes 2= no)	
		B= A motor cycle [ ]	(1=yes 2= no)	
		C= Private car [ ]	(1=yes 2= no)	
		D= Taxi/passenger vehicle [ ]	(1=yes 2= no)	
		E= Truck [ ]	(1=yes 2= no)	
		F= Corn/Cassava mill [ ]	(1=yes 2= no)	

Household Survey Instrument: post implementation

Questionnaire for pregnant women/mothers of children <1 year

Interviewer ID Number [ ] Date of interview ___/___/___

District _____ District Code [ ]

Cluster number [ ]

Village name _____

Name of respondent _____ Age [ ]

Education background (highest level of education attended)

1) None [ ]
2) Primary [ ]
3) Middle/JSS [ ]
4) Secondary/SSS/Tech/Voc [ ]
5) Tertiary (polytechnic, university) [ ]

Q1	Members of the household (those who normally live and sleep in the household)											
	Ask respondent				Complete after interview is finished							
	First name	Age	Sex	Pregnant	Number of nets in the household [ ]							
					Net 1		Net 2		Net 3		Net 4	
					Slept under a net last night	Net treated	Slept under a net last night	Net treated	Slept under a net last night	Net treated	Slept under a net last night	Net treated
01												
02												
03												
04												
05												
06												
07												
08												
09												
10												
11												
12												

			Go to
Q2	Does your household have any mosquito nets that can be used while sleeping? [I am not talking about baby nets that just fit an infant or screening on windows and doors]	1= Yes	Q4
		2= No	Q3

			Go to
Q3	Why doesn't your household have any mosquito nets? Don't read responses. Allow multiple responses	A= Don't have any/enough money [ ]	
		B= Too expensive [ ]	
		C= Not available / don't know where to get them [ ]	
		D= Don't like them [ ]	
		E= Don't need them [ ]	
		F= There are no mosquitoes here [ ]	
		G= Nets won't fit on the sleeping place [ ]	
		H= Other (specify) [ ]	
		I= DK[1] [ ]	
			Q37/41

Q4	How many mosquito nets does your household have?	Number of nets [ ]				
						Go to
Q5	Ask respondent to show you the net(s) in the household [newest net = net 1, etc.]	Net 1 observed	Net 2 observed	Net 3 observed	Net 4 observed	
		1=Yes [ ]	1=Yes [ ]	1=Yes [ ]	1=Yes [ ]	Q6
		2=No [ ]	2=No [ ]	2=No [ ]	2=No [ ]	Q7

						Go to
Q6	What is the condition of the net. Interviewer's assessment. Do not ask the respondent.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		Q6a Holes in the body of the net that are larger than 1 finger but smaller than 1 fist (include those that have been repaired)				
		1= 0 holes [ ]	[ ]	[ ]	[ ]	
		2= 1 – 5 holes [ ]	[ ]	[ ]	[ ]	
		3= > 5 holes [ ]	[ ]	[ ]	[ ]	
		Q6b Holes in the body of the net that are larger than a fist (include those that have been repaired)				
		1= 0 holes [ ]	[ ]	[ ]	[ ]	
		2= 1 – 5 holes [ ]	[ ]	[ ]	[ ]	
		3= > 5 holes [ ]	[ ]	[ ]	[ ]	
		Q6c Are there any holes larger than a fist in the seams?				
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	

						Go to
Q7	Did you get your net ready made, or did you buy the material and have it sewn into a net?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Ready made [ ]	[ ]	[ ]	[ ]	
		2= Bought material then sewn by someone [ ]	[ ]	[ ]	[ ]	
		3= DK [ ]	[ ]	[ ]	[ ]	

[1] DK = Don't know

Q8	Observe the net. What type of fabric is the net made from? **[Check against fabric swatches provided]**[2] If the net not observed show the swatches to the respondent.	1= Standard netting	[ ]	[ ]	[ ]	[ ]	
		Other fabrics					
		2= Patterned non-standard netting	[ ]	[ ]	[ ]	[ ]	
		3= Plain non-standard netting	[ ]	[ ]	[ ]	[ ]	
		4= Non-netting (including calico)	[ ]	[ ]	[ ]	[ ]	
		5= Mixed (2 or more of the above)	[ ]	[ ]	[ ]	[ ]	
		6= Plastic	[ ]	[ ]	[ ]	[ ]	
Q9	What brand is the net? Ask respondent.	1= Permanet	[ ]	[ ]	[ ]	[ ]	
		2= Dawanet	[ ]	[ ]	[ ]	[ ]	
		3= K-O Net	[ ]	[ ]	[ ]	[ ]	
		4= IcoNet	[ ]	[ ]	[ ]	[ ]	
		5= Olyset	[ ]	[ ]	[ ]	[ ]	
		6= Sleeping Beauty	[ ]	[ ]	[ ]	[ ]	
		7= Sleeping Comfort	[ ]	[ ]	[ ]	[ ]	
		8= Pest Repellent Mosquito Net	[ ]	[ ]	[ ]	[ ]	
		9= New Insecticide Treated Mosquito Net	[ ]	[ ]	[ ]	[ ]	
		10= Hak Kerajaan	[ ]	[ ]	[ ]	[ ]	
		11= Unbranded/DK	[ ]	[ ]	[ ]	[ ]	
							Go To
Q10	What is the name on the label [Check label]	1= Permanet	[ ]	[ ]	[ ]	[ ]	Q11
		2= Siamdutch	[ ]	[ ]	[ ]	[ ]	Q12
		3= C.K. Trading (1994) Co., Ltd	[ ]	[ ]	[ ]	[ ]	Q12
		4= Olyset	[ ]	[ ]	[ ]	[ ]	Q12
		5= Akrungaroon Industry Co. Ltd	[ ]	[ ]	[ ]	[ ]	Q12
		6= Other (specify) [ ]		[ ]	[ ]	[ ]	Q12
		7= No label	[ ]	[ ]	[ ]	[ ]	Q12
Q11	What is the code number on the label	1= 1 124 4	[ ]	[ ]	[ ]	[ ]	
		2= 1 122 4	[ ]	[ ]	[ ]	[ ]	
		3= 1 100 4	[ ]	[ ]	[ ]	[ ]	
		4= 2 012 4	[ ]	[ ]	[ ]	[ ]	
		5 = Other, specify [ ]		[ ]	[ ]	[ ]	

Q12	How long ago did you get the net? Do not prompt	**Net 1**		**Net 2**	**Net 3**	**Net 4**
		1= 6 months or less	[ ]	[ ]	[ ]	[ ]
		2= 7-12 months	[ ]	[ ]	[ ]	[ ]
		3= 13-23 months	[ ]	[ ]	[ ]	[ ]
		4= 2-3 years	[ ]	[ ]	[ ]	[ ]
		5= >3 years (specify)	[ ]	[ ]	[ ]	[ ]
		6= DK	[ ]	[ ]	[ ]	[ ]

[2] The interviewer is provided with swatches of available varieties of fabric, categorised as netting and non-netting fabric

						Go to
Q13	When you got your mosquito net did it come packaged with an insecticide?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q15
		3= DK [ ]	[ ]	[ ]	[ ]	Q15

		Net 1	**Net 2**	**Net 3**	**Net 4**	
Q14	Were the instructions clear to you? Do not prompt	1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	
		3= Didn't read them [ ]	[ ]	[ ]	[ ]	
		4= Someone explained to me when I bought it [ ]	[ ]	[ ]	[ ]	
		4= DK [ ]	[ ]	[ ]	[ ]	

Q15	When you bought the net, was it **already** treated with an insecticide to kill or repel mosquitoes?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	
		3= DK [ ]	[ ]	[ ]	[ ]	
Q16	**Since** you bought the net, was it treated with an insecticide to kill or repel mosquitoes?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q26
		3= DK [ ]	[ ]	[ ]	[ ]	Q26

Q17	How was it treated? Allow the respondent to describe – do not prompt.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Net dipped in insecticide solution [ ]	[ ]	[ ]	[ ]	Q18
		2= Aerosol spray or flit-gun [ ]	[ ]	[ ]	[ ]	Q26
		3= Bought already treated [ ]	[ ]	[ ]	[ ]	Q26
		4= Other (specify) [ ]	[ ]	[ ]	[ ]	Q26
		5= DK [ ]	[ ]	[ ]	[ ]	Q26
Q18	How many times has the net been soaked or dipped in a liquid to repel mosquitoes or bugs? (This includes the time of buying it)	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= 1 [ ]	[ ]	[ ]	[ ]	
		2= 2 [ ]	[ ]	[ ]	[ ]	
		3= 3 [ ]	[ ]	[ ]	[ ]	
		4= >3 [ ]	[ ]	[ ]	[ ]	

Q19	Did you soak or dip the net in insecticide yourself, or did you take it somewhere else to be soaked or dipped?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Treated it myself [ ]	[ ]	[ ]	[ ]	Q20
		2= Took it somewhere else to be treated [ ]	[ ]	[ ]	[ ]	Q21
		3= DK [ ]	[ ]	[ ]	[ ]	Q21

Q20	Where did you get the insecticide? [Answer even if it was packaged with a net] Do not prompt One answer only per net.	**Net 1**	**Net 2**	**Net 3**	**Net 4**	**Go to**
		1= General shop [ ]	[ ]	[ ]	[ ]	
		2= Market [ ]	[ ]	[ ]	[ ]	
		3= Pharmacy [ ]	[ ]	[ ]	[ ]	
		4= Chemical seller [ ]	[ ]	[ ]	[ ]	
		5= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	
		6= Clinic / hospital [ ]	[ ]	[ ]	[ ]	
		7= Vaccination campaign [ ]	[ ]	[ ]	[ ]	
		8= School [ ]	[ ]	[ ]	[ ]	
		9= Gift – someone gave it to me [ ]	[ ]	[ ]	[ ]	
		10= Employer [ ]	[ ]	[ ]	[ ]	
		11= Other (specify) [ ]	[ ]	[ ]	[ ]	
		12= DK [ ]	[ ]	[ ]	[ ]	
						Go to
Q21	Where did you take the net to get it treated with insecticide? Do not prompt	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= General shop [ ]	[ ]	[ ]	[ ]	Q23
		2= Market [ ]	[ ]	[ ]	[ ]	Q23
		3= Pharmacy [ ]	[ ]	[ ]	[ ]	Q23
		4= Chemical seller [ ]	[ ]	[ ]	[ ]	Q23
		5= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	Q23
		6= Clinic / hospital [ ]	[ ]	[ ]	[ ]	**Q22**
		7= Outreach clinic [ ]	[ ]	[ ]	[ ]	**Q22**
		8= Community volunteer [ ]	[ ]	[ ]	[ ]	Q23
		9= Vaccination campaign [ ]	[ ]	[ ]	[ ]	Q23
		10= School [ ]	[ ]	[ ]	[ ]	Q23
		11= Employer [ ]	[ ]	[ ]	[ ]	Q23
		12= Other (specify) [ ]	[ ]	[ ]	[ ]	Q23
		13= DK [ ]	[ ]	[ ]	[ ]	Q23
Q22	Who in the clinic did the treatment	1= Clinic staff [ ]	[ ]	[ ]	[ ]	
		2= Community volunteer [ ]	[ ]	[ ]	[ ]	

Q23	How long ago was the net soaked or dipped in a liquid to repel mosquitoes or bugs? I am not talking about treating with an aerosol spray or a flit-gun	**Net 1**	**Net 2**	**Net 3**	**Net 4**	**Go to**
		1= 6 months or less [ ]	[ ]	[ ]	[ ]	
		2= 7-11 months [ ]	[ ]	[ ]	[ ]	
		3= 1-3 years [ ]	[ ]	[ ]	[ ]	
		4= > 3 years [ ]	[ ]	[ ]	[ ]	
		5= DK [ ]	[ ]	[ ]	[ ]	
Q24	Is the insecticide still working?	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	
		3= It never worked [ ]	[ ]	[ ]	[ ]	
		4= Other (specify) [ ]	[ ]	[ ]	[ ]	

						Go to
Q25	What was the name of the product that was used to treat your net?	Net 1	Net 2	Net 3	Net 4	
		1= K-O Tab [ ]	[ ]	[ ]	[ ]	
		2= Solfac [ ]	[ ]	[ ]	[ ]	
		3= IcoNet [ ]	[ ]	[ ]	[ ]	
		4= Deltamethrin [ ]	[ ]	[ ]	[ ]	
		5= Other (specify)[ ]	[ ]	[ ]	[ ]	
		6= DK [ ]	[ ]	[ ]	[ ]	
						Go to
Q26	Did anyone sleep under this mosquito net last night	Net 1	Net 2	Net 3	Net 4	
		1= Yes [ ]	[ ]	[ ]	[ ]	
		2= No [ ]	[ ]	[ ]	[ ]	Q28
		3= DK [ ]	[ ]	[ ]	[ ]	
Q27	Who slept under this mosquito net last night? [Use person code from Q1]	01 [ ]	[ ]	[ ]	[ ]	
		02 [ ]	[ ]	[ ]	[ ]	
		03 [ ]	[ ]	[ ]	[ ]	
		04 [ ]	[ ]	[ ]	[ ]	
		05 [ ]	[ ]	[ ]	[ ]	
		06 [ ]	[ ]	[ ]	[ ]	
		07 [ ]	[ ]	[ ]	[ ]	
		08 [ ]	[ ]	[ ]	[ ]	
		09 [ ]	[ ]	[ ]	[ ]	
		10 [ ]	[ ]	[ ]	[ ]	
		Other [ ]	[ ]	[ ]	[ ]	
		14= Visitor [ ]	[ ]	[ ]	[ ]	
		15= DK [ ]	[ ]	[ ]	[ ]	

			Go to
Q28	When in the year do people in your household use a mosquito net? Do not prompt	1= Throughout the year/all year [ ]	
		2= Rainy season [ ]	
		3= Dry season/harmattan [ ]	
		4= Other (specify) [ ]	
Q29	Every night or sometimes?	1= Every night [ ]	
		2= Sometimes [ ]	
Q30	How many months a year do people in your household use a mosquito net?	1= Months [ ]	
		2= DK [ ]	

						Go to
Q31	Where did you get the mosquito net? [Do not read responses. One answer only for each net]	**Net 1**	**Net 2**	**Net 3**	**Net 4**	
		1= Market [ ]	[ ]	[ ]	[ ]	
		2= Local kiosk [ ]	[ ]	[ ]	[ ]	
		3= Street hawker [ ]	[ ]	[ ]	[ ]	
		4= Table top vendor [ ]	[ ]	[ ]	[ ]	
		5= Table top vendor close to clinic [ ]	[ ]	[ ]	[ ]	
		6= General shop [ ]	[ ]	[ ]	[ ]	
		7= Clothes/Fabric shop [ ]	[ ]	[ ]	[ ]	
		8= Wholesaler [ ]	[ ]	[ ]	[ ]	
		9= Pharmacy [ ]	[ ]	[ ]	[ ]	
		10= Chemical seller [ ]	[ ]	[ ]	[ ]	
		11= Project (e.g. NGO) [ ]	[ ]	[ ]	[ ]	
		12= Clinic/hospital [ ]	[ ]	[ ]	[ ]	
		13= Outreach clinic [ ]	[ ]	[ ]	[ ]	
		14= School [ ]	[ ]	[ ]	[ ]	
		15= Gift/somebody bought t for me [ ]	[ ]	[ ]	[ ]	
		16= Employer [ ]	[ ]	[ ]	[ ]	
		17= Other (specify) [ ]	[ ]	[ ]	[ ]	
		18= DK / can't recall [ ]	[ ]	[ ]	[ ]	
Q32	In which town did you get it?	1= hometown [ ]	[ ]	[ ]	[ ]	
		2= other town within this sub-district [ ]	[ ]	[ ]	[ ]	
		3= other town within this district [ ]	[ ]	[ ]	[ ]	
		4= town in another district within this region [ ]	[ ]	[ ]	[ ]	
		5= town within another region [ ]	[ ]	[ ]	[ ]	
Q33	District name	District [ ]	[ ]	[ ]	[ ]	
Q34	Region name	Region [ ]	[ ]	[ ]	[ ]	
Q35	How long does it take to get to where you bought the net?	1= < 1 hour [ ]	[ ]	[ ]	[ ]	
		2= 1-2 hours [ ]	[ ]	[ ]	[ ]	
		3= > 2 hours [ ]	[ ]	[ ]	[ ]	
		4= DK [ ]	[ ]	[ ]	[ ]	
Q36	How do you get to this place?	1= walk [ ]	[ ]	[ ]	[ ]	
		2= bus [ ]	[ ]	[ ]	[ ]	
		3= taxi [ ]	[ ]	[ ]	[ ]	
		4= other, specify [ ]	[ ]	[ ]	[ ]	
Q37	How much does it cost you to travel to this place?	1= <500 cedis [ ]	[ ]	[ ]	[ ]	
		2= 501 to 1,000 cedis [ ]	[ ]	[ ]	[ ]	
		2= 1,001 to 5,000 cedis [ ]	[ ]	[ ]	[ ]	
		3= >5,000 cedis [ ]	[ ]	[ ]	[ ]	

Q38	Did you use a voucher to pay for your net?	1= yes [ ]	[ ]	[ ]	[ ]	
		2= no [ ]	[ ]	[ ]	[ ]	Q40
		3= don't know about vouchers [ ]	[ ]	[ ]	[ ]	Q40
Q39	How much discount did this give you?	1= 40,000 cedis [ ]	[ ]	[ ]	[ ]	
		2= Other, specify [ ]	[ ]	[ ]	[ ]	
Q40	How much money did you pay for the mosquito net?	Cedis [ ]	[ ]	[ ]	[ ]	
		CFA [ ]	[ ]	[ ]	[ ]	
		Nothing, it was free [ ] =8888	[ ]	[ ]	[ ]	
		3= DK / Can't remember [ ] =9999	[ ]	[ ]	[ ]	
Q41	Did you pay for the net outright or in instalments?	1= Outright [ ]	[ ]	[ ]	[ ]	
		2 = In 2 instalments [ ]	[ ]	[ ]	[ ]	
		3 = In 3 instalments [ ]	[ ]	[ ]	[ ]	
		4 = In > 3 instalments [ ]	[ ]	[ ]	[ ]	
		5 = Other (specify) [ ]	[ ]	[ ]	[ ]	

			Go to
Q42	When you got your newest net, did you use it to replace an old net?	1= Yes [ ]	
		2= No [ ]	Q44 / Q54
		3= This is my first net [ ]	Q44 / Q54
Q43	Where is the old net now?	1= Still in the household [ ]	
		2=Thrown away [ ]	
		3= Given to another household [ ]	
		4= Other (specify) [ ]	
		5= DK [ ]	

