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Scaling-up ITN access and use in sub-Saharan Africa: Estimated LLIN requirements and coverage outcomes based on the global delivery strategy mix

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ACRONYMS

ANC	Antenatal Clinic
DHS	Demographic and Health Surveys
DRC	Democratic Republic of Congo
EPI	Expanded Programme on Immunisation
GMAP	Global Malaria Action Plan
ITN	Insecticide Treated Net
LLIN	Long Lasting Insecticidal Net
MARA	Mapping Malaria Risk in Africa
MICs	Multiple Indicator Cluster Surveys
RBM	Roll Back Malaria
WHO-GMP	World Health Organisation Global Malaria Programme

EXECUTIVE SUMMARY

We estimate the numbers of LLINs (Long Lasting Insecticidal Nets) needed to provide universal access for vulnerable groups, and for the total population at risk of malaria in 42 countries of sub-Saharan Africa. These estimates are based upon a strategy of delivering 1 LLIN through antenatal clinic, 1 LLIN through the Expanded Programme on Immunisation (EPI), and 1 LLIN through either a campaign targeting children under 5 years of age, or the total population (general campaign), as recommended in the WHO Global Malaria Programme ITN Position Statement. Assumptions and limitations of the methods of estimation are discussed.

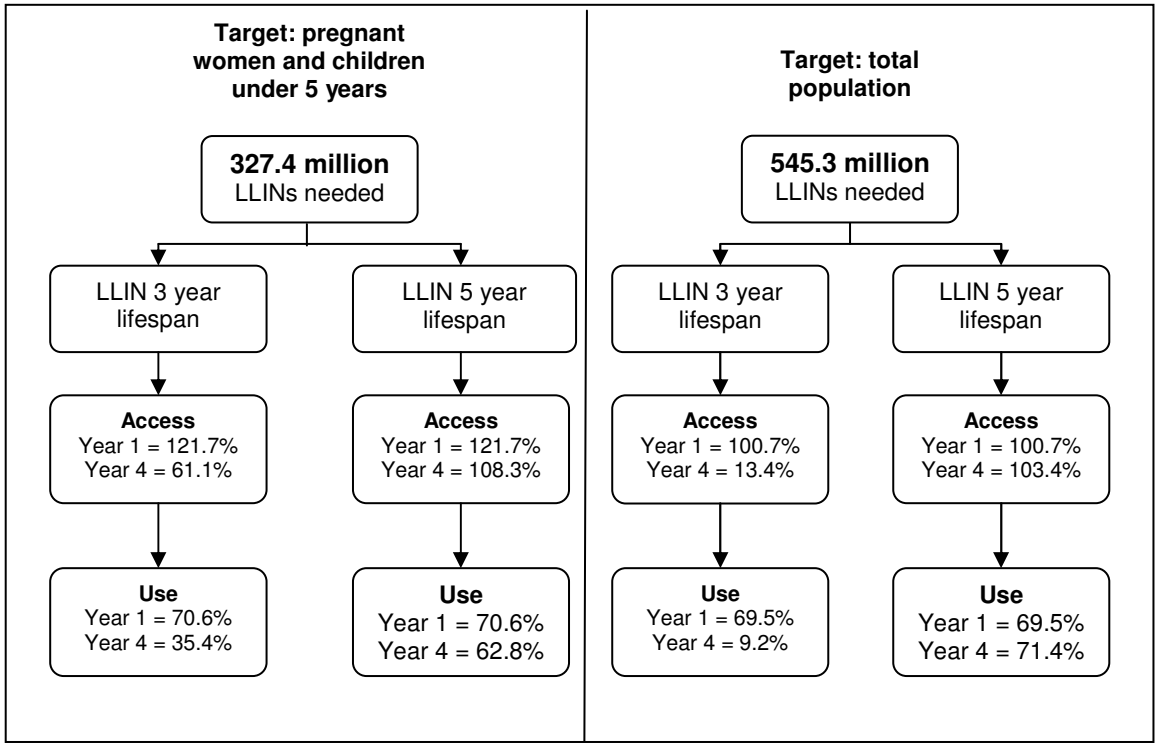
Based on the above strategy 327.4 million LLINs will be needed between 2008 and 2012 were the campaigns to target children under 5 years, and 545.3 million if the target for the campaigns were the general population (based upon delivery of 2 ITNs per household).

Access to ITNs within the household will not remain constant over this 5 year period but will reach a peak during the year in which the campaign is conducted and then decline at a rate dependent upon the lifespan of the net. Polyester nets may be generally expected to have a lifespan of around 3 years and polyethylene approximately 5 years. Based on routine delivery plus campaigns targeting children under 5 years, access to an LLIN would reach 121.7% for pregnant women and children under 5 years in a campaign year and decrease to 61.1% by 4 years post campaign. Using 5 year nets in an identical campaign, access would be maintained at above 100% of the target group during year 4. Where nets of a 3 year lifespan are used, campaigns would need to be conducted every 2 to 3 years, and where 5 year nets are used, every 4 to 5 years, in order to maintain universal access by target groups. This equates to an increase in the number of nets needed by 40% where 3 year rather than 5 year nets are delivered.

Based on the WHO Global Malaria Programme ITN Position Statement, assumptions on target groups and delivery channels, this study estimates that 327 million LLINs will be needed between 2008 and 2012, if targeting pregnant women and children under 5, and 545 million LLINs, if targeting universal access

Relying solely on campaigns without keeping up access through routine systems – ANC and EPI - would result in lower coverage between campaigns. This effect is exacerbated if 3 – year rather than 5-year nets are delivered.

Access does not translate directly to use, with the maximum use by pregnant women and children under 5 years during a campaign year estimated at 70.6%, falling to 62.8% or 35.4% 3 years post campaign (using nets with a 5 or 3 year lifespan, respectively).



Our estimates suggest that relying solely on campaigns without keeping up access through routine systems would result in low coverage. In the absence of routine delivery (through ANC and EPI) access to an LLIN in the campaign year would reach 90% and fall to 0% by year 4 for LLINs with a 3 year lifespan. For LLINs with a 5 year lifespan access to an LLIN in year 4 without routine delivery would be 26.0% and 90.6% with targeted under five campaigns and general (total population) campaigns respectively.

