Comparing changes in morbidity and mortality in under-five year olds in Kilombero and Bagamoyo district hospitals

IFAKARA HEALTH INSTITUTE
research | training | services

Report prepared by:
Jeje Williams
Angel Dillip
Paul Smithson
Zoe Hildon

Comparing changes in morbidity and mortality in under-five year olds in Kilombero and Bagamoyo district hospitals

By Jeje William, Angel Dillip, Paul Smithson and Zoe Hildon

IFAKARA HEALTH INSTITUTE

Comparing changes in morbidity and mortality in under-five year olds in Kilombero (2001-2010) and Bagamoyo (2006-2010) district hospitals

Additional hard copies of this report can be obtained from:
IHI Resource Centre,
P.O. Box 78373, Dar es Salaam.
Tel.: +255 222 774 714

EDITORS:
Mbarwa Kivuyo
David Mbulumi
Paul Smithson

For more details, contact:
Chief Executive Director, IHI
info@ihi.or.tz
ISBN: 978-9987-9652-3-6

Contents

List of Tables

List of Figures

Acknowledgments

The authors and contributors of this report would like to thank the individuals and institutions that have contributed to this output. We extend our gratitude to the management of St. Francis Designated District Hospital and Bagamoyo District Hospital for facilitating the implementation of inpatient and outpatient surveillance system. Equally, we thank all paediatric ward staff for allowing us to work with them closely.

We highly acknowledge the hard work and commitment of the clinical surveillance system teams, both at St Francis DDH, Ifakara and Bagamoyo DH sites.

We are grateful to the study participants who consented to sharing information and made this study possible. We thank Prof David and Prof Joanna Schellenberg for their invaluable input.

Special thanks should go to our funders,CORE partners; Abdallah Mkopi, Mbaraka Amuri and Nahya Salim for their contributions.

Executive summary

Malaria transmission, paediatric admissions and fatalities seem to decline in Africa. To document changes in the Tanzanian context and inform policy, this report presents findings from the Clinical Surveillance System (CSS) monitoring childhood admissions, focusing on inpatient morbidity and mortality in under five years olds in Kilombero (St Francis Designated District Hospital, Ifakara) from 2001-2010 and Bagamoyo (Bagamoyo District Hospital) from 2006-2010.

These locations have been frequent test sites for malaria control trials and interventions and can yield important information on the changing pattern of illness in babies and children. Our objectives are two-fold:

(1) Document the CSS inpatient methodology and data completeness for admissions, morbidity and mortality outcomes in under five year olds in Ifakara for over ten years (2000-2010) and five years in Bagamoyo. This analysis can be used :

   i. To make recommendations for addressing existing gaps in the data.

   ii. To inform ways of identifying improvements in future data collection.

(2) Examine, within the context of identified missing data, the prevalence and changes in admissions, morbidity and mortality across two comparable paediatric wards in urban/peri-urban Tanzania.

With respect to objective (1), identified data losses are summarised as follows: Overall, 2006 was a challenging year for both St Francis DDH and Bagamoyo DH since diagnosis was missing for up to a quarter of combined admissions. Lab confirmed outcomes were also moderately missing in both sites, that is under a third of malaria blood slides at St Francis and blood samples for anaemia at Bagamoyo sites were never processed in the labs. This type of data loss first occurred in 2001 whereby 67% of clinical diagnoses of malaria were never examined for parasitology at St Francis DDH.

With respect to laboratory detected results both facilities showed gaps in data processing. In Bagamoyo this was particularly true for malaria in

all years, with biggest gaps appearing in the more recent years of data collection, 55% in 2010. In Kilombero, this was the case particularly for anaemia, again with growing gaps until 2010 which saw 100% missing data.

Otherwise the Bagamoyo DH data were exceptionally well collected since 2007, in particular the mortality data, which appear robust on most counts; whereas St Francis DDH deaths were, on the other hand, substantially missing until 2009-2010.

Details of gaps in data are summarised in pages 24-25. These reveal that trend analyses are limited by the scattered nature of the missing data. If we were to exclude years with the most missing data the best morbidity analyses would feature from 2002-2005 for Kilombero; and for analyses comparing both Bagamoyo and Kilombero we propose only using 2007-2008 data.

Imputation methods might on the other hand seek to use existing data to complete a full analysis of all time points. At the very least further data cleaning could be used to sensitively report proportions of lab confirmed malaria, excluding data that was not sent to laboratories at all. This would mean most Bagamoyo DH data would be usable for both morbidity and mortality analyses.

Further investigation of methods of imputation will be undertaken. Follow-up with data collectors in the both sites are underway.

With respect to objective (2), comparing facilities yielded interesting findings. Admissions at St Francis DDH, peaked in 2003 to 3,956(17%), they were at their lowest in 2007 1,345(6%), returning to similar levels,1,354(6%), in 2010. These changes warrant further investigation. In contrast Bagamoyo DH displayed a steady reduction in admissions over time. This gradient was reduced over three fold in 2006-2010, from 1,250 (30%) to only 371 (9%) admissions.

Diagnosed clinical malaria blood samples were systematically confirmed by laboratory results. Over the period of 2001-2010, between 10-58% of clinical cases were confirmed at St Francis DDH by laboratory detection. At Bagamoyo DH, an average of 63% for clinical cases were confirmed in the period of 2006-2010. In contrast, it is common for anaemia to be chronically under-diagnosed. Forty-six percent and 38% of true anaemia cases at St Francis and Bagamoyo respectively were recognised by incidental lab checks.

Overall, analysis indicates that clinical diagnosis is an unreliable indicator for malaria outcomes as true cases are often overestimated.

Despite missing data on laboratory detected outcomes, it appears that malaria in under five year olds in both districts is on the decline. At St Francis DDH laboratory detected malaria peaked in 2003 to 47%, declining to 20% by 2009. In Bagamoyo we observed a drop from 28% to 23% from 2006-2009.

Anaemia appears to remain one of the most prevalent illnesses in hospitalised children. Bagamoyo DH which had complete data for this outcome, showed that a very large (57%) of admissions in 2010 were anaemic. It also accounted for m for many deaths particularly most recently (2010), where 19 of all explained Bagamoyo DH deaths (n=25) were due to this outcome (n=10 to pneumonia; n=2 to watery diarrhoea; n=2 other diseases).

Also at this same facility, deaths attributed to malaria were recorded to plummet from 13 in 2006 to 0 in 2010; nevertheless crude death rate rose to its highest rate per 1000 of 70 also in 2010 at Bagamoyo. Notwithstanding this, for the comparable mortality time points between facilities (2009-2010), Bagamoyo DH averaged 60 deaths per 1000 compared to 62 per 1000 at St Francis. Overall, however, Bagamoyo recorded fewer deaths averaging at 44 per 1000 (2006-2010). The lower rates in preceding years may partly be due to data collection lags.

Introduction

1.1 Background

The number of deaths in under-fives has seen a worldwide declined from more than 12 million in 1990 to 7.6 million in 2010 [1]. This finding indicates the substantial progress that has been made toward achieving the Millennium Development Goal 4, to reduce mortality in under-five children by two-thirds between 1990 and 2015. However, the rate of infant mortality still remains the highest in Sub-Saharan Africa, where it has been estimated that 1 in 8 children die before age 5, more than 17 times the average for developed regions (1 in 143)[1]. In Tanzania, under-five mortality rates have dropped by 40%, from 137 deaths per 1,000 births in the mid-nineties to 81 for the period 2006-10[2].

In Sub-Saharan Africa, however, malaria has been long cited as the leading cause of infant mortality[3] totalling 16% of deaths in this population group[1]. Although malaria remains for Tanzanian children one of the main known causes of death, it has been documented that malaria transmission is decreasing both here and worldwide[1 4 5 6]. Moreover, as the intensity of malaria transmission declines in Africa through the scaling up of insecticide-treated nets and other vector control measures, we observe a related decline in paediatric admissions and fatalities[7 8 9]. Therefore we can expect to find a steady change in the pattern of admissions in children, and there is a need to document this change to inform related treatment prioritisation.

1.2 Purpose and rationale

The current report examines The Clinical Surveillance System (CSS) monitoring childhood admissions in mainland Tanzania, focusing on inpatient morbidity and mortality in under five years olds in Kilombero (St Francis Designated District Hospital, Ifakara) from 2001-2010 and Bagamoyo (Bagamoyo District Hospital) 2006-2010 districts. These locations have been frequent test sites for malaria control trials and interventions, notably in Kilombero, ITN and IPTi interventions [6 8 10 11] and in Bagamoyo, malaria drug and vaccine trials[12].

The Clinical Surveillance System was developed to capture end-points in vaccine trials but more important the CSS in Ifakara was initiated to evaluate the KINET programme, a multi-district social marketing programme, assumed to have a likely influence on clinical diseases presenting to St Francis

DDH. We have focused down on selected years in order to meaningfully compare sites and to complement existing published studies using CSS data from St Francis DDH, Ifakara. The Ifakara site data were collected from the mid-nineties, a decade prior to the extension to Bagamoyo (full CSS data collection sites and methods are described below).

Existing published studies using the St Francis DDH data pool show fast moving changes over time. From 1995-96, at the outset of the surveillance it was reported that there were 72 deaths among 2,432 confirmed clinical malaria diagnosis; 44% of the cases and 54% of the deaths were in individuals less than 1 year of age[13]. Children presenting with hypoglycemia, tachypnoea (1–7 months), dehydration (8 months-4 years), inability to localize a painful stimulus, as well as being in the bottom quartile of weight-for-age, were more likely to die.

