

## Down but not out. The impact of malaria control in Tanzania

**Paul Smithson, IHI**

This year's theme for Africa Malaria Day is "Counting Malaria Out". Ifakara Health Institute has undertaken a rapid appraisal of evidence on progress in malaria control in Tanzania. Our results show that malaria in Tanzania is indeed down – but it is a long way yet from being "counted out".

### Headlines

- ◇ In 2007/8, nearly 20% of Tanzanian under-fives tested positive for malaria. Prevalence in rural areas is more than double that in urban areas, and there are huge variations across regions.
- ◇ Data from previous surveys and studies indicate that malaria prevalence in Tanzania has roughly halved over the past decade.
- ◇ There has been a decline of similar timing and magnitude in malaria transmission, severe anaemia, fever incidence, malaria inpatient admissions and the proportion of fever cases positive for malaria.
- ◇ The reduction in malaria transmission, prevalence and morbidity corresponds closely to the increase in use of nets and ITNs. The protection afforded by nets extends beyond individual users to benefit the community as a whole.

- ◇ The fact that multiple malaria interventions have been implemented in conjunction makes it difficult to assign causation to any one particular control measure.
- ◇ All-cause under-five mortality has declined by nearly 40% since 1999. The evidence suggests that malaria-related deaths have declined by a similar extent.
- ◇ The fact the proportion of deaths directly attributable to malaria has not changed might be explained by a large *indirect* impact of malaria control on all-cause mortality.

The rest of this paper is divided into sections that assemble and interpret data on the following malaria-related indicators:

- Advances in malaria control
- Malaria prevalence
- Malaria transmission intensity
- Anaemia
- Malaria-related illness
- Mortality trends

### What has been done?

A range of complementary malaria control measures have been implemented, commencing in the late 1990s. The main milestones in malaria control are depicted in Figure 2, below. After two decades of growing drug resistance, the first line therapy for clinical malaria was changed – first from Chloroquine (CQ) to "SP" (in 2002), and later from "SP" to "Alu" (in 2007). In Zanzibar, CQ was replaced by Amodiaquine-Artesunate in 2003.

The use of "SP" for prevention of malaria in pregnancy was introduced in 2001/2, and continues to date. ITN social marketing at national scale began around 2002

and subsidised ITNs have been provided to pregnant women and infants through the “Hati punguzo” voucher scheme since 2004 and 2006 respectively. Free distribution of long-lasting ITNs for under-fives took place in specific places, including Rufiji District, Lindi and Mtwara Regions and the islands of Zanzibar.

Zanzibar also benefited from indoor residual spraying, as did certain areas on the mainland (Muleba Municipality, Kagera Region). Meanwhile, additional interventions at pilot stage were deployed in limited localities, including IPTi (Mtwara and Lindi), larviciding (Dar es Salaam) and rapid diagnostic tests (Dar es Salaam, Rufiji and Kilombero).

The ownership and use of mosquito nets has grown steadily, from less than 30% of households in 1999 to nearly 60% in 2007. Urban net ownership has consistently outpaced net ownership in rural areas.

ITN use by under-fives and pregnant women has risen from nearly zero in 1999 to more than 25% in 2007. The proportion of pregnant women receiving preventive treatment (IPT, 2+ doses) rose from 22% in 2004/5 to 30% in 2007/8.