More LLIN s will be needed than predicted by current estimates, which are between 115 million and 273 million lower than estimates of need presented here, for the period 2008 – 2012.

Access does not translate directly to use, with the maximum use by pregnant women and children under 5 years during a campaign year estimated at 70.6%, falling to 62.8% or 35.4% 3 years post campaign (using nets with a 5 or 3 year lifespan, respectively).

Our estimated LLIN need equates to 273.3 million more than the McKinsey estimate and 115.8 to 165.8 million more than the RBM estimate[1] when adjusted for the differing time periods across which the estimates were made. Our estimate assumes that all 42 countries included in the analysis adopt the latest global strategy (1 LLIN through ANC, 1 LLIN through EPI and 2 LLINs per household through a campaign every 3 to 5 years). Where countries do not fully adopt the global strategies, the numbers of LLINs needed are reduced and the coverage achieved will be decreased in parallel.

This report differs from previous estimates: rigour of the methodology, clarity of assumptions, factoring in operational realities of delivery systems

This report was requested given the range in estimates of numbers of LLINs needed and attempts to provide a step-by-step approach to estimating this need between 2008 and 2012 to facilitate the policy of universal coverage. This approach differs from previous estimates in several respects: 1) the basis for the estimate is clearly stated as the global strategy advocated by WHO-GMP in the ITN Position Statement; 2) a methodology is provided for all steps in the estimation together with clarity on the assumptions made and the likely impact of these assumptions on the estimate; 3) our estimation incorporates operational realities, that is the overlap in delivery to households through routine and campaign systems.

Our study outlines several areas where more research is needed: 1) the gap between ownership of LLINs and their use; 2) understanding which households get LLINs from each delivery strategy and quantification of the overlap in the coverage through the three global delivery strategies; 3) the cost effectiveness of developing and implementing strategies for reducing these overlaps versus acknowledging that there will be overlaps and accepting them within the context of striving to cover all.

This study focuses on numbers of LLINs in terms of totals needed. Further work is needed to factor in numbers of nets in the pipeline or for which funding has already been promised, in order to calculate the gap between available nets and need.

This study focuses on estimating the numbers of LLINs needed only and does not take account of LLINs already in the pipeline, or for which funding is promised over the next few years. Further work is needed to address the gap between numbers needed, and recent grants awarded for delivery of LLINs country by country.

In conclusion, there is currently unrealistic optimism on the levels of access to LLINs and their use that can be achieved within the next few years; and on the numbers of LLINs needed to reach these targets. More LLINs will be needed than predicted by current estimates. Even where more LLINs are delivered we will not achieve universal use without paying much more attention to the gap between household ownership of LLINs and the factors that influence their consistent use.

Use of LLINs is lower than access. Research is needed to understand the factors that influence use.

The authors of this report met with the authors of the GMAP and shared their ideas.

1. INTRODUCTION

LLIN delivery emphasis has recently shifted to public sector campaigns. WHO-GMP ITN position statement recognises importance of maintaining LLIN access through routine delivery channels.

Momentum to scale-up delivery of insecticide treated nets (ITNs), and more recently Long Lasting Insecticidal Nets (LLINs), has increased exponentially in the last few years. The increase in resources has resulted in a shift in the long running debates on the most effective, cost effective and sustainable ways in which to deliver ITNs. The focus of delivery has moved almost exclusively to the public sector and mainly to campaigns targeting children under 5 years of age. These campaigns have been both integrated and stand-alone [1, 2]. The importance of routine delivery to maintain access to ITNs by the cohort of children born between campaigns and for women becoming pregnant in the years between campaigns was emphasised by the WHO-GMP ITN Position Statement [3]. The role of the private sector has become heavily biased towards manufacturers and distributors, with the current context of intensive heavily subsidised delivery through the public sector a prohibitive environment for private retailers.

Multiple delivery systems, often targeting identical groups, may result in overlap, i.e. target groups receiving LLINs from more than one source

Although massive advances have been made in delivering LLINs across sub-Saharan Africa, the outcomes have been consistently below expectations. There are a multitude of factors that contribute to lower than expected household ownership and use of ITNs by target groups, some of which are related to sub-optimal delivery, and some due to the methods and indicators used in measuring outcomes. Where multiple delivery systems are employed, and particularly, but not exclusively where they have identical target groups, there will be overlaps in delivery through each system. That is, the target groups may receive an LLIN from more than one source.

Standard measurement indicators fail to register multiple nets within a household as an increase in household ownership

In order to increase household ownership the LLINs must reach and be retained within the households to which they are targeted. The standard indicator for household ownership is the proportion of households with at least one ITN/LLIN [4]. Therefore an increase in household ownership is only recorded where households previously without ITNs/LLINs are reached, and not where more LLINs are introduced into LLIN owning households. Increasing the number of LLINs within a household, however, may be a contributing factor to their use by pregnant women and/or children under 5 years of age [5].

Based upon evidence that ITNs exert a community 'mass effect' [6] together with personal protection of the person under the net, a new wave of advocacy is now promoting the idea of general campaigns to contribute to 'rapid scale-up' of malaria control [7]. These campaigns would aim to provide universal access to an LLIN by every member of the population. Operationally this could translate to 1 LLIN per two people, 2 LLINs per household or 3 LLINs per household; however the modalities of delivery and the operational definition(s) of universal access are as yet undefined.

The recommendation to move towards universal access through general campaigns rather than a targeted approach to reach under fives and pregnant women has major implications for the numbers of nets required.

Existing estimates of the number of LLINs needed for scale-up have been made, based upon differing assumptions and with targets of either full 'coverage' of children under 5 years, or on universal access. These estimates have been presented in one published paper [8], one advocacy report [7], and on a fund raising website [9] supported by RBM. Miller *et al* [8] estimated a need for 192 million ITNs in 2007 and 37 million annually 2008 to 2010 to achieve 80% use by pregnant women and children under 5 years of age across 43 countries of sub-Saharan Africa. The McKinsey report [7] suggested that approximately 68 million LLINs would be needed each year for the next 4 years (2008 – 2012) to cover 100% of the population in the 30 countries of sub-Saharan Africa with the highest need. The fund raising RBM estimates suggest that 250 million LLINs need to be distributed by 2010 [9].