The same authors reported in subsequent years, between 1995-2000, a lowering in age-specific parasite prevalence in the Ifakara community-based cohort studies which was accompanied by a drop in incidence of confirmed clinical malaria from 0.8 in 1995 to 0.43 episodes per infant per year in 2000, an incidence rate ratio of 0.53 ($P < 0.0001$).

Meanwhile, using CSS data, somewhat paradoxically, an increase in clinical malaria admissions of 12.7% (n=791 to n=892) was demonstrated between 1995 and 2000, and it was found that the average age of admission had risen from 1.55 to 2.33 years of age; concurrently the proportion of malaria cases aged under one year old had decreased from 39% to 17%. In contrast, there was little change in the age distribution of non-malaria admissions, there was no significant change in both these other admissions and in malaria admissions case fatality rates over this period.

In the earlier 1995-6 analysis, eight percent of the malaria cases had severe anaemia (packed cell volume , 15%; 24% received a blood transfusion); but the following 1995-2000 study found a decrease in the proportion of malaria cases presenting with severe anaemia dropping to 1.5%).

While in the 1990s in Tanzania malaria was the single most important infectious disease both in terms of admissions and as a cause of death in under-five children [6 13 14] other principal causes of mortality have emerged in the region since then. Related to malaria is severe anaemia. Others include acute respiratory infections and tuberculosis, bacterial meningitis or septicaemia, and following global patterns[4] pneumonia and diarrhoea[15].

1.3 Study aim and objectives

As we head towards malaria elimination our aim of examining the prevalence and changes in other leading diseases affecting under-five children in developing countries will usefully inform health policy, health services and delivery.

Related to this aim our objectives are:

(1) Document the CSS inpatient methodology and data completeness for admissions, morbidity and mortality outcomes in under five year olds in Ifakara for over ten years (2000-2010) and five years in Bagamoyo. This analysis can be used :

   i. To make recommendations for addressing existing gaps in the data.

   ii. To inform ways of identifying improvements in future data collection.

(2) Examine, within the context of identified missing data, the prevalence and changes in admissions, morbidity and mortality across two comparable paediatric wards in urban/peri-urban Tanzania.

METHODOLOGY

2.1 Data collection purpose

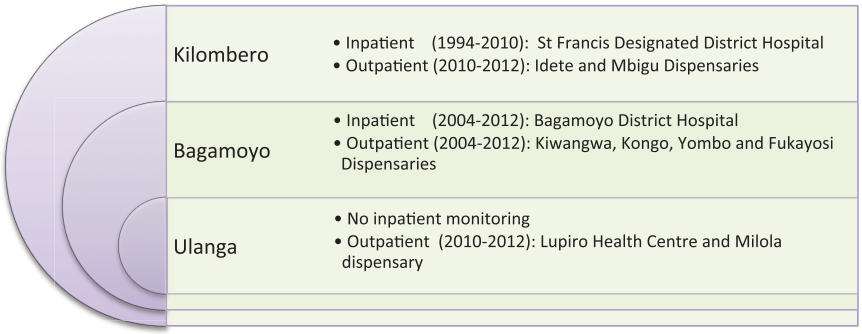
The CSS was introduced to evaluate interventions delivered as part of controlled trials undertaken in collaboration with IHI. Therefore the platform can be used to facilitate an assessment of safety and efficacy of different clinical interventions. Additionally it can help monitor morbidity and mortality patterns in children under the age of five years presenting with illness at selected inpatient and outpatient facilities. Currently we focus on such inpatient analyses. Findings will set the backdrop for future trials and provide the bedrock to inform paediatric health services delivery and policy in these districts.

2.2 Data collection sites

CSS data are collected in a total of three districts including Kilombero, Bagamoyo and recently Ulanga. Data collection is categorised into two components of admissions monitoring in this population group: the Inpatient Surveillance System (ISS) and the Outpatient Surveillance System (OSS). Admissions monitoring for CSS began in the mid 90's and has since grown with the addition of two districts, see figure 1. Starting with Kilombero's St Francis inpatient monitoring in 1994, data collection was only recently extended in 2010 to outpatient monitoring in this district to include Idete and Mbingu dispensaries.

In 2004 Bagamoyo District Hospital was added to the inpatient monitoring system and outpatient facilities were integrated at the same time including Kiwangwa, Kongo, Yombo and Fukayosi dispensaries. In Ulanga District, collection of outpatient data alone began in 2010 at Lupiro health centre and Milola dispensary. While Ulanga is part of the Ifakara HDSS where a number of health interventions have also been taking place, Lupiro health facility is the only health centre within the Ifakara-Ulanga HDSS receiving quite number of out-patients in the area. Monitoring trends in diseases in this area is therefore crucial for disease management.

Figure 1: Facility and periods of data collection for Inpatient and Outpatient admissions monitoring



2.3 Inpatient facilities

St Francis Designated District hospital was appointed a Referral Hospital on June 28, 2010 by the Ministry of Health and Social Welfare. For consistency we refer to it by its original name herein. Now this facility is one of 9 Referral Hospitals in Tanzania. That means that all hospitals in the surrounding districts which lack the necessary personnel and equipment and cannot treat certain patients properly transfer them to St Francis. Its area of responsibility has been extended in this way and the responsible staff face new challenges including more case load and more complex or severe cases.

This facility has 371 beds and is divided into Surgery, Internal Medicine, Gynaecology and Obstetrics, Paediatrics, Chronic Diseases and Intensive Care departments. There are 70 beds in the paediatric ward and children of up to 12 years are admitted in that ward. Fourteen clinical staff are providing service to the paediatric ward, 4 are employed by Ifakara Health Institute (IHI). The hospital also operates supplementary clinics for special conditions for children, including for example sickle cell. Neonates under 28 days are referred to a specialised facility.

Bagamoyo District Hospital has a total bed capacity of 125, with 19 beds assigned to paediatric ward. Until 2010 this facility only admitted five year olds, but recently this has been extended to accommodate children of up to nine years. Total clinical staff, including staff employed directly by the hospital or through IHI including field staff providing paediatric support approximates 62 healthcare workers; all contribute to the data collection. Currently the ward is staffed by two paediatricians, this was extended from

only one clinician who was resident from 2007 - 2011. The ward is usually for routine care and management including Serious Adverse Events for study specific subjects. A special ward is used for short drug trials. Neonates under 28 days are also referred for specialist treatment elsewhere.

2.4 Inpatient clinical surveillance procedures

Ifakara Health Institute have therefore operated a surveillance system of all admissions to these inpatient pediatric wards (0–15 years of age). On admission, verbal informed consent to complete a standardized questionnaire was sought by specially trained project Clinical Officers (COs) and obtained from parents or carers of children under five years of age.

Questionnaires were scrutinized by a project physician and errors/ inconsistencies were discussed with the CO concerned. A clinical diagnosis of the disease is documented by a clinician at the time of admission. This is recorded based on a hierarchy of up to four *diagnoses*. For inpatients a final ordered diagnostic is assigned at the time of discharge, as is the *outcome* of treatment: alive, dead absconded or referred, appendix 1. The questionnaire key components (socio-demographic, signs and symptoms, blood, treatment, other investigation) are shown in Box 1.

For all diagnoses initially a clinical investigation was undertaken. Only for malaria and anemia were these intended to be systematically confirmed by laboratory test and the parasitology results recorded.

Box 1: Information systematically collected from all children

Key data collection components	
Socio-demographic	Age, sex
Symptoms	Fever, cough, diarrhea, dysentery, vomiting, history of difficulty breathing, haematuria, convulsions
Signs	Temperature, height/weight, respiration rate, pulse, pallor, jaundice, chest in-drawing, nasal flaring, crackles, level of consciousness, Blantyre coma score, position, neck stiffness, fontanelle, spleen size, liver size, dehydration, oral candida, flaky paint skin
Blood	Parasitemia, blood glucose concentration, packed cell volume count or haemoglobin level
Treatment	Drugs given during hospitalization, e.g. anti-malarials and other management e.g. blood transfusion
Other investigation	LP, X-ray, urine sample etc.

2.5 Case definitions

Clinical diagnoses were made following the WHO (2005) guidelines[16]. Clinical diagnosis of malaria included signs of fever, enlarged spleen, signs of anaemia – pallor. However, cases of malaria were defined as those children admitted with history of fever in whom parasitaemia was confirmed with blood film microscopy, that is asexual *P. falciparum* in peripheral blood.

Thick blood smears were prepared to look for malaria parasites after staining with Giemsa. Blood slides were read according to laboratory standard procedures. The number of asexual forms per 200 leucocytes was counted independently by at least two slide readers and a parasite concentration calculated by assuming a white cell count of 8000/µL and multiplying by the geometric mean parasite count.

Children were considered anaemic if the Packed Cell Volume (PCV) was < 27% or Hb <8g/dL . At St Francis Designated District Hospital a finger prick blood sample was collected in a microcapillary tube for the measurement of PCV, while Bagamoyo District Hospital, a capillary blood sample was collected to measure haemoglobin using hemoque machine.

In terms of the other leading causes of admission and fatalities examined herein pneumonia was defined as children presenting with a cough or difficulty in breathing plus at least one of the following signs: chest wall in-drawing, nasal flaring, fast breathing and crackles on auscultations[17].

No chest x-ray diagnosis was used for pneumonia except for very severe cases. Diarrhoea was defined as a child with three or more loose stool per day and two or more of the following: sunken eyes, drinks eagerly, thirsty and skin pinch goes back slowly.