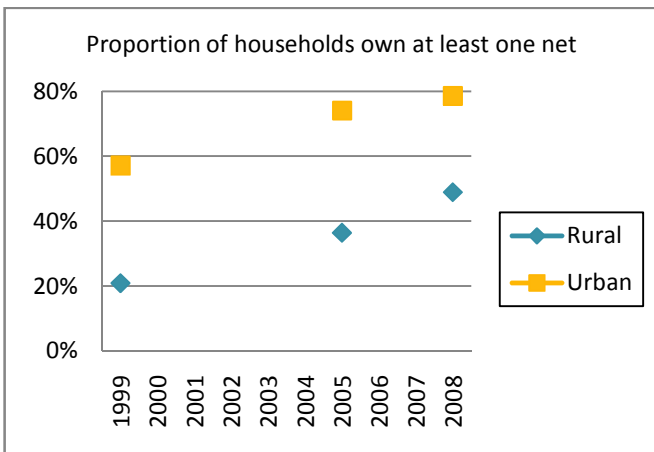


Figure 1, Sources: TRCHS 1999, TDHS 2004/5, THMIS 2007/8

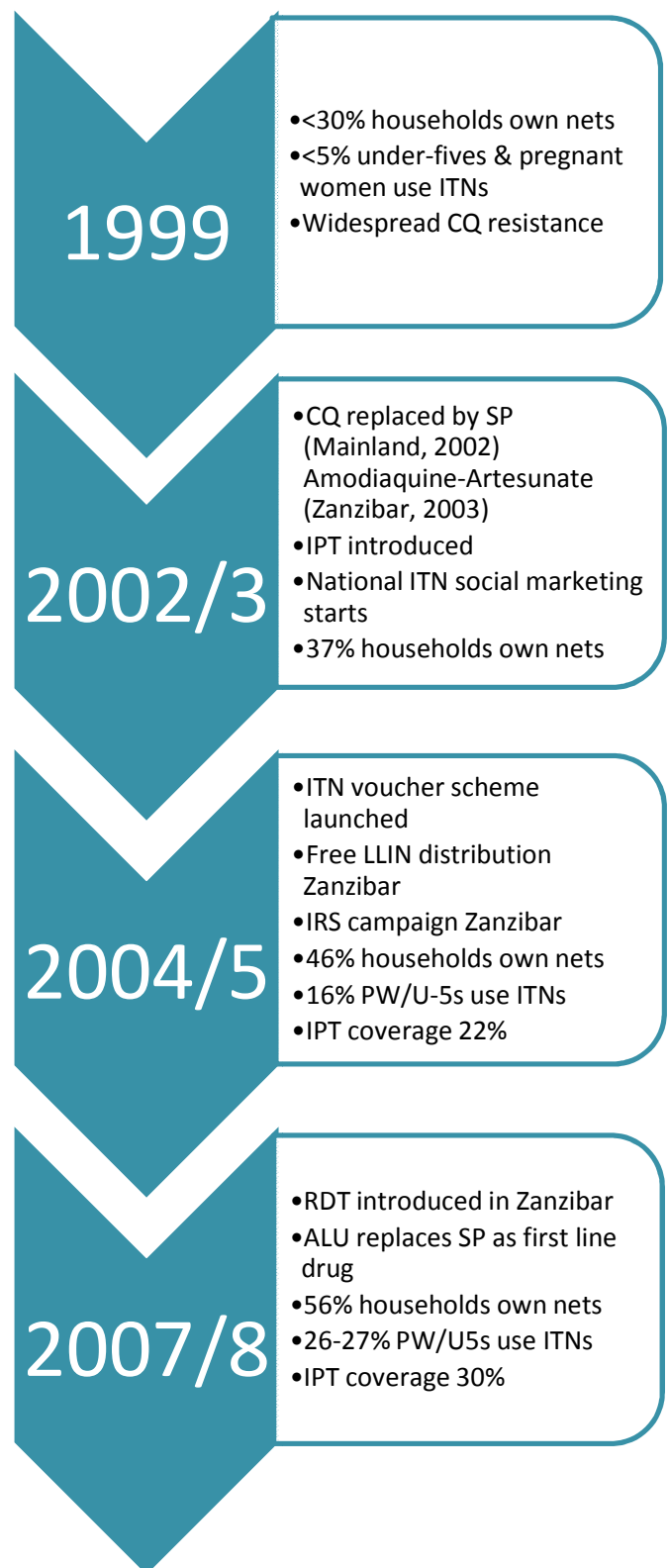


Figure 2: Milestones in malaria control, 1999-2008

# Malaria Prevalence

The first national, population-based survey of malaria prevalence (THMIS, 2007/8) revealed that 18% of under-fives were positive for malaria. Rural areas had more than double the prevalence (20%) of urban areas (8%). The survey confirmed earlier findings that prevalence increases rapidly with age, from around 10% in infants (6-11 months) to around 20% in children aged 2-4 years. There were marked regional variations. Six regions had prevalence of 30% or more, while another six had prevalence rates of less than 2%.

