The World Bank Group

Maternal & Child Health in Sudan

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A. INTRODUCTION

One objective of this report is to provide a reference on the levels and trends in under-five mortality, the coverage of evidence-based child and maternal survival interventions for individuals in need and the characteristics of health financing in Sudan using relevant, population representative data sources. In addition, this paper examines patterns in access to health services associated with socio-demographic characteristics in order to help identify where gaps exist and where progress has been made. Table A1 provides an overview of the data sources available to generate population based health indicators for Sudan (including South Sudan). This report draws primarily from the 1989-1990 Sudan Demographic and Health Survey (DHS), the 2006 and 2010 Sudan Household Health Survey (SHHS), the 2008 Census and the 2008 National Baseline Household Survey (NBHS) and focuses primarily on Sudan (excluding South Sudan which gained independence in July of 2011 and is the focus of a sister report available here:). A note on usage, Sudan and Sudan (North) are used interchangeably.

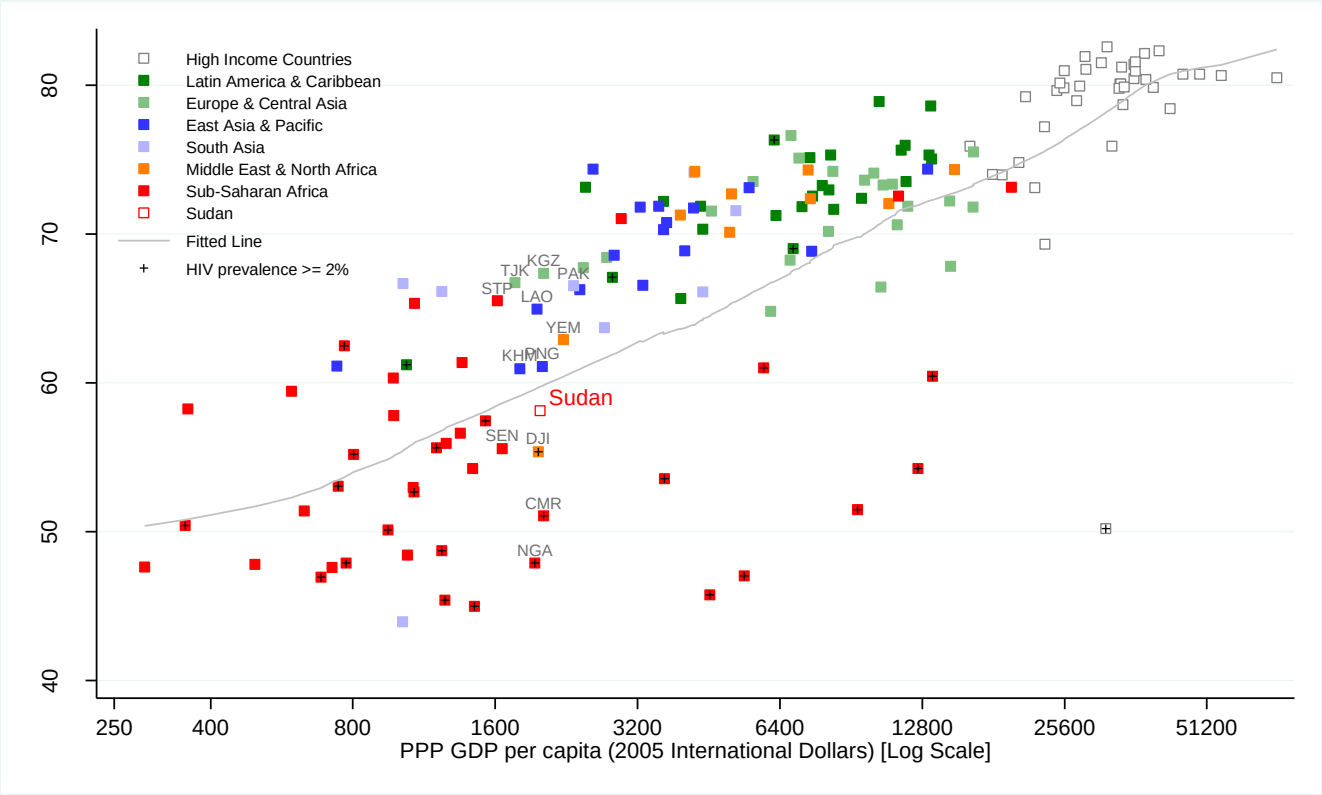
Table A1. Data sources for population based measures of health in Sudan