Urinary tract infections were defined by costovertebral angle or suprapubic tenderness, crying on passing urine, passing urine more frequently than usual, incontinence in previously continent child; and upper respiratory tract infection by symptoms of cough / cold infection and no systemic upset.

Septicemia was diagnosed as seriously and obviously ill with no apparent cause,purpura, petechiae, shock or hypothermia in young infant or severely, malnourished child. Meningitis was diagnosed as stiff neck, bulging fontanelle, meningococcal rash (petechial or purpuric) with no use of lumber puncture.

Other diseases may be diagnosed by clinical data alone or supported by laboratory results e.g. Urinary Tract Infections (UTIs) could be confirmed by white blood cells and/or bacteria in urine on microscopy, or positive dipstick. But these lab results were not systematically recorded.

2.6 Data management

Data were double entered by different data entry clerks. All data are stored and processed in a dedicated secure directory into server. A data manager performs daily cross checking routines to detect and correct any discrepancies between the two entries. Discordances detected at this point are recorded in a log file permitting quality control of the data checking process.

Weekly checks for duplicate records, completeness of the databases, range, inconsistencies and referential integrity were due to be performed. However, changes in management, clinician turnover and related holdups in training have meant that data cleaning was not undertaken on an ongoing basis and data completeness will need examining prior to analyses.

2.7 Study population

From 2001 to 2010, there were a total of 22,888 children who were admitted at St. Francis DD Hospital; 8,615 of these were admitted in the second half of the decade 2006-2010. In Bagamoyo D Hospital, during the same recent period there were a total of 4,192 admissions. Socio-demographic information was as follows (see Table 1.

Broadly, both facilities admitted similar sex and ages of young children including more boys (13-9%) than girls. Despite a few missing data on age (n=83 or 0.6% at St Francis and n=108 or 2.6% at Bagamoyo) in both facilities just over a third were under one year of age, around 27.5% were between 12 and 23 months, 29% were between 24 to 47 months, with the fewest, 7%, being in the oldest age band of 48-59 months.

Table 1: Description of study population admitted to Saint Francis DD Hospital and Bagamoyo D Hospital

Characteristics	St Francis DD Hospital N(%)			Bagamoyo D Hospital N(%)
	2001-2005	2006-2010	Total	2006 – 2010 Total
Total children admitted N	**14,273**	**8,615**	**22,888**	**4,192**
Male	7,968 (55.8)	4,992 (58.0)	12,960 (56.6)	2,293 (54.7)
Female	6,305 (44.2)	3,623 (42.1)	9,928 (43.4)	1,899 (45.3)
Under 12 months	5,009 (35.1)	3,078 (35.7)	8,087(35.3)	1,461 (34.9)
12-23 months	4,057 (28.4)	2,395 (27.8)	6,452 (28.2)	1,145 (27.3)
24-35 months	2,956 (18.2)	1484 (17.2)	4,080 (17.8)	710 (16.9)
36-47 months N	1,280 (10.27)	980 (11.4)	2,508 (11.0)	485 (11.6)
48-59 months N	1,000 (7.0)	678 (7.9)	1,678 (7.3)	283 (6.8)
Missing age band N	83 (0.6)	0 (0.0)	83 (0.4)	108 (2.6)

% of total admissions for that year

2.8 Methods of analyses

Descriptive analyses of data completeness and key summary changes in number of admissions, sex, age and the top 15 disease categories and mortality outcomes present in both St Francis and Bagamoyo facilities were undertaken. Ranking of diseases was derived based on average proportion of diagnosis on admissions over five year blocks, accounting for each of the four potential levels of diagnoses and examining laboratory confirmed malaria and anaemia outcomes contrasted to clinical diagnoses. Initially the ten most important diseases for each site were listed. These were then matched across both Bagamoyo and the Ifakara based facilities resulting in comparable list of 15 disease categories.

Trends over time (Kilombero District 2001-2010 and Bagamoyo 2006-2010) were then examined for the top five disease categories, anticipating that these would include malaria, pneumonia, anaemia, watery diarrhoea and an 'other' (combined) disease category.

Building on these analyses we then examined related mortality over time. These were examined in relation to the first diagnosis and lab confirmed diagnoses only. Analysis was stratified by age (less than or equal to one year vs. over one year of age).

Data were analyzed using STATA version 12.0 (Stata Corp, TX, USA).

Results

3.1 Data interpretation: Signposting

In this section results are presented in two sub-sections structured in respect of the earlier stated objectives and related analyses.

The first section provides a descriptive overview with a particular focus on reporting data completeness, examining: admissions and first diagnosis, lab pa itology vs. clinical data, and outcome of admission (absconded, referred, not recorded) data across the ranked top 15 diseases categories. We also summarise data completeness for mortality.

The second section compares sites examining morbidity and mortality over time, summarising outcomes and trends in the diagnoses and mortality in under five year olds between the two facilities.

Throughout reporting analyses we use traffic light coding to highlight missing data gaps.

Green highlights indicate less than 10% missing data; **amber** between 11-33%; and **red** over one third (or more that 34%) of missing data.

▲ Highest and lowest ▼ outcomes are also indicated throughout.

3.2 Data completeness

3.2.1 Morbidity data: admissions and diagnoses in under five year olds

At St Francis admissions in under five year old children have fluctuated over time, peaking in 2003 and showing another rise in 2005; but otherwise the admissions appear to be decreasing across both districts, in line with the expected trend given on-going health promotion campaigns in these areas, see Table 2.

Table 2: Description of total admissions over time for Saint Francis DD Hospital (N = 22,888) and Bagamoyo D Hospital (N = 4,192)

	Saint Francis DD Hospital				Bagamoyo D Hospital			
Year	Total N (%)	% female	Average age	% missing diagnosis	Total N (%)	% female	Average age	% missing diagnosis
2001	2,676(11.7)	42.4	2.17	0.4	-----	-----	-----	-----
2002	2,321(10.1)	44.4	2.27	0.3	-----	-----	-----	-----
2003	3,956(17.3)▲	44.7	2.39	0.4	-----	-----	-----	-----
2004	2,329(10.2)	46.8	2.24	1.6	-----	-----	-----	-----
2005	2,991(13.1)	42.8	2.17	2.1	-----	-----	-----	-----
2006	1,819(8.0)	41.4	2.11	13.6▲	1,250(29.8) ▲	46.2	2.26	27.6 ▲
2007	1,345(5.9) ▼	40.3	2.30	11.0	1,055(25.2)	44.3	2.23	7.5 ▲
2008	1,984(8.7)	43.3	2.40	1.1	984(23.5)	45.3	2.30	8.6
2009	2,113(9.2)	42.0	2.35	0.0	532(12.7)	45.1	2.30	9.8
2010	1,354(5.9)	43.0	2.20	0.0	371(8.9)	45.3	2.18	9.2
Total	22,888(100)	43.4	2.26	0.3	4,192(100)	45.3	2.26	14.1

% of total admissions for that year

▲ highest and ▼ lowest for that outcome over total period; notable findings highlighted

Peaks in admissions at St Francis in 2003 coincide with a sharp rise in malaria admissions, while the 2008-2009 peak with a comparatively milder rise in both pneumonia and anaemia admissions (section 3.2 figure 3a). The 2003 rise in admissions also coincides with a dryer than usual spell, and so cannot be explained by longer than usual transmission season[18]. A drop in rice harvest yield in the Kilombero Valley and related malnutrition has been advanced as one important contextual determinant of the 2003 admissions[19].

The lowest admission rates were in recent years, in 2010 for both sites. A lowering of admission rates appears to coincide with less female children being b ought to facilities, most notably in 2007 when only 40% of admissions were girls. Following earlier findings that the average age of admission was rising in Ifakara[6] our data suggests that since then the average age of admission has remained fairly consistent at around 2.3 across both sites.

Data completeness of admission and morbidity records (first diagnosis, lab parasitology data and outcome of admission data) were examined prior to analyses. At St Francis during 2001-2008 data completeness on morbidity was generally good, see also Table 2; only 550 (0.3%) of admissions were not attributed a first diagnosis. However, data loss peaked suddenly in 2006

(14%). This could be explained by staffing shortages and concurrent staff retraining initiatives required to establish the Bagamoyo DH data collection.

Meanwhile, also in 2006 Bagamoyo D Hospital experienced an even larger proportion of missing data in diagnosis recording (28%), but recovered quickly, down to 8% the following year in 2007, and remained at overall good levels of data completeness from this period onwards. By 2010 missing diagnoses totalled 592 (14%).

A different picture emerges when we study data completeness on laboratory follow-up of clinical diagnoses of malaria and anaemia (pallor), see Tables 3a-d. Diagnosed clinical malaria blood samples were to be systematically confirmed by laboratory results. And, at St Francis DDH (Table 3a) the system appears to have worked very well from 2002 to 2009, where consistently very few clinical diagnoses (generally well under 5%, except in 2009) were missing malaria parasitology follow-up. However, in 2001 a substantial (67%) data loss occurred, and again a moderate data loss has been highlighted more recently in 2010 (19%).