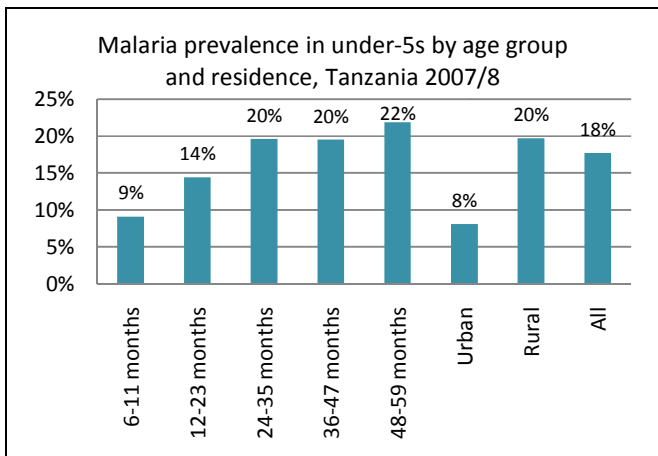


Figure 3: Source THMIS, 2007/8

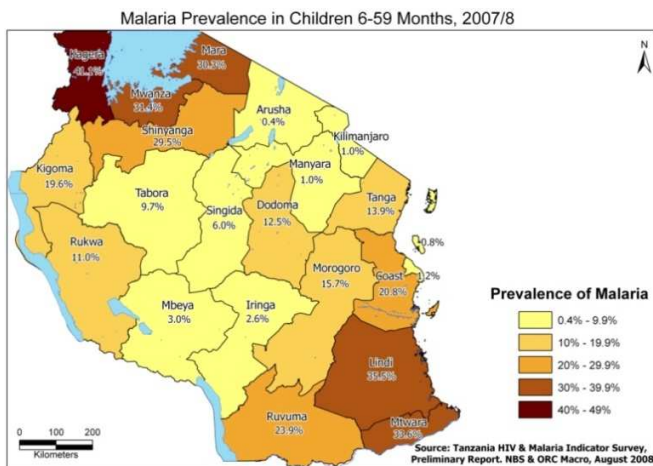


Figure 4: Source: THMIS 2007/8

The absence of a prior national survey makes it difficult to assess how much malaria parasitaemia may have declined in recent years. To do so, we must look to alternative sources of data. A NMCP/MOHSW survey in

21 districts covering around 8000 under-fives found that prevalence declined from 20% in **2006** to 14% in **2008** – a relative reduction of approximately 30%. This reduction in parasitaemia occurred both in urban and rural areas.

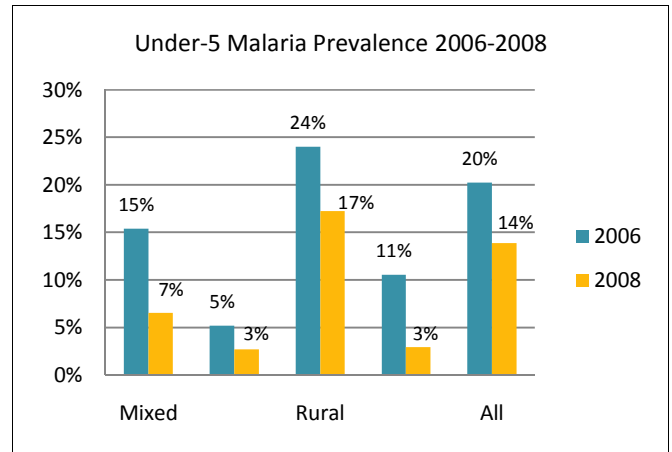


Figure 5, Source NMCP/MOHSW

Data for a longer time series from the (highly endemic) Ifakara and Rufiji DSS areas display a decline that began earlier and from a higher baseline. The gradient of decline is similar in both areas, amounting to a relative reduction of 50%-60% between 2000 and 2008.

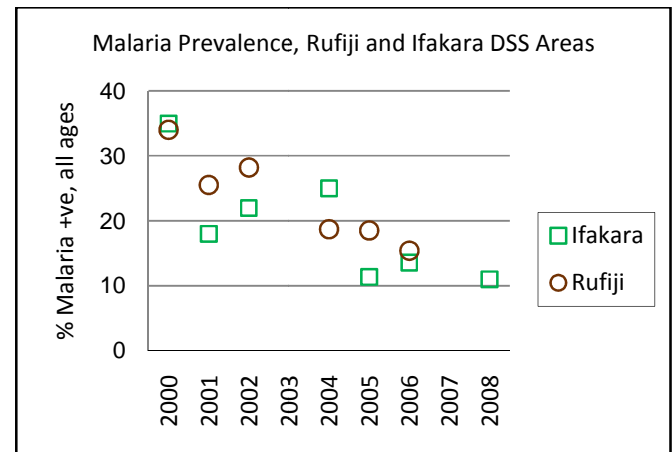


Figure 6: Source: Impact and ALIVE projects, Ifakara Health Institute (unpublished)

In Dar es Salaam, the reduction in (all-age) malaria prevalence has been more dramatic – from 24% in 2004 to just 4% in 2008. Again, the absence of figures from earlier years leaves open to conjecture the actual time and baseline from which the decline began.

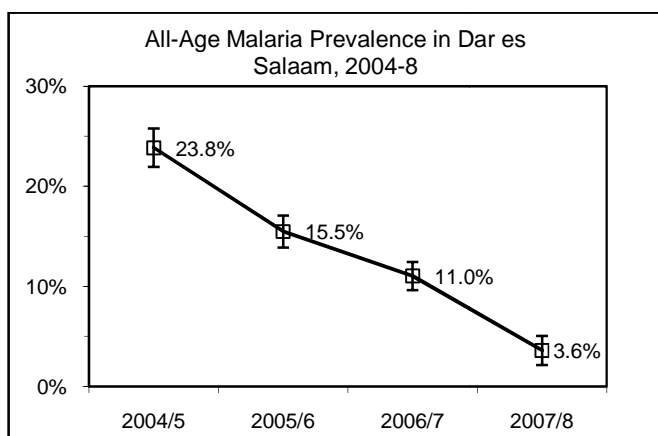


Figure 7: Source: Urban Malaria Control Project, DSM City Council & IHI (unpublished)