Existing estimates of the number of LLINs needed have failed to factor in delivery channels

Amongst these estimates, only Miller *et al* have presented clear methods and assumptions. Here calculation of numbers of ITNs needed is based on population estimates, household ITN ownership and the assumption that 55% of ITNs in households are used by pregnant women and children under 5 years of age [5]. The assumptions made in the McKinsey report are not presented and it is not clear how 'coverage' is defined within this context. The basis for the RBM estimates is not presented.

Here estimates are made on LLIN need for the next five years, factoring in strategic mixes of delivery systems according to the most current global strategy document: WHO-GMP ITN Position Statement.

In order to assess the actual numbers of LLINs needed to sustain any improvement in access, and to assess the likely outcome of such massive delivery in terms of people sleeping under LLINs, more careful estimates based on strategic mixes of delivery systems are needed. Here estimates are made of the numbers of LLINs needed over the next five year period to provide access to LLINs via the delivery systems recommended by the most current global strategy document, the WHO-GMP ITN Position Statement. Access outcomes are estimated based on current coverage of target groups through each of these systems, and extrapolations made on use of ITNs based on previous evidence on ratios of household ownership to use by target groups.

2. METHODS

A total of 43 countries were included in the analysis, that is all countries lying south of the Sahara with the exception of South Africa, Lesotho and Botswana where malaria transmission is now extremely low due to effective national, malaria control programmes. The small island states of the Seychelles, Mauritius and Cape Verde were also excluded.

In order to provide a starting point for the analysis, we collated survey data on current use of ITNs by pregnant women and children under 5 years of age. Data was extracted from the Demographic and Health Surveys (DHS) [10] and Multiple Indicator Cluster Surveys (MICs) [11] on existing ITN coverage: household ownership of any ITN; child under five years reported sleeping under an ITN the previous night; pregnant women reported sleeping under an ITN the previous night. For each of these indicators, data were extracted on the national coverage and coverage by wealth quintile. The wealth quintile data was used to calculate the concentration index thereby providing a measure of disparities in coverage across socio-economic quintiles [12, 13].

2.1 Estimating numbers of LLINs needed for delivery to the target populations

The 'number of LLINs needed' is defined as the number of LLINs required to provide access to an LLIN for all those target groups accessing the point of delivery. As such, the number of LLINs needed was calculated based on a) the population of pregnant women and children under 5 years of age b) those amongst this group living in areas with malaria transmission, and c) those amongst this group with access to the system through which the LLINs will be delivered. Population data was derived from World Population Prospects Population Databases [14]. Total populations, number of infants and number of children under five years were taken directly from the 2006 Revision database which provides annual population projections for the period 2005-2050 from the most recent population data available for each country, obtained usually from a population census or a population register. Numbers of pregnant women were calculated from number of live births plus the number of maternal deaths during pregnancy.

Estimates of populations living in areas at risk of malaria transmission were calculated from the Mapping Malaria Risk in Africa project [15], multiplying target population figures by the percentage at any risk of malaria transmission (epidemic and endemic). Djibouti was excluded from the analysis at this point based on the MARA estimate of 0% of the population at risk of malaria.

The recent WHO Global Malaria Programme (GMP) ITN Position Statement [3] recommends that all pregnant women and children under 5 years should receive an LLIN through ANC and EPI and that this routine delivery should be supplemented every 4 years by a campaign targeting children under 5 years of age with 1 LLIN. Estimates of LLINs needed were based on this combination of delivery strategies, and were also contrasted with a strategy where the campaigns targeting children under 5 years are replaced with campaigns targeting the general population. This focus on general campaigns is in response to recent calls for universal access [16] and for universal use [17].

Coverage of both ANC and EPI is less than 100% in all countries. The LLIN need estimates were made using 1) nationally representative survey data, and 2) administrative data. Existing coverage of EPI vaccinations and ANC attendance was collated from nationally representative DHS and MICS conducted after 2000, taking the most recent survey available for any given country. Data was extracted from country reports on DPT1 coverage (as an indicator of the proportion of children making at least one visit to a routine immunisation clinic before their first birthday) and ANC coverage (as an indicator of the proportion of women making at least one visit to ANC during pregnancy). Calculations based on administrative data used DPT1 coverage from the

most recent country routine data (2006) as reported to WHO/UNICEF using the Joint Reporting Form, which is adjusted by WHO/UNICEF according to known biases and local information [18].

Table 1: Characteristics of routine and campaign delivery systems for LLINS

Strategy	***Target Group***	***Frequency***
ANC	Pregnant women	Constant
EPI	Children under 1 year	Constant
Integrated measles campaigns	Children 9 to 59 months	Every 3 to 5 years
Integrated polio campaigns	Children 0 to 59 months	Every 3 to 5 years
Stand alone LLIN campaigns	Children 0 to 59 months	Every 3 to 5 years

Equatorial Guinea and Liberia were the only countries for which data was not available on any of the variables. In this case mean values for the appropriate indicator from Cote d'Ivoire, DRC and Sierra Leone were taken as proxy post-complex emergency countries. Other missing figures were estimated using median values from countries where data was available.

In order to estimate the number of LLINs needed to achieve maximum delivery to target groups via routine delivery channels it must be assumed that all pregnant women and children under 5 years old attend ANC or EPI at least once, and all receive an LLIN when they do so. Assuming that an LLIN lasts for 5 years, a child receiving an LLIN with a routine childhood vaccination would have access to an LLIN until reaching their 5^{th} birthday. If we assume that an LLIN lasts just 3 years then they will require a replacement in their 3^{rd}/4^{th} year of life.

The proportion of vulnerable groups accessing campaigns was estimated at 90% of children under 5 years of age [2], pregnant women are not targeted through these campaigns. The same level of access, 90%, was assumed for the total population through general campaigns, although we have as yet no actual data upon which to base these estimates. It was assumed that all countries would implement a national campaign in 2009. In reality, this is unlikely to happen, but this method was used a) to simplify calculations of the numbers of LLINs needed and b) to be able to extrapolate to the regional level (i.e. sub-Saharan Africa) patterns of access and use that would be seen at the country level.