Table 3a: Description of malaria clinical and laboratory based diagnoses data completeness over time for Saint Francis DD Hospital (N = 22,888)

	Saint Francis DD Hospital				
	Malaria clinical diagnosis* N (%)	Malaria *all* confirmed lab diagnoses* N (%)	% of clinical malaria diagnoses confirmed by lab	% of lab detected malaria as incidental**	% missing lab follow-up of clinical malaria
2001	1,895(70.8)	499(18.65)	24.4	7.4	**67.0▲**
2002	1,643(70.8)	963(41.49)	54.8	6.5	**1.4**
2003	3,078(77.8)▲	1868(47.22)	58.3▲	3.9	**4.5**
2004	1,731(74.3)	821(35.25)	44.0	7.6	**3.2**
2005	2,280(76.2)	785(26.25)	32.3	6.1	**3.2**
2006	1,145(63.0)	292(16.05)	20.7	18.8	**1.7**
2007	887(66.0)▼	257(19.11)	22.9	21.0▲	**3.4**
2008	1,378(69.5)	391(19.71)	27.1	4.3	**0.3▼**
2009	1,636(77.4)	419(19.83)	26.6	0.2▼	**7.6**
2010	968(71.5)	102(7.53)	9.6▼	8.8	**19.1**
Totals	**16,641(72.7)**	**6397(27.95)**	**34.2**	**6.7**	**11.5%**

*of Diagnoses 1-4; **not initially clinically diagnosed

% of total admissions for that year

▲ highest and ▼ lowest for that outcome over total period; notable findings highlighted

Moreover, still at St Francis, we observe that over the whole period a range of between 10 to 58% of cases were confirmed by malaria parasitology follow-up, averaging just over a third of clinical cases, at 34%. Interestingly, a few lab diagnosed cases were identified *incidentally* without initial clinical diagnoses, these comprised an average of 7% of all lab diagnosed cases. These type of cases peaked in 2005-6, at 19% and 21%. In contrast Bagamoyo DH (Table 3b) we observed a consistently larger proportion, over 22%, of clinical malaria diagnoses that were not followed-up and a substantial data loss in 2010 at 56%.

Table 3b: Description of malaria clinical and laboratory based diagnoses data completeness over time for Bagamoyo D Hospital (N = 4,192)

Bagamoyo D Hospital					
	Malaria clinical diagnosis* N (%)	Malaria *all* confirmed lab diagnoses* N (%)	% of clinical malaria diagnoses confirmed by lab	% of lab detected malaria as incidental**	% missing lab follow-up of clinical malaria
2006	484(38.7)▲	354(28.3)▲	70.0 ▲	4.2▲	**21.9**▼
2007	469(44.5)	312(29.6)	65.2	1.9	**28.8**
2008	449(45.6)	308(31.3)	67.7	1.3	**22.5**
2009	213(40.0)	124(23.3)	54.9	5.7	**31.9**
2010	106(28.6)▼	28(7.5)▼	26.4	0.0▼	**55.7**▲
Totals	**1,721(41.1)**	1126(26.9)	**63.6**	**2.8**	**27.3**

*of Diagnoses 1-4; **not initially clinically diagnosed

% of total admissions for that year

▲ highest and ▼ lowest for that outcome over total period; notable findings highlighted

Overall, therefore clinical diagnoses are an unreliable indicator for malaria outcomes and can greatly overestimate the number of true cases. As for anaemia, the unreliability of clinical outcomes fares in the opposite direction, see Tables 3c-d. In both cases, however, existing data on differences between clinical and lab diagnosed outcomes might inform imputation of missing laboratory outcomes.

Anaemia, clinically diagnosed using pallor, for example in the palm of the hand, appeared chronically underdiagnosed. So much so that when clinical diagnoses are systematically checked, see Bagamoyo DH data (Table 3d), 96% of these turn out to be confirmed by blood biology readings. Moreover a much larger proportion of the all lab confirmed anaemia results can be attributed to incidental lab checks. That is in St Francis DDH 46% and in Bagamoyo DH 38% of lab confirmed results were not gleaned from initial clinical diagnoses.

Table 3c: Description of clinical anaemia (pallor) and laboratory based diagnoses data completeness over time for Saint Francis DD Hospital (N = 22,888)

	Saint Francis DD Hospital				
	Anaemia - clinical diagnosis* N(%)	Anemia *all* lab confirmed diagnoses* N (%)	% of clinical anaemia diagnosis confirmed by lab	% of lab detected anaemia as incidental**	% missing lab follow-up of clinical anaemia-
2001	617(23.1)	957(35.8)	94.3	39.2 ▼	**2.9**
2002	567(24.3)	919(39.6)	97.0	40.2	**0.4**
2003	910(23.0)▲	1436(36.3) ▲	92.0▲	41.7	**1.8**
2004	395(17.0)	704(30.2)	91.1	48.9	**1.3**
2005	651(21.8)	858(28.7)	79.6	39.6	**4.3**
2006	256(14.1)	320(17.6)	56.2	55.0	**23.8**
2007	161(12.0)▼	372(27.7)	75.8	67.2▲	**4.3**
2008	367(18.5)	713(35.9)	85.3	56.1	**0.0** ▼
2009	433(20.5)	163(7.7)▼	17.32▼	54.0	**77.8**
2010	224(16.5)	--	--	--	**100.0**▲
Totals	**4,581(20.0)**	6442(28.1)	**76.4**	**45.7**	**15.2**

*of Diagnoses 1-4 using 'pallor; **not initially clinically diagnosed

% of total admissions for that year

▲ highest and ▼ lowest for that outcome over total period; notable findings highlighted

A system failure in the St Francis DDH laboratory data recording system for anaemia has been identified which is currently being investigated. This has meant substantial missing anaemia data (Table 3c) in 2009 (78%) and 2010 (100%). Otherwise data completeness on the anaemia variable is good for St Francis DDH, notwithstanding a moderate rise in missing lab follow-up (24%) in 2006. Bagamoyo DDH data completeness for anaemia is very good, with missing lab follow-up at under 2% for all years.

Table 3d: Description of clinical anaemia (pallor) and laboratory based diagnoses data completeness over time for Bagamoyo D Hospital (N = 4,192)

	Bagamoyo D Hospital				
	Anaemia - clinical diagnosis* N(%)	Anemia *all* lab confirmed diagnoses* N (%)	% of clinical anaemia diagnosis confirmed by lab	% of lab detected anaemia as incidental**	% missing lab follow-up of clinical anaemia-
2006	304(24.3)	448(35.8)▲	97.7▲	33.7	1.0
2007	254(24.1)	367(34.8)	94.9	34.3	1.6▲
2008	326(33.1)▲	439(44.6)	95.4	29.2▼	0.6▼
2009	172(32.3)	290(54.5)	92.4	45.2	0.6
2010	93(25.1)▼	212(57.1)▼	96.8▼	57.5▲	1.1
Totals	**1,149(27.4)**	1756(41.9)	**95.6**	**37.5**	1.0

*of Diagnoses 1-4 using 'pallor'; **not initially clinically diagnosed

% of total admissions for that year

▲ highest and ▼ lowest for that outcome over total period; notable findings highlighted

In terms of outcomes of admissions, in particular restricting to after diagnosis (discharged/dead/unknown absconded, referred or not recorded), see Tables 4a-b, and treatment at St Francis DDH data completeness was generally good. Most of the categorised diseases had recorded over 90% of the outcomes of admissions. However, absconding was more common with a pneumonia diagnosis as were referrals elsewhere. Particularly frequent absconders tended to be diagnosed with HIV/AIDS, as well as nutritional marasmus and meningitis. Septicaemia, asthma and the other diseases categories were rare and these less severe illness outcomes had greater tendency to not be recorded.

Table 4a: Prevalence for top 15 disease categories and related data completeness - outcomes of admission - across 5 year blocks for Saint Francis DD Hospital (N = 22,888)

St Francis DDH	2001-2005 Outcomes			2006-2010 following admission			2001-2010 Totals	
	Diagnosed N (%)	Absconded N (%)	Referred N (%)	Diagnosed N (%)	Absconded N (%)	Referred N (%)	Diagnosed total N (%)	% diagnosed but missing (discharged/dead) outcome*
Anaemia lab	4874(30.9)▲	389 (8.0)	49 (1.0)	1568 (19.9)▲	170 (10.8)	12(0.8▲	6,442(27.2)▲	9.9
Malaria lab	4936(31.3)	185 (3.8)	40 (0.8)	1461 (18.5)	66 (4.5)	8 (0.6)	6,397(27.0)	5.1
Pneumonia	2899(18.4)	305 (10.5)	22 (0.8)	2050 (26.0)	157 (7.7)	90 (0.9)	4,949(20.9)	11.7
Watery diarrhoea	1628(10.3)	134 (8.2)	15 (0.9)	1358 (17.2)	83(6.1)	4 (0.3)	2,986(12.6)	8.1
URTI	347(2.2)	10 (2.9)	5 (1.4)	228(2.9)	6 (2.6)	0 (0.0)	575(2.4)	3.7
UTI	166(1.1)	3 (1.8)	1 (0.6)	209(2.7)	7 (3.2)	0 (0.0)	375(1.6)	2.9▼
Nutritional Marasmus	128(0.8)	42 (32.8)	4 (3.1)▲	102(1.3)	13 (12.8)	3 (2.9)	230(1.0)	27.0
HIV/AIDS	125(0.8)	76 (60.8)▲	0 (0.0)	85(1.1)	18 (21.2)▲	3 (3.5)	210(0.9)	46.2▲
Meningitis	107(0.7)	42 (39.3)	2 (1.9)	119(1.5)	29 (24.4)	1 (0.8)	226(1.0)	33.2
Bronchiolitis	80(0.5)	4 (5.0)	0 (0.0)	23(0.3)	1 (4.4)	0 (0.0)	103(0.4)	5.8
Skin infection	74(0.5)	2 (2.7)	2 (2.7)	79(1.0)	4 (5.1)	0 (0.0)	153(0.6)	5.2
Measles	48(0.3)	0 (0.0)	2 (4.2)	6(0.1)▼	0 (0.0)▼	0 (0.0) ▼	54(0.2)	3.7
Septicaemia	15(0.1)	6 (40)	0 (0.0)▼	80(1.0)	8 (10.0)	0 (0.0)	95(0.4)	14.7
Asthma	7(0.0)▼	1 (14.3)	0 (0.0)	37(0.5)	3 (8.1)	1 (2.7)	44(0.2)▼	11.4
Other Diseases	352(2.2)	60 (12.5)	5 (1.1)	477(6.1)	63 (17.9)	8 (2.8)	829(3.5)	16.5
Totals	**15786 (100.0)**	**1259 (8.0)**	**147 (0.9)**	**7882(100.0)**	**628 (7.9)**	**130 (1.6)**	**23668 (100.0)**	**9.4**

*Derived from counts of absconded, referred or not recorded by diagnosis total for that year
% of total diagnoses for that time period
▲ highest and ▼ lowest for that outcome over total period; notable top 5 findings highlighted

In contrast, Bagamoyo DH demonstrated very good data completeness on outcomes after admission, explaining the outcome of at least up to 95% of cases for most disease categories.