Studies from the early 1990s in Idete village, Kilombero, documented malaria prevalence in children of 80% and more (Alonso et al, 1994, Kitua et al, 1996). At the start of the Kinet project in 1997, malaria prevalence in under-2s was 49% in the 18 villages comprising the study area. Just two years later this had declined to 26% while ITN ownership rose from 10% to 61% (Abdulla et al, 2001). Meanwhile, in the semi-urban area surrounding Ifakara town, malaria prevalence in 1-year olds fell from 17% in the mid-1990s to 8.5% in 2000/1; prevalence in infants fell from 9.1% to 3.5%, and incidence of clinical malaria in under-twos almost halved (Schellenberg D et al, 2004).

Many parasitaemia surveys, usually unpublished, have been undertaken over the years. This (non-random) collection of surveys, across varying age groups, cannot provide a definitive national estimate. However, they do at least give an impression of the likely level of malaria infection in earlier periods. Over the period 1987 to 1996, the mean malaria positivity rate across 219 studies was 39% (unpublished data, NMCP/MOHSW).

In summary, the absence of a baseline to which the 2007/8 survey can be compared makes it difficult to gauge the extent and timing of the decline in malaria. The NMCP survey records a 30% decline between 2006 and 2008, Rufiji and Ifakara have registered a 50%-60% (all-age) decline since 2000, and Dar es Salaam witnessed an 85% reduction over the past five years

alone. Compared to the mean of 219 parasitaemia studies in the ten years up to 1996, malaria prevalence has roughly halved.

## Malaria Transmission

The intensity of malaria transmission is influenced by the number of times a person is bitten by female *Anopheles* mosquitoes, and the proportion of those mosquitoes that are carrying the malaria parasite. Together, these indicators provide the “entomological inoculation rate” (EIR) – or the number of infective bites per person per year. The parasite rates in humans and mosquitoes are closely related and in high transmission areas, a substantial reduction in the EIR is necessary for a modest reduction in human parasite rates.

Prompt and effective treatment of malaria can reduce the infectiousness of the human reservoir. Historic data show that the proportion of mosquitoes carrying malaria dropped between the 1930s and 1970s - when Chloroquine became readily available. The transmission of malaria increased again in the 1980s and 1990s as Chloroquine resistance became increasingly widespread (Mboera & Magesa, 2001).

Historical measurements of the EIR in the Kilombero Valley, Tanzania are amongst the highest recorded. Recent results show that the EIR has drastically reduced after a decade of bednet use. The use of bednets reduces malaria transmission by providing personal protection and as a result reduces the feeding frequency, lifespan and density of mosquitoes (Gimnig et al., 2003, Killeen et al, 2007). During the 1990s in Idete village, EIR was more than 2000 infective bites per person per year, while in Namwawala it was over 600. By 2001-2003, this had declined to around 350 and 300 respectively (Killeen et al, 2007). The authors conclude: “Although malaria transmission remains intense in Kilombero, [malaria] exposure has been reduced by approximately 4-fold for non-users of nets, 6-fold for the average resident, 7-fold for users of typical nets and 14-fold for users of truly insecticidal nets, when compared with an exceptionally high historical mean of

1481 infectious bites per person per year.” By 2008 the EIR had declined further still – to 42 and 120 in Idete and Namwawala respectively (T Russell, personal communication). Overall, this is an *additional* 4 fold reduction in the past 5 years. These data reinforce earlier findings that nets and ITNs can reduce malaria transmission across whole communities (Killeen & Smith, 2007; Govella, Okumu & Killeen, forthcoming).

## Anaemia

In highly-endemic areas, around 60% of severe anaemia in young children is attributable to malaria (Menendez et al, 1997). Historic trends in anaemia therefore provide some insight on the likely trajectory of malaria decline.

Anaemia in children aged 6 to 59 months was measured in the Tanzania DHS 2004/5 and again in the Tanzania HIV and Malaria Indicator Survey 2007/8. Comparison of the results shows a relative reduction of severe anaemia in the order of 30%, with the effect being most evident in rural areas.