Access to an ITN is based upon a combination of the proportion of the target population accessing the delivery point and the lifetime of the ITN. To model the proportion of the vulnerable population (children under five years and pregnant women) and total population that will have access to an ITN via the different delivery strategies, a number of key assumptions were made.

2.2 Estimating the proportion of populations with access to an LLIN by delivery strategy

Access to an ITN was defined based upon a combination of the proportion of the target population accessing the delivery point and the lifetime of the ITN. That is, a person with access to an ITN at its point of delivery was presumed to have access to the ITN for its lifetime. To model the proportion of the vulnerable population (children under five years and pregnant women) and total population that will have access to an ITN via the different delivery strategies, a number of key assumptions were made: (i) children less than 9 months of age were not excluded from national campaigns targeted at under five year olds; (ii) children born after an under fives campaign do not have access to a campaign ITN; (iii) women who become pregnant and children born after a general campaign will have access to a campaign ITN; (iv) all pregnant women and infants who attend ANC or EPI receive one ITN and only one; (v) children in their first year of life have access to the ITN received by their mother during pregnancy the previous year (the number of infants with access to ITNs given to pregnant women was calculated as 90% of pregnant women reached to take account of maternal and infant mortality); (vi) every two people in the general population have access to one ITN distributed by the national general campaign; (vii) access to an effective ITN is influenced by the lifespan of nets distributed, set at either 3 or 5 years [19].

Household ownership is only a proxy for *LLIN use*. Large scale surveys have revealed a median ITN use in net-owning households during the rainy season of 56% for pregnant women and 60% for children under 5.

2.3 Estimating the use of LLINs that will be achieved through the proposed delivery strategies

Ownership or 'access' to an ITN does not translate directly to its use [5]. Estimates of access by pregnant women and children under 5 years, and for the total population were multiplied by estimates of percentage of use by these groups within net owning households. Findings from five large-scale surveys have shown a median ITN use in net-owning households of 56% for pregnant women and 60% for children under five [20]. Median use by anyone in the household was 69%. These surveys were conducted during the rainy season and so are assumed to represent a maximum ownership-use relationship.

2.4 Modelling socio-economic disparities in access to LLINs

To assess the variation in access to ITNs according to socioeconomic status, the ANC and EPI coverage figures for the lowest and highest socioeconomic quintiles were extracted from the national DHS or MICS surveys (where available). National level campaigns (targeting children under 5 years, and the general population) were assumed to reach all socioeconomic groups in an equal manner [1, 21].

Table 2: Ownership, use and socioeconomic disparities in ownership and use of ITNs by children under five and pregnant women

		Household ITN ownership			ITN use by children under 5 years old			ITN use by pregnant women		
Country	Data Source	National coverage (%)	Concentration index	95% CI	National coverage (%)	Concentration index	95% CI	National coverage (%)	Concentration index	95% CI
Angola	MIS 2006	27.5	0.049	(0.024, 0.074)	17.7	-0.004	(-0.076, 0.068)	22.0	-0.129	(-0.404, 0.146)
Benin	DHS 2006	24.5	0.226	(0.120, 0.332)	20.1	0.234	(0.128, 0.340)	19.6	0.222	(0.101, 0.344)
Burkina Faso	DHS 2003	4.6	0.462	(0.398, 0.526)	1.6	0.438	(0.170, 0.706)	2.6	0.441	(0.201, 0.682)
Burundi	MICS 2000	-	-	-	1.3	0.597	(0.406, 0.789)	-	-	-
Cameroon	DHS 2004	1.4	0.243	(0.169, 0.317)	0.9	0.377	(0.276, 0.477)	1.3	0.491	(0.197, 0.785)
CAR	MICS 2006	-	-	-	15.1	0.290	(0.141, 0.440)	-	-	-
Chad	DHS 2004	-	-	-	-	-	-	-	-	-
Comoros	MICS 2000	-	-	-	9.3	0.278	(0.153, 0.403)	-	-	-
Congo	DHS 2005	8.0	0.152	(0.043, 0.261)	6.1	0.105	(-0.014, 0.225)	4.2	-0.032	(-0.110, 0.045)
Cote d'Ivoire	MICS 2006	10.3	0.112	(0.029, 0.195)	3.0	-	-	-	-	-
Djibouti	MICS 2006	-	-	-	1.3	-	-	-	-	-
DRC	MICS 2001	-	-	-	0.7	0.684	(0.489, 0.878)	-	-	-
Eq. Guinea	-	-	-	-	-	-	-	-	-	-
Eritrea	DHS 2002	-	-	-	4.2	-	-	2.9	0.132	(-0.132, 0.396)
Ethiopia	DHS 2005	3.4	0.159	(0.051, 0.267)	1.5	0.167	(-0.013, 0.347)	1.1	0.424	(-0.031, 0.878)
Gabon	DHS 2000	-	-	-	-	-	-	-	-	-
Gambia	MICS 2006	49.5	-0.169	(-0.263, -0.075)	49.0	-0.097	(-0.195, 0.002)	-	-	-
Ghana	MICS 2006	-	-	-	21.8	-0.027	(-0.063, 0.009)	-	-	-
Guinea	DHS 2005	0.5	0.434	(0.276, 0.591)	0.3	0.661	(0.440, 0.881)	0.4	0.452	(-0.134, 1.038)
Guinea Bissau	MICS 2006	43.6	-0.051	(-0.125, 0.023)	39.0	-0.022	(-0.090, 0.045)	-	-	-
Kenya	DHS 2003	5.9	0.323	(0.241, 0.406)	4.6	0.402	(0.226, 0.577)	4.4	0.229	(0.040, 0.419)
Liberia	-	-	-	-	-	-	-	-	-	-
Madagascar	DHS 2003/04	-	-	-	-	-	-	-	-	-
Malawi	MICS 2006	35.0	-	-	23.0	0.203	(0.084, 0.323)	31.4	-	-
Mali	DHS 2006	50.0	0.020	(-0.029, 0.070)	27.1	0.041	(-0.024, 0.105)	28.9	-0.014	(-0.041, 0.017)
Mauritania	DHS 2003	0.6	-	-	2.1	-	-	-	-	-
Mozambique	DHS 2003	-	-	-	-	-	-	-	-	-
Namibia	DHS 2000	-	-	-	-	-	-	-	-	-
Niger	DHS 2006	43.0	-0.003	(-0.022, 0.016)	7.4	0.169	(0.015, 0.323)	6.7	0.208	(0.029, 0.387)
Nigeria	DHS 2003	2.2	-0.227	(-0.433, -0.021)	1.2	-	-	1.3	-	-
Rwanda	DHS 2005	14.7	0.355	(0.192, 0.517)	13.0	0.327	(0.155, 0.499)	17.2	0.249	(0.070, 0.429)
Sao Tome & Principe	MICS 2000	-	-	-	22.5	0.219	(0.064, 0.374)	-	-	-
Senegal	MIS 2006	36.3	-0.017	(-0.036, 0.002)	16.4	-0.110	(-0.187, -0.033)	17.2	-0.122	(-0.355, 0.112)
Sierra Leone	MICS 2005	4.9	0.170	(0.081, 0.260)	5.3	0.140	(0.090, 0.189)	-	-	-
Somalia	MICS 2006	12.2	0.207	(0.081, 0.333)	16.5	-	-	-	-	-
Sudan (North)	MICS 2000	-	-	-	1.9	0.268	(0.115, 0.420)	-	-	-
Sudan (South)	MICS 2000	-	-	-	-	-	-	-	-	-
Swaziland	DHS 2006/07	4.4	-0.076	(-0.277, 0.126)	0.6	0.005	(-0.292, 0.302)	0.9	-0.110	(-0.613, 0.393)
Tanzania	DHS 2004	22.6	0.411	(0.291, 0.531)	16.0	0.461	(0.300, 0.622)	15.6	0.447	(0.279, 0.616)
Togo	MICS 2006	40.2	-0.001	(-0.029, 0.026)	38.4	-0.033	(-0.051, -0.015)	-	-	-
Uganda	DHS 2006	15.9	0.114	(-0.027, 0.255)	9.7	0.044	(-0.152, 0.240)	10.0	0.167	(0.063, 0.271)
Zambia	DHS 2001/02	13.6	-	-	6.5	-	-	7.9	-	-
Zimbabwe	DHS 2005/06	8.5	0.188	(0.067, 0.308)	2.9	0.283	(0.195, 0.372)	3.2	0.444	(0.282, 0.606)