Table 4b: Prevalence for top 15 disease categories and related data completeness - outcomes of admission - for Bagamoyo D Hospital (N = 4,192)

Bagamoyo DH	2006-2010 Outcomes following admission			
	Diagnosed N (%)	Absconded N (%)	Referred N (%)	% diagnosed but missing (discharged/ dead) outcome*
Anaemia lab	1756 (31.7)▲	8(0.5)▲	60(3.4)	**4.0**
Pneumonia	1418(25.5)	10(0.7)	26(1.8)	**2.5**
Malaria lab	1126(20.3)	5(0.4)	15(1.3)	**1.8**
Watery diarrhoea	433(7.8)	5(1.2)	4(0.9)	**2.1**
Septicaemia	222(4.0)	3(1.4)	13(5.9)▲	**7.2**▲
Bronchiolitis	129(2.3)	0(0.0)	1(0.8)	**0.8**
UTI	117(2.1)	1(0.9)	2(1.7)	**2.6**
Asthma	81(1.5)	0(0.0)	0(0.0)	**0.0**
Measles	78(1.4)	1(1.3)	0(0.0)	**1.3**
URTI	56(1.0)	0(0.0)▼	0(0.0)	**0.0**▼
HIV/AIDS	35(0.6)▼	2(5.7)	0(0.0)	**5.7**
Meningitis	---	---	---	---
Nutritional Marasmus	---	---	---	---
Skin infection	---	---	---	---
Other diseases	83(1.5)	0 (0.0)	3 (3.6)	**3.6**
Total	**5,534 (100.0)**	**35(0.6)**	**124(2.2)**	**2.9**

*Derived from counts of absconded, referred or not recorded by diagnosis total

% of total diagnoses for that time period

▲ highest and ▼ lowest for that outcome over total period; notable top 5 findings highlighted

However, comparisons across sites revealed some data collection discrepancies. That is it appeared that nutritional marasmus, meningitis codes and skin infection codes were not collected for Bagamoyo DH.

All above outlined data losses inform the mortality rates or unexplained deaths which are now discussed below.

3.2.2 Mortality data and diagnoses in under five year olds

With respect to mortality data, the pattern of more complete data collection at Bagamoyo continues. Reviewing the data for St Francis, see Table 5a, the inexplicably strikingly low counts showed that data on mortality was not systematically recorded from 2001-2008. Overall prevalence is boosted to what epidemiologists might expect from 2009-10 and these data appear comparable to Bagamoyo DH data; although even for these latter years many of the St Francis deaths DDH, 53% compared to 24% in Bagamoyo DH, remain unexplained due to missing lab data or admission outcome.

Table 5a: Deaths over time at St Francis DDH (N = 22,888)

Year	Malaria lab diagnosis	Anaemia lab diagnosis	Pneumonia	Watery diarrhoea	Other diseases	Explained deaths	Total deaths
				N (%)			
2001	0 (0.0)	4 (1.6)	2 (0.8)	0 (0.0)	0 (0.0)	6 (85.0)	**7(2.7)**
2002	3 (1.2)	3 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)	6 (75.0)	**8(3.1)**
2003	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0(0.0)	**4(1.6)**
2004	3 (1.2)	2 (0.8)	1 (0.4)	0 (0.0)	0 (0.0)	6(66.7)	**9(3.5)**
2005	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	1(33.3)	**3(1.2)**
2006	0 (0.0)	0(0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0(0.0)	**1(0.4)**
2007	0 (0.0)	3 (1.2)	1 (0.4)	0 (0.0)	0 (0.0)	4(80.0)	**5(2.0)**
2008	0 (0.0)	1 (0.4)	2 (0.8)	0 (0.0)	0 (0.0)	3(60.0)	**5(2.0)**
2009	18(7.0)▲	0 (0.0)	12(4.7)	10(3.9)	20(7.8)▲	60(46.9)	**128(49.8)**
2010	4(1.6)▼	0 (0.0)	11(4.3)	8(3.1)	11(4.3)	34(39.1)	**87(33.9)**
Totals	**28(10.9)**	**14(5.4)**	**29(11.3)**	**18(7.0)**	**31(12.1)**	**120(46.7)**	**257(100.0)**

% of total deaths for that time period

On the other hand, save for the known missing malaria data – likely to be accounted for by a substantial proportion of the unexplained deaths since other variables are all near complete, the Bagamoyo DH data appears robust, Table 5b.

Table 5b: Deaths over time Bagamoyo DH (N = 4,192)

Year	Malaria lab diagnosis	Anaemia lab diagnosis	Pneumonia	Watery diarrhoea	Other diseases	Explained deaths	Total deaths
				N (%)			
2006	13(7.0)	19(10.2)	13(7.0)	1(0.5)	4(2.2)	36(66.7)	54(29.2)
2007	3(1.6)	15(8.1)	10(5.4)	3(1.6)	3(1.6)	24(85.7)	28(15.1)
2008	10(5.4)	33(17.8)▲	15(8.1)	5(2.7)	6(3.2)	49(96.0)▲	51(27.6)
2009	5(2.7)▼	18(9.7)	9(4.9)	3(1.6)	4(2.2)	25(96.2)▼	26(14.1)
2010	0(0.0)	19(10.3)	10(5.4)	2(1.1)	3(1.6)	25(96.2)	26(14.1)
Totals	**31(16.8)**	**104(56.2)**	**57(30.8)**	**14(7.6)**	**20(10.8)**	**159(85.9)**	**185 (100.0)**

% of total deaths for that time period

3.2.3 Summary of data completeness report

With respect to identified data losses, we conclude the following. For *attributing at least one diagnosis*, data from both St Francis DDH and Bagamoyo DH suffered the highest proportion of missing data in 2006 (14% and 28% respectively).

Likewise, with respect to *laboratory detected* results both facilities displayed gaps in data collection and processing. For follow-up of clinical malaria with laboratory parasitology data, St Francis DDH had substantial data loss in 2001 (67%), and moderate losses in 2010 (19%). For this outcome Bagamoyo DH displayed moderate losses (between 22% and 32%) at lab follow-up over most of the data collection period of 2006-2009, peaking to 56% in 2010.

The most missing data related to laboratory confirmed anaemia was identified at St Francis, at a moderate level in 2006 (24%), peaking (to 78%) in 2009, and ultimately rising to 100% missing follow-up in 2010 (investigation underway). In contrast, anaemia data in Bagamoyo DH showed few (less than 2%) missing follow-up over the whole period of data collection.

These differences appear to reflect the length of the data collection initiatives, the personnel involved, particularly during setting-up periods and the size of the ward. Pertaining to the latter, the smaller ward - which is also concurrently home to several clinical trials - may be easier to manage. Moreover recent changes from district to referral hospital at St Francis DDH may have contributed to the missing data reported for 2010.

In Bagamoyo it is likely that 2010 data losses for malaria outcomes are due to a backlog of data entry and may be recouped. However, laboratory detected malaria needs to be more closely monitored as this is an important outcome – in particular for resident trials - and yet we found for these outcomes moderate data losses since data was collected. Otherwise these Bagamoyo DH data were exceptionally well collected since 2007.

Outcomes following diagnosis on admission (discharged/dead/unknown - absconded, refereed and not recorded) were concurrently robustly captured at Bagamoyo DH, although checks should be performed to ensure the same disease categories are being collected compared to St Francis DDH. At St Francis DDH outcomes for pneumonia (12%), HIV/AIDS (46%), meningitis (33%) and nutritional marasmus (27%) and other rarer and

less serious diseases have the most missing data. Mortality data are likely to be affected at St Francis from absconding along with the more serious diseases such as pneumonia or AIDS.

Mortality data appears robustly recorded in Bagamoyo for all years, although with moderate losses to cause of death. Due to this affecting only one variable (lab confirmed malaria) data loss in this case may be easily addressed with further data cleaning. However, we incurred irretrievable losses to mortality prevalence data in St Francis until 2009-2010.

The completeness status of both data sets are summarised in Figure 3a in terms of gaps in morbidity data and in Figure 3b for the mortality data.