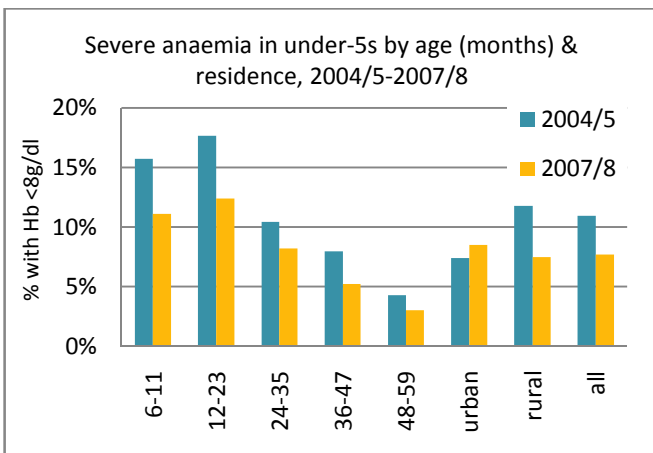


Figure 8: Source THMIS 2007/8 & TDHS 2004/5

Again, absence of earlier national surveys leaves us guessing what anaemia prevalence looked like some years earlier. The chart below juxtaposes the national (rural) anaemia results with earlier data from Ifakara DSS area. While the latter has higher malaria transmission than the national rural average, it is striking to note that severe anaemia in under-twos was

nearly 50% in the Ifakara DSS area as recently as 1997, falling to 12-18% in 2004/5 and declining again to around 10% in 2006/8. Recent levels and trends are comparable to the national average for rural under-fives.

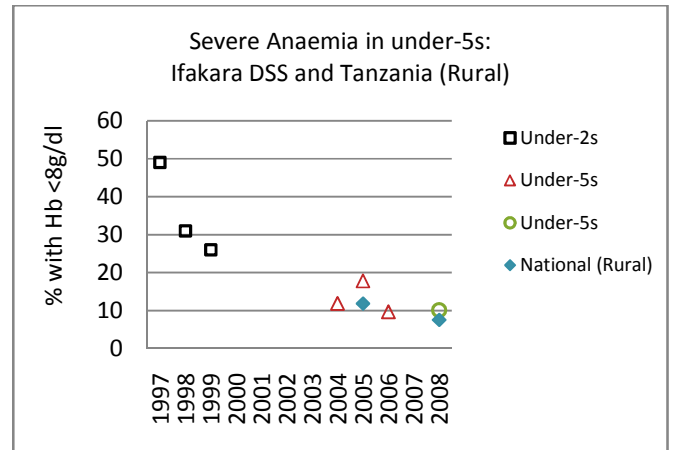


Figure 9, Sources: 1997-1999 - Abdulla et al (2001); TDHS 2004/5 & THMIS 2007/8; other data points - unpublished IHI data

A second historic data set comes from the laboratory of Rubya District Designated Hospital, in Muleba, where the proportion of cases (all-age, OPD/IPD) with severe anaemia (Hb <7g/dl) declined from around 60% in 1997/8 to 23% in 2008. In this instance, the decline is more pronounced after 2002.

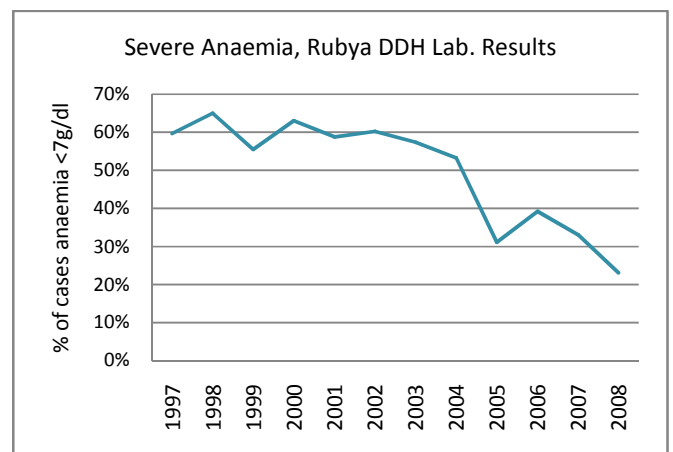


Figure 10 Source: Rubya DDH / NMCP, MOHSW

A decline of similar magnitude has been described in Lindi and Mtwara regions within the past five years. In this study area, severe anaemia in children aged 2-11 months declined from 31% in 2004 to 14% in 2006.

During the same period, malaria prevalence in this age group dropped from 58% to 34% (Schellenberg JA et al, submitted for publication).

## Morbidity

Malaria is the leading cause of illness in Tanzania. In this section we review population-based and facility-based data to assess trends in malaria-related morbidity.

Successive DHS surveys have recorded the proportion of children under-five who were ill with fever in the two weeks before the survey. Comparison across surveys reveals no distinctive trend prior to the TRCHS (1999), followed by a steep decline. The 2007/8 point represents a ~40% reduction in fever compared to the 1990s and a 23% reduction since 2004/5. These figures are corroborated by population-based under-five data morbidity measurements in the Ifakara DSS area (IHI, unpublished data), showing a 21% reduction in fever incidence between 2004 and 2006.