3. RESULTS

Across 26 of the 42 countries of sub-Saharan Africa for which recent data was available, the median household ownership of an ITN was 12.9% ranging between 0.5% in Guinea to 50.0% in Mali (Table 2).

Data on use of ITNs by children under 5 years was available from 35 countries, whereas use of ITNs by pregnant women was available from only 20 of the 42 countries, that is less than 50% of countries. Use of ITNs by children under 5 years ranged between 0.3% in Guinea to 49.0% in The Gambia, median 6.5%, and use by pregnant women between 0.4% in Guinea to 31.4% in Malawi, median 5.6%. Six out of 35 and 5/20 countries showed a higher level of use of ITNs amongst those in poorer households (concentration index <0.000) by children under 5 years and pregnant women, respectively. For use by children under 5 years, in two of these 6 countries, Senegal and Togo, the pro-poor bias was statistically significant (95% Confidence Interval: -0.187 to -0.033; and -0.051 to -0.015, respectively). For pregnant women, none of the countries showed a statistically-significant pro-poor bias, although this may reflect to some degree the smaller sample sizes involved. Amongst the remaining countries 3/35 and 0/20 countries showed a low level of socio-economic disparity (concentration index ≤0.100) in use of ITNs by children under 5 years and pregnant women, respectively. All other countries showed a bias towards the least poor in use of ITNs by children under five years (26/35 countries) and pregnant women (15/20 countries).

3.1 Numbers of LLINs needed for delivery to target populations

This study estimates that 327 million LLINs will be needed between 2008 and 2012, if targeting pregnant women and children under 5, and 545 million, if targeting universal access by the general population.

The total population in 42 countries of sub-Saharan Africa living at risk of malaria, including both endemic and epidemic areas, is approximately 717 million. Of those living at risk of malaria, around one fifth can be classified as biologically 'vulnerable', including 123.1 million children under the age of five years and 30.9 million pregnant women. Total numbers of at risk vulnerable populations vary greatly between individual countries, with Nigeria alone accounting for 20% of those living in the 42 endemic countries.

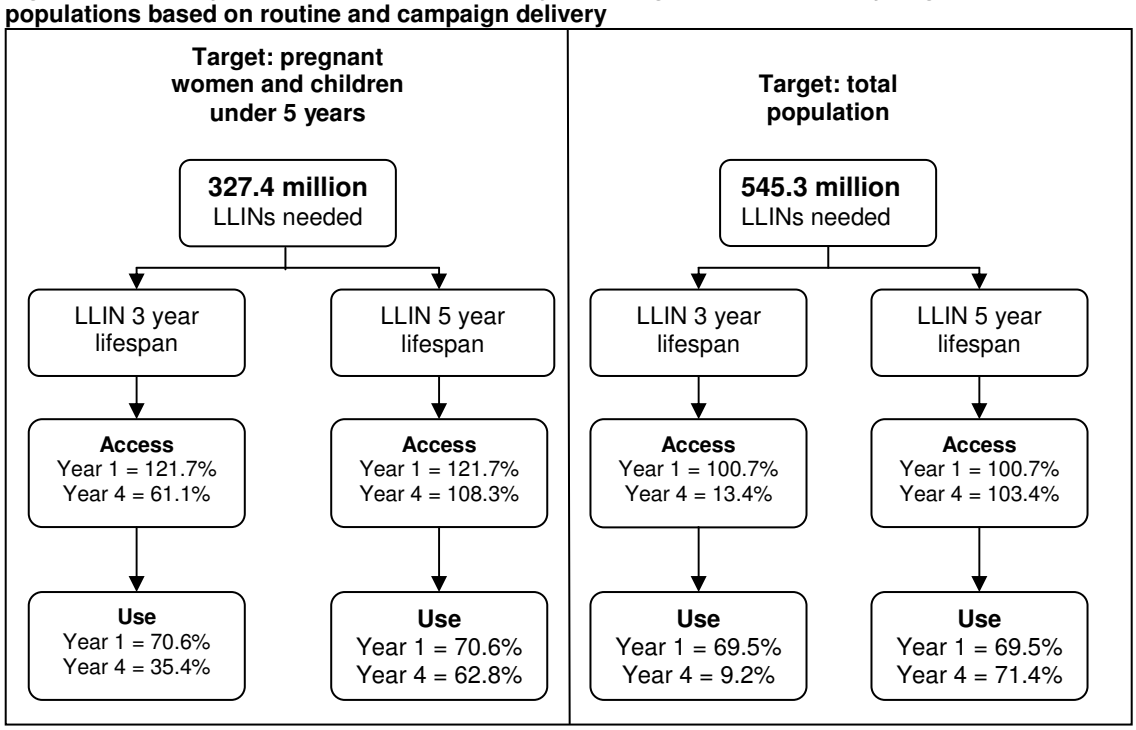
Based on current coverage of ANC and EPI using survey data (DHS, and MICS) and assuming 90% access to LLINs from campaigns targeted at children under 5 years of age, then 327.4 million LLINs are needed between 2008 and 2012 to be delivered to pregnant women and children under 5 years across 42 countries of sub-Saharan Africa with malaria transmission (Table 3). If the campaign targeting children under 5 years were to be replaced with a general campaign, again with 90% of the total population accessing LLINs through the campaign at 1 LLIN per 2 people, then the number of LLINs needed would increase to 545.3 million during this same 5 year time period (Figure 1).