Figure 3a: Checklist for morbidity data usability

	St Francis DDH			Bagamoyo DH		
	Diagnoses on admission Data	Malaria lab confirmed	Anaemia lab confirmed	Diagnoses on admission Data	Malaria lab confirmed	Anaemia lab confirmed
2001	✓	×	✓	-----	-----	-----
2002	✓	✓	✓	-----	-----	-----
2003	✓	✓	✓	-----	-----	-----
2004	✓	✓	✓	-----	-----	-----
2005	✓	✓	✓	-----	-----	-----
				-----	-----	-----
2006	~	✓	~	~	~	✓
2007	~	✓	✓	✓	~	✓
2008	✓	✓	✓	✓	~	✓
2009	✓	✓	×	✓	~	✓
2010	✓	~	×	✓	×	✓

As displayed above trend analysis is limited by the scattered nature of the missing data. If we were to exclude years with the most missing data the best analysis would feature from 2002-2005 for Kilombero. For inter district comparisons we might only use 2007-2008 for both the St Francis district hospital and that of Bagamoyo.

Imputation methods might on the other hand seek to use existing data to complete a full analysis of all time points. At the very least further data cleaning could be used to sensitively report proportions of lab confirmed malaria, excluding data that was not sent to laboratories at all. This would mean all Bagamoyo DH data from 2006-2009 would be usable.

Figure 3b: Checklist for mortality data usability

	St Francis DDH		Bagamoyo DH	
	Mortality prevalence	Cause of death	Mortality prevalence	Cause of death
2006	-----	-----	✓	~
2007	-----	-----	✓	~
2008	-----	-----	✓	✓
2009	✓	×	✓	✓
2010	✓	×	✓	✓

Further data cleaning of morbidity may render all mortality data from Bagamoyo DH complete, as it stands there is minimal missing data. However it is likely that only two time points for St Francis prevalence data will be reportable. Further investigation of methods of imputation to be undertaken.

3.3 Morbidity and mortality in under five year olds across sites

Following the above findings missing data have been highlighted in forthcoming analyses. **Amber** highlights means a moderate (10--33%) and **red** means (over one third) substantial *underestimations* of aggregated data are likely.

With respect to changes in disease diagnoses over 5 year blocks at St Francis DDH, Figure 4a, we see a sharp drop in the proportion of lab confirmed malaria outcomes from 2006 onwards. From 31% (and likely to be larger in fact) reported from 2001-2005 to 19% in 2006. On the other hand, while the proportion of watery diarrhoea and pneumonia rise accordingly, anaemia data remains interpretable due to missing lab outcomes. However, based on two time points of complete data (2007-2008, these average 32%) we can surmise that this outcome is likely to at least have remained stable compared to 2001-2005 data.

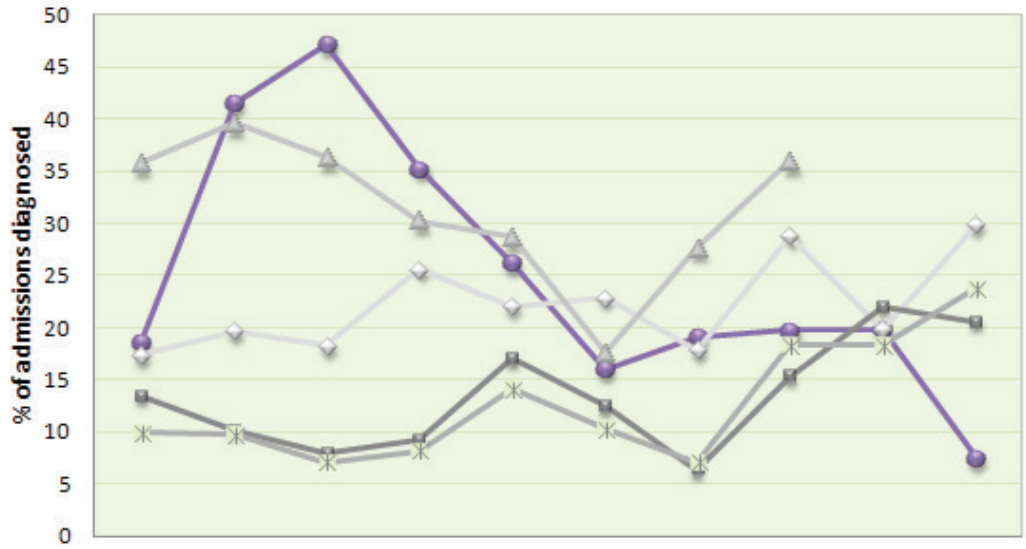
Moreover, missing data aside, Bagamoyo DDH appears to have proportionally more clinical malaria diagnosed currently compared to St Francis DDH, but would come up broadly similar in terms of the other key disease categories, Figure 4b.

Figure 4a: Comparison of disease prevalence for first given diagnosis at St Francis DDH over across 5 year blocks (N = 22,888); % based on total counts for each time period

Figure 4b: Comparison of disease prevalence for first given diagnosis at St Francis DDH (N=8,615) and Bagamoyo DH (N= 4,192) over 5 years; % based on total counts for each site

Morbidity trends are summarized in Figures 5a and 5b. St Francis data dipped sharply, likely due to the combinations of missing data, in 2006. Otherwise, there appears a steady drop in laboratory detected malaria. The same does not appear true from anaemia, which when last fully collected had remained stable at 36% (in 2008) compared to 2001. The slopes for trend analysis of pneumonia and watery diarrhoea both show statistically significant rises.

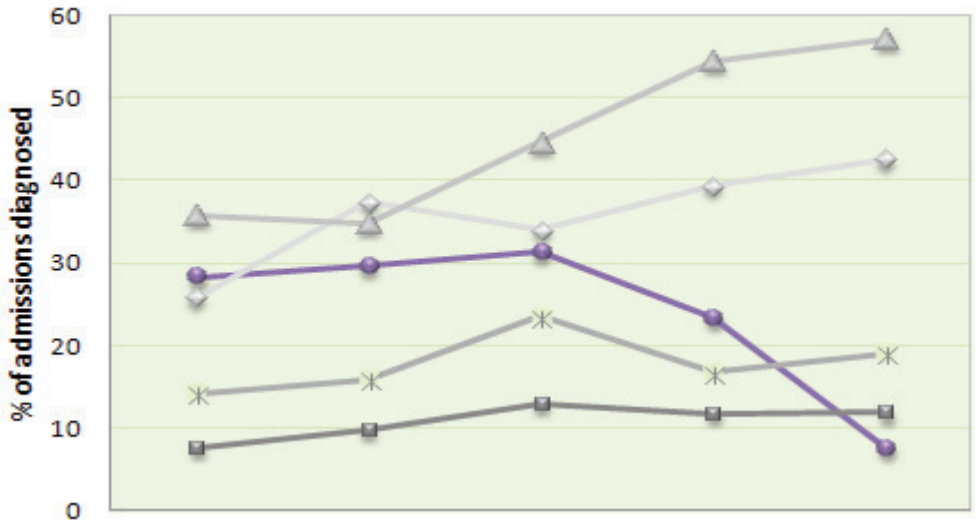
Figure 5a: Morbidity trends for diagnoses 1-4 (therefore more than one diagnosis possible) at St Francis DDH N=22,888; % based on total counts for each time period



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010		
	N (%)										Slope	P value
Malaria lab	499 (18.65)	963 (41.5)	1,868 (47.2)	821 (35.3)	785 (26.3)	292 (16.1)	257 (19.1)	391 (19.7)	419 (19.8)	102 (7.5)	-0.05 ▼	0.0001
Anaemia lab	957 (35.8)	919 (39.6)	1,436 (36.3)	704 (30.2)	858 (28.7)	320 (17.6)	372 (27.7)	713 (35.9)	163 (7.7)	—	-0.01 ▼	0.0001
Pneumo-nia	464 (17.3)	457 (19.7)	723 (18.3)	596 (25.6)	659 (22.0)	416 (22.9)	240 (17.8)	570 (28.7)	419 (19.8)	405 (29.9)	0.01 ▲	0.0001
Watery diarrhoea	358 (13.4)	235 (10.1)	313 (7.9)	214 (9.2)	508 (17.0)	226 (12.4)	86 (6.4)	304 (15.3)	464 (22.0)	278 (20.5)	0.01 ▲	0.0001
Other diseases	266 (9.9)	228 (9.8)	281 (7.1)	191 (8.2)	424 (14.2)	188 (10.3)	96 (7.1)	363 (18.3)	386 (18.3)	322 (23.8)	0.01 ▲	0.0001

At Bagamoyo DH (Table 5b), even though some missing data is present at all time points for laboratory detected malaria, this outcome appears on the decline from 2008 and 2009. As a proportion of all diagnoses anaemia has significantly risen as has pneumonia; while the slope for remaining diseases, although not significantly, have somewhat increased overall.

Figure 5b: Morbidity trends for diagnoses 1-4 (therefore more than one diagnosis possible) at Bagamoyo DH N= 4,192; % based on total counts for each time period



	2006	2007	2008	2009	2010	Slope	P value
			N (%)				
Malaria lab	354(28.3)	312(29.6)	308(31.3)	124(23.3)	28(7.6)	-0.06 ▼	0.0001
Anaemia lab	448(35.8)	367(34.8)	439(44.6)	290(54.5)	212(57.1)	0.00 ▲	0.0005
Pneumonia	323(25.8)	394(37.4)	334(33.9)	209(39.3)	158(42.6)	0.04 ▲	0.0004
Watery diarrhoea	96(7.7)	104(9.9)	127(12.9)	62(11.7)	44(11.9)	0.01 ▲	0.1099
Other Diseases	178(14.2)	168(15.9)	231(23.5)	89(16.7)	71(19.1)	0.01 ▲	0.1087

As for mortality data, Table 6, there was a small rise in crude death rates from 61-64 per 1000 at St Francis DDH (from 2009-2010). Overall, these rates were larger than at Bagamoyo DH (averaging 44 per thousand). Hower due to a sharp rise in 2010 (to 70 per 1000) averages for the same period were pretty comparable (60 per 1,000 from 2009-2010 at BDH). These fluctuations warrant further investigation.