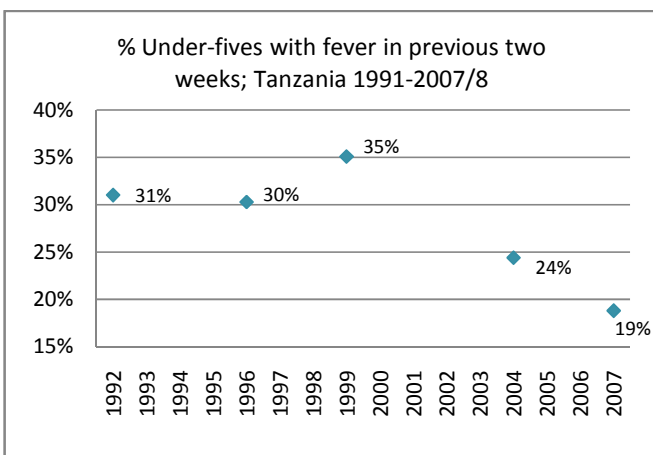


Figure 11 Sources: TDHS 1992, TDHS 1996, TRCHS 1999, TDHS 2004/5, THMIS 2007/8

Unpublished data from clinical settings tell a similar story. In St Francis District Designated Hospital (Ifakara), the number of paediatric malaria admissions declined by more than 50% between 2001/2 and 2007. At Rubya District Designated Hospital (Kagera Region), the number of blood slides positive for malaria declined from over 10,000 per year in the late 1990s to 4,000 in 2007. Across 13 sentinel hospitals around the country under NMCP surveillance, the annual number of blood

slides testing positive has halved between 2000/1 and 2007.

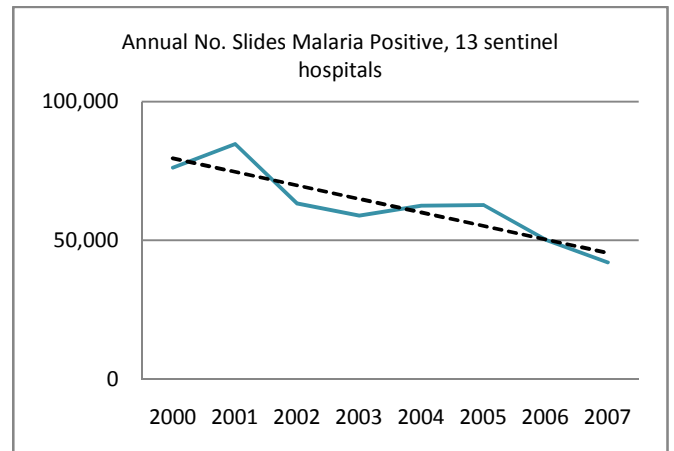


Figure 12 Source: NMCP, MOHSW

## Mortality

Comparison of estimates from the last three national surveys shows major improvements in child survival in Tanzania over recent years. Under-five mortality in the latest survey (2007/8) was 38% lower than in the 1999 survey. The improvement in under-five mortality between each of the last three surveys is statistically significant ( $p < 0.05$ ). Disaggregation of the survey data into annual estimates suggests that the decline started from around 1999/2000 (Masanja et al, 2008).

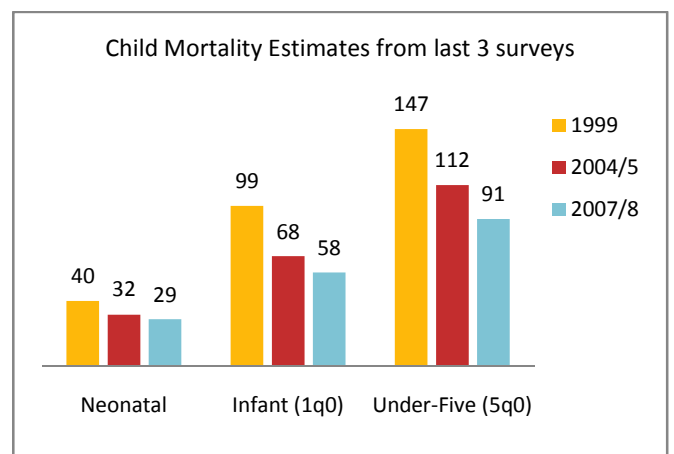


Figure 13 Source: TRCHS 1999, TDHS 2004/5, THMIS 2007/8

Cause-specific mortality data is obtainable from Demographic Sentinel Surveillance, using “verbal autopsy” to assign probable cause to recent deaths. Unfortunately, there is no single data-set for cause-

specific mortality that spans the area of interest – from the late 1990s to the present. The AMMP/MOH DSS sites found no change in the proportion of under-five deaths attributable to acute febrile illness (AFI)/malaria in Dar es Salaam, Hai and Morogoro between 1995/6 and 2000/1. Similarly, since the start of the DSS in Ifakara (from 1997) and Rufiji (from 2002) there is no distinct trend in the fraction of all under-five deaths attributable to AFI/malaria.