	Question to pregnant women only	**If not pregnant women Go To 51**	**Go to**
Q44	Is this your first pregnancy?	1= Yes [ ]	
		2= No [ ]	
Q45	How many months pregnant are you?	No. months [ ]	
Q46	Have you visited an antenatal clinic since you have been pregnant this time?	1= Yes [ ]	
		2= No [ ]	Q63
Q47	How many times have you visited an antenatal clinic during this pregnancy?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
Q48	How many different antenatal clinics have you visited during this pregnancy?	1= 1 [ ]	
		2= >1 specify [ ]	

Q49	Were you given a vaccination on any of your visits to antenatal clinic during this pregnancy?	1= yes [ ]	
		2= no [ ]	Q51
		3= don't remember [ ]	Q51
Q50	How many times were you given a vaccination in all of your visits to antenatal clinic with this pregnancy?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
		5= Don't remember [ ]	
Q51	During this pregnancy were you given any drugs to **prevent** you from getting malaria when you went to antenatal clinic? (I don't mean drugs for when you were ill)	1= Yes [ ]	
		2= No [ ]	Q53
		3= Don't know [ ]	Q53
Q52	How many times were you given drugs to **prevent** you from getting malaria when you visited antenatal clinic during this pregnancy?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
Q53	Were you asked to buy a mosquito net at the clinic?	1= Yes [ ]	
		2= No [ ]	

	Question to mothers of children <1 only	**If not a mother of a child <1 Go To Q58**	**Go to**
Q54	How many children do you have?	1= 1 [ ]	
		2= 2- 3 [ ]	
		3= 4 or more [ ]	
Q55	Did you visit an antenatal clinic whilst you were pregnant with your youngest child?	1= Yes [ ]	
		2= No [ ]	Q63
Q56	How many times did you visit an antenatal clinic during the pregnancy with your youngest child?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
Q57	How many different antenatal clinics did you visit during the pregnancy with our youngest child?	1= 1 [ ]	
		2= >1 specify [ ]	
Q58	Were you given a vaccination on any of your visits to antenatal clinic whilst pregnant with your youngest child?	1= yes [ ]	
		2= no [ ]	Q60
		3= don't remember [ ]	Q60
Q59	How many times were you given a vaccination in all of your visits to antenatal clinic whilst pregnant with your youngest child?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
		5= Don't remember [ ]	

Q60	When you were pregnant with your youngest child were you given any drugs to **prevent** you from getting malaria when you went to antenatal clinic? (I don't mean drugs for when you were ill)	1= Yes [ ]	
		2= No [ ]	Q62
		3= Don't know [ ]	Q62
Q61	How many times were you given drugs to **prevent** you from getting malaria when you visited antenatal clinic when you were pregnant with your youngest child?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
Q62	Were you asked to buy a mosquito net at the ANC?	1= Yes [ ]	
		2= No [ ]	

Questions to all respondents

Q63	Were you offered a voucher for a mosquito net at the clinic?	1= Yes [ ]	
		2= No [ ]	Q69
		3= Don't remember [ ]	Q69
Q64	Did you take a voucher?	1= Yes [ ]	Q66
		2= No [ ]	Q65
Q65	Why did you not take a voucher?	1= don't have money for the net [ ]	Q69
		2= midwife refused to give [ ]	Q69
		3= already have a net(s) [ ]	Q69
		4= don't like nets [ ]	Q69
		5= don't like/afraid of insecticide [ ]	Q69
		6= other, specify	Q69
Q66	How many vouchers did you take?	1= 1 [ ]	
		2= 2 [ ]	
		3= 3 [ ]	
		4= >3 [ ]	
Q67	How many nets have you used a voucher to buy?	1= 1 [ ]	Q69
		2= 2 [ ]	Q69
		3= 3 [ ]	Q69
		4= >3 [ ]	Q69
		5= 0 [ ]	**Q68**
Q68	Why have you not used the voucher to buy a net?	1= don't have money for the net [ ]	
		2= midwife refused to give [ ]	
		3= no nets available [ ]	
		4= already have a net(s) [ ]	
		5= don't like nets [ ]	
		6= don't like/afraid of insecticide [ ]	
		7= other, specify	

			Go to
Q69	If you wanted to get a net, where is the nearest place you could get one?	Hometown [ ]	
		Other town within this sub-district [ ]	
		Other town within this district [ ]	
		Town in another district [ ]	
		Town in another region [ ]	
Q70	If you want to buy a net would you go and buy it yourself or would you send someone else?	1= Buy it myself [ ]	
		2= Get someone else to buy it for me [ ]	
		3= Other (specify) [ ]	
		4= DK [ ]	
Q71	How long does it take to get to this place?	1= Less than 1 hour [ ]	
		2= 1-2 hours [ ]	
		3= More than 2 hours [ ]	
		4= DK [ ]	
Q72	How often do you or someone from your household visit this place?	1= Every day [ ]	
		2= Every week [ ]	
		3= Every 2 weeks [ ]	
		4= Every month [ ]	
		5= Every 2-3 months [ ]	
		6= Less frequently than every 3 months [ ]	
		7= DK [ ]	
Q73	What type of place can you get the net from in [name of place quoted above]. Do not read responses First answer only.	1= Market [ ]	
		2= Local kiosk [ ]	
		3= Street hawker [ ]	
		4= Table top vendor close to clinic [ ]	
		5= General shop [ ]	
		6= Clothes/Fabric shop [ ]	
		7= Wholesaler [ ]	
		8= Pharmacy [ ]	
		9= Chemical seller [ ]	
		11= Project (e.g. NGO) [ ]	
		12= Clinic/hospital [ ]	
		13= Outreach clinic [ ]	
		14= School [ ]	
		15= Other (specify) [ ]	
		16= Don't know [ ]	
			Go to
Q74	Have you ever bought anything from a shop at a petrol station?	1= Yes [ ]	
		2= No [ ]	
Q75	Do you use anything else to stop mosquitoes biting you?	1= Yes [ ]	
		2= No [ ]	

Q76	What do you use? Ask all respondents (even when the answer to Q75 was no) Read responses. Multiple answers allowed	A = Coils [ ]	
		B = Sprays or flit-guns [ ]	
		C = Skin repellents [ ]	
		D = Screening on windows/doors [ ]	
		E = Have the house sprayed professionally [ ]	
		F = Other (specify) [ ]	
		G= Ceiling fan [ ]	
		H= Air conditioner [ ]	
			Go to
Q77	When in the year do mosquitoes bother or bite you most? Don't read responses	1= Rainy season [ ]	
		2= Dry season/harmattan [ ]	
		3= Through out the year [ ]	
		4= Other (specify) [ ]	
Q78	When in the day do mosquitoes bother or bite you the most **in the house**? One response only	1= Morning [ ]	
		2= Afternoon [ ]	
		3= Evening or night before sleeping [ ]	
		4= At night when you are sleeping [ ]	
		5= All day long [ ]	
			Go to
Q79	In the last 12 months have you seen or heard any information about insecticide treated mosquito nets/bednets and/or retreatment of mosquito nets?	1= Yes [ ]	
		2= No [ ]	Q56
Q80	Where did you see or hear this information Do not read responses Allow multiple answers	A= Radio [ ]	
		B= Television [ ]	
		C= Newspaper / magazine [ ]	
		D= Staff at shop / pharmacy / market [ ]	
		E= Health staff [ ]	
		F= Poster / notice at health facility [ ]	
		G= Church / mosque [ ]	
		H= School [ ]	
		I= Drama group / road show [ ]	
		J= Friends / neighbours / relatives [ ]	
		K= Billboards [ ]	
		L= Women's group(s) [ ]	
		M= Organisation (specify) [ ]	
		N= Other (specify) [ ]	
		O= Don't know / can't recall [ ]	

			Go to
Q81	What is the **main** source of **drinking** water for members of your household?	**Piped water**	
		1= Piped into house [ ]	Q83
		2= Piped into compound [ ]	Q83
		3= Piped into neighbours compound [ ]	
		3= Public tap [ ]	
		Water from open well	
		4= Open well in compound [ ]	Q83
		5= Open public well [ ]	
		Water from covered well or bore hole	
		6= Protected well in compound [ ]	Q83
		7= Protected public well [ ]	
		Surface water	
		8= Spring [ ]	
		9= River/Stream [ ]	
		10= Pond/Lake [ ]	
		11= Dam [ ]	
		12= Rainwater [ ]	
		13= Tanker truck [ ]	
		14= Bottled water [ ]	
		15= Sachets of water [ ]	
		16= Other (specify) [ ]	
Q82	How long does it take you to go there, get water and come back?	Minutes [ ]	
Q83	What kind of toilet facilities do you have **within your house or compound**?	1= Flush toilet [ ]	
		2= Pit latrine (traditional) [ ]	
		3= Pit latrine (KVIP) [ ]	
		4= None [ ]	
		5= Other (specify) [ ]	
Q84	Do you share these facilities with other households?	1= Yes [ ]	
		2= No [ ]	
Q85	Does your household own Read responses Tick if yes	Electricity [ ] (1= yes 2= No)[3]	
		Radio [ ] (1= yes 2= No)	
		Television [ ] (1= yes 2= No)	
		Video deck [ ] (1= yes 2= No)	
		Telephone : landline [ ] (1= yes 2= No)	
		Mobile telephone [ ] (1= yes 2= No)	
		Refrigerator [ ] (1= yes 2= No)	
		Deep freeze [ ] (1= yes 2= No)	

[3] For data entry only

Appendix 2: Ethics committee approvals

GHANA HEALTH SERVICE ETHICAL REVIEW COMMITTEE

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ber and date of this
r should be quoted.

Ref. : No.ERC..03
r Ref. No.

Health Research Unit
Ghana Health Service
P. O. Box GP-184
Accra

Tel: +233- 679323/681109
Fax + 233-21-226739

Email: Hannah.Frimpong@hru-ghs

September 24th, 2004

ETHICAL CEARANCE

GHS-ERC: ID NO. 07/09/04

The Ethical Review Committee of the Ghana Health Service, on the 22nd of September, 2004, unanimously approved your research protocol titled: **Monitoring and Evaluation of the Pilot Insecticide Treated (ITN) Voucher Scheme Project in the Volta Region**

PRINCIPAL INVESTIGATOR: Dr. Margaret Kweku

This approval requires that you submit periodic review of the protocol to the Committee and a final full review to the Ethical Review Committee (ERC) at the completion of the study. The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Please note that any modification of this project must be submitted to the ERC for review and approval before its implementation.

You are also required to report all serious adverse events related to this study to the GHS-ERC within seven days verbally and fourteen days in writing.

SIGNED.....

PROF. ALBERT GEORGE BAIDOE AMOAH
(GHS-ERC CHAIRMAN)

cc: Dr. John Gyapong (Director)
Health Research Unit
Ghana Health Service
Accra.

GHANA HEALTH SERVICE ETHICAL REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted.

My Ref. :GHS-ERC: 3
Your Ref. No.

Health Research Unit
Ghana Health Service
P. O. Box GP-184
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Tel: +233-21-681109
Fax + 233-21-226739
Email: John.Gyapong@hru-ghs.org
April 6 , 2006

ETHICAL CLEARANCE

ID NO: GHS-ERC- 07/09/04

The Ethical Review Committee of Ghana Health Services has given approved for the implementation of the "**Amendment II**" of your Protocol titled:

Monitoring and Evaluation of the Pilot Insecticide Treated (ITN) Voucher Scheme Project in the Volta Region and Baseline survey in the Eastern Region

PRINCIPAL INVESTIGATOR: Margaret Kweku (Dr.)

This approval requires that you submit periodic review of the protocol to the Committee and a final full review to the Ethical Review Committee (ERC) at the completion of the study. The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Please note that any modification of the project must be submitted to the ERC for review and approval before its implementation.

You are also required to report all serious adverse events related to this study to the ERC within seven days verbally and fourteen days in writing.

You are requested to inform the ERC and your mother organization before any publication of the research findings.

Please always quote the protocol identification number in all future correspondence in relation to this protocol.

SIGNED.....

PROF. ALBERT GEORGE BAIDOE AMOAH
(GHS-ERC CHAIRMAN)

Cc: Dr. John Gyapong
(Director)
Health Research Unit
Ghana Health Service
Accra

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

ETHICS COMMITTEE

APPROVAL FORM
Application number: 2016

Name of Principal Investigator	**Jayne Webster**
Department	**Infectious and Tropical Diseases**
Head of Department	**Professor Hazel Dockrell**

Title **Strategies for the distribution of ITNs in Ghana: monitoring and evaluation of a pilot ITN voucher scheme and investigation of the informal market in mosquito nets.**

Approval of this study is granted by the Committee.

Chair
Professor Tom Meade T.W. Meade .....

Date 22 November 2004

Approval is dependent on local ethical approval having been received.

Any subsequent changes to the consent form must be re-submitted to the Committee.

Appendix 3: Published papers from this thesis

Published by Oxford University Press in association with The London School of Hygiene and Tropical Medicine
Health Policy and Planning 2007;**22**:277–293
doi:10.1093/heapol/czm021

Delivery systems for insecticide treated and untreated mosquito nets in Africa: categorization and outcomes achieved

Jayne Webster,[1]* Jenny Hill,[2] Jo Lines[1] and Kara Hanson[3]

Accepted 2 April 2007

Introduction Coverage of insecticide-treated nets (ITNs) in sub-Saharan Africa is still low despite their proven efficacy, effectiveness and cost-effectiveness. Delivery systems for ITNs have been hotly debated, but there has been no structured approach to assessing their relative effectiveness. This paper aims to: propose a categorization of ITN and mosquito net delivery systems; classify existing systems according to this categorization; critique coverage measures reported; synthesize evidence about the levels of coverage achieved by each system; and identify current analytical gaps and future priorities.

Methods We undertook a systematic review of published papers complemented by grey literature from projects and programmes. A 4-by-3 matrix was developed of delivery sector and cost to end user. Delivery systems were placed in the matrix based on project descriptions. Coverage and equity of coverage outcomes of the identified delivery systems were assessed for consistency with standard Roll Back Malaria (RBM) coverage indicators. These were placed in the matrix for comparison of outcomes by ITN delivery category.

Results Only 17 references with coverage data were identified, and amongst these there was variation from the RBM indicators. We identified three sets of coverage data where delivery and surveys to assess coverage of target groups were at national scale: public-free delivery in Togo; mixed-partially subsidized delivery in Malawi, and private-unsubsidized delivery in The Gambia. The highest level of household ownership was achieved through public-free delivery (62.5%), whilst use by pregnant women and by children under 5 was highest through private-unsubsidized delivery (67.2 and 67.7%, respectively).

Conclusions There are no comparative studies of delivery systems for ITNs from which definitive evidence can be drawn, so conclusions on the relative merits of different delivery systems and levels of subsidy cannot be made. Development of methods of attributing household-level outcomes to specific delivery systems would aid in providing this evidence base. As countries scale-up efforts to deliver ITNs, our matrix provides an analytical tool for developing

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a comprehensive mapping of systems and outcomes. To guide strategic decision-making, cross-country and cross-regional comparisons of the outcomes of systems are needed to facilitate an analysis of the influence of contextual factors.

Keywords Insecticide treated nets, bednets, malaria, coverage, delivery

KEY MESSAGES

- No comparative studies of the effectiveness or the impact of levels of subsidy of different delivery systems for ITNs have been undertaken.
- Development of methods of attributing household-level outcomes to specific delivery systems would potentially provide a method of doing this, even at the large-scale.
- Our delivery system matrix provides an analytical tool for developing a comprehensive mapping of systems and outcomes for evidence to drive strategic decision-making, cross-country and cross-regional comparisons.

Introduction

Insecticide-treated nets (ITNs) are an effective intervention against malaria, which is one of the most important causes of child mortality in Africa. They have been shown to reduce the number of childhood deaths by about one-fifth, therefore saving around six lives for every 1000 under-five children protected per year in countries of sub-Saharan Africa (Lengeler 2004). ITNs have been shown to be cost-effective, with an estimated cost per disability-adjusted life year (DALY) averted of US$48 (Goodman *et al.* 1999). Coverage of ITNs, defined as use by children under 5 years of age, is currently low at an average of 3% across sub-Saharan Africa (WHO 2005). We need to identify the most effective ways of delivering ITNs to the populations at risk, in order to increase coverage levels significantly (Victora *et al.* 2004).

The delivery system for mosquito nets, ITNs and/or insecticide is defined here as the mechanism by which product moves from the manufacturer to the household and involves several stages. An ITN consists of a mosquito net and insecticide, which may be delivered separately or in combination. When delivered in combination the ITN may be a long lasting insecticidal net (LLIN), a pre-treated net or an untreated net that is packaged (bundled) with an insecticide treatment kit. There are wide varieties of mosquito net and insecticide products available.

Historically, mosquito nets were sold in markets in Africa and Asia long before the development of the new technology of ITNs (Aikins *et al.* 1993); these nets were untreated and unsubsidized. ITNs were originally provided free to selected populations taking part in efficacy trials by researchers, and were therefore mainly delivered by implementers of the research, free of charge (D'Alessandro *et al.* 1995a; Binka *et al.* 1996; Nevill *et al.* 1996; Habluetzel *et al.* 1997; Habluetzel *et al.* 1999). These efficacy studies confirmed ITNs as a powerful intervention for reducing child morbidity and mortality (Lengeler 1998) and were followed by effectiveness studies to determine impact under programme conditions (D'Alessandro *et al.* 1995b; D'Alessandro *et al.* 1997; Rowland *et al.* 1997; Abdulla *et al.* 2001). Effectiveness studies involved a variety of delivery systems, the first one being The Gambia National ITN Programme (D'Alessandro *et al.* 1997), where insecticide was delivered free (though charges were implemented subsequently) to treat mosquito nets purchased through the retail sector. The focus of both efficacy and early effectiveness studies was impact of ITNs on malaria morbidity and mortality; the systems through which the ITNs were delivered were not evaluated.

The diversity of products constituting an ITN, and the corresponding diversity of mechanisms through which they can be distributed from manufacturers to households, has led to considerable debate. Key to this debate is whether ITNs, nets and/or insecticide are public or private goods, and the respective roles of the public and private sector in their delivery (Curtis *et al.* 2003; Lines *et al.* 2003), such that ITN policy has evolved significantly over the past 15 years (Hill *et al.* 2006). Roll Back Malaria (RBM) has attempted to provide guidance on delivery mechanisms by developing a consensus framework based on existing evidence, which provides strategic recommendations for African countries developing national strategies for scaling-up delivery of ITNs (WHO 2002). The framework proposes a two-pronged approach: targeted and sustained subsidies for those at greatest risk (biological, economic or geographic risk), and the development of an enabling environment for expansion of the commercial sector. There is, however, still some confusion over free versus subsidized commodities, commercial delivery versus public delivery, and how best to achieve a balance between 'quick wins' today versus sustaining coverage for tomorrow (Curtis *et al.* 2003; Lines *et al.* 2003).