Table 6: Crude death rate

	St Francis DDH 2001-2010 N=22,888			Bagamoyo DH 2006-2010 N = 4,192		
Year	Death	Total	Crude death rate per 1000	Death	Total	Crude death rate per 1000
2006	--	--	--	54	1,250	43.20
2007	--	--	--	28	1,055	26.54
2008	--	--	--	51	984	51.83
2009	128	2,113	60.58	26	532	48.87
2010	87	1,354	64.25	26	371	70.08
Total	**215**	**3,467**	**62.42**	**185**	**4,192**	**44.13**

An examination of the most complete mortality data over time (2008-2010) collected in Bagamoyo revealed a few differences. Although the crude death rate had risen from 51 to 70 per 1000 we see some rises in deaths in anaemia and pneumonia, although none is statistically significant. Stratifying death to under and over one year olds also showed no significant differences.

Table 7: Deaths in under one year olds at Bagamoyo D Hospital (N=4,192)

	2008 N=984	2010 N=371	P value
Malaria admissions	N (%)	N (%)	
Total malaria*	308(31.3)	28(7.6)	0.008
Malaria deaths	10(3.3)	0(0.0)	-
Malaria deaths <1	4(8.3)	0(0.0)	-
Top non-malaria admissions			
Total anaemia*	439(44.6)	212(57.1)	0.002
Anaemia*deaths	33(7.5)	19(9.0)	0.848
Anaemia deaths <1	12(9.6)	10(14.3)	0.733
Total pneumonia**	267(27.1)	121(32.6)	0.267
Pneumonia deaths	15(5.6)	10(8.3)	0.791
Pneumonia deaths <1	13(9.9)	7(11.1)	0.932
Total Watery diarrhoea**	90(9.2)	33(8.9)	0.959
Watery diarrhoea deaths	5(5.6)	2(6.1)	0.979
Watery diarrhoea deaths <1	4(10.8)	1(5.6)	0.875
Other non-malaria admissions			
Total other diseases**	63(6.4)	26(7.0)	0.917
Other diseases deaths	6(9.5)	3(11.5)	0.925
Other diseases deaths <1	4(15.4)	0(0.0)	-

*Based on lab confirmed admissions (case fatality rate)

** Based on first diagnosis (case fatality rate)

Conclusions and recommendations

4.1 Summary findings

4.1.1 Admissions

At St Francis DDH total admissions began the decade at 2,676 (12%), but peaked in 2003 to 3,956(17%), they were at their lowest in 2007, that is 1,345(6%), returning to similar levels in 2010 1,354(6%). These changes are in themselves interesting findings that warrant further investigation. In contrast Bagamoyo DH displayed a steady reduction in admissions over time. This gradient was reduced over three fold in 2006-2010, from 1,250 (30%) to only 371 (9%) admissions.

4.1.1 Clinical malaria and laboratory based diagnosis

Diagnosed clinical malaria blood samples were systematically confirmed by laboratory results. Over the period of 2001-2010, between 10-58% of clinical cases were confirmed at St Francis DDH. On the other hand, at Bagamoyo DH, the study observed that an average of 63% of clinically recorded cases were confirmed.

Overall, analysis indicates that clinical diagnosis is an unreliable indicator for malaria outcomes as true cases are often overestimated.

4.1.2 Clinical anaemia and laboratory based diagnosis

In contrast, it is common for anaemia to be chronically under-diagnosed, as demonstrated by the 46% and 38% of true anaemia cases at St Francis and Bagamoyo respectively that were recognised by incidental lab checks. Nevertheless, clinical outcomes for both malaria and anaemia may be contrasted to existing laboratory rates to inform imputation.

4.1.3 Outcomes of admission for top 15 diseases

Both at St Francis DDH and Bagamoyo DH, most of the categorised diseases (over 85%) had a recorded outcome (dischared or dead). While at St Francis DDH the total absconders (8%) were the same for the two 5 year blocks, most of these cases were diagnosed with pneumonia, HIV/AIDS, nutritional marasmus and meningitis. In contrast, for Bagamoyo DH total absonders (0.6%) were very low.

4.1.4 Morbidity and mortality trends summary findings

Despite missing data on laboratory detected outcomes, it appears that malaria in under five year olds in both districts is on the decline. Particularly

at St Francis DDH, laboratory detected malaria peaked in 2003 to 47%, declining to 20% by 2009. In Bagamoyo we observed a drop from 28% to 23% from 2006-2009.

Anaemia appears to remain one of the most prevalent illnesses in hospitalised children. Bagamoyo DH which had complete data for this outcome, showed a very large percentage (57%) of admissions in 2010 were anaemic. This accounted for many deaths particularly most recently (2010), where 19 of all explained Bagamoyo DH deaths (n=25) were due to this outcome (n=10 to pneumonia; n=2 to watery diarrhoea; n=2 other diseases). Also at this same facility from 2006 deaths attributed to malaria were recorded to plummet from 13 to 0 in 2010; nevertheless crude death rate rose to its highest rate per 1000 of 70 in 2010 in Bagamoyo.

Notwithstanding this, for the comparable mortality time points (2009-2010) between facilities, Bagamoyo DH averaged 60 deaths per 1000 compared to 62 per 1000 at St Francis. Overall, however, Bagamoyo recorded fewer deaths, averaging 44 per 1000 (2006-2010). Although the lower rate in preceding years may partly be due to data collection lags.

4.2 Strengths and limitations

The main limitation for successful completion of the analysis was existence of missing data for a number of years in study districts. These hampered analyses because gaps were scattered throughout making it harder to cluster prospective analyses.

Also these data do not account for neonatal deaths and are limited to district hospitals that often have ongoing trials in the paediatric wards; similarly many interventions –to improve malaria outcomes have been undertaken in these districts.

Moreover, the current analyses does not account for co-morbidities, and indeed the cumulative burden of multiple diseases which may be an important determinant in mortality analyses.

Nevertheless, these data inform up to ten years of changes in the rural and peri-urban Tanzania and once gaps are accounted for could be further used to usefully inform the epidemiology of under five year olds and concurrent recommendations for clinical practice or community interventions.

4.3 Proposed analytic strategy

Imputation: Missing data is a very common problem in health research. To achieve optimum data completeness, we recommend imputation. Imputation has been recognized as the best technique of dealing with missing data, which in the current dataset would allow us to capture the more compelling trend analyses. Imputation will also enable us to fully compare changes in morbidity and mortality between the two study districts. To ensure correct estimates of standard errors and confidence intervals we propose multiple imputation of relevant missing data as highlighted in data completeness sections.

Epidemiological analyses: Further analyses would account for determinants of mortality and burden of disease; co-morbidities should be explored as should analyses of height, weight, malnutrition and other predictors such as age that have not been fully examined in the current analyses.

Triangulation: To improve validity and scope of results we recommend triangulation with different data sources. Data on morbidity and mortality are being collected within IHI's HDSS for Ifakara Kilombero, whereas SAVVY and FBIS data are being recorded in Bagamoyo. Using these data sources clinical data may be complemented with Verbal Autopsy data on cause of death and health seeking in the community. Through triangulation we should be in a position to further examine current findings, and to build on our overlapping platforms, in order to gain further insights piecing together the broader Tanzanian picture on health outcomes in under five year olds.

Reference list

1. UNICEF (2011). Levels & Trends in Child Mortality. UNICEF/ NYHQ2009-0908. New York, United Nations Children's Fund.

2. NBS (2010). Tanzania Demographic and Health Survey (2010 TDHS). Dar es Salaam, National Bureau of Statistics.

3. Abdullah S, Adazu K et al. (2007). Patterns of age-specific mortality in children in endemic areas of sub-Saharan Africa. Am J Trop Med Hyg, 77(6 Suppl): 99-105.

4. MOHSW (2008). The United Republic of Tanzania Ministry of Health and Social Welfare Health Sector Strategic Plan III "Partnerships for Delivering the MDGs" July 2009 – June 2015. H. I. d. f. T. 29-08-2008. Dar es Salaam, Ministry of Health and Social Welfare Health.

5. Snow RW, Bastos de Azevedo I et al. (1994). Severe childhood malaria in two areas of markedly different falciparum transmission in east Africa. Acta Trop, 57: 289-300

6. Schellenberg D, Menendez C, et al. (2004). The changing epidemiology of malaria in Ifakara Town, southern Tanzania." Tropical Medicine & International Health, 9: 68-76.

7. Okiro E, Al-Taiar A, Reyburn H et al. (2009). Age patterns of severe paediatric malaria and their relationship to Plasmodium falciparum transmission intensity. Malaria Journal, 8:4, 1-11.

8. Menendez C, Schellenberg D, Macete E, Aide et al. (2007). Varying efficacy of intermittent preventive treatment for malaria in infants in two similar trials: public health implications, Malaria Journal, 6:132

9. Smithson P et al. (2012)

10. Armstrong Schellenberg JRM, Mukasa O et al. (2001). The Ifakara Demographic Surveillance System. In INDEPTH Monograph Series: Demographic Surveillance Systems for Assessing Populations and their Health in Developing Countries, Population, Health and Survival in INDEPTH Sites Volume 1. Edited by: INDEPTH. Ottawa: IDRC/ CRDI.