This presents a paradox. If the burden of malaria has declined to the extent shown by other indicators, why has malaria mortality not dropped faster than all-cause mortality? The first explanation is that verbal autopsy is an imperfect tool that is neither perfectly sensitive nor specific in detecting malaria deaths.

The second consideration is the “indirect” impact of malaria. Rowe & Steketee (2007) conservatively estimate that the number of under-five deaths per 1,000 indirectly caused by malaria is at least half as many as those that are directly attributable to malaria, and that this fraction could be greater still in areas with high transmission. If the direct and indirect effect of malaria on mortality were equal, we would expect to find no change in the fraction of deaths directly attributable to malaria. Instead, we would find double the expected mortality reduction than that which would have been expected from averting “malaria” deaths alone. This hypothesis is consistent with the mortality data over the past decade in Tanzania.

## Conclusions

This paper has attempted to assemble and interpret data on the impact of malaria control efforts in Tanzania, in spite of the lack of nationally-representative baseline.

Nonetheless, national surveys do show a nearly 40% (relative) reduction in the prevalence of severe anaemia since 2004/5 and a decline of similar magnitude in the incidence of fevers in under-fives since 1999. Meanwhile, cross-sectional surveys of malaria

prevalence in under-fives found a decline from 20% in 2006 to 14% in 2008.

In the Ifakara DSS area (where the increase in net/ITN coverage pre-dated the rest of the country), the decline can be traced back at least to the late 1990s. Studies in various sites in the area found that prevalence of severe childhood anaemia dropped from around 50% in 1997 to around 10% in 2007/8; parasitaemia fell from around 30% to 15%; transmission intensive fell by as much as 80%-95%; the incidence of clinical malaria in infants almost halved between 1995 and 2000; paediatric malaria hospital admissions dropped by 34% between 2002 and 2007, and all-cause under-five mortality fell by 35% in the 10 years to 2007. Very similar trends were observed in the Rufiji DSS area, albeit over a more recent period (since 2002).

Although Ifakara and Rufiji DSS areas are not representative of the country as a whole, the evidence available from other parts of the country also shows improvement in malaria-related indicators. The national trend data on fevers and all-cause mortality suggest that this progress dates from 1999/2000, when net/ITN use became increasingly common. Since then, the improvements in net/ITN use have been complemented by the introduction of preventive treatment for pregnant women, and much more efficacious first line malaria treatment. Particularly steep declines in malaria prevalence have been achieved in Zanzibar, following earlier adoption of new anti-malarials, mass distribution of LLINs and indoor residual spraying (Bhattarai *et al*, 2007).

Further increases in ITN coverage (following the anticipated mass distribution of LLINs to under-fives in 2009 and to all households in 2010) are likely to have further impacts on parasitaemia, anaemia, incidence, admissions and deaths. As malaria transmission intensity falls, ACTs may have an additional impact on transmission (Okell *et al*, 2008). IPTi should help to reduce the burden of malaria disease in infants. The indirect impact of malaria control on all-cause mortality can be expected to multiply the (direct) effect of

malaria deaths averted, especially among under-fives – leading to a continuation of the decline in all-cause under-five mortality.

In spite of the abundant evidence of improvement, malaria still remains a major threat to public health in Tanzania. The 2007/8 survey (conducted during the dry season) still shows that more than nearly one in five children were infected with malaria, and that this proportion rises to more than 30% in certain parts of the country. Malaria in Tanzania is certainly down – but it is a long way yet from being counted out.

## Acknowledgements

The author would like to register appreciation to the following: R Khatib and B Genton for providing unpublished data on parasitaemia and anaemia in Ifakara and Rufiji; D Schellenberg and J Schellenberg for contributing anaemia and parasitaemia data for Mtwara & Lindi (submitted for publication); NMCP for providing unpublished hospital inpatient, laboratory and parasitaemia data; A Lutambi for re-analysis of anaemia and net ownership data from TDHS 2004/5 and TRCHS 1999 respectively; H Mwanyika for analysis of AMMP/MOH DSS data; B Amuri for contributing data from Ifakara Hospital and G Killeen and T Russel for EIR data from Kilombero.

I am grateful to all of my colleagues at Ifakara Health Institute who have pointed out relevant literature and data sets (published and unpublished) and for their comments on early drafts of this paper.

## References

Abdulla S, Schellenberg JA, Nathan R, Mukasa O, Marchant T, Smith T, Tanner M & Lengeler C, 2001. Impact on malaria morbidity of a programme supplying insecticide treated nets in children aged under 2 years in Tanzania: community cross sectional study. *BMJ*, 2001; 322:270-3.