There have been few attempts to clarify options better by systematic evaluation of clearly defined delivery systems for ITNs. Hanson *et al.* (2004) described four models for the delivery of nets and insecticides by public sector or non-governmental organizations (NGOs): (1) purely public sector delivery; (2) community-based projects; (3) social marketing; and (4) encouraging the development of the private sector. Feilden (1996) distinguished the delivery and financing of nets

and constructed a matrix of public, mixed or private sector delivery and public, mixed or private sector financing (for distribution, logistics, sales and services). A similar focus was taken in the Long Lasting Insecticidal Net (LLIN) business plan (MSH 2004) where the separation of delivery from financing source/mechanism was used as an aid to look at where different stakeholders participate in the mosquito net industry. Lines (1996) focused on the delivery of insecticide, distinguishing between public and private routes through which insecticides for net treatment could be delivered to users.

Delivery systems for mosquito nets and ITNs have diversified over the last two decades and there is a need to develop frameworks within which the systems are classified so that their outcomes may be compared to facilitate strategic decisions on which delivery systems are the most effective in a range of settings. The effectiveness of a delivery system may be assessed by measuring the outcome it achieves, that is, the coverage of ITNs at the household level. The objectives of this paper are to propose a categorization of ITN delivery systems; classify existing systems according to this categorization; critique coverage measures reported; synthesize evidence about the levels of coverage achieved by each system; and identify analytical gaps and future priorities.

Methods

We undertook a review of the ways in which mosquito nets and ITNs have been delivered to households, using the PubMed electronic online database (US National Library of Medicine, Bethseda, USA). Key search terms used were net, bednet, bed net, mosquito net, insecticide treated, and ITN. The reference list of each paper thus identified was searched for further relevant publications. Published papers were supplemented with grey literature where available, in acknowledgment that many evaluations of ITN programmes are not published.

We reviewed coverage outcomes achieved through each of the different systems identified by the search. In order to facilitate comparison of the coverage outcomes of different delivery systems amongst different target groups and socio-economic groups, we developed a matrix within which we present a categorization of delivery systems for ITNs. Our matrix is an adaptation of that developed by Feilden (1996) with rows representing delivery sectors (public, mixed public-private, private and community based) that are the source of logistical or human resource input into moving the ITNs from manufacturer to end user, and columns representing cost to the end user (free, partially subsidized and unsubsidized). Delivery sectors are further divided into delivery channels, which are the route through which the ITNs pass from manufacturer to end user.

Public sector is defined as largely under the control of central/local government, and private sector includes all those outside of the public sector whether their aim is philanthropic or commercial (Mills *et al.* 2002). Public sector delivery channels include routine health services, enhanced routine services and campaigns. Mixed delivery channels involve both public and private sector input into delivery of ITNs (logistic and/or human resource rather than purely financial input), and include voucher schemes and private-sector-assisted delivery through public sector outlets (where assistance is provided by NGOs or commercial organizations). Private sector delivery includes employer-based schemes including those supported by NGOs, 'non-profit' organizations facilitating delivery through commercial outlets, and the retail sector. Community-based delivery involves a heterogeneous mix of systems where the point of delivery is within the community and involves a philanthropic aim (not necessarily exclusively) through links with the public sector, NGOs or community-based organizations. In our matrix, cost to the end user can be free, partially subsidized or unsubsidized. We make the assumption that the channel through which an ITN is delivered and the cost to the end user are the major factors affecting outcomes and do not distinguish the source of the subsidy. For example, where donor money is used to assist the private sector, without public sector activities in the delivery, we classify this as unsubsidsed private sector delivery. Delivery systems were placed in this matrix based on project descriptions identified in the literature.

Coverage indicators were assessed and compared with the RBM recommended indicators. RBM recommend the use of three standard indicators of coverage: 'the proportion of households with at least one ITN', 'the proportion of pregnant women who slept under an ITN the night before the survey', and 'the proportion of children under five years of age who slept under an ITN the night before the survey' (Roll Back Malaria 2000; Roll Back Malaria *et al.* 2006). We reviewed each of the studies reflected in Table 1 for outcome data on coverage with ITNs for public and mixed delivery sectors and on mosquito nets for private sector delivery. Although several projects have begun to support delivery of ITNs through the private sector, this is relatively recent and subsequent to most available data sources (Webster *et al.* 2005). Where RBM indicators have been used, outcomes were placed in their relevant position within the delivery system matrix. Where RBM indicators were not used but indicators could be explained with a simple qualification, they were also included in the matrix with the relevant annotation.

The equity ratio was used to compare equity of coverage achieved by the different delivery systems. Households are first divided into socio-economic quintiles based upon housing conditions and ownership of a range of household assets (Filmer and Pritchett 1998). The equity ratio is then calculated as the ratio of coverage in the poorest quintile compared with the least poor (or richest) quintile.

The majority of data points available on coverage of ITNs are from household surveys undertaken following the implementation of specific programmes of delivery of ITNs. They tend to assume that the bulk of the coverage can be attributed to this specific delivery system. In our matrix we make this same assumption. However, the validity of this assumption will depend upon the history of delivery of ITNs within the area, particularly on private sector activity, and will tend to overestimate coverage by the delivery system presented. A more important limitation is where the equity of coverage within target groups is assumed to be due to a specific delivery system. For example, a new programme may deliver ITNs in an area where coverage has previously been very inequitable. Unless baseline and post-implementation surveys are undertaken, any improvement in equity may be masked.

Table 1 Matrix of net/ITN/insecticide delivery systems by category and cost to the end user

Delivery sector			Delivery category: Cost to the end user		
	Delivery channel		Free	Partially subsidized	Unsubsidized
Public	Routine services	ANC/EPI/MCH/Child clinics	**Kenya** (Guyatt *et al.* 2002a, Guyatt and Ochola 2003) **Eritrea** (Eisele *et al.* 2006)	**Ghana** (Lines and Webster 2003)	
		Intervention packages – mixed delivery	**Mali** (UNICEF 2005)	**Benin** (UNICEF 2005) **Ghana** (UNICEF 2005) **Senegal** (UNICEF 2005)	
	Enhanced routine	Child Health Week/Days	**Ghana** (UNICEF 2005) **Senegal** (UNICEF 2005)		
	Campaigns	Measles	**Ghana** (Grabowsky *et al.* 2005b) **Niger** (Loewenberg 2006) **Togo** (CDC 2005) **Zambia** (Grabowsky *et al.* 2005a)		
		Polio National Immunization Days		**Ghana** (WHO Ghana 2006)	
Mixed public-private	Assisted routine services	ANC/EPI		**Kenya** (Noor *et al.* 2006, PSI 2006) **Malawi** (Kadzandira and Munthali 2004, PSI 2005)	
	Voucher scheme	Routine service – retail		**Ghana** (Kweku *et al.* 2005) **Senegal** (Nachbar 2004) **Tanzania** (CARE 2003, World Vision 2003, Hanson *et al.* 2005a, Hanson *et al.* 2005b) **Tanzania** (Marchant *et al.* 2002, Mushi *et al.* 2003) **Tanzania** (Magesa *et al.* 2005) **Uganda** (Killian 2004)	
		Campaign – retail	**Zambia** (Grabowsky *et al.* 2005a)		

Private	Employer-based	Workplace	**Kenya** (Ngugi *et al.* 2004)	
	'Non-profit' organizations	Retail outlets	**Ghana** (GSMF 2003) **Kenya** (Noor *et al.* 2006) **Malawi** (Holtz *et al.* 2002) **Tanzania** (Schellenberg *et al.*1999) **Tanzania** (Hanson and Worrall 2002) **Tanzania** (Magesa *et al.* 2005)	
	Retail sector	Formal/Informal		**Cameroon** (Desfontaine *et al.* 1990) **Ethiopia** (NetMark 2004a) **Kenya** (Hamel *et al.* 2001, Guyatt *et al.* 2004, Noor *et al.* 2006) **Ghana** (NetMark 2004b) **Mali** (NetMark 2003) **Mozambique** (NetMark 2001a) **Nigeria** (Netmark 2001b, Netmark 2004d) **Senegal** (NetMark 2001c, NetMark 2004e) **Tanzania** (Kikumbih *et al.* 2005) **Uganda** (NetMark 2001d, Nuwaha 2001) **Zambia** (NetMark 2001e, NetMark 2004c)
		Formal sector		**Burkina Faso** (Okrah *et al.* 2002)
		Informal sector		**The Gambia** (MacCormack *et al.* 1989, Aikins *et al.* 1993, D'Alessandro *et al.* 1994, Clarke *et al.* 2001, Panter-Brick *et al.* 2006)
Community-based	Community-based	Community (community-based organizations, NGOs, women's groups etc.)	**Kenya** (Guyatt *et al.* 2002b) **Tanzania** (Maxwell *et al.* 2002)	**Mali** (Rhee *et al.* 2005) **Zambia** (Dembo Rath and Hill 1998)

Notes: ANC = antenatal care; EPI = Expanded Programme on Immunization; MCH = maternal and child health; NGO = non-governmental organization.

Findings

Our literature search identified 45 records with reference to delivery systems for ITNs, from 18 countries. These included 8 references to public sector delivery, 17 to mixed, 26 to private and 4 to community-based delivery. Several of the references provided information on more than one delivery sector. Out of the 45 references identified, only 17 provided coverage data: 5 of these were on public sector delivery, 5 on mixed public-private sector, 6 on private sector and one on community-based delivery.

Categorization of delivery systems

The range of delivery systems that have been employed over the last two decades to deliver ITNs (excluding efficacy trials), as described in available published and grey literature, is presented in Table 1. We use the term 'category' to distinguish both the delivery sector and the cost to the end user in a 4-by-3 matrix, which is extended to a 9-by-3 matrix when delivery sector is expanded to include different delivery channels. Delivery of ITNs through routine health services has involved public-free and public-partially subsidized categories of delivery systems. Child Health Days and Child Health Weeks are a form of expanded routine activities, and involve the public-free category of delivery system. Combined delivery of ITNs with immunization campaigns has involved both public-free and public-partially subsidized categories of delivery system; however, the former has been more commonly used to date. Mixed-partially subsidized is by far the predominant delivery category within the mixed public-private sector, but there are examples of mixed-free delivery. Within the private sector, delivery of ITNs and mosquito nets involves both private-partially subsidized and private-unsubsidized categories of delivery system.

Public sector delivery channels

Routine services

Two main channels of delivery have been utilized for delivering ITNs through routine health facilities: routine clinics, such as antenatal clinics (ANC) and the Expanded Programme on Immunization (EPI), and intervention 'packages', such as the UNICEF Accelerated Child Survival and Development (ACSD) programme in West Africa. Delivery through routine health facilities has involved either full or partial subsidies to the end user. Although there are now many examples of delivery of free ITNs through ANC and to a lesser extent EPI in Africa (WHO AFRO 2005; Worrall *et al.* 2005; Eisele *et al.* 2006), documented experiences are few. In Ghana, delivery of subsidized ITNs through ANC is managed by the National Malaria Control Programme (NMCP), the Regional Health Directorates and the District Health Management Teams. The cost of the ITN to the pregnant woman is approximately US$2.20. In Eritrea, ITNs are delivered to pregnant women through ANC free of charge.

The ACSD programme involves a package of interventions termed ANC+, EPI+ and IMCI+. ACSD was originally implemented in four countries of West Africa (Benin, Ghana, Mali and Senegal) and then expanded to other countries including Burkina Faso, Cameroon, Chad, The Gambia, Guinea Bissau, Guinea Conakry and Niger (UNICEF 2005). Strategies for delivering ITNs through ACSD vary among countries, including delivery of ITNs through routine health systems and through community-based agents. In Benin, Ghana and Senegal, the end user has to pay a small fee, for example the fee to pregnant women in Ghana is approximately US$0.50. In Mali, the ITNs are free to the end user.

Expanded routine

Child Health Days and Child Health Weeks usually involve packages of child survival interventions such as the EPI vaccinations, vitamin A supplementation and deworming tablets. ITN (re)treatment has been added to the package in some countries including Ghana, Malawi, Senegal and Zambia. In some districts of Ghana and Zambia ITNs were also delivered through Child Health Week, but less frequently than (re)treatment. All interventions are generally delivered free of charge to the end user.

Campaigns

Documentation is currently available on the combined delivery of ITNs with immunization campaigns in four countries (Ghana, Niger, Togo and Zambia), although combined campaigns have now taken place in other countries. ITNs were delivered alongside measles campaigns in Ghana, Togo and Zambia; and in Ghana and Niger, they were delivered during a polio national immunization day. Ghana was the first of the combined measles and ITN campaigns, with the activity taking place in one district (Lawra, Upper West Region) during a national measles campaign in 2002. This was followed by implementation in five districts of Zambia, four in which ITNs were delivered as a direct product and one in which the (full) subsidy was delivered in the form of a voucher. Togo provided the first example of the combined delivery of ITNs with a measles campaign at the national level. ITNs were delivered free of charge to the end user in each of the measles campaigns. During the 2004 polio national immunization days in Ghana, ITNs were delivered with vaccinations in one Region (Central Region). Unlike measles campaigns which involve vaccination at static points, polio national immunization days involve door-to-door delivery of vaccinations. In order to avoid the logistical difficulties of volunteers carrying bulky heavy ITNs, coupons were delivered to those vaccinated. The coupon entitled the holder to buy an ITN for approximately US$4 at designated health facility delivery points, thereby providing a partial subsidy (approximately US$2.20) on the ITN.

Mixed public-private sector delivery channels

In voucher schemes, the subsidy is generally delivered through the public sector, and the product delivered through the private sector. This allows targeting of the subsidy at the public sector level whilst still allowing the private sector to benefit from a sale, as well as allowing the programme to take advantage of an existing distribution system. Where the voucher has been delivered through routine health services, all subsidies have been partial, with the end user paying a top-up fee when exchanging the voucher for an ITN. However, in the Zambia pilot study where delivery was through a combined measles and ITN campaign, the ITN subsidy was delivered via a voucher which provided a 100% subsidy.

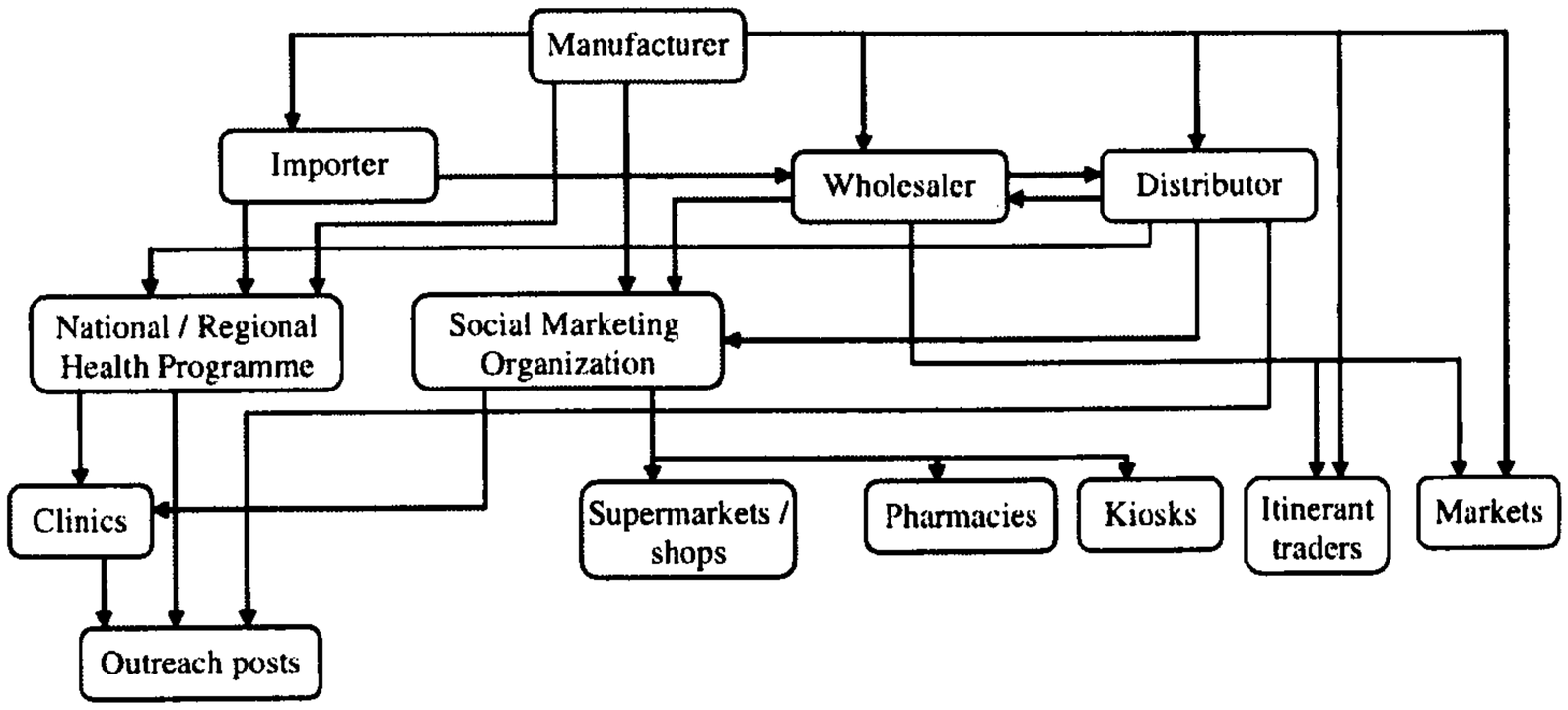

Figure 1 Public, public-private and private delivery systems for mosquito nets and insecticide-treated mosquito nets

In many countries (10 including Angola, Benin, DRC, Kenya, Madagascar, Malawi, Mali, Rwanda, Zambia and Zimbabwe), the delivery of partially subsidized ITNs through routine health facilities is supported by an NGO (Population Services International, PSI). The scale of distribution varies from one district (Angola) to national level (Malawi and Kenya) and the cost to the end user from US$0.40 in Malawi to US$2.80 in Angola. Although this model of delivery is often referred to as the 'ANC model' of social marketing (PSI 2005), it is quite different from classical social marketing and, in addition, ITN delivery is not limited to pregnant women through ANC services but often includes children under 5 years reached through EPI. We define this delivery channel as assisted routine services.