Table 3: Summary of estimates of LLIN needs by strategies they are based upon and the LLIN gap

Year	*Delivery strategies*			
	Based on: 1) current coverage of ANC & EPI (survey data) 2) assuming 90% access through campaigns		**Assuming: 100% coverage of ANC & EPI, and access to campaigns**	
	ANC, EPI <5s campaign	**ANC, EPI general campaign**	**ANC, EPI <5s campaign**	**ANC, EPI general campaign**
2008	39,948,277	39,948,277	58,017,561	58,017,561
2009	155,055,639	372,877,080	186,312,303	428,336,126
2010	42,886,168	42,886,168	62,318,815	62,318,815
2011	44,126,154	44,126,154	64,128,840	64,128,840
2012	45,413,900	45,413,900	66,007,425	66,007,425
Total need	**327,430,137**	**545,251,578**	**436,784,943**	**678,808,766**

The estimates above are based on current coverage with ANC and EPI using survey data, if administrative data was used then the estimates of LLINs needed would increase to 349.4 million targeting campaigns at children, and 567.2 million including a general campaign. The maximum number of LLINs needed can be estimated by assuming that all children under 5 years attend EPI and all pregnant women attend ANC at least once. Using this scenario 436.8 million and 678.8 million LLINs are needed for routine delivery along with a campaign for children under 5, and for routine delivery together with a campaign for the general population, respectively.

Figure 1: Summary of LLINs needed for delivery, resulting access and use by target populations based on routine and campaign delivery



Note Year 1 = campaign year and year 4 = 3 years post campaign

3.2 Proportion of population with access to an LLIN by delivery strategy

Assuming access to LLINs through routine systems is equivalent to current coverage of ANC and EPI as assessed through surveys and 90% access to LLINs via campaigns targeting children under 5 years, access by **vulnerable groups** would reach 127.0%

Relying solely on campaigns without keeping up access through routine systems – ANC and EPI - would result in lower levels of access. This effect is exacerbated if 3 – year rather than 5-year nets are delivered (unless the campaign is repeated after 3 years).

during a campaign year and decrease to 68.9%, based upon an LLIN lasting 3 years (Table 4). If LLIN delivery was based upon campaigns alone then access during the campaign year would be 71.9% and after 3 years would decrease to 0%. Replacing campaigns for children under 5 years with 'general campaigns' would increase access by vulnerable groups in the campaign year to 139.8% and after 3 years this would fall to an estimated 61.1%. In the absence of routine delivery, these estimates would translate to 90.0% access in the campaign year and 0% after 3 years. If LLINs were assumed to have a 5 year lifespan then the access to an LLIN by vulnerable groups would remain over 100% for a 4 year period (108.3% and 141.8% in the fourth year through under 5 campaigns and general campaigns, respectively); in the absence of routine delivery the access to an LLIN four years post-campaign would be 26.0% and 90.6% with targeted under five and general campaigns, respectively. This difference is largely accounted for by the assumption that children born or women becoming pregnant after a targeted campaign will not have access to a campaign net, in contrast to those children born or women becoming pregnant after a general campaign that it was assumed would have access to a campaign net.

In Table 5 we assume that access to LLINs through routine systems is equivalent to current coverage of ANC and EPI as assessed through surveys and 90% access to LLINs via campaigns targeting children under 5 years. This means that every pregnant woman who accesses ANC gets an LLIN, every child under 5 who accesses EPI gets an LLIN and 90% of children under 5 get an LLIN from a campaign. Although the target of these strategies is not total population, access by the **total population** would reach 27.3% during a campaign year and decrease to 15.1%, based upon an LLIN lasting 3 years (Table 5).

Table 4: Percentage of vulnerable population with access to an LLIN according to delivery strategy

Year	*Delivery strategies*			
	Based on: 1) an LLIN 3 year lifespan 2) current coverage of ANC & EPI 2) assuming 90% access through campaigns		**Based on: 1) an LLIN 5 year lifespan 2) current coverage of ANC & EPI 3) assuming 90% access through campaigns**	
	ANC, EPI <5s campaign	**ANC, EPI general campaign**	**ANC, EPI <5s campaign**	**ANC, EPI general campaign**
2008	25.9	25.9	25.9	25.9
2009	121.7	139.8	121.7	139.8
2010	115.4	149.3	115.4	149.3
2011	100.9	134.7	111.6	145.5
2012	61.1	61.1	108.3	141.8

These low access levels for the total population reflect that they are not the target of these campaigns and therefore access is lower than that expected to be achieved amongst the target groups. Replacing campaigns for children under 5 years with 'general campaigns' would increase access in the campaign year to 100.7% for the total population and after 3 years this would fall to an estimated 13.4%. If LLINs were assumed to have a 5 year lifespan then the access to an LLIN by the total population would remain above 100% at 103.4% by 4 years post general campaign; four years after an under five campaign, 23.7% of the total population would have access to an LLIN.