Year	Census/ Survey	Sample Size (households)	Coverage	Micro-Data Publicly Available
1973	Sudan Census	NA	North & South	No
1978-79	Sudan Fertility Survey (SFS)	12,000	North	The Office of Population Based Research at Princeton University: http://opr.princeton.edu/archive/wfs/SD.asp
1983	Sudan Census	NA	North & South	No
1989-1990	Sudan Demographic & Health Survey (SDHS)	6,891	North	Measure DHS (with approval): http://www.measuredhs.com/accesssurveys/
1992-1993	Pan Arab Project for Child and Mother Health (PAPCHILD)	6,940	North, South	No
1993	Sudan Census	NA	North	No
1999	Safe Motherhood Survey (SMS)	16,075	North, 3 southern urban centers	No
2000	Multiple Indicator Cluster Survey II (MICS II)	North: 23,192 South: 1,551	North, 3 southern urban centers	UNICEF MICS program (with approval): http://www.childinfo.org/mics2_datasets.html
2006	Sudan Household Health Survey (SHHS)	North: 14,970 South: 9,557	North & South	South Sudan Center for Census, Statistics and Evaluation (with approval): http://www.ssccse.org/
2008	Sudan Census (Long Form)	North: 922,816 South: 92,592	North & South	Minnesota Population Center - IPUMS http://www.ipums.org/
2008	National Baseline Household Survey (NBHS)	North: *7,913* South: *4,969*	North & South	No
2009/2010	Sudan Household Health Survey	North: 14,778 South: 9,369	North & South	In progress

Source: Adapted from the International Monetary Fund's General Data Dissemination System (http://dsbb.imf.org/pages/gdds)

In 2008, Sudan's life expectancy – the average number of years a newborn can expect to live if exposed to the age-specific mortality rates prevailing in the population - was 58 years[1] (Figure A1) up from 48 years in 1960 (Figure A2). For countries closely matched in terms of purchasing power parity income per capita to Sudan, life expectancy varies from a minimum of 48 years in Nigeria to a maximum of 67 years in the Kyrgyz Republic. Among this group of countries, those with shorter expected life spans are in Sub-Saharan or North Africa and have either higher under-five mortality rates, a generalized HIV/AIDS epidemic or a combination of the two; while those with longer expected life spans are in the Middle East, East Asia and Central Asia have lower under-five mortality rates and no generalized HIV/AIDS epidemics. In 2007, UNAIDS estimated HIV/AIDS prevalence at 1.4 percent of the adult population between the ages of 15 and 49 (320,000 adults) (UNAIDS 2008). In 2009, estimates produced from an epidemiological and behavioral review on HIV/AIDS in the North and South placed national HIV/AIDS prevalence at 1.1 percent (0.67% in the North) with a projected increase to 2.2% by 2011 (Sudan National Aids Program 2009).

Figure A1. Life Expectancy vs. Purchasing Power Parity Gross Domestic Product per capita by country & region, 2008