Private sector delivery channels

Private sector delivery of mosquito nets involves a diverse array of traders including manufacturers, wholesalers and retailers selling ITNs through a wide range of outlets (Figure 1). It was difficult to determine which part of the private sector was involved in many of the documented experiences. Classical social marketing supported by NGOs with delivery of the ITNs through retail outlets may be viewed as an 'assisted private sector' approach. The same applies to projects such as NetMark (NetMark 2006) where the NGO provides technical and marketing support to the private sector, and the Futures programme in Nigeria with a subsidy on promotion (Futures Group 2006). These latter projects where the subsidy is not directly applied to the product are also sometimes referred to as social marketing. Due to the diversity of approaches for delivery of ITNs that are loosely called social marketing, we use other modes of description. We define the support by NGOs to the delivery through retail outlets as 'non-profit' organization delivery channels. Within such channels, the ITNs are usually delivered to the retail outlets by the NGO rather than being sourced by the retailer themselves, and are subsidized (in the form of subsidized product and/or subsidized marketing and promotion) before reaching the retail outlets. Assisted private sector delivery of ITNs may involve costs covered by donors, such as technical support, marketing and distribution, even where the price of the ITN itself is not directly subsidized. Within our delivery system matrix we define subsidies as those directly applied to the ITN, and such forms of assisted private sector delivery are therefore described as unsubsidized.

Within the 'non-assisted private sector', there are two different types of delivery system defined by their delivery points. The 'formal commercial sector' includes static or 'closed' outlets such as shops, supermarkets and pharmacies where products remain in the outlets overnight, and the 'informal commercial sector' includes markets, kiosks and itinerant traders where products are removed from their point of delivery at the end of each trading day.

We found no examples of free nets or ITNs delivered through the private sector; though social marketing through retail outlets has involved partial subsidies on ITNs.

Community-based delivery

Most community-based distribution of ITNs has been through small-scale projects. Such projects have been implemented in many countries since the 1980s, and most have focused on a few villages or districts (Chavasse *et al.* 1999). Projects involving community-based delivery are heterogeneous in structure, some with governmental support such as the Ministry of Health/ UNICEF supported project in Luapula Province Zambia (Dembo Rath and Hill 1998), and others with no governmental input. Some projects have delivered ITNs to the community free of charge but most have involved partial subsidies, the small charge to the end user often providing some level of incentive to the community-based volunteer or sales agent.

Coverage outcomes by delivery system

Coverage data were available for the public-free, public-partially subsidized, mixed-partially subsidized, private-partially subsidized and private-unsubsidized categories (Table 2). The country, scale and timescale of delivery of ITNs and mosquito nets through each of the delivery systems vary. The evaluation surveys are snapshots of outcomes which do not reflect changes over time, nor do they reflect the intended period of delivery, or point in the programme cycle. In Table 3 we clarify the country,

Table 2 Summary of coverage outcomes by delivery systems and cost to the end users

Delivery sector			Delivery category: Cost to the end user		
	Delivery Channel		Free	Partially subsidized	Unsubsidized
Public	Routine services	ANC/EPI/MCH/Child clinics	HH: 82.2%[1] PW: 84% (ht)[2]; 58% (lt)[2] 52.4%[1] <5s: 76.1%[1]		
		Intervention packages – mixed delivery	HH: PW: 67.6%[3] <5s: 70.7%[3]	HH: PW: 27.0% [3]; 26.0%[3]; 47.3%[3] <5s: 28.1%[3]; 21.0%[3]; 69.2%[3]	
	Enhanced routine	Child Health Week/Days			
	Campaigns	Measles	HH: 94.4%[4]; 85.2%[5]; **62.5%**[6] PW: **35.8%**[6] <5s: *[60.2%][4]; *[46.3%][5]; ***[43.5%]**[6]		
		Polio National Immunization Days			
Mixed public-private	Assisted routine services	ANC/EPI		HH: **42.9%** (26.1–87.5)[7], **44%**[8] PW: **31.4%** (3.5–69.6)[7] <5s: **35.5%** (17.3–63.4)[7]	
	Voucher scheme	Routine service - retail		HH: 73%[9] PW: **[53%][10], 50.0%[11]; 24.5%[11] <5s: 27.9%[11]; 12.2%[11], 46%[9]	
		Campaign - retail			
Private (nets)	Employer-based	Workplace			
	'Non-profit' organizations	Retail outlets	HH: 19.9%[12] PW: <5s: 6.0%[13]; 24.0%U[12]; 3.3%R[12];		
	Retail sector	Formal/Informal			HH: 49%[14]; 48%[15], ***44%[16], ****32%[16] PW: <5s: 2.7%[13]
		Formal sector			
		Informal sector			HH: PW: **67.2%**[17] <5s: **67.7%**[17]
Community-based	Community (community-based organizations, NGOs, women's groups etc.)		HH: 50%[18] PW: 46%[18] <5s: 33%[18]		

Notes: ANC = antenatal care; EPI = Expanded Programme on Immunization; MCH = maternal and child health; NGO = non-governmental organization; U = urban; R = rural; ht = high transmission; lt = low transmission.

HH = household ownership = 'proportion of households with at least one ITN'; PW = pregnant women = 'proportion of pregnant women who slept under an ITN the night before the survey'; <5s = children under 5 years = 'proportion of children under five years who slept under an ITN the night before the survey'.

[ ] = none standard indicators.

*'Proportion of households where the index child slept under an ITN the night before the survey' where index child is the youngest child in the household who was above 6 months of age at the time of the survey.

**Use a net regularly rather than the standard 'slept under an ITN the night before the survey'.

***Households with a pregnant woman.

****Households with a child under 5 years of age.

National level data are bold.

Reference key:

[1](Eisele *et al.* 2006); [2](Guyatt *et al.* 2002a); [3](UNICEF 2005); [4](Grabowsky *et al.* 2005b); [5](Grabowsky *et al.* 2005a); [6](CDC 2005); [7](Kadzandira and Munthali 2004); [8](PSI 2006); [9](Schellenberg *et al.* 1999); [10](Marchant *et al.* 2002); [11](Hanson *et al.* 2005a); [12](Holtz *et al.* 2002); [13](Noor *et al.* 2006); [14](Okrah *et al.* 2002); [15](Desfontaine *et al.* 1990); [16](Kikumbih *et al.* 2005); [17](D'lessandro *et al.* 1994); [18](Dembo Rath and Hill 1998).

duration of implementation, point in the programme cycle (completed or ongoing), the number of months after commencement or completion of the project at which the evaluation was undertaken, and scale of the programmes from which the coverage data were derived. The coverage data presented in Table 2 should be interpreted in the light of the duration of implementation presented in Table 3. Where the programme has ended, the level of coverage presented is likely to represent the highest achieved by the specific system. In the absence of an alternative system or replacement system, coverage is likely to fall subsequently. An exception to this is where there are seasonal variations in use, depending upon the time of implementation of the survey by which coverage was assessed.

There were few variations in the use of the household ownership indicator, and where present these related to presentation of the results by target group, that is households with a pregnant woman and households with a child under 5 years of age (Kikumbih *et al.* 2005). Variations on the standard use indicator were found for both children under 5 years and for pregnant women. Evaluations of the measles campaigns used an indicator 'proportion of households where the index child slept under an ITN the night before the survey', where the index child is the youngest child in the household who was above 6 months of age at the time of the survey. This means that the denominator is households with a child meeting the age criterion rather than all children meeting the age criteria. Other variations included 'proportion of women who slept under a net during their pregnancy', 'use of a net regularly' rather than the night before the survey, and 'proportion of children under 5 who slept in a bed with a net hanging over it'. Overall, surprisingly few data points were available, despite allowing the inclusion of non-standard indicators.

Public sector delivery of free ITNs (public-free)

Household ITN ownership data were available only from routine health facility delivery in Eritrea and from the measles campaigns in three countries. Ownership was 82.2% in Eritrea (Eisele *et al.* 2006), and through the measles campaigns varied from 62.5% at the national level in Togo (CDC 2005) to 94.4% in one district of Ghana (Grabowsky *et al.* 2005b). On use by target groups, a greater number of data points were available. Use by pregnant women varied from 35.8% at the national level through the Togo measles campaign[1] to 84% in high transmission areas across 35 districts of Kenya where ITNs were delivered through routine health facilities (Guyatt *et al.* 2002a). Use by children under 5 years varied from 43.5% through the national level measles campaign in Togo to 76.1% through routine health facility delivery across two *zobas* of Eritrea (Eisele *et al.* 2006). Amongst these examples of free public sector delivery, only the programmes in Eritrea and Mali are ongoing; the other examples from Kenya, Ghana, Togo and Zambia were all short-term delivery models (several months for Kenya, and several days for Ghana, Togo and Zambia). Coverage in the campaign categories of delivery was evaluated 1 to 6 months after completion of the campaign, and 12 to 18 months after commencement of delivery in the routine delivery category examples.

Public sector delivery of partially subsidized ITNs (public-partially subsidized)

Outcome data on public-partially subsidized delivery of ITNs was available only for intervention packages of the ACSD programme. These programmes did not assess household ownership. Use by pregnant women and children under 5 years varied from 26.0 and 21.0%, respectively, through an intervention package in six districts of Ghana (UNICEF 2005), to 47.3 and 69.2%, respectively, through a similar intervention package system in two districts of Senegal (UNICEF 2005). These data represent findings 2–3 years post-commencement of the ACSD programmes, which are still ongoing.

Mixed delivery of partially subsidized ITNs (mixed-partially subsidized)

Where the delivery system involved both public and private sectors, household ownership varied from 42.9% through social marketing at the national level in Malawi (Kadzandira and Munthali 2004) to 73% through a mixture of social marketing and a voucher scheme in two districts of Tanzania (Schellenberg *et al.* 1999); use by pregnant women varied from 24.5 to 50.0% in the two districts in which a voucher scheme was implemented in Tanzania (Hanson *et al.* 2005a), and 53% through a mixed voucher and retail sector social marketing programme in two districts of Tanzania (Marchant *et al.* 2002). Use by children under 5 years varied from 12.2 to 27.9% through a voucher system in two districts of Tanzania (Mushi *et al.* 2003). The surveys assessing coverage through these mixed-partially subsidized delivery models were undertaken approximately 1–2 years post-commencement of delivery at the stated scale. With national scale public-private delivery of ITNs through routine health facilities, there is a marked disparity across districts in household ownership of nets in Malawi, ranging from 26.1 to 87.5% (Kadzandira and Munthali 2004).

Private sector delivery of partially subsidized ITNs (private-partially subsidized)

Available data showed household ownership of 19.9% through retail sector social marketing in one district of Malawi (Holtz *et al.* 2002) in a survey undertaken just over a year post-commencement of the project. We found no data on use by pregnant women of ITNs delivered through retail sector social marketing or other private sector delivery systems involving partial subsidies. Use by children under 5 years through this same category of delivery system varied from 3.3% in a rural area of one district of Malawi (Holtz *et al.* 2002) to 24% in an urban area of the same district.

Private sector delivery of unsubsidized nets (private-unsubsidized)

Ownership of unsubsidized nets reaching households through the unassisted private sector, where formal and informal distinctions were not made, varied between 49% in one province of Burkina Faso (Okrah *et al.* 2002) and 32% in one district of Tanzania (Kikumbih *et al.* 2005). We found no data within this category on use by pregnant women; use by children in four districts of Kenya was 2.7% (Noor *et al.* 2006). Use of nets delivered through the informal commercial sector was 67.2% for pregnant women and 67.7% for children under

Table 3 Details of coverage data points by type of delivery system across countries

Category of delivery system	Country	Scale	Duration of implementation	No. months post-commencement (c) or completion (co) of delivery at which evaluation was undertaken	Household ownership	Use of ITNs by <5s (district range)	Use of ITNs by pregnant women (district range)	Equity ratio of household ownership with ITNs
Public-free								
Routine – ANC	**Kenya** (Guyatt and Ochola 2003)	35 districts	4 months 2001	16 months (c) 12 months (co)	–	–	[84%][2] ht [58%][2] lt	–
Routine – ANC	**Eritrea** (Eisele *et al.* 2006)	2 zobas	2002 to date	12 months (c)	82.2%	76.1%	52.4%	
Routine – intervention package	**Mali** (UNICEF 2005)	6 districts	2001 to date	approx. 18 months (c)	–	70.7	67.7	–
Campaign – measles	**Ghana** (Grabowsky *et al.* 2005b)	1 district	6 days 2002	5 months (co)	94.4%	[60.2%][1]	–	[0.92][1]
Campaign – measles	**Togo** (CDC 2005)	national	7 days 2004	1 month (co)	62.5%	[43.5%][1]	35.8	[1.02][1]
Campaign – measles	**Zambia** (Grabowsky *et al.* 2005a)	5 districts	6 days 2003	6 months (co)	82.3% urban 88.0% rural	[46.3][1]	–	[rural 0.88 urban 1.19][1]
Public-partially subsidized								
Routine – intervention package	**Benin** (UNICEF 2005)	6 districts	2001 to date	approx. 18 months (c)	–	28.1	27.0	–
Routine – intervention package	**Ghana** (UNICEF 2005)	6/110 districts	2001 to date	approx. 18 months (c)	–	21.0	26.0	–
Routine – intervention package	**Senegal** (UNICEF 2005)	2 districts	2001 to date	approx. 18 months (c)	–	69.2	47.3	–
Mixed-partially subsidized								
Assisted routine – ANC/EPI direct product	**Malawi** (Kadzandira and Munthali 2004)	national	2000 (pilot) 2002 (national)	approx 18 months (c) national	42.9 (26.1–87.5)	35.5 (17.3 – 63.4)	31.4 (3.5 – 69.6)	[87.8% in wealthiest 31.1% in poorest]
Assisted routine – ANC/EPI	**Kenya** (PSI 2006)	3 provinces	2004 (national)	approx 12 months	44% (national)	46%	50%	–
Voucher scheme – routine service – retail + assisted routine – ANC/EPI	**Tanzania** (i) (Schellenberg *et al.* 1999) (ii) (Marchant *et al.* 2002) (iii) (Nathan *et al.* 2004)	2 districts	1997 to date	(i) 18 months (c) (ii) 1–12 months (c) (iii) 36 months (c)	73% (iii)	46% (i)	[53%][7](ii)	0.3 (1997) 0.6 (2000)
Voucher scheme – routine service – retail	**Tanzania** (Hanson *et al.* 2005a)	2 districts	1 year (2003–2004)	18 months (c)	–	27.9 (district 1) 12.2 (district 2)	50 (district 1) 24.5 (district 2)	0.11 children <5 0.33 pregnant women

Private-unsubsidized (nets)									
'Non-profit' organizations – retail	**Kenya** (Noor *et al.* 2006)	4 districts	2001 to date	–			6.0%	–	0.14
'Non-profit' organizations – retail	**Malawi** (Holtz *et al.* 2002)	1 district	1998	–		19.9%	24.0%[3] urban 3.3%[3] rural	–	–
'Non-profit' organizations – retail	**Tanzania** (Mills *et al.* 2002)	4 districts	2000–2002	–		58.5%	67%	–	0.44[2]
Retail sector – informal commercial	**Burkina Faso** (Okrah *et al.* 2002)	1 province	unknown	–		49%	–	–	–
Retail sector – formal/informal commercial	**Cameroon** (Desfontaine *et al.* 1990)	1 city	unknown	–		48%	–	–	–
Retail sector – formal/informal commercial	**The Gambia** (D'Alessandro *et al.* 1994)	national	unknown	–		–	67.7% (<1s)[4] 71.8% (1–4s)	67.2%	–
Retail sector – formal/informal commercial	**Kenya** (Noor *et al.* 2006)	4 districts	unknown	–		–	2.7%	–	–
Retail sector – formal/informal commercial	**Kenya** (Guyatt *et al.* 2001)	4 districts	unknown	–		–	–	[7.2%][6]	–
Retail sector – formal/informal commercial	**Kenya** (Hamel *et al.* 2001)	1 district	unknown	–		–	[5%][5]	–	–
Retail sector – formal/informal commercial	**Uganda** (Nuwaha 2001)	1 municipality	ongoing	–		55.0%	–	–	–
Community based – partially subsidized									
Community-based – partially subsidized	**Zambia** (Dembo Rath and Hill 1998)	1 district	1997			50%	33%	46%	–

Notes: ANC = antenatal care; EPI = Expanded Programme on Immunization; [] = non-standard indicators.

[1]'Proportion of households where the index child slept under an ITN the night before the survey', where index child is the youngest child in the household who was above 6 months of age at the time of the survey.

[2]Sample group were those pregnant women who had received a free ITN, not the general population of pregnant women. ht = high transmission, lt = low transmission.

[3]Any net – not necessarily an ITN.

[4]In one region (Central) a proportion of the nets may have been delivered through trials rather than the commercial sector.

[5]Proportion of children <5 who slept in a bed with a net hanging over it.

[6]Slept under a net during their pregnancy.

[7]Defined as use a net regularly rather than the standard 'slept under an ITN the night before the survey'.

Note, these are coverage data from household surveys in areas where the specified interventions were implemented; they do not necessarily represent direct outcomes of the specified intervention alone.

Private-unsubsidized is nets not ITNs; other sections are all ITNs (currently treated).

5 years of age at the national level in The Gambia (D'Alessandro *et al.* 1994).

Community-based delivery

Most community-based delivery is conducted on a small scale and is not evaluated, or if evaluated the results are not published and not widely circulated; therefore data are not available on the coverage outcomes achieved through the variety of systems within this category. We were able to access data from one district of Zambia only, where household ownership of nets was 50%, use by pregnant women 46% and use by children under 5 years 33% (Dembo Rath and Hill 1998). Although (re)treatment rates were assessed in the household survey from which these data were obtained, data on ownership and use of ITNs was not presented.

Cost to the end user

It is clear from our matrix (Table 2) that there are very few examples of delivery through specific delivery systems with different levels of subsidy and subsequent costs to the end user. We did not identify any examples of studies that could determine the impact of varying cost to the end user on coverage of nets or ITNs.

Activities at a national scale

In Table 2 we highlight three sets of data where delivery is at the national level. These include public delivery of free nets (free delivery of ITNs through measles campaigns), mixed delivery of partially subsidized nets (through routine health facilities) and private delivery of unsubsidized nets (informal commercial sector). Household ownership of ITNs varies from 42.9% for mixed delivery supported by PSI through routine health facilities with partial subsidies in Malawi (Kadzandira and Munthali 2004), to 62.5% for public sector measles campaigns where ITNs are free to the end user in Togo (CDC 2005). The mixed-delivery model in Malawi had only recently scaled-up at the time of the survey and there is scope for increasing household ownership over time through this model. Conversely, there is no scope for increasing the level of household ownership achieved through a one-off distribution such as the measles campaign in Togo, and ownership will therefore decrease over time as the nets wear out. Maintenance of ownership levels achieved by a campaign would require a complementary system of delivery through other consistent means.