Table 5: Percentage of total population with access to an LLIN according to delivery strategy

Year	*Delivery strategies*			
	Based on: 1) **an LLIN 3 year lifespan** 2) current coverage of ANC & EPI 2) assuming 90% access through campaigns		Based on: 1) **an LLIN 5 year lifespan** 2) current coverage of ANC & EPI 3) assuming 90% access through campaigns	
	ANC, EPI <5s campaign	**ANC, EPI general campaign**	**ANC, EPI <5s campaign**	**ANC, EPI general campaign**
2008	5.6	5.6	5.6	5.6
2009	26.2	100.7	26.2	100.7
2010	25.2	104.2	25.2	104.2
2011	22.0	101.5	24.4	103.8
2012	13.4	13.4	23.7	103.4

3.3 Estimates of use of LLINs through the proposed delivery strategies

Based on estimates of the proportion of pregnant women, children under 5 years and all household members who use a net in net owning households [20], delivery of LLINs through ANC, EPI and campaigns for children under 5 years of age would result in 70.6% of vulnerable groups using an LLIN in the campaign year, decreasing to 35.4% within 4 years where LLINs have a 3 year lifespan (Table 6). Where LLINs are assumed to have a 5 year lifespan, use would be maintained at 62.8% after 4 years post campaign. In the absence of routine delivery, these estimates would translate to 0% 4 year post campaign where an LLIN has a 3 year lifespan and 15.1% where an LLIN has a 5 year lifespan.

Where LLINs are delivered through general campaigns, use by the total population is estimated to reach 69.5% in the campaign year and fall to 9.2% 4 years post campaign where LLINs are assumed to have a 3 year lifespan and 71.4% where they are assumed to have a 5 year lifespan.

Table 6: Estimates of use of ITNs amongst target populations according to delivery strategy

Year	*Delivery strategies*							
	1) current coverage of ANC & EPI 2) 90% access through <5s campaigns				**1) current coverage of ANC & EPI 2) 90% access through general campaigns**			
	Use by pregnant women and <5s		**Use by total population**		**Use by pregnant women and <5s**		**Use by total population**	
	3 yr LLIN	**5 yr LLIN**	**3 yr LLIN**	**5 yr LLIN**	**3 yr LLIN**	**5 yr LLIN**	**3 yr LLIN**	**5 yr LLIN**
2008	15.0	15.0	3.8	3.8	15.0	15.0	3.8	3.8
2009	70.6	70.6	18.0	18.0	81.1	81.1	69.5	69.5
2010	67.0	67.0	17.4	17.4	86.6	86.6	71.9	71.9
2011	58.5	64.7	15.2	16.8	78.1	84.4	70.0	71.6
2012	35.4	62.8	9.2	16.3	35.4	82.2	9.2	71.4

3.4 Socio-economic disparities in access to LLINs

Delivery of ITNs through campaigns has been shown to decrease socio-economic disparities in household ownership and in use of ITNs by children under 5 years of age [2]. Based on current evidence of a combination of routine and campaign delivery systems, access to LLINs by pregnant women and children under 5 years amongst the poorest households will be consistently lower than those amongst the least poor households (Table 7). Socio-economic disparities in access as measured by the equity ratio are reduced during the campaign year, 0.66 one year pre-campaign, and 0.84 during the campaign year, and return to the pre-campaign level within 3 years post implementation of the campaign.

Table 7: Percentage of vulnerable population with access to an LLIN according to delivery strategy amongst the poorest and least poor socio-economic quintiles

Year	***Delivery strategies***					
	Based on: 1) **an LLIN 3 year lifespan** 2) current coverage of ANC & EPI 3) assuming 90% access through **<5s campaigns**			Based on: 1) **an LLIN 5 year lifespan** 2) current coverage of ANC & EPI 3) assuming 90% access through **<5s campaigns**		
	Poorest quintile	**Least poor quintile**	**Equity ratio**	**Poorest quintile**	**Least poor quintile**	**Equity ratio**
2008	21.3	32.5	0.66	21.3	32.5	0.66
2009	112.9	134.3	0.84	112.9	134.3	0.84
2010	104.5	131.0	0.80	104.5	131.0	0.80
2011	89.8	116.6	0.77	98.5	130.4	0.76
2012	50.0	76.9	0.65	93.0	130.0	0.72

4. DISCUSSION

Ownership and use of ITNs by children under 5 years and pregnant women is still well below international targets, both old and new. Although the datasets used in the analysis are the most current nationally representative data, in some cases they are several years old. In many cases significant numbers of LLINs have been delivered in country since these surveys were conducted. Data post national campaign delivering LLINs to children under 5 years are however captured in these datasets for some countries, for example Togo, where both ownership and use are still below the original Abuja targets of 60% use by children under 5 years of age. Togo however, does not have large scale routine delivery of LLINs with which to complement the campaign.

The total number of LLINs needed to provide universal access by vulnerable groups and by the total population of 42 SSA countries is 545 and 678 million respectively.

We have estimated the number of LLINs needed to provide universal access by vulnerable groups and by the total population of 42 countries of sub-Saharan Africa as 545.3 million and 678.8 million LLINs respectively. These estimates are based upon delivery through a mix of routine and campaign systems and assume 100% coverage of target populations of each of these systems. Based on current estimates of coverage of ANC and EPI, and assuming implementation of a campaign targeting a) all vulnerable groups or b) the total population with a campaign, our estimates of the number of LLINs needed in the next 5 years decreases substantially. However, the outcomes achievable through these systems then also decrease in parallel. There is therefore a balance to be made between delivering multiple LLINs to some households in order to reach as far as possible those currently un-reached and who represent the most vulnerable.