Alonso PL, Smith T, Schellenberg JA, Masanja H, Mwankusye S et al, 1994. Randomised trial of efficacy of SPf66 vaccine against *Plasmodium falciparum* malaria in children in southern Tanzania. *Lancet*, 1994; 344: 1175-81.

Bhattarai A, Ali AS, Kachur SP, Martensson A, Abbas AK, et al., 2007. Impact of artemisinin-based combination therapy and insecticide treated nets on malaria burden in Zanzibar. *PLoS Med* 4(11): e309. doi:10.1371/journal.pmed.0040309

Gimnig JE, Kolczak MS, Hightower AW, Vulule JM, Schoute E, Kamau L, Phillips-Howard PA, Ter Kuile FO, Nahlen BL, Hawley WA, 2003. Effect of permethrin-treated bed nets on the spatial distribution of malaria vectors in Western Kenya. *Am. J. Trop. Med. Hyg.* 68, 115–120.

Govella NJ, Okumu FE & Killeen GF (forthcoming). Hypothesis: Insecticide treated nets can reduce malaria transmission across entire communities even when they confer minimal personal protection. Accepted for publication.

Killeen GF, Smith TA, Ferguson HM, Mshinda H, Abdulla S, Lengeler C & Kachur SP, 2007. Preventing childhood malaria in Africa by protecting adults from mosquitoes with insecticide-treated nets. *PLoS Med* 4(7): e229. doi:10.1371/journal.pmed.0040229

Killeen GF & Smith TA 2007. Exploring the contributions of bed nets, cattle, insecticides and excitorepellency to malaria control: a deterministic model of mosquito host-seeking behaviour and mortality. *Trans. R. Soc. Trop. Med. Hyg.* 2007 September ; 101(9): 867–880.

Kitua AY, Smith T, Alonso PL, Masanja H, Urassa H, Menendez C, Kimario J, Tanner M, 1996. *Plasmodium falciparum* malaria in the first year of life in an area of intense and perennial transmission. *Trop. Med. Int. Health.* 1996 Aug;1(4):475-84.

Mboera LEG & Magesa SM, 2001. The rise and fall of malarial sporozoite rates in *Anopheles Gambiae s.l.* and *An. Funestus* in north-eastern Tanzania, between 1934 and 1999. *Annals of Tropical Medicine & Parasitology*, Vol.95, No.4, 325-330.

Masanja H, de Savigny D, Smithson P, Schellenberg JA, John T et al, 2008. *Lancet* 2008; 371: 1276-83.

Menendez, C, Kahigwa E, Hirt R, Vounatsou P, Aponte JJ, Font F, Acosta CJ, Schellenberg DS, Galindo C M, Kimario J, Urassa H, Brabin B, Smith TA, Kitua AY, Tanner M, Alonso PL, 1997. Randomised placebo-controlled trial of iron supplementation and malaria chemoprophylaxis for prevention of severe anemia and malaria in Tanzanian infants. *Lancet* 350:844–850.

O'Kell LC, Drakeley CJ, Bousema T, Whitty CJ, Ghani AC, 2008. Modelling the impact of artemisinin combination therapy and long-acting treatments on malaria transmission intensity. *PLoS Med.* 2008 Nov 25;5(11):e226; discussion e226.

Rowe K & Steketee R, 2007. Predictions of the impact of malaria control efforts on all-cause child mortality in Sub-Saharan Africa. *Am. J. Trop. Med. Hyg.* 77(Suppl 6), 2007, pp48-55.

Schellenberg D, Menendez C, Aponte J, Guinovart C, Mshinda H, Tanner M & Alonso PL, 2004. The changing epidemiology of malaria in Ifakara Town, southern Tanzania. *Trop.Med.Int.Health.* Vol.9 No.1, 68-76.

Schellenberg JA, Shirima K, Maokola W, Manzi F, Mrisho M, Mushi A, Mshinda H, Alonso PL, Tanner M & Schellenberg DM (forthcoming). Community effectiveness of Intermittent Preventive Treatment for Infants (IPTi) in rural southern Tanzania. Submitted for publication.

URT, 2000. Tanzania Reproductive and Child Health Survey (TRCHS 1999). National Bureau of Statistics & Macro International.

URT, 2004. The policy implications of Tanzania's mortality burden. Volume 1: A ten-year community-based perspective. Ministry of Health/AMMP, 2004

URT, 2005. Tanzania Demographic and Health Survey (TDHS, 2004-05), Dar es Salaam, Tanzania. National Bureau of Statistics & Macro International, 2005

URT, 2008. Tanzania HIV/AIDS and Malaria Indicator Survey 2007-08. Dar es Salaam, Tanzania: TACAIDS, ZAC, NBS, OCGS & Macro International, 2008.