Use by pregnant women and children under 5 years is highest for nets delivered unsubsidized through the informal commercial sector, at 67.2 and 67.7% respectively, in The Gambia (D'Alessandro *et al.* 1994), and lowest for ITNs delivered through assisted routine health facilities with partial subsidy, at 31.4 and 35.5% respectively, in Malawi (Kadzandira and Munthali 2004). Data in Table 2 which have not been highlighted are from sub-national surveys varying from one city to several districts. The informal commercial sector in The Gambia has been delivering nets to the population for many years, and is likely therefore to have reached its full potential in the absence of any interventions to increase demand.

Equity of coverage by delivery system

We identified seven data sources where it was possible to calculate an equity ratio of coverage amongst the lowest and highest socio-economic quintiles (Table 3). Three of these assessed the equity ratio of household ownership of ITNs in households with a child targeted by a measles campaign, one the equity ratio of use by children under 5 years, one of pregnant women, and the remainder were based on non-standard indicators. The findings cannot, therefore, be directly compared. However, based on non-standard indicators the measles campaigns have achieved equitable coverage, even in rural areas [equity ratio: 0.92 in one district of Ghana (Grabowsky *et al.* 2005b); 1.19 (urban), 0.88 (rural) in five districts of Zambia (Grabowsky *et al.* 2005a); and 1.02 at the national level in Togo (CDC 2005)]. Household ownership at the national level through public-private delivery of ITNs in health facilities in Malawi was classified by wealthiest, medium and poorest socio-economic groups, rather than by socio-economic quintiles. Ownership in the wealthiest households was nearly three times that in the poorest (Kadzandira and Munthali 2004). Using the few data points available, coverage achieved through mixed delivery systems with partial subsidies, that is social marketing and voucher schemes, has generally been quite inequitable, varying from 0.11 for use by children under 5 years via a voucher scheme in two districts of Tanzania (Hanson *et al.* 2005a), to 0.6 for a scheme involving both social marketing and vouchers in two districts of Tanzania (Nathan *et al.* 2004). However, it is unclear whether these schemes have increased or decreased any previously existing inequity of coverage. Equity of coverage is likely to vary considerably according to the point in time and average level of coverage at which it is measured.

Discussion

In order to go to scale with ITNs, an evidence-based understanding of the most effective delivery systems is needed. Although delivery systems for ITNs have been debated over the last few years, most of the debates have focused on: (a) whether delivery should be free or subsidized, and (b) the necessity of involving the private sector (Curtis *et al.* 2003; Lines *et al.* 2003). The evidence used in these debates has been limited to data from small-scale research projects and therefore does not necessarily reflect what could be expected from large-scale programmes. Rigorous methodological approaches are used to evaluate the effectiveness of ITNs and other preventative interventions for malaria control. Since the effectiveness of the delivery system will increase or decrease the effectiveness of the intervention, similarly structured approaches using rigorous methodologies are also needed to assess the effectiveness of these different delivery systems. Our approach to developing a structured methodology to determine the effectiveness of the various delivery systems involves: (1) defining and describing the categories of delivery system, (2) development of a matrix in which outcomes may be recorded and comparisons made between these categories at periodic intervals, thereby providing an analytical tool for focusing on changes over time, and (3) assessment of the evidence base for achievements of each delivery system to date.

The current emphasis on scaling-up delivery has shifted the focus from small-scale projects to national-level systems. Delivery of ITNs has been reported to have taken place 'at a national level' in at least five countries of sub-Saharan Africa. Two of these involve public sector delivery, through routine health facilities in Eritrea (with some delivery also taking place to high-risk communities and the military), and through a combined measles and ITN campaign in Togo. The other three experiences involve mixed public-private sector delivery, in Kenya and Malawi through routine health facilities with the support of a 'non-profit' NGO, and in Tanzania through a voucher scheme where the subsidy is delivered through routine health facilities and the product through the private retail sector. ITNs are free to the end user through public sector delivery in both Eritrea and Togo, and involve partial subsidies through mixed delivery in Kenya, Malawi and Tanzania. The number of countries in which there is 'national level' unassisted private sector delivery of nets through either the formal or informal private sector is unclear. Our review suggests that The Gambia is one such country and the relatively high coverage of never-treated nets in Guinea Bissau (59% use by children under 5) (Webster *et al.* 2005) would suggest that this is another. Malawi and Togo were the only two of these countries where we were able to access national-level data for all three RBM coverage indicators. Available data for Eritrea were from two *zobas* only, for Kenya on household ownership only, and for Tanzania data were not yet available as national-scale delivery has only very recently been achieved (May 2006).

We need to define delivery 'at the national level' within the context of the different categories of delivery system, as well as malaria epidemiology. Where delivery is through the public sector or via mixed systems, should 'national-level delivery' be defined as delivery of ITNs (or ITN subsidies) in every district? Or should we have a district-level target with delivery through a certain proportion of facilities? How do we define national-level delivery through the private sector? These questions need to be answered bearing in mind that malaria epidemiology varies across districts of endemic countries, with not all districts being endemic.

As more programmes scale-up, the geographic disparities across countries will certainly need to be addressed, as in the case of Malawi described above. There are lessons to learn from EPI, which, in recognition of district-level disparities in coverage, now has a target of 90% national coverage (with three doses of DPT in children 1 year of age), with at least 80% coverage in all districts (UN General Assembly Special Session on Children, May 2002). As more countries scale-up delivery of ITNs, such targets would be useful in order to both assess and address geographic inequities.

Our review of the literature has outlined three areas relating to delivery of ITNs where clarity is needed, or diversity recognized. The first relates to a general lack of clarity in the description of delivery channels, particularly in the use of the term social marketing. We therefore recommend that social marketing is replaced by a more specific description of the delivery channels, as represented in our matrix. For example, in the existing literature social marketing is variously used to describe: the mixed public-private sector delivery of ITNs through routine health facilities with partial subsidies, private sector delivery through retail outlets with partial subsidies on the ITNs, and assisted private sector delivery where the ITNs *per se* are unsubsidized, but marketing, promotion or technical support are given. A further example of lack of distinction is where 'non-profit' organization and retail sector delivery channels use retail outlets as their delivery point. These are two distinct types of delivery system (see Figure 1). In 'non-profit' organization channels, the ITNs are generally 'pushed' to a retailer and sold at a subsidized price determined by the organization. Private sector delivery involves a 'pull' on a wholesaler or other supplier from the retailer in response to an identified demand (a pull from consumers), and prices will vary according to market forces. 'Non-profit' organization delivery through retail outlets is dependent upon donor money for the subsidy (either for the ITN itself, promotion or pushed distribution) and the programme infrastructure. Unassisted private sector delivery is independent of donor and other public sector input.

Our review suggests that after distinguishing private sector delivery from assisted private sector delivery by 'non-profit' organizations of ITNs through retail outlets, further distinctions should be made within the private sector. The coverage and the equity of coverage achieved through formal and informal delivery outlets varies enormously, with the informal commercial sector being particularly successful in countries of West Africa (NetMark 2001a-e; NetMark 2003; NetMark 2004a-e). In much of West Africa there has been a tradition of using mosquito nets for many years, the majority of which have been supplied through markets (MacCormack *et al.* 1989). These nets are made from a variety of materials and the reasons for using them and the preferences for the different fabrics vary accordingly (Panter-Brick *et al.* 2006). There is a lack of evidence on whether the bias towards the poorest households of nets delivered through the informal sector is due to the delivery points, that is markets rather than supermarkets and pharmacies, or whether it is due to the type and/or cost of the 'local nets'. Delivery of a range of ITNs through the informal sector, thereby increasing choice, may help to answer this question.

The second area requiring clarification is the objectives of voucher schemes. The objective of a voucher scheme is to provide targeted subsidies through the public sector whilst delivering the product through the private sector, thereby promoting private sector growth, and ultimately its sustainability. The retailers involved in the scheme therefore exchange a voucher for an ITN, usually with the addition of a top-up fee; this transaction represents a public-private partnership in delivery. Voucher schemes also aim to facilitate a general increase in availability such that those not targeted by subsidies may also buy ITNs at full commercial price, which would involve a purely private sector transaction. These schemes should be distinguished from delivery which involves a 'paper' subsidy through the public sector where the product is also delivered through the public sector. An example is the combined polio national immunization day and ITN distribution in Central Region Ghana, where coupons were given to the caretakers of children under 5 years of age. This coupon entitled the bearer to buy a subsidized ITN at a pre-determined number of sites which were mainly health facilities.

The coupon was used simply as a method of delivering the right to a subsidy, and of avoiding logistical problems of transport of ITNs by immunization volunteers.

The third issue concerns timing. There are at least four dimensions of timing which are relevant: duration of delivery, intended duration of delivery (that is, programme objectives and timeframe), changes in the nature of the programme over time, and seasonality in coverage and time of its measurement. Timing may therefore impact on coverage outcomes achieved, coverage outcomes measured, and should be considered in the interpretation of relative achievements. Delivery of ITNs through integration with immunization campaigns provides a 'quick fix' or 'catch-up' solution to scaling-up coverage. The maximum level of household ownership is achieved within the few days of the campaign. Where no other system is in place to 'keep-up' this coverage, then ownership is transient and will fall as the ITNs wear out. Delivery of ITNs/nets through routine systems (public and/or private) may also be used to 'catch-up' coverage, but the pace is slower. These systems, however, are also designed to 'keep-up' coverage. In order to compare the effectiveness and cost-effectiveness of these two systems, they should be mapped over a period of at least 3–5 years. These issues of timing should be addressed directly when results are reported, so that there is an explicit statement of the time elapsed between the commencement of delivery, intended period of delivery and the point at which coverage is measured.

Programmes can also change over time, suggesting that they may move between cells in the matrix, which is why the proposed tool/framework should be used repeatedly at suitable periodic intervals. Finally, use of ITNs/nets is seasonal and therefore the coverage measured is highly influenced by the season in which the survey is undertaken. This should be taken into account in interpreting the outcomes of delivery systems as measured through cross-sectional surveys such as the Demographic and Health Surveys.

Using the categories we defined, we found some intra-category variations and some inter-category overlaps. All examples of intervention packages were from the UNICEF ACSD programmes in West Africa. These generally involve delivery through routine health facilities, but sometimes this occurs via community agents either in the facilities, as in Upper East Region of Ghana, or within the communities. This is therefore a combination of two types of delivery, routine health systems and community-based. The KINET programme in Tanzania was primarily a social marketing programme, but also introduced the delivery of discount vouchers for ITNs delivered to pregnant women through ANC.

Although RBM has recommended three outcome indicators for ITN programmes, these are often not used or are modified so that direct comparisons across programmes and countries are not possible. 'Coverage' is a term which is loosely used, such that it is often difficult to interpret. Coverage is variably used to refer to household ownership, use by pregnant women or use by children under 5 years of age. We recommend that coverage of ITNs and nets is always qualified as either household ownership, or use by a specific target group.

The data points included in our review are taken mainly from post-delivery household surveys undertaken by programmes using a specific category of ITN delivery. The assumption has been that the contribution of ITNs delivered through other systems to this coverage has been negligible. We found only one example of a direct comparison of coverage outcomes from specific delivery systems, which was that of Kikumbih *et al.* (2005) in Tanzania, who compared coverage achieved in one district through both social marketing of ITNs and commercial sector activity with that of coverage in another district using commercial sector delivery only. Methods are needed such that coverage achieved at the household level (ownership and use by target groups) collected in household surveys may be attributed to specific delivery systems. NetMark surveys focus on the source of nets (proportion of nets/ITNs in households that came from each source). A further step of linking this data to target groups would allow the assessment of the three RBM coverage indicators by delivery system. Inclusion of these methods in the Demographic and Health Surveys and Multiple Indicator Cluster Surveys would allow collection and collation of the urgently needed data to compare the effectiveness of different delivery systems for ITNs within a range of contexts.

We focused within our review on two outcomes: effectiveness and equity. Other outcomes include cost-effectiveness and sustainability. A review of cost and cost-effectiveness studies on ITNs has recently been undertaken, which has emphasized the diversity of methods used (Kolaczinski and Hanson 2006). Sustainability has not been addressed. Within our review we compare the transient nature of coverage through campaign-style delivery with the ongoing routine delivery through public and/or private sectors. A wider review of sustainability is beyond the scope of this review and, indeed, is not possible with existing published data sources which tend to report coverage achieved at a single point in time.

Our review has outlined the diversity of delivery systems for ITNs and the weakness of the evidence base currently available to aid in strategic decision making for national scale-up with the increased funding now available to countries. Where data are available, ITNs have been delivered by programmes which have been implemented at a variety of scales, in different countries and over different time periods, making it impossible to draw clear conclusions as to their relative merits. There are no comparative studies from which definitive evidence can be drawn in the way that there are randomized control trials for the efficacy of interventions such as ITNs.

The response to the debates on whether delivery should be free or subsidized and on the necessity for involving the private sector will be different depending upon the country of focus and upon the context of ITN delivery systems used within that country. Even in countries where delivery is 'at the national scale', it is clear that geographical access is not universal and therefore it is impossible to draw conclusions on the impact of cost. The variation in impact of another large-scale intervention, the Integrated Management of Childhood Illness (IMCI), between different contexts has recently been shown across five countries (Victora *et al.* 2005). Research is needed on the contextual factors which either enable or act as barriers to the delivery of ITNs through various categories of delivery systems currently used. Our matrix presents an analytical framework within which this can be conducted. We may then be able to ascertain under what circumstances free, partially subsidized or unsubsidized ITNs are necessary/most appropriate, and whether

and under what circumstances the private sector may make important contributions to ensuring that children under 5 years and pregnant women are protected from malaria by ITNs.

A comprehensive mapping of systems and outcomes is needed, incorporating an analysis of the influence of context, with a view to providing evidence to guide strategic decision making. Currently, even basic information about household ownership and use by target groups is lacking, thereby severely restricting our ability to make evidence-based decisions about the most effective delivery systems for any given context.

Endnote

[1] Pregnant women are not a target group of the measles campaigns, which generally target children 9–59 months of age, but may sometimes include children of 9 months to 15 years depending upon measles epidemiology.

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Evaluating Delivery Systems: Complex Evaluations and Plausibility Inference

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Abstract. Delivery system evaluation is poorly defined and therefore a barrier to achieving increased coverage of interventions. We use a pre- and post-implementation cross-sectional observational study with assessment of the intermediate processes to evaluate a new delivery system for insecticide-treated nets (ITNs) in two regions of Ghana. In Volta Region, ownership of at least one net rose from 38.3% to 45.4% ($P = 0.06$), and 6.5% of respondents used a voucher in the purchase. In Eastern Region, ownership of a net rose from 13.7% to 26.0% ($P < 0.001$) and 0.5% of households used a voucher to purchase a net. Just 40.7% and 21.1% of eligible antenatal clinic (ANC) attendees were offered a voucher in Volta and Eastern Regions, respectively, and 36.0% and 30.7% used their voucher in the purchase of an ITN. Without attributing nets to the specific delivery system, in Eastern Region the success of the new system would be overestimated.

INTRODUCTION

There are many efficacious interventions, which have the potential to reduce morbidity and mortality and achieve the Millennium Development Goals (MDGs) if they are delivered effectively.[1,2] However, coverage of many of these interventions remains inadequate, limiting the achievement of improvements in population health. Improving coverage requires focusing attention on the systems through which interventions are delivered, and adapting the methods traditionally used to assess the clinical effectiveness of interventions to answer questions about the effectiveness of delivery systems at increasing coverage with essential health interventions.[2] Advances within this field of research are hampered by a plethora of sometimes distinct, but often overlapping terminologies and concepts. Clarity in the concepts and methods of evaluating effectiveness of interventions and their delivery systems would strengthen the evidence base for effective public health policies and programs.

Methods for assessing the effectiveness of interventions have been addressed in the literature on program evaluation[3–6] and complex evaluations;[7] both literatures highlight the importance of understanding and assessing the intermediate steps (causal chain) between implementation and outcomes. The assessment of this causal chain has been defined by the UK Medical Research Council as process evaluation.[7] The assessment of outcomes is seen as the priority for assessing the effectiveness of an intervention in both literatures, but the study designs used vary. The program evaluation literature has suggested that the "gold standard" randomized controlled trial (RCT) is not only operationally difficult and resource heavy, but may also be inappropriate.[5] The use of observational studies with different levels of inference (probability, plausibility, and adequacy) that the outcome was a result of the intervention, has been proposed.[3] The complex evaluation literature recommends that experimental designs (RCT, stepped wedge designs) should be used where possible, but recognizes that they are not always appropriate.[7]

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Methods for assessing the effectiveness of delivery systems for public health interventions have not been defined. We propose that the approaches to evaluating delivery system effectiveness can be simpler than those for evaluating intervention effectiveness. Where the objective is to assess the effectiveness of a system that delivers, interventions of known effectiveness, and particularly its ability to achieve scaled up delivery of these interventions, the appropriate outcome measure is coverage of the intervention.

We use a case study of an evaluation of an insecticide-treated net (ITN) voucher scheme in two regions of Ghana, to show how pre- and post-implementation cross-sectional surveys with attribution of the source of intervention (ITN) can provide a plausibility level of inference that coverage outcomes were caused by the new delivery system. In this context the clinical effectiveness of the intervention (ITNs) has been proven through clinical trials and effectiveness trials in a range of settings, but the effectiveness of the delivery system (the voucher scheme) is yet to be demonstrated.

CASE STUDY

Background. Before introduction of the ITN voucher scheme in 2004, the proportion of households owning at least one net was 46.1% in Volta Region and 10.3% in Eastern Region.[8] Mosquito nets had been delivered through diverse systems in both regions, with targeting of subsidies to vulnerable groups through the public sector, and promotion of widespread availability and distribution of ITNs through the private sector. Public sector delivery of nets was through the sale of nets to pregnant women and children less than 5 years of age at a price of US$2.2 in health facilities. These nets were distributed to districts from the National Malaria Control Program (NMCP). Some District Health Management Teams (DHMTs) also procured their own nets from the commercial market and sold them through health facilities using the pricing and targeting strategies recommended by the NMCP. The nets were of a variety of types: factory pre-treated, bundled with insecticide, and untreated nets with separate insecticide treatment tablets, depending on donations and availability.

As of 2003, several private sector partners were involved in the promotion and distribution of mosquito nets including: AgriMat, Vestergaard Frandsen, Transcol, and NetMark (Accra, Ghana). AgriMat marketed Dawa net, which is a

factory pre-treated ITN, K-O net, which is an untreated net bundled with insecticide, and K-O Tab, which is a deltamethrin tablet for the (re)treatment of nets. By 2003 AgriMat were supplying nets to all regions of the country through their agricultural distribution networks, with the exception of the northern regions where they were not able to compete with the highly subsidized United Nations Children's Fund (UNICEF) nets. Delivery points for AgriMat products were within the formal retail sector including pharmacies, chemical sellers, and general shops. Vestergaard Frandsen marketed PermaNet, a long lasting insecticidal net (LLIN), through outlets including Total and Mobil petrol stations, pharmacies, and supermarkets. Their products were distributed by Transcol. NetMark, established by United States Agency for International Development (USAID) with the aim of increasing coverage with ITNs through partnerships with private sector companies, launched their activities in Ghana in November 2002, and worked with all the previously listed importers, wholesalers, distributors, and retailers. Formal private sector delivery points included general shops, clothes/fabric shops, wholesalers, pharmacies, and chemical sellers (private sector outlets, which are static and the goods remain at the point of sale overnight).