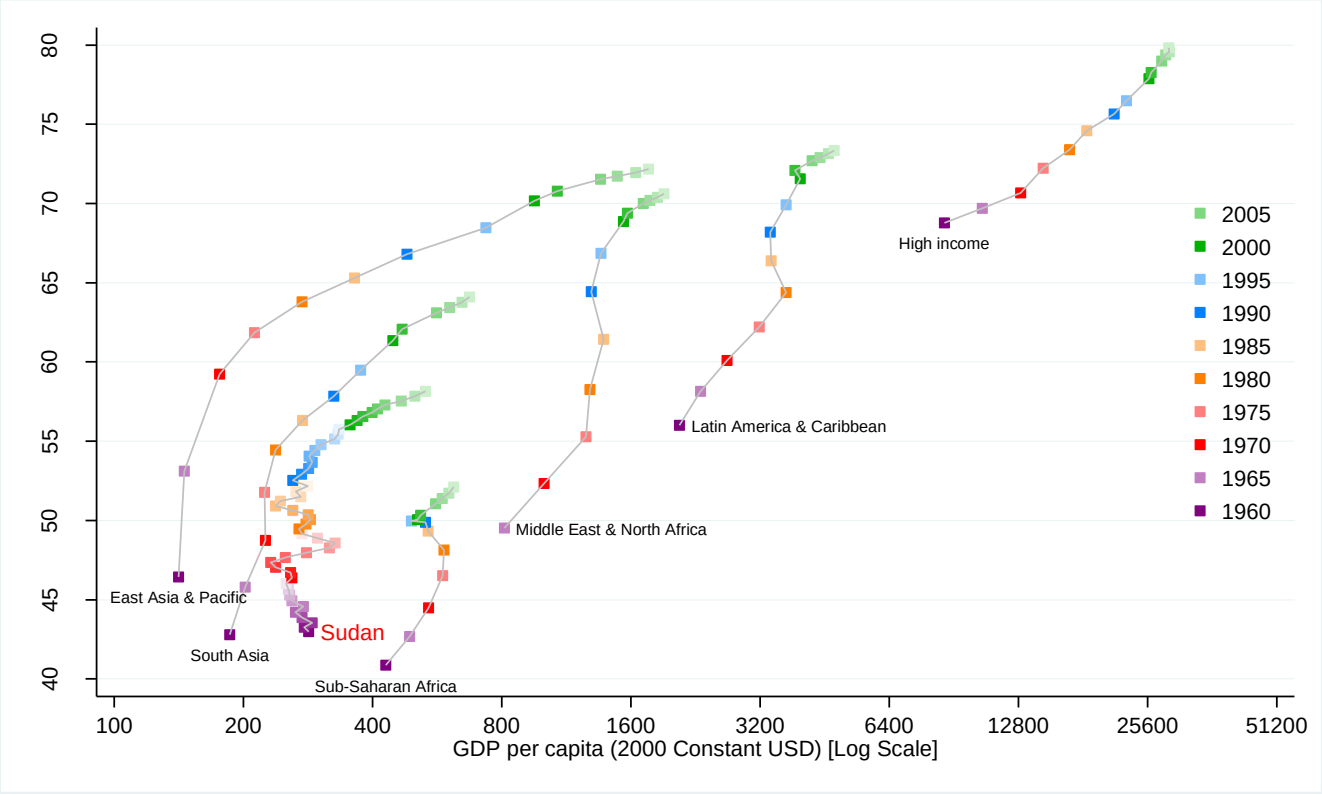


Source: World Development Indicators 2010.

[1] The United Nations Population Division (UNPD) life expectancy estimates for Sudan are derivations (using model life tables) from indirect estimates of infant and child mortality using the proportion of children ever born and surviving from census and survey data (http://esa.un.org/wpp/sources/country.aspx)

Much of Sudan's gains in life expectancy between 1960 and 2008 occurred despite periods of stagnant and declining growth in real income per capita. Approximately sixty percent of the total gains in life expectancy over this 48-year period were made in the 30 years between 1960 and 1990 when Sudan's real income per capita had no net improvement (Figure A2). Over this period, Sudan's real income per capita grew at an average annual rate of 0.99 percent. Since 1994 – fueled in part by the production of oil - Sudan's income per capita has been increasing at an average rate of 4.3 percent per year. Relative to geographical groupings of other low and middle-income countries, Sudan's gains since 1960 outpaced the gains made by Sub-Saharan countries as a whole - where real income per capita and life expectancy improved at an average rate of 0.22 and 0.43 percent per year - but lagged behind overall trends for the Middle East and North Africa (1.40 and 0.85 percent per year), South Asia (2.48 and 0.77 percent per year) and East Asia (5.63 and 0.73 percent per year). Since the early 1990's, economic growth in Sudan has outpaced gains in population health. While measures of life expectancy and income per capita provide a basis for comparing Sudan's population health and economic performance over time and with other countries – these measures have several drawbacks. Firstly, they do not capture how income or health is distributed in the population – so while average income or life expectancy may improve, those gains may be concentrated in only a small proportion of the population. This report explores variations in health outcomes and service coverage for key population sub-groups in an effort to provide a more complete picture of how health outcomes and service provision has changed over time in Sudan.

Figure A2. Life Expectancy and GDP per capita by region, 1960-2008



Source: World Development Indicators 2010

B. MATERNAL AND CHILD SURVIVAL

Levels and trends in under-five and infant mortality

Key findings and discussion

- In Sudan, under-five mortality declined by 43 percent (on average, 1.5 percentage points per year) between 1965 and 2008 - from 157 to 89 deaths per 1000 live births. Improvements in under-five mortality during this period were driven primarily by reductions in child mortality (deaths among children aged 1-5). Progress in reducing infant mortality was slower by contrast – falling from 86 to 59 infant deaths per 1000 live births – at a rate of 0.7 percent per year.