11. Schellenberg D, Aponte J, Kahigwa E et al. (2003). The use of active case detection to describe malaria epidemiology in Ifakara, southern Tanzania. Transactions of the Royal Society of Hygiene and Tropical Medicine, 97: 387-394.

12. Abdulla S, Oberholzer R, Juma O et al. (2008). Safety and immunogenicity of RTS,S/AS02D malaria vaccine in infants. New England Journal of Medicine, 359:25 33-44.

13. Schellenberg d, Menendez c, Kahigwa e et al. (1999). African children with malaria in an area of intense plasmodium falciparum transmission: features on admission to the hospital and risk factors for death. Am J Trop Med Hyg, 61, 431-438.

14. Petit PL, JK van Ginneken (1995). Analysis of hospital records in four African countries, 1975-1990, with emphasis on infectious diseases. J Trop Med Hyg, 98: 217-227.

15. Rosenberg, M. (2007). Global child health: burden of disease, achievements, and future challenges. Curr Probl Pediatr Adolesc Health Care, 37: 338-62.

16. WHO (2005). Pocket book of hospital care for children: guidelines for the management of common illnesses with limited resources, World Health Organization.

17. Graham SM, English M et al. (2008). Challenges to improving case management of childhood pneumonia at health facilities in resource-limited settings. Bull World Health Organ, 86: 349-355.

18. African Country-Average CMAP Weighted Anomaly Standardized Precipitation (WASP) with Selectable Baseline. **Data Source**: Latest available release of monthly CPC Merged Analysis of Precipitation (CMAP, version 2, combined gauge and satellite estimates) on a 2.5 x 2.5 deg. lat/lon grid.

19. Alba S 2012. An analysis of shortage in rice harvest yeild in the Kilombero Valley, 2003. IHI comissioned report .

Appendix 1

INPATIENT SURVEILLANCE FORM

Demographics		
1	Date admitted (dd/mm/yyyy)	|__|__| / |__|__| / |__|__|__|__|
2	Outpatient contact number	|__|__|__|__|__|
3	Inpatient contact number	|__|__|__|__|__|
4	Subject ID number	|__|__|__|__| - |__|__|
5	Subject RCH number	|__|__|__|__|__|__|__|__|__|__|
6	Child's first name	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
7	Child's family name	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
8	Date of birth (dd/mm/yyyy)	|__|__| / |__|__| / |__|__|__|__|
9	Sex (1=male, 2=female)	|__|
10	Mother's first name	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
11	Mother's family name	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
12	Village	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|
13	Balozi/mjumbe	|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

History		
13	Fever (1=yes, 2=no / number of days)	|__| / |__|__|
14	Runny nose (1=yes, 2=no / number of days)	|__| / |__|__|
15	Cough (1=yes, 2=no / number of days)	|__| / |__|__|
16	Difficulties in breathing (1=yes, 2=no / number of days)	|__| / |__|__|
17	Sucking/drinking (1=as usual, 2=less, 3=eagerly)	|__|
18	Has the child vomited (1=yes, 2=no / number of days)	|__| / |__|__|
	If yes: how many times in the last 24 hours	|__|__|
19	Constipation (1=yes, 2=no / last stool how many days ago)	|__| / |__|__|
20	Diarrhea (1=yes, 2=no / number of days)	|__| / |__|__|
	If yes: how many times in the last 24 hours	|__|__|
21	Blood in stool or melena (1=yes, 2=no / number of days)	|__| / |__|__|
22	Convulsions (1=yes, 2=no / started how many days ago)	|__| / |__|__|
	I*f yes:* number of seizures in the last 24 hrs	|__|__|
23	Others/comments:_____	
	_____	

	_____ _____	
24	Has the child been seen by another doctor for this illness (1=yes, 2=no)	|__|
	If yes, where: _____ _____	
	and treatment given:	ICD-10 code
	_____ _____	|__|__|
	_____ _____	|__|__|
	_____ _____	|__|__|
Vital signs		
25	Weight (kg)	|__|__|.|__|
26	Height (cm)	|__|__|__|
27	Axillary temperature (°C)	|__|__|.|__|
28	Pulse rate (beats per minute)	|__|__|__|
29	Respiratory rate (breaths per minute)	|__|__|__|

Physical examination		
	Integument	
30	Pallor (1=yes, 2=no)	|__|
31	Jaundice (1=yes, 2=no)	|__|
32	Visible pus in ears (1=no, 2=right, 3=left, 4=both ears)	|__|
33	Oral thrush (1=yes, 2=no)	|__|
34	Skin rash (1=yes, 2=no)	|__|
	If yes, specify:_____ _____	
	Hydration status	
35	Dehydration (1=no, 2=moderate, 3=severe)	|__|
36	Edema (1=no, 2=puffy face, 3=peripheral, 4=generalized)	|__|
	Nutritional status	
37	Flaky paint skin (1=yes, 2=no)	|__|
38	Orange hair (1=yes, 2=no)	|__|
39	Visible wasting (1=yes, 2=no)	|__|
	Cardiovascular	
40	Gallop rhythm (1=yes, 2=no)	|__|
41	Heart murmurs (1=yes, 2=no)	|__|

42	Signs of congestive heart failure (1=yes, 2=no)	|__|
43	Signs of shock (1=yes, 2=no), *if yes specify below*	|__|
	Capillary refilling time (number of seconds)	|__|
	Cool extremities (1=yes, 2=no)	|__|
	absent peripheral pulse (1=yes, 2=no)	|__|
	Lungs	
44	Nasal flaring (1=yes, 2=no)	|__|
45	Chest in drawings (1=yes, 2=no)	|__|
46	Breath sounds (1=normal, 2=peripheral bronchial, 3=reduced, 4=both)	|__|
47	Adventitious intermittent sounds (1= no, 2=crackles)	|__|
48	Adventitious continuous sounds (1=no, 2=wheezes, 3=rhonchi, 4=both)	|__|
	Abdomen	
49	Palpation (1=normal, 2=tenderness, 3=peritonism)	|__|
50	Hepatomegaly (1=yes, 2=no)	|__|
51	Splenomegaly (1=yes, 2=no)	|__|
52	Bowel sounds (1=normal, 2 =increased, 3=decreased, 4=absent)	|__|
53	Quality of bowel sounds (1=normal, 2=high pitched)	|__|
	Neurology	
54	Eye movements (0=not directed, 1=directed)	|__|
55	Verbal response (0=none, 1=inappropriate cry, 2=appropriate cry)	|__|
56	Motor response (0=none, 1=withdraw from pain, 2=localises pain)	|__|
57	Bulging fontanelle (1=yes, 2=no)	|__|
58	Meningism (1=yes, 2=no)	|__|
59	Position (1=normal, 2=decerebrate, 3=decorticate, 4=opistotonus)	|__|
60	Able to sit (1=yes, 2=no)	|__|
61	Cerebral palsy (1=yes, 2=no)	|__|
62	Others/ specifications: _____ _____	
63	Initials of investigator and reviewer	|__|__|__| / |__|__|__|

Investigations

64 Blood slide for malaria taken (1=yes, 2=no) *if yes stick sample brady numbers below subsequently* |__|

Write or stick sample brady number of 1st, 2nd and 3rd slide

|__|__|__|__|__|__|__| 1st |__|__|__|__|__|__|__| 2nd |__|__|__|__|__|__|__| 3rd

65 First blood slide (1=positive, 2=negative) |__|

66 Hemoglobin (g/dl)

1st measurement |__|__|.|__|

2nd measurement |__|__|.|__|

3rd measurement |__|__|.|__|

4th measurement |__|__|.|__|

67 Blood glucose (mg/dl)

1st measurement |__|__|__|

2nd measurement |__|__|__|

68 Chest x-ray taken (yes=1 ,no=2) |__|

If yes: 1=normal, 2=pathologic |__|

69 Lumbar puncture done (1=yes, 2=no) |__|

If yes: signs of meningitis (1=yes, 2=no) |__|

70 Blood transfusion given (1=yes, 2=no) |__|

If yes: date of transfusion |__|__| / |__|__| / |__|__|__|__|

Hb measurement before blood transfusion (g/dl) |__|__|.|__|

71 Urine sticks

1st measurement (1=normal, 2=infection, 3=proteinuria, 4=both) |__|

2nd measurement (1=normal, 2=infection, 3=proteinuria, 4=both) |__|

72 Other investigations with results_____

_____

_____

Diagnosis		ICD 10 code
73	1st diagnosis: _____	|__|__|__|
74	2nd diagnosis:_____	|__|__|__|
75	3rd diagnosis:_____	|__|__|__|
76	4th diagnosis:_____	|__|__|__|
77	5th diagnosis:_____	|__|__|__|

Procedures		
78	Outcome (1=discharged home, 2=absconded, 3=referred, 4=death)	|__|
79	Date of leaving ward	|__|__| / |__|__| / |__|__|__|__|
	treatment given:	ICD-10 code
80	_____	|__|__|
81	_____	|__|__|
82	_____	|__|__|
83	_____	|__|__|
84	_____	|__|__|
85	Initials of investigator/ second opinion reviewer or supervisor	|__|__|__| / |__|__|__|

ISBN: 978-9987-9652-3-6

Published by:
Ifakara Health Institute.
Plot 463, Kiko Avenue, Mikocheni.
P.O. Box 78373, Dar es Salaam, Tanzania.
Web: www.ihi.or.tz ;
E-mail address: info@ihi.or.tz
Phone: +255 (0)22 2774756
Fax: +255 (0)22 2771714