Within the informal retail sector the majority of mosquito nets were untreated and made from a variety of materials and fabrics,[9] ITNs were rarely found in the informal retail sector. Informal private sector outlets included markets, local kiosks, table top vendors, and street hawkers (private sector outlets that are non-static where the goods are stored elsewhere overnight).[10]

Intervention evaluation. In 2004, the Ghana National Malaria Control Program (NMCP), supported by the Department for Internal Development (DFID) and USAID, introduced an ITN voucher scheme with the aim of increasing coverage of ITNs. The scheme started in Volta Region, and within a few months it was scaled up to the adjacent region (Eastern Region). In the voucher scheme pregnant women attending antenatal clinic (ANC) were eligible for a voucher, which entitled them to a US$2.2 discount on an ITN. This discount voucher was to be used together with a "top-up" cash payment, to purchase an ITN in the retail sector. Voucher scheme ITNs were available only in outlets that had agreed to take part in the voucher scheme. The intervention therefore consisted of delivery of a subsidy in the public sector and delivery of the ITN in the formal private sector. Informal private sector providers were not invited to take part in the voucher scheme.

This intervention was implemented within the context of the pre-existing delivery systems for mosquito nets, as described previously (Figure 1). At the time of implementation of the ITN voucher scheme pilot in the two regions, the national strategy for delivery of ITNs to pregnant women was direct delivery for US$2.2 on visiting ANC. To avoid confusion, the decision was taken by the NMCP in agreement with the Regional Health Management Teams (RHMTs) that they would not supply ITNs to health facilities in Volta and Eastern Regions during the period of the voucher scheme pilot. However, during the period of the pilot many of the health facilities did actually receive ITNs from both public sector and private sector suppliers. The result of this was that during implementation of the voucher scheme some midwives exchanged vouchers for ITNs within the health facility. This was not an intended strategy for the voucher scheme and therefore ITNs delivered in this way are not attributed to the voucher scheme.

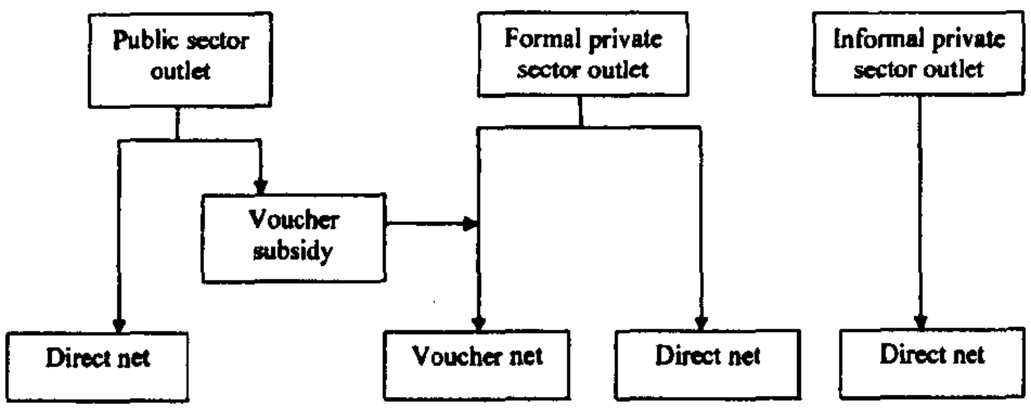

FIGURE 1. Categorization of delivery systems of nets (internal comparators).

Pre- and post-implementation household surveys were undertaken in March 2004 (pre) and April 2005 (post) in Volta Region and in July 2004 (pre) and July 2006 (post) in Eastern Region. A stratified multistage cluster sampling method was used to select households across each of the two regions for both surveys. Two districts in each of the northern, central, and southern zones of each region were selected using probability proportional to population size (PPS). Thirty clusters (villages) within each of these districts were selected using PPS. Seven households were randomly selected per cluster using a modified Expanded Program of Immunization (EPI) sampling technique. Households were sampled if they had either a currently pregnant woman or a mother of a child less than 1 year of age (< 1) in the household. The same districts in each region were sampled for the post-implementation surveys, and the same sampling procedures were used to select the 30 clusters within each of the districts and seven households within each cluster. Thus, the selected clusters and households in the pre- and post-implementation surveys are independent samples. The total number of households by region and district for each survey are shown in Table 1.

Control groups and attribution. To assess the effectiveness of the voucher scheme the other delivery systems in the two regions (see above) were defined as internal comparison groups. No external control arm was used because 1) the scheme was implemented in all districts of each of the two regions and 2) differences in contextual factors between the study regions and the other bordering regions would have precluded the usefulness of such an external control.

Attribution of nets in households to the delivery system through which they reached the household was achieved through the use of questions on the source of the net.

Respondents were asked two questions to determine the source of each of the mosquito nets owned in the household. 1) Where did you get this mosquito net? 2) Did you use a voucher to pay for this net?

Process evaluation. Four intermediate steps in the delivery and use of a voucher subsidy were defined, which describe the causal pathway through which a mosquito net reaches a household. Four questions were included in the post-implementation survey in each region to assess these intermediate steps. 1) Whether the pregnant woman or mother of a child less than 1 year of age had attended ANC during her current/last pregnancy; 2) whether she was offered a voucher for a mosquito net during this visit; 3) whether she accepted the voucher; and 4) whether she had used the voucher to purchase a net.

Analysis. On the basis of the reported sources, nets were categorized to public, formal private, or informal private

TABLE 1
Distribution of sample households

Volta Region			Eastern Region		
District	Pre-implementation	Post-implemenation	District	Pre-implemenation	Post-implemenation
Krachi	197	204	Kwahu South	212	245
Jasikan	197	211	Manya Krobo	211	166
Kpando	168	168	East Akim	209	251
Hohoe	247	251	Suhum Kraboa Coaltar	211	168
Ketu	308	309	Akwapim South	211	149
South Tongu	115	111	Birim South	211	247
Total	1,232	1,254		1,265	1,226

sector nets. Formal private sector nets were further classified to unsubsidized net or voucher-subsidy net. The proportion of households having any net and the voucher-subsidy net was compared between pre- and post-implementation time points in the regions separately. Analyses were conducted using STATA 10 software (STATA, College Station, TX) adjusting for the cluster design of the surveys. Pearson's design-based F test was used to test the significance of the differences in proportions between the two cross-sectional surveys in each district.

RESULTS

Across the four surveys in the two regions 2,019 nets were reported in the sampled households. The source of 1,891 (93.7%) of these nets was reported as known by the respondent. The remaining 128 were from sources that the respondent was not able to identify (including gifts).

Effectiveness of the voucher scheme. In Volta Region, ownership of mosquito nets rose from 38.3% to 45.4% ($P = 0.06$) pre and post implementation of the voucher scheme Table 2. Formal private sector nets purchased with a voucher subsidy reached 6.5% of households. In Eastern Region, the proportion of households owning at least one net rose during one year's implementation of the voucher scheme from 15.0% to 26.0% ($P < 0.001$). However, formal private sector nets purchased with a voucher subsidy reached only 0.5% of households.

An assessment of the change in proportion of nets reaching the household by alternative delivery systems pre and post implementation of the voucher scheme provides greater insight into the impact of the voucher scheme in each of the regions. In Volta Region, before the implementation of the voucher scheme, 3% of households owned at least one net that they got from the public sector, 1.5% from the formal private sector, and 31.8% from the informal private sector. Post implementation of the voucher scheme households with at least one public sector net increased to 8.4% ($P < 0.001$), households with a formal private sector net to 10.4% ($P < 0.001$), and households with an informal private sector net decreased to 27.2%. Approximately 60% of those households who got a net through the formal private sector used a voucher in the purchase. Surprisingly, 3.4% of households reported using a voucher in the process of acquiring a net through the public sector. The voucher-subsidy net was used by 9.9% of households (3.4% public sector and 6.5% formal private sector).

In Eastern Region, before implementation of the voucher scheme, 4.3% of households owned at least one net that they got from the public sector, 2.1% from the formal private sector, and 7.4% from the informal private sector. Post implementation of the voucher scheme, 17.6% ($P < 0.001$) of households owned a mosquito net from the public sector, 1.4% from the formal private sector, and 4.4% ($P = 0.05$) from the informal private sector. The increase in households owning at least one net during the voucher implementation period was through the public sector delivery system. Fifteen percent of households purchased a net directly through a public sector outlet. As in Volta Region, 4.3% of households reported purchasing a net through a public sector outlet and using a voucher subsidy in this purchase. This means that the voucher was used to purchase a net in the clinic, rather than at a retail outlet.

Delivery processes. To benefit from the ITN voucher scheme, women must attend ANC. Attendance at ANC at least once was high, particularly in Volta Region, 92.2% and 84.4% of

TABLE 2
Delivery system outcomes pre and post implementation of the insecticide-treated nets (ITNs) voucher scheme

	Volta Region		Eastern Region	
Source of net	Pre-implementation n (%)	Post-implementation n (%)	Pre-implementation n (%)	Post-implementation n (%)
Public sector				
Directly subsidized	37 (3.0)	65 (5.2)	54 (4.3)	173 (13.7)
Voucher subsidized	0	43 (3.4)	0	49 (3.8)
Total	**37 (3.0)**	**105 (8.4)*** **	**54 (4.3)**	**222 (17.6)*** **
Formal private sector				
Unsubsidized	18 (1.5)	50 (4.0)	27 (2.1)	11 (0.9)
Voucher subsidized	0	82 (6.5)	0	6 (0.5)
Total	**18 (1.5)**	**130 (10.4)*** **	**27 (2.1)**	**17 (1.4)**
Informal private sector				
Unsubsidized	392 (31.8)	341 (27.2)	93 (7.4)	55 (4.4)*
Total with at least 1 net	**472 (38.3)**	**571 (45.4)**	**190 (15.0)**	**328 (26.0)*** **
Survey population	**1,232**	**1,254**	**1,265**	**1,260**

* $P \leq 0.05$;
** $P \leq 0.005$;
*** $P \leq 0.001$.

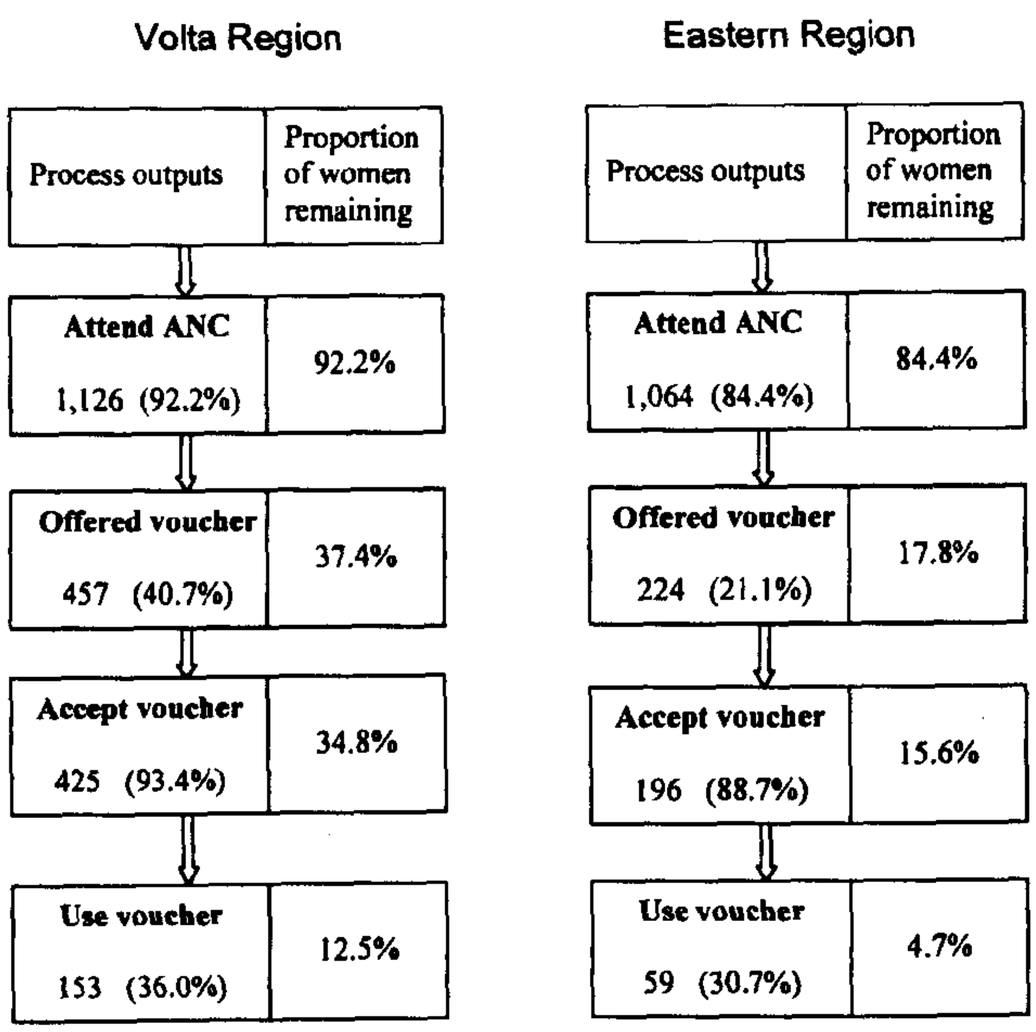

FIGURE 2. Insecticide-treated nets (ITNs) voucher scheme delivery processes in Volta and Eastern Regions.

currently or recently pregnant women attended ANC in Volta and Eastern Regions, respectively (Figure 2). However, only 12.5% of respondents in Volta Region and 4.7% of respondents in Eastern Region said that they had used a voucher to buy a net. Examination of the four intermediate steps in the delivery process identified, shows clearly that there were two processes where the delivery of nets by the voucher subsidy broke down. These delivery disorders arose in the process of offering a voucher to eligible ANC attendees (only 40.7% and 21.1% in Volta and Eastern Regions, respectively), and in the process of using a voucher in exchange for a mosquito net (36.0% and 30.7% in Volta and Eastern Regions, respectively).

DISCUSSION

The aggregate increase in the proportion of households owning at least one mosquito net was of borderline significance in Volta Region and significant in Eastern Region. These changes are as could be expected with implementation of a complex system such as that of a voucher scheme, in comparison with a more rapid increase in coverage that could be expected from less complex delivery systems such as campaigns. The simple pre- and post-implementation evaluation of delivery outcomes suggested that, particularly in Eastern Region, an adequate increase in the proportion of households owning at least one mosquito net occurred within the timeframe of implementing the voucher scheme.

Using information linking the coverage achieved to the specific delivery systems presents a different picture of the effectiveness of the new delivery system. Using the reported delivery point to attribute the nets in households to the specific system through which they were delivered and reached the household, suggested that only 6.5% and 0.5% of households with pregnant women or a child less than 5 years of age in Volta and Eastern Regions, respectively, had a mosquito net that was delivered in a formal private sector outlet by the voucher scheme. In Eastern Region, the majority of the increase in the coverage of ITN during the first year of implementation of the voucher scheme was caused by direct delivery of mosquito nets through the public sector.

Assessment of the delivery processes provided additional evidence that it was not plausible that the increase in ITN coverage in Eastern Region was caused by the voucher scheme because only 4.4% of respondents in sampled households reached the endpoint of the delivery system by using a voucher to purchase a mosquito net. This delivery process evaluation also identified the points at which there were "disorders" in the delivery system impeding its effective operation.

Assessing the household ownership of nets pre and post implementation of the voucher scheme provided a measure of the aggregate change in coverage that occurred during this time. However, where there is more than one delivery system operating for a particular intervention, distinguishing the contributions of each individual system to aggregate coverage becomes important. In this case, it would have been inappropriate to infer that the total change in coverage was caused by the voucher scheme. In fact if this interpretation had been made, the effectiveness of the voucher scheme would have been over estimated. Attributing the nets in the household to the system through which they were delivered provided a strong inference on the proportion of the measured change that was caused by each specific delivery system, including that of the new voucher delivery system.

Although plausible inferences can be reached using pre-post implementation studies and this study design is appropriate for the evaluation of delivery systems, one should consider the limitations and advantages with respect to other methodologies. The cross-sectional plausibility study used here is based on the comparison of outcomes in an intervention group with a non-randomized control group. Such observational studies with non-randomized controls have generally weaker internal validity than studies using randomized controls. However, robust sampling techniques would improve this validity by reducing selection bias and random errors. Our pre-post evaluation of coverage did not assess or adjust for any contextual factors, and we recognize this limitation. Nonetheless, the use of alternative delivery systems as internal controls has the advantage that each of the systems will be influenced by the same temporal trends in external contextual factors.

The discordance between the results in the two regions suggests that the voucher scheme was highly dependent on contextual factors. There are differences between the two regions in terms of the socio-economic status of the populations, levels of education, levels of economic activity, and levels of use of mosquito nets. The process evaluation suggests that the most important contextual factors are those that acted at two steps in the causal pathway of implementation of the voucher scheme, namely offer of a voucher to an eligible woman, and use of the voucher by the pregnant woman to purchase an ITN. Qualitative analysis of the factors influencing the success of the individual processes of the voucher scheme is reported elsewhere (Webster J and others, in preparation).

The finding that vouchers were being used for ITNs delivered within the clinic was an unexpected outcome of implementation of the voucher scheme. However, it corresponded to anecdotal evidence that ITNs were being sold in health facilities that had been supplied with vouchers. Because of stock outs of ITNs in the formal private sector outlets in the

regions, the NMCP supplied ITNs to the districts for delivery from health facilities to pregnant women. This resulted in ANC staff having both vouchers and ITNs. The use of a voucher for an ITN delivered within a health facility was one of the outcomes of this complex situation.

The delivery of NMCP ITNs to the health facilities was a major contextual change, which resulted in the presence of two directly competing delivery systems for ITNs. The increase in the proportion of households owning a public sector directly subsidized ITN in Eastern Region (4.3–13.7%) compared with Volta Region (3.0–5.2%) over the period of implementation of the voucher scheme, suggests that the impact of this competition may have been greater in the Eastern Region. This difference is likely the result of timing, as the NMCP ITNs were distributed 9 months into the period of evaluation in Volta Region and within 2 months of the voucher scheme beginning in Eastern Region.