- Under-five mortality levels for Sudan are 30 percent lower than the average for Africa and 51 percent higher than the global average. Sudan's under-five mortality rate is at the average for low-middle income countries.

- Mortality among children is heavily concentrated during their first year. An estimated 65 percent of deaths occurring before the age of five, happen during infancy (before children reach one year of age) and approximately 33 percent of deaths occurring before the age of five happen during the neonatal period (in the first 30 days after birth).

- Child survival varies widely between state and region. River Nile and Gezira (with under-five mortality rates averaging below 70 between 2005 and 2008) have relatively favorable child survival conditions while South Kordofan, Blue Nile and Gadarif (with under-five mortality rates averaging 145, 128 and 124, respectively, between 2005 and 2008) have the highest under-five mortality rates in the country.

Data and methods

Under five mortality – the probability of dying between birth and exact age five (5q0) - can be measured using census, vital registration or survey data. While the most precise estimates of under-five mortality are obtained from vital registration systems that capture all births and deaths, in their absence, measurement of under-five mortality relies on surveys that retrospectively ask women to report on the births and deaths of their children. The assessment of the levels and trends in under-five mortality presented here draws from three household surveys and a census: the 2006 and 2010 Sudan Household Health Survey (SHHS), the 1989-1990 Demographic Health survey (DHS) and the 2008 Census Long Form. The SHHS and Census cover all states and are representative at the state level. The DHS only covers states in Sudan (North) and is representative at the regional level. In 2008, Sudan conducted a census as part of the Comprehensive Peace Agreement (CPA). In addition to the full enumeration of the population, a 10% random sample of households completed a more detailed questionnaire – the long form - on household characteristics and included questions on vital events (such as births and deaths). The analysis conducted here was limited to this sample. Table B1 summarizes the key characteristics of each data source.

Table B1. Data sources for analyses of under-five mortality

	Demographic Health Survey (DHS)	Sudan Household Health Survey (SHHS)	Census (Long Form)	Sudan Household Health Survey (SHHS)
Year	1989/1990	2006	2008	2010
Number of households interviewed				
Sudan (North)	6,891	14,826	922,816	14,778
South Sudan	0	9,220	92,592	9,369
Number of women (of reproductive age 15-49) interviewed				
Sudan (North)	5,860	18,186	1,196,309	17,174
South Sudan	0	8,737	129,802	9,077
Number of live births recorded				
Sudan (North)	25,805	47,120	2,810,651	47.092
South Sudan	0	30,499	339,200	28,720
Number of live births per women (overall)				
Sudan (North)	4.40	2.59	2.35	2.74
South Sudan	--	3.49	2.61	3.16
Geographic coverage	North	North & South	North & South	North & South
Sub-Nationally Representative?	By region	By state	By county	By state

Source: Author's calculations from DHS, SHHS and CENSUS

When using survey data to measure under-five mortality, two methods are available: the complete birth history (or direct) method and the summary birth history (or indirect) method. The direct method uses data from several questions asked to mothers of reproductive age regarding each birth, including the child's date of birth, sex, survival status, current age, or if deceased - the age at death. Data from these questions enable the direct estimation of probabilities of survival and death at different ages. Details of the methodology used to estimate under-five mortality using the direct method are provided in Annex 2.

The indirect method by contrast, requires answers to only two questions: the total number of live births and surviving children per mother. The proportion of children ever born who have died by five-year age groups of mothers is then used to obtain estimates of under-five mortality (displayed in Table B8). This technique was originally developed based on observations of a strong relationship between these proportions and population-level child mortality rates (Brass and Coale 1968). Subsequent refinements enabled the estimated rates of mortality to be localized in time (Feeney 1980).

Two indirect methods were used: the Standard Indirect (Brass) Method described in United Nations' Manual X and incorporated in the software package QFIVE (United Nations 1983); and the Maternal Age Cohort-Derived Method (MAC) developed by the Institute for Health Metrics and Evaluation (IHME) and described in a recent paper (Rajaratnam, Tran et al. 2010). Only MAC estimates are presented in the results below. In addition, under-five mortality estimates using the indirect method from mothers between the ages of 15-19 are not used.