Factoring in current estimates of coverage via ANC and EPI, estimates of LLINs still needed reduce to 327 million (targeting vulnerable groups) and 545 million (aiming for universal access)

Achieving delivery of 327.4 million (under 5 campaigns) or 545.3 million (general campaigns) LLINs through implementation of large-scale campaigns over the next few years would be a massive undertaking (figures based on current coverage of ANC and EPI, 90% coverage by campaigns). We have no evidence of what is achievable through general campaigns or on the most appropriate strategies to achieve the best outcomes, as these have not yet taken place. Our estimates suggest that relying on campaigns without keeping up access through routine systems would result in very low levels of access in the years between campaigns, particularly where campaigns have targeted vulnerable groups.

Relying on campaigns without keeping up access through routine systems would result in very low levels of access in the years between campaigns, particularly where campaigns have targeted vulnerable groups.

We have made two major assumptions in order to support our calculations that have an impact on the numbers of nets estimated to be needed each year to provide access to target populations (whether vulnerable groups or the total population). The first is that LLINs have a 3 year or 5 year lifespan, in reality the lifespan of LLINs is not so sharply defined and is more likely to follow a normal distribution with a median of approximately 3 years for polyester and approximately 5 years for polyethylene nets. This increases the onus on the need for routine systems that provide constant access to LLINs, as even if campaigns were able to be implemented every 3 years, there would still be a proportion of those at risk needing a replacement LLIN. Where LLINs are available through routine systems and through the private sector, owners of the large number of LLINs that reach the end of their lifespan before the median life expected, would have the opportunity of replacing them and not having to wait for another campaign. This also applies to those with a child born in the 3 to 5 years between campaigns.

Secondly, we assumed that all countries would have a campaign in 2009. If the campaigns were staggered over a few years, as is more likely in reality then the numbers of LLINs needed would differ by year, but not vary greatly in the total needed across the next 5 years (numbers will increase for each year that national campaigns are delayed beyond 2009 due to population growth). Staggering of the campaigns would result in changes in the proportion of vulnerable and total populations with access to and using LLINs by year. However, the same patterns of expected annual coverage and use will apply to individual countries, centred on their campaign year.

The numbers of LLINs needed where general campaigns are employed will be sensitive to the targeting strategies employed, particularly where countries have already been relatively successful in the delivery of LLINs. Where the objective of the campaign is to reach two LLINs per household, blanket delivery of 2 LLINs to all households in areas

It may not be cost-effective to try and track LLIN ownership in order to target new nets to non-owning households. Studies have shown that increasing the number of LLINs within a household may be a contributing factor to their use by pregnant women and/or children under 5 years of age.

of malaria transmission may be conducted, or there may be a strategy of targeting households based on their current levels of ownership. This second option would involve a system of household registration. This would be complex and heavy on resources; although where countries already have high levels of household ownership of LLINs it may be more cost effective than blanket delivery. These strategic options need to be addressed by modelling of cost effectiveness with the alternative strategies, followed by measured cost effectiveness during implementation.

Conceptually, at the household level, campaigns targeting children under 5 years will only provide access to households with a child under 5 years, and use to that child. Conversely, campaigns targeting the general population will provide access to all households and to all members of the household. This means that they should provide access to women who become pregnant within the lifespan of the LLIN and to their child when they are born.

Even under a scenario where 100% access was achieved, evidence suggests that this would not translate to 100% use. The factors influencing use of LLINs present within households have not been fully elucidated. It is clear that season influences use, and that this is reflected in the timing of surveys. It is not clear whether the strategy by which an LLIN is delivered impacts upon the proportion of owned LLINs that are used and more research is needed on this topic.

The factors influencing use of LLINs are not fully known. It is not known how the delivery channel and strategy affects the proportion of LLINs that are used.

No mention has been made of the substantial coverage with untreated locally made nets, particularly in West Africa. However, the impact of these delivery systems should not be underestimated. Careful assessment is needed country by country of the ways in which this resource can be included in the national level strategic mix of delivery systems, for example treatment of local nets in wholesale markets in Ghana to produce 'local ITNs'

The outcomes estimated are below expectations of 80% use and the more optimistic 100% use as recently proposed by the UN Secretary General.

The outcomes estimated are below expectations of 80% use [22] and the more optimistic 100% use as recently proposed by the UN Secretary General [17]. There are as yet only 3 countries amongst these 42 where a combination of at least 2 delivery strategies are working on a large-scale which are Eritrea, Kenya, and Tanzania [23]. To achieve our estimated outcomes, and to aim for the RBM goal of universal access by 2010 [16], 39 countries of sub-Saharan Africa need to undergo massive scale-up to implement routine delivery of LLINs through health facilities and/or the community, and to have at least one campaign delivering LLINs to children under 5 or the general population in the next two years. This is unlikely to be achieved.

To achieve our estimated outcomes, and to aim for the RBM goal of universal access by 2010, 39 countries of sub-Saharan Africa need to undergo massive scale-up through a combination of routine delivery and campaigns in the next two years.

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ANNEX FOR DFID ON NUMBERS OF LLINS IN THE PIPELINE AND 'THE LLIN GAP'.

Methods

Information on the number of LLINs already funded in any particular country was collected from a review of all successful and unsuccessful GFATM Round 7 proposals. Part of the GFATM application process now includes a gap analysis of needed and existing LLINs; for Round 7 this covered the same years as our analysis (2008-2012). For the countries with a successful Round 7 proposal, existing LLIN resources were calculated as those requested in the proposal (assuming that the number requested will be the number procured and distributed) and the numbers already identified in country from other sources. For the countries that were not successful, only the numbers already identified in country were included.

The LLIN gap was calculated as the number of LLINs needed by delivery strategy minus the number of LLINs in the pipeline.

Results

Based upon data extracted from the 21 Round 7 GFATM proposals 310.7 million LLINs are 'in the pipeline'. Subtracting the number of LLINs in the pipeline from the number needed means that there is an estimated gap of 16.7 million LLINs to enable delivery to children under 5 and pregnant women via routine and campaign systems at current levels of ANC and EPI coverage. Replacing the under 5 campaigns with general population campaigns over the 5 year period 2008 to 2012, the LLIN gap increases to 126.1 million LLINs . Based on our knowledge of individual countries, this estimate of the number of LLINs in the pipeline is seriously inflated.

We do not believe that currently available data on LLINs in the pipeline is reliable. RBM have recently undertaken LLIN needs assessments in several countries which should provide a more reliable estimate, but these are not yet complete.