It could be argued that a cluster RCT of the voucher scheme with controlled implementation would have provided a better measure of the efficacy of this new delivery system. However, RCTs can have limited external validity even to the whole population of the area in which the trial was conducted in a subsample of the population. Well-conducted cross-sectional observational studies will have good generalizability to the population from which they were sampled. Therefore, if a survey is undertaken at the national level, the findings are then generalizable at the national level. Cross-sectional observational studies with a plausibility inference have the advantage that they are less complex and expensive than studies using randomized controls and are therefore more applicable at scale.

This move to a strong plausibility inference in our case study was achieved through the simple addition of two questions on the cross-sectional household surveys for attribution, and four questions on delivery processes. This study design allows relatively simple assessment of the effectiveness of a delivery system on an operational scale. Minor adaptations to the method would allow an assessment of the impact of competition between two alternative delivery systems for ITNs.

This example was of the delivery of mosquito nets, but the same basic steps would apply to delivery of other public health products such as drugs. The conceptual framework could be further developed for application to the delivery of information through communication interventions. Additionally, our model can enable comparison of delivery system strategies. For example, the effect of applying different pricing strategies, different products, or different communication messages, to an intervention delivered through a specific delivery channel could be evaluated using this approach.

A limitation of this method is that it applies to the evaluation of delivery systems. The novel methodological approach is attribution of coverage and the use of internal controls to enable a plausible inference that the outcomes were because of the intervention. This method is based on the relationship between the delivery system and coverage outcomes, which is the endpoint of a delivery system evaluation. Where an intervention is under evaluation the outcome that must be assessed is that of health impact. Although the effectiveness of a delivery system contributes substantially to the effectiveness, or health outcome of an intervention, other factors such as consistency of use or adherence to dosing schedules may also contribute. The presence of these factors and others that confound the relationship between coverage and health outcome, invalidate the use of this method for evaluation of interventions. It would not be possible to infer that the health outcomes were caused by the intervention over and above the impact of confounding factors. We would suggest, however, that a substantial number of external influences on intervention effectiveness are in fact delivery system factors.

Our cross-sectional observational study design provides a relatively simple method for assessing the effectiveness, and contributing to assessment of the cost effectiveness of delivery systems for public health interventions. Within the context of the recognition that more than one delivery system is needed to reach all target groups,[11] this method is able to assess the relative contributions of a number of delivery systems to a single outcome.

In one region (Volta Region), we were able to show strong plausibility that the increase in household ownership of nets was a result of the voucher scheme; and in the other region (Eastern Region) it was implausible that the increase in ownership of nets was because of the voucher scheme. However, we recognize that the differences in contextual factors between the two regions should be taken into account in interpreting this plausible inference.

CONCLUSION

Our case study highlights that a cross-sectional observational study design conducted pre and post implementation of a new delivery system for ITNs without an external control can provide a strong plausibility inference on the impact of the delivery system. This is achieved by attributing coverage outcomes to the delivery system through which the intervention reached the household. In the absence of this attribution, the impact of the new delivery system would have been overestimated.

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Methods for evaluating delivery systems for scaling-up malaria control intervention

Jayne Webster[1*], Daniel Chandramohan[1], Kara Hanson[2]

Abstract

Background: Despite increased resources over the past few years the coverage of malaria control interventions is still inadequate to reach national and international targets and achieve the full potential of the interventions to improve population health. One of the reasons for this inadequate coverage of efficacious interventions is the limited understanding of the optimum delivery systems of the interventions in different contexts. Although there have been debates about how to deliver interventions, the methods for evaluating the effectiveness of different delivery systems have rarely been discussed. Delivery of interventions is relatively complex and a thorough evaluation would need to look holistically at multiple steps in the delivery process and at multiple factors influencing the process. A better understanding of the strength of the evidence on delivery system effectiveness is needed in order to optimise delivery of efficacious interventions.

Methods : A literature review was conducted of methods used to evaluate delivery systems for insecticide treated nets, intermittent preventive treatment in pregnant women, and treatment for malaria in children.

Results: The methodology of delivery system evaluations varied. There were inconsistencies between objectives and methods of the evaluations including inappropriate outcome measures and unnecessary controls. There were few examples where the delivery processes were adequately described, or measured. We propose a cross sectional observational study design with attribution of the outcomes to a specific delivery system as an appropriate method for evaluating delivery systems at scale.

Conclusions: The proposed evaluation framework is adaptable to natural experiments at scale, and can be applied using data from routine surveys such as the Demographic and Health Surveys, modified by the addition of one to two questions for each intervention. This framework has the potential to enable wider application of rigorous evaluations and thereby improve the evidence base on which decisions about delivery systems for malaria control and other public health interventions are taken.

Introduction

The efficacy of insecticide treated nets (ITNs) [1,3,4], intermittent preventive treatment in pregnant women (IPTp) [5-9] and artemisinin combination therapies (ACTs) [10-12] have been proven. However, coverage of these interventions is still low: the most recently available data indicate that among populations at risk, only 24% of children under 5 years of age use a treated net, 20% of pregnant women receive at least two doses of IPTp, and less than 15% of febrile children receive prompt treatment with an ACT. [13]. Whether insecticide treated nets should be delivered free of charge, whether they should be delivered through the public or private sector, and whether through routine systems or campaigns is debated. The low coverage of IPTp delivered through routine antenatal care has prompted questions on whether delivery of IPTp through community based systems could increase coverage. Interventions to improve access to ACT through public, private and community based delivery systems are being implemented. Despite these debates about how to scale-up the delivery of these interventions, there has been little discussion of the methods of evaluation of the effectiveness of different delivery systems, limiting understanding of the strength of the evidence base on which the merits of different systems can be considered.

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Delivery systems have two components: (1) the channels through which a product moves from the national level to the end user; (2) the strategies applied to facilitate movement of the product from step to step of the delivery channel. The delivery channels may be within the public sector such as antenatal clinics (ANC) and campaigns, the private sector such as Licensed Chemical Sellers, or composed of a mix of the two such as voucher schemes for ITNs. The strategies to facilitate movement of the product applied to these channels include pricing policies (level of subsidy), the type or brand of product, the extent and form of training of health workers, and the formulation and packaging of the drugs. There are therefore a multitude of potential delivery systems for most public health interventions and most interventions will be delivered at any one time through more than one delivery system (different channels, strategies, or both). A public health programme such as a malaria control programme will consist of multiple products delivered through a multitude of delivery systems.

Evaluation of the effectiveness of delivery systems is essential to identify optimum delivery systems to scale up interventions. However, the methodology for evaluating delivery systems has not been well defined. Evaluations in general have focussed on the effectiveness of the intervention, or on the health impact of public health programmes. Approaches proposed for programme evaluation provide a useful framework for development of delivery system evaluations. Three types of programme evaluation have been defined based upon the strength of inference of the causal relationship between the interventions that are implemented and the outcomes. In increasing order of complexity and strength of inference, these are adequacy, plausibility, and probability evaluations [14]. The UK Medical Research Council has developed a similar framework for evaluating 'complex interventions' where they acknowledge the need to examine the causal pathway of interventions, which they call a process evaluation [15]. Although primarily developed from experience within high income countries, this approach may be adapted to the needs of programme evaluation within the developing country context. Examples of this approach to date have mainly been conducted within the context of Randomised Controlled Trials (RCTs).

Although there have been calls for scaling up the delivery of effective interventions over the last few years [16,17] there have been few advances in how to assess the effectiveness of the systems required to achieve this objective. In order to optimise delivery of efficacious interventions it is critical to understand the way in which these delivery systems have been evaluated so as to assess the strength of the evidence base. Our objective is therefore to review the methods used in evaluations of delivery systems for ITNs, IPTp, and effective case management for febrile children; and, drawing on the findings from this review and upon elements of programme evaluation methodology, to develop a relatively simple approach to delivery system evaluation applicable to use by a wide range of programmes.

Methods

We reviewed evaluations of the delivery of ITNs, IPTp, and case management of malaria in febrile children that were found in the PubMed electronic online database (US National Library of Medicine, Bethseda, USA). Key search terms used were insecticide treated nets, ITNs, bednet, bed net, intermittent preventive treatment, IPT, IPTp, malaria treatment, malaria case management, delivery, distribution, coverage, adherence, and evaluation. The titles and abstracts were checked for relevance to the evaluation review. The reference list of each identified paper was searched for further relevant publications.

Studies were included if they involved evaluation of the delivery of ITN, IPTp or ACT through one specific delivery system, through multiple systems, or through a new delivery system. Because IPTp is almost exclusively delivered through ANC, studies of coverage of IPTp were included; in contrast, ITNs and effective case management for malaria may be delivered through a myriad of systems and therefore studies of coverage of ITNs and effective case management for malaria were excluded unless they referred to a specific delivery system(s), or a component of a specific delivery system. This review focused on the delivery channel. Thus, evaluations of delivery strategies to improve uptake and use such as pricing policies, pre-packaging of drugs, education of providers and other such strategies were excluded. For each study, the defined objective, evaluation method, primary outcome, type of control and scale were extracted.

Objectives and approaches to evaluation from the public health programme literature and the complex evaluation literature were used to develop a framework for delivery system evaluation and to discuss the limitations of the reported delivery system evaluations.

Results

Review of delivery system evaluations

An initial screening of 1,039 study titles identified 65 papers on ITNs, 16 on IPTp, and 54 on effective case management of malaria, that were relevant to delivery system evaluation. Upon reviewing the abstracts of these publications, 27 of the ITN, 6 of the IPTp, and 17 of the effective case management papers met the inclusion criteria. The majority of the ITN paper exclusions were

due to a lack of focus on a delivery system. Excluded IPTp papers included those where health outcomes rather than coverage outcomes were reported, where the focus was on effect modifiers, for example the influence of timing of ANC visits on IPTp coverage [18], and where there was no empirical data. The reasons for exclusion of papers focused on case management were relatively wide ranging including: health rather than coverage outcomes, a specific focus on diagnosis, qualitative studies, descriptive analyses of routine data, focus on training of health workers and other effect modifying strategies.

Studies remaining in the review were divided into evaluations of new delivery systems and evaluations of existing delivery systems (including components of systems). Studies of ITN delivery included 20 evaluations of new systems, and 7 evaluations of existing systems (Additional file 1). The IPTp studies included 3 evaluations of new systems and 3 evaluations of coverage achieved through existing (ANC) systems. For effective case management 4 evaluations of new delivery systems and 13 evaluations of one or more components of existing delivery systems were identified.

Insecticide Treated Nets

New systems for delivery of ITNs in the public sector included routine delivery through ANC/EPI, campaign delivery integrated with other interventions (immunisations and ivermectin), and voucher systems. In the private sector, delivery has involved social marketing. Three of the studies of new systems were comparisons of two different systems, employer versus community based systems [19], sales through commercial shopkeepers versus groups of community leaders [20], and social marketing alone and together with free delivery through ANC [21]. Each of these 3 studies had a primary outcome of 'the proportion of households with at least one net/ITN', one was a cluster randomised controlled trial and the others used observational cross sectional surveys with comparison between geographic areas where each of the interventions were implemented.

Amongst the 20 studies of new delivery systems 16 used observational cross sectional surveys, 5 including both pre-and post delivery surveys through the new system and 11 post- only. Two of the pre- and post delivery studies used an internal control, attribution of nets in households to the system through which they were delivered [22,23]; whilst the others used external geographic controls [24], and no controls [25]. Of the post-delivery only surveys, 1 used the colour of the net to attribute it to a specific delivery system, 5 used an historical internal control, 3 used an external geographic control, and 1 used no control. Historical internal controls used questions in post ITN-vaccination campaigns on ownership and/or use of ITNs pre campaign.

One out of the 7 studies with a focus on existing ITN delivery systems aimed to evaluate two specific systems [26], two evaluated one specific system [27,28], and the remainder the mix of existing systems. Six of the studies used observational cross sectional surveys and 6 collected data in such way that it was possible to attribute nets in households to the system through which they were delivered.

Intermittent Preventive Treatment in Pregnancy

All 3 studies identified that evaluated new delivery systems for IPTp involved community based approaches, one integrated with ivermectin delivery [29], and 2 stand alone [30,31] (Additional file 1). All three were non-randomised intervention studies and involved external geographic controls. The three studies that evaluated delivery of IPTp through ANC were observational cross sectional studies that did not include a control. Primary outcome measures were the proportion of pregnant women who received 1, 2 or >2 doses of IPTp.

Case management

Four studies were identified that evaluated new delivery systems for case management of malaria. These included home management/community based delivery mechanisms [32-34] and distribution by school teachers [34]. The primary outcomes were diverse, encompassing receiving an ACT, receiving treatment according to protocol, and treatment incidence density per person-year. A similar diversity was seen in the methods and controls used in these 4 studies. One of the studies used an RCT and the other 3 used observational cross sectional surveys post-delivery only. Amongst the cross sectional survey evaluations 2 used external geographic controls and one did not use a control. The 13 evaluations of existing delivery systems for malaria case management were diverse in their objectives, and primary outcomes ranged from evaluations of quality of case management after a policy change to studies on adherence. However, the majority of the studies used observational cross sectional surveys either at health facilities or the household, and did not use controls.

A framework for delivery system evaluation

Our review found that evaluations of delivery systems for malaria control interventions have been diverse in their objectives, outcomes measured, methods and controls used. The type of control used is a major factor in determining the strength of inference that the outcomes were due to the delivery system. However, different types of controls introduce different levels of complexity and resource needs (research costs).

We identified only 3 published evaluations of delivery systems for malaria control interventions that had taken place at the national level [22,35,36]. An effective delivery system (or mix of delivery systems) should be able

to deliver the intervention to the entire target group, on a large scale. There should be no disparities in the coverage of the intervention between sub groups of the target population, for example to different socio-economic groups. The effectiveness of the delivery system in reaching different population groups is likely to vary, as is its relative effectiveness at the small and large scale. We explore the evaluation elements required and propose a framework for the evaluation of delivery systems for malaria control interventions.

Objectives and outcome measures of delivery system evaluations

The first step in designing a delivery system evaluation is to define the purpose and objectives of the evaluation (Table 1). Generally the effectiveness of a delivery system in reaching the maximum target population is assessed. Thus the primary outcome measure in a delivery system evaluation is coverage of the intervention achieved through the specific delivery system(s) (Figure 1). Secondary outcomes include tempo (how quickly a system can reach high coverage), equity (the socio-economic distribution of coverage achieved), cost and/or cost-effectiveness, and others. Primary outcome measures are classified further into proximal and distal outcomes (Table 2). Proximal outcomes are those intrinsically linked to delivery such as ownership of an ITN, delivery of a dose of IPTp, and delivery of an ACT and therefore measure the effectiveness of the causal chain or the intermediate steps within the delivery system. Distal outcomes relate to use of the intervention once it has been delivered, such as use of an ITN by the target group, and adherence to an ACT regimen, all of which may be mediated by factors other than the delivery channel (e.g. the delivery strategies but also other factors). If IPT is delivered by directly observed therapy (DOT) within the ANC then this is a proximal outcome. However, if IPTp is prescribed rather than given by DOT (or given to be taken later) then use of the IPTp is a distal outcome (Table 1). Thus the distal outcomes evaluate the steps in the causal chain that are not entirely within the delivery system. Measuring health outcomes (impact) is not essential unless there is a plausible reason that identical coverage of the intervention achieved via different delivery systems would result in different health impacts.

The second step in conducting a delivery system evaluation is to clearly characterise the pathway of the delivery system and to define the proximal and distal coverage outcomes. For example, IPTp may be intended to be delivered as DOT, however, if there is no water in the health facility the woman may be given the SP to take at home; similarly, stock outs of SP may result in the woman being given a prescription for the SP. The absence of SP in the ANC and the absence of water in the ANC are independent 'implementation related factors' [37]. The probability of a pregnant woman receiving 2 doses of SP-IPT will therefore be the product of these events in the pathway of the IPT delivery system.

Table 1 Steps in designing a delivery system evaluation

	Examples	Comments
Determine the purpose of the evaluation	- To evaluate a new delivery system for ITNs - To evaluate a new delivery system for IPTc - To assess the delivery of IPTp through ANC	Evaluation of a new delivery system for an existing intervention requires a pre-post survey with attribution of nets by source. A process analysis is required to assess the outputs at each intermediate step in the causal chain of delivery
Select the evaluation method	- cross sectional pre-post survey with attribution of outcomes by source of intervention - cross sectional post intervention survey with attribution of outcomes by source of intervention - cross sectional post only survey with no control	For evaluation of a new delivery system for an existing intervention a pre-post survey with attribution of outcomes by source would provide causality for proximal indicators and plausibility inference for distal indicators.
Define the outcome indicators	- the proportion of children under 5years using an ITN - the proportion of children under 5 years taking a full course of IPT - the proportion of pregnant women who attend ANC receiving at least 2 doses of IPT	The primary outcome indicator may be a distal or proximal indicator
Define the pathway of delivery	- include several proximal and more than one distal steps - includes several proximal and one distal steps - the evaluation terminates at proximal steps	The number of steps varies with interventions and with delivery systems. Many pathways are linearNot all pathways are linear
Characterise the contextual factors	- malaria transmission levels - structure of the health system - socio-demographics of the population	Disaggregate outcomes by contextual factorsDescribe contextual factors