Estimates of under-five mortality obtained from the direct and indirect methods from each data source were synthesized using a locally weighted scatterplot smoothing (lowess) procedure to obtain a single trend. In the absence of objective criteria and additional detail about the data collection process for each survey, the lowess procedure used here gives equal weight to all estimates, regardless of the data source or method of estimation. Estimates of infant mortality – the probability of dying between birth and exact age one - were obtained by

using direct estimates of infant and under-five mortality to compute the share of under-five deaths occurring before the first year of life and applying these shares to the lowess estimates of under-five mortality. Where available, estimates from other studies and surveys were used to validate the estimates produced here.

Sources of error in mortality measurement

The degree of accuracy of mortality estimates depends on sampling variability and on non-sampling errors. Non-sampling errors depend on the extent to which information provided by mothers is accurate and complete and the extent to which the mothers interviewed are representative of the general population of mothers in South Sudan. One important drawback of the direct approach is that it places high demand on the respondent to recall dates of birth and deaths (Rajaratnam, Tran et al. 2010). In the areas of Sudan where literacy and numeracy is low, fertility rates are high and decades of violent conflict have displaced large populations (such as Darfur and Kordofan) – the risk of recall bias is high. Omission of births and deaths affects mortality levels, misreporting of birth and death dates impacts mortality trends, and misreporting of age at death may distort the age pattern of mortality (DHS 1991).

Both direct and indirect estimates will be affected by the composition of women interviewed at the time of the survey. If interviewed women are systematically different from women who are not interviewed (for various reasons discussed below), selection bias will introduce error in mortality estimates. One important source of selection error is associated with the fact that as only surviving women are interviewed, no information is collected on the mortality conditions of children who have been orphaned (Preston, Heuveline et al. 2001) - in populations severely affected by conflict and elevated adult mortality, historical under-five mortality estimates based on interviews of surviving women in the 2000s will likely be underestimated. A related issue is that the household surveys exclude women who have emigrated and include women who have returned to South Sudan and whose children were born elsewhere.

Another potential source of selection error that affects both direct and indirect estimates, stems from non-response to the SHHS individual women's questionnaire among eligible women of reproductive Overall non-response for Sudan was 6.8 percent in 2006, 7.7 percent in 2010 and 5.8 percent and in the 1989/90 DHS, non-response among eligible women respondents was 4.4 percent. Table B2 displays the response rates for the Sudan and South Sudan as well as the range in response rates across individual states.

Table B2. Individual Women questionnaire non-response in the SHHS

Region	Number of Eligible Women	Percent Interviewed	Range (min-max)
2006*			
Sudan (North)	19,507	93.2%	85% [Khartoum] – 99% [Gezira]
South Sudan	13,092	66.7%	55% [Western BEG] – 84% [Eastern Equatoria]
2010			
Sudan (North)	18,614	92.3%	87 % [Northern] – 97.7% [Gezira]
South Sudan	11,568	78.5%	73 % [Unity, Central & Eastern Equatoria] – 90% [North BEG]

Notes: *Adapted from table HH1 on page 12 of the 2006 SHHS report.

Unreported survival status, birth date and age at death is another source of measurement error if these omissions are associated with characteristics of the mother or household that are themselves associated with mortality risks. The degree of missing data from the SHHS for Sudan is provided in Table B3. In some settings, underreporting of early childhood deaths has been observed for deaths occurring shortly after birth. Women may be reluctant to discuss deaths at early ages, especially if deaths occur before the child has been named (DHS 1991). Whether early neo-natal deaths (occurring between 0 and 6 days after birth) are selectively under-reported can be detected by observing abnormally low ratios of early-neonatal to neo-natal deaths (occurring between 0 – 30 days after birth). Overall, there isn't strong evidence for systematic under-reporting of early-neonatal deaths in the SHHS – the ratio of early-neonatal to neo-natal deaths in Sudan ranges from 0.54 to 0.72 in the 2006 and 2010 SHHS which is comparable to those observed in neighboring countries (Annex 2B). Another known source of error is that mothers also tend to misreport the birth dates of deceased children to avoid answering lengthy questions about these children (known as birth transference) which tends to under-estimate under-five mortality in the period closest to the survey.

Under-five mortality estimates produced in this report do not attempt to correct for non-response bias, survivorship bias or birth transference; however, missing values resulting from unreported or unknown birth dates or ages at death were imputed to minimize error in the measurement of under-five mortality resulting from non-random missing data. This imputation process is explained in Annex 2C.