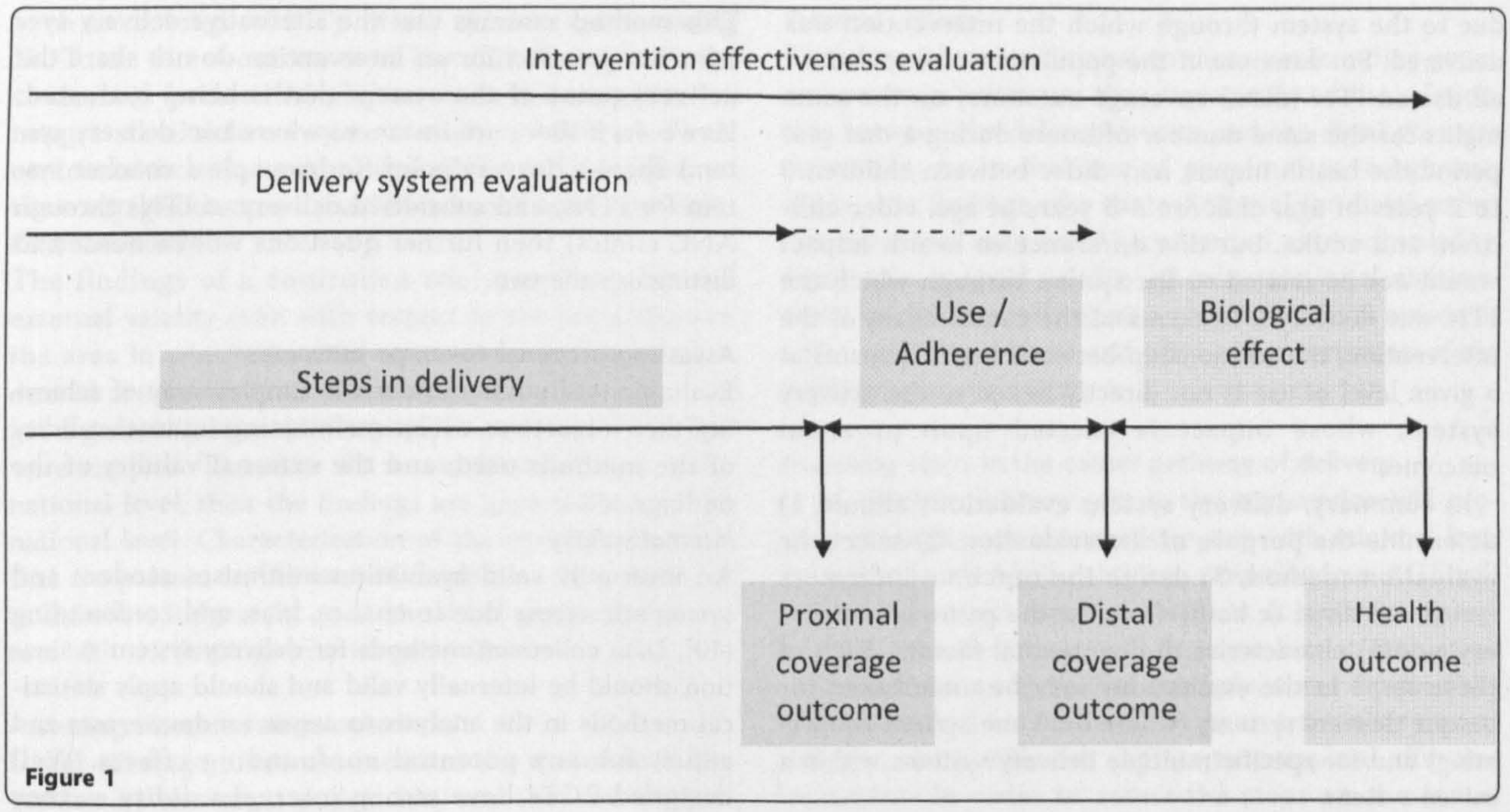

Figure 1

It is plausible that the relationship between the proximal coverage outcome and the distal coverage outcome would depend upon the system through which the intervention is delivered. For example, pregnant women and children under 5 years receiving free ITNs delivered through ANC may be more, or less, likely to use the ITNs than those mothers and children obtaining ITNs delivered through social marketing in the retail sector, or from the informal private sector. Children may be more or less likely to be given a full dose of ACT (correct number of tablets each time, correct number of times per day, correct number of days) if their carers get the drug from the public sector than from the private retail sector.

The relationship between distal outcomes and health impact is dependent upon the intervention itself and upon the context. Similar distal coverage outcomes of an intervention could result in different health impacts among different population groups including different age groups, those living in different transmission intensity areas, and different socio-economic groups. However, it is unlikely that this difference in health impact is

Table 2 examples of proximal and distal coverage outcomes for three malaria control interventions

Intervention	Delivery details	1st level of proximal coverage outcome	Subsequent proximal coverage outcomes	Distal coverage outcome
ITNs	Direct delivery through ANC	Proportion of households owning at least one ITN delivered through ANC		Proportion of the target group who slept under an ITN delivered through ANC
IPTp	Directly Observed Treatment (DOT)	Proportion of pregnant women taking 2 doses of IPTp		None
	Dose given but not DOT	Proportion of pregnant women given 2 doses of IPTp		Proportion of pregnant women who take 2 doses of IPTp
	SP prescription given	Proportion of pregnant women given 2 IPTp prescriptions	Proportion of women who collect the SP	Proportion of pregnant women who take 2 doses of IPTp
ACTs	Delivery to febrile children through health facilities	Proportion of febrile children accessing public sector health facilities for whom ACT is prescribed	1. Proportion of carers of children prescribed ACTs who collect the ACT (correct number of tablets)2. Proportion of carers of children who are explained the dosing regimen	Proportion of children given ACTs who take the correct dosing regimen (number of tablets each time, number of times each day, number of days)

due to the system through which the intervention was delivered. For example, if the population of one district all use an ITN (distal coverage outcome) on the same nights for the same number of hours during a one year period the health impact may differ between children 0 to 2 years of age, children 3-5 years of age, older children, and adults, but this difference in health impact would not be related to the system through which the ITN was delivered. In terms of the causal chain of the intervention, the relationship between health impacts at a given level of use is not directly linked to the delivery system, whose impact is exerted upon proximal outcomes.

In summary, delivery system evaluations should 1) determine the purpose of the evaluation, 2) select the evaluation method, 3) define the outcome indicators (proximal, distal or both) 4) define the pathway of delivery, and 5) characterise the contextual factors. Each of these steps in the evaluations may be undertaken for unique delivery systems (where only one system is operating) and for specific multiple delivery systems within a mixed system.

Attribution of coverage outcomes to a specific delivery system as an internal control

If an intervention is delivered through a unique system, then coverage outcomes can be directly attributed to this specific delivery system. For example, Intermittent Preventive Treatment for Infants (IPTi) is only delivered through the Expanded Programme on Immunisation (EPI). Where an intervention is delivered through more than one system, then further methods are needed to attribute the coverage achieved by each system. This has been done for mosquito nets based on whether the net was treated or not [38], upon the source or delivery point of the net [39] and whether a voucher was used in the purchase of the net [22,23]. A single cross sectional survey may be used to assess the relative proportion of coverage of an intervention that is due to one specific delivery system, or to all known delivery systems. A new delivery system introduced within existing multiple systems, can be evaluated by attributing the proportion of coverage to each delivery system pre and post implementation of the new delivery system.

Attribution to specific delivery systems requires a simple way of matching the coverage to the system through which it was achieved. All malaria control interventions have a point at which they are delivered to the users. The coverage of an intervention can be matched to a specific delivery system by identifying the delivery point at which the recipient received the intervention. This can be done by adding a few questions to cross sectional surveys. For example "where did you get this net" or "where did you get these medicines for your child"? This method assumes that the alternative delivery systems in operation for an intervention do not share the delivery point of the system that is being evaluated. However, if there are instances where two delivery systems share a delivery point (for example a voucher system for ITNs, and subsidised delivery of ITNs through ANC clinics) then further questions will be needed to distinguish the two.

Assessing proximal coverage outcomes

Evaluations should consider the simplest way of achieving their objectives whilst maintaining internal validity of the methods used, and the external validity of the findings.

Internal validity

An internally valid evaluation minimises random and systematic errors due to chance, bias, and confounding [40]. Data collection methods for delivery system evaluation should be internally valid and should apply statistical methods in the analysis to assess random errors and adjust for any potential confounding effects. Well designed RCTs have strong internal validity as they minimise both random and systematic errors. However, assessment of a number of delivery systems using an RCT would be prohibitively complex and expensive, and potentially infeasible. Cross sectional observational studies are generally of weaker internal validity than are RCTs. However, using structured random sampling techniques to select an adequate number of appropriate units can reduce selection bias and random errors, and data on potential, confounding factors can be collected and accounted for in the analysis.

Inference

Where an intervention is delivered through a single system, then the proximal coverage outcomes can be directly attributed to this delivery system and it is appropriate to infer that the delivery system had a causal relationship to the proximal coverage outcome. However, unless the intervention is new, then it cannot be assumed that it is delivered through only one system. In this situation either formative work must be undertaken to ensure that there is only one delivery system in operation, or a question on source should be included in the evaluation. Where a new delivery system is evaluated within the context of multiple existing delivery systems, if the relative proportion of the proximal coverage outcome is attributed to each of the delivery systems, then a plausibility statement can be made on what proportion of the outcome was due to the new delivery system. In this type of evaluation, the existing delivery systems are acting as internal controls and thus it is possible to infer that the changes in coverage were due to the new delivery system, above and beyond the influence of other external factors. As proximal outcomes,

such as coverage of IPTp in any delivery system using DOT, are direct outcomes of the delivery systems, the contextual factors that play a role in this outcome are integral to all delivery systems that are assessed. These contextual factors should be described and their effect on the coverage outcome should be assessed where possible.

External validity

The findings of a controlled trial may have limited external validity even with respect to the population in the area in which the trial was conducted. Well conducted cross sectional observational studies will have good generalisability to the population from which they were sampled. Therefore if a survey is undertaken at the national level, then the findings are generalisable at the national level. Characterisation of the contextual factors that are present in the area of implementation will help to inform a judgement as to the other geographic areas to which the findings may be generalised.

Assessing distal coverage outcomes

Distal coverage outcomes measure the use of an intervention by the target population, and they are the primary link between intervention coverage and health impact.

Internal validity

Distal coverage outcomes are measured in the same way as proximal coverage outcomes through RCTs or cross sectional observational studies. The methodological issues in the internal validity of proximal coverage outcomes mentioned above would therefore apply to that of distal coverage outcomes.

Inference

The effect of the "user related factors" that influence the distal coverage outcomes may vary depending on the way the intervention was delivered (implementation related factors), or there may be external factors that modify the distal coverage outcomes. The effect of implementation related factors on the distal coverage outcome may be assessed by measuring the relative dose-response relationship (although care must be taken to assess any selection biases in the dose received) [14,40]. For example the relationship between ownership and use of ITNs from specific delivery systems can be measured. External factors are more difficult to define and to assess. For example, the proportion of those owning an ITN who use it may depend upon factors such as season (temperature), levels of biting nuisance, housing characteristics, irrespective of the system through which they got the ITN. If use of ITNs amongst those owning them is attributed to specific delivery systems then the other delivery systems act as an internal control for external factors. This would enable a plausibility inference as to the observed association between ITN use and a specific delivery system.

External validity

There are factors additional to those confounding proximal coverage outcomes that may confound the relationship between the delivery system and the distal coverage outcomes. As in the case of proximal coverage outcomes, the findings of a controlled trial for distal coverage outcomes may have very limited external validity. Again the external validity of cross sectional observational studies depends upon a population level representative sampling scheme and upon characterisation of the implementation context.

Assessing steps in the causal pathway of delivery

In an effective delivery system, the intervention will progress through each intermediate step with minimal loss, for example, all febrile children prescribed an ACT will receive the correct number of tablets. It is likely in practice however, that there will be some loss at each stage of the delivery process. For example, some febrile children prescribed an ACT will be given artesunate monotherapy, or insufficient tablets to complete effective treatment. In order to assess the steps on the causal pathway of delivery of an intervention it is necessary to define these steps. The evaluation can then be designed to assess the proportion of the population that progress successfully through each step. Often during implementation, variations to the causal pathway will be introduced. These may involve health worker strategies for coping with drug stock-outs such as writing a prescription and sending the child to another health facility or the private market. Where important blockages in the steps of the causal pathway are identified, for example those eligible for an intervention not being offered it [23], then further research is needed to identify the reasons why the problems occur. Once the problems have been identified steps may be taken to prevent them reoccurring. Factors that impact upon the delivery system are termed implementation related factors, and they function as effect modifiers.

Assessing the factors that influence the relationship between proximal and distal coverage outcomes

Factors influencing the relationship between proximal and distal outcomes can be related to 1) delivery system, 2) the intervention, 3) the target group, and 4) context and factors external to the delivery system. For example the delivery point of an ITN, and the accompanying information and education, is likely to influence household ownership, but may also affect use of ITNs that are already owned.

For example, the delivery point for an ITN is more likely to influence household ownership than use of ITNs. It is possible however, that the strategies that make up the delivery system may influence use, for

example, whether the ITN was given free of charge or was purchased. Information exchanged during delivery may also affect use or patterns of intra-household use. The nature of the ITN, such as its shape, material or colour may influence whether it is used. Target group characteristics include number of household members, number of ITNs owned, education of the household head and their spouse, and socio-economic status. External factors include season, levels of biting nuisance, cultural norms etc. The external factors will have an equal influence on households with ITNs delivered through different systems and therefore do not necessarily need to be measured, but should be described.

Other factors influencing selection of method

Policy status

Depending upon the policy status of the intervention to be delivered, it may not be possible to include control groups to whom the intervention will not be delivered. Where an intervention is part of the national policy it is unethical and likely to be politically impossible to systematically exclude sub groups of the population from a particular delivery system. In this situation, delivery system evaluations would therefore need to compare outcomes among those receiving the intervention through one delivery system compared to an alternative system, or through a combination of the two.

Cross sectional observational studies are not limited by whether an intervention is policy or not. As they are able to use internal controls, cross sectional observational studies are applicable to evaluating the role of alternative delivery systems in operational contexts, and to evaluating proximal and distal outcomes of interventions. For example, evaluation of the delivery of ITNs through ANC in an area with ongoing delivery of ITNs through social marketing would assess the relative proportion of the coverage due to delivery through ANC compared with that achieved through social marketing, and other systems in operation such as the formal and informal private sectors.

Scale

RCTs are not usually conducted at scale because they are very expensive, prohibitively difficult, and randomisation to intervention and control groups on a large scale is practically and politically difficult. The complexity and level of feasibility of evaluating at scale depends upon the type of RCT. The most feasible would be to randomise relatively large geographic areas , such as districts or sub-districts, and allocate these to different delivery systems [40].

Where a delivery system is in operation at the national level, pre and post implementation cross sectional observational studies can be undertaken using standard sampling techniques to provide coverage estimates attributable to the delivery system being evaluated that are representative at the national level.

Discussion

In evaluating the effectiveness of a delivery system we wish to know the proportion of the target population that have been reached with the intervention, and whether there are any geographic or socio-economic disparities in coverage. Where coverage is less than required, we also need to know where on the causal pathway of intervention delivery the problems are located. In order to provide the link between delivery system effectiveness and the health outcomes we should also assess the use or adherence to the intervention by the target population. Assessment of health outcomes is not necessarily required for delivery system evaluations. If a need to measure health outcomes is identified, then an evaluation of the intervention itself is required, which may or may not, include delivery system effectiveness as a composite element of the evaluation.

Different approaches to evaluation of delivery systems for ITNs as compared with IPTp and effective case management are likely to have been influenced by the nature of the intervention. Mosquito nets to which insecticide treatment is added to produce an ITN have been household goods in most of Africa, but particularly in West Africa, for many years. They have therefore been delivered through a variety of systems, and there is no innately obvious appropriate system through which they should be delivered to reach the whole target population. Consequently, delivery system evaluations have covered a range of options, and evaluation methods have generally been aimed at assessing the relative coverage attributable to existing delivery systems, or to new ones within the context of those existing, and to the population groups targeted. IPTp and effective case management, however, are drug based, and national policy usually dictates that they should be delivered through public sector health facilities, and often in combination with other delivery systems, for example policies in many countries now allow delivery of ACTs through the private sector. With a target group of pregnant women, ANC is the obvious delivery system for IPTp. Alternative delivery systems would be required if the target population were not being reached through ANC.

There is unlikely to be a situation where ITNs are delivered by one system alone. As such, there will always be the need to attribute outcomes to specific delivery systems and the possibility of using the other delivery systems as internal controls. This should negate the need for external (geographic) controls and randomization. For example, in the cluster randomized trial of introduction of a new delivery system for ITNs within

the context of an existing delivery system by Mueller *et al* [21], the use of a randomized control introduced unnecessary complexity. Rather than using a cross sectional survey pre and post RCT to assess the proximal coverage outcome, cross-sectional surveys pre and post implementation in routine operational conditions with attribution of the proximal coverage outcome to the specific ITN delivery systems would have been sufficient to achieve the objective of this evaluation. This approach would provide useful information about the effectiveness of each of these systems, and whether they are complementary or competing.

Other ITN delivery system evaluations have used longitudinal cohort studies and observational cross sectional surveys with attribution of the outcomes to the system through which they reached the target population. The outcomes of these studies have been both proximal and distal coverage outcomes. Although it has not always been noted within the reports, these studies have demonstrated either causality for the proximal outcomes or at the least strong plausibility that the distal outcomes were due to the delivery systems being studied.

Few studies have described in sufficient detail the structure of the delivery systems being evaluated, and only in a minority has the causal pathway been described [20,41] and several proximal outcomes assessed [22,23,42,43]. Generally, very little information is provided on the causal pathway of the delivery of the intervention. Only by describing the causal pathway is it possible to identify the implementation effect modifiers and to ensure that these are included in evaluation. There is perhaps a greater tendency towards assessment of health outcomes (that is evaluation of the effectiveness of the intervention) than to greater exploration of the delivery system and its enabling and disabling factors.

Evaluations of the delivery of IPTp have mostly involved the use of non-randomized controls. These studies have involved delivery of IPTp through 2 or more systems. As for the delivery of ITNs, where doses of IPTp are attributed to specific delivery systems, external controls are unnecessary. Non-randomized external geographic controls may be subject to a myriad of confounders which influence the relationship between the delivery system and the outcomes. Where a new delivery system is implemented it is essential that evaluations provide information on the period of time between implementation and evaluation as the tempo of different delivery systems in achieving increased coverage with interventions will differ.

There have been few evaluations of new systems for delivering effective case management to febrile children and there has been no common methodological approach. Study designs are complicated by the choice of whether to include [inclusion or exclusion of] diagnosis for the presence of malaria parasites.

In summary, where an intervention is delivered through two or more systems, attribution of outcomes to the specific delivery systems will enable a causal inference that proximal outcomes were due to the system through which they were delivered, and a plausible inference for distal outcomes. Each delivery system functions as an internal control for the other systems and as such is affected by existing external contextual factors. Implementation effect modifiers are internal to each specific delivery system. The causal pathway of the delivery system should be defined so that proximal outcome indicators at each step can be determined and assessed. Likely effect modifiers at each of these steps may then also be identified and included within the evaluation. If health outcomes need to be measured then an intervention effectiveness study should be conducted rather than a delivery system evaluation. This methodology may be applied to the conventional cross sectional surveys addressed here, or could also be applied to models of continuous surveys as recently recommended by Rowe *et al* [44].

Conclusions

The practical implications of this evaluation framework are that observational cross sectional surveys can be implemented on a large scale, and applied easily to either the evaluation of new delivery systems, natural experiments, or to evaluation of the current situation. The addition of one to two questions per intervention to national surveys such as the demographic and health surveys would enable such evaluations at little or no extra cost.

Additional material

Additional file 1: Summary of delivery system evaluationsSummary of delivery system evaluations

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JW conceptualized the paper, conducted the review and wrote the first draft. DC and KH critiqued the proposed methodology and revised the draft.

Competing Interests
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