Table B3. Completeness of reporting: percentage of cases with missing birth dates, survival status and age, Sudan

	2006	2010		2006		2010	
Reference Group	N	N	Attribute	Percent missing	N	Percent missing	N
Live births to women aged 15-49	47,120	47,092	Birth Date				
			Month only missing	31.7	14,947	30.2	14,223
			Year only missing	0.14	64	0.06	28
			Month & year missing	5.22	2,459	2.65	1,249
			Survival Status	2.71	1,276	0	0
Surviving children	40,066	41,902	Age	0.22	87	2.39	100
Deceased children	5,778	5,190	Age at death	7.98	461	13.6	706
Live births among women of ages 15-49	47,120	47,092	All birth history questions: birth date, survival status, current age, age at death	0.26	121	0	0
Number of observations (live births) with complete data after imputation					46,999		47,092

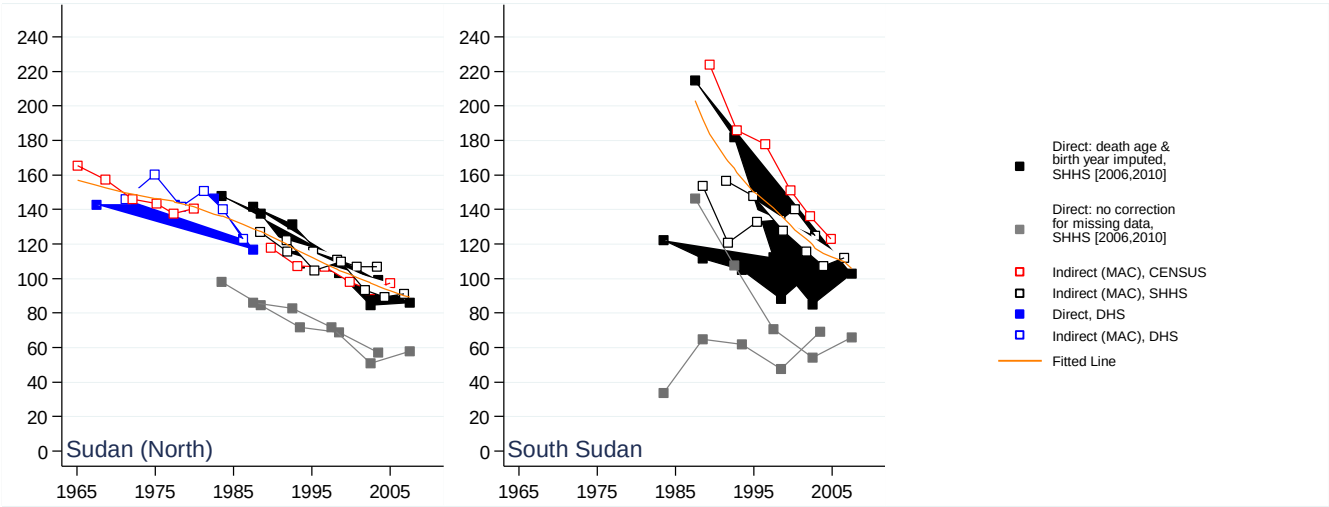
Source: Author's calculations from the 2006 and 2010 SHHS.

Results

Figure B1 displays estimates of under-five mortality obtained using: (1) the direct method (for five 5-year periods prior to the DHS, SHHS and Census) for Sudan and South Sudan (2) the indirect method and (3) the lowess procedure. More specifically, two sets of direct estimates are provided. The first set uses the original data where cases with missing birth dates or ages at death were dropped from the analysis, while the second set uses imputed birth dates and ages at death where this information was missing from the birth history. As can be seen by the upward shifts in the trend lines, dropping cases with missing birth dates or ages at death from the

SHHS datasets yields implausibly low under-five mortality rates. The tight clustering of mortality estimates from overlapping reference years and data sources for Sudan (North) provides a basis for having high confidence in the levels and trends in under-five mortality. Estimates from available data sources using alternative methods for South Sudan, on the other hand, vary widely. Indirect estimates of under-5 mortality from the 2008 Census for South Sudan, for example, are systematically higher than estimates from the 2006 and 2010 SHHS even though there is considerable overlap in the calendar years of exposure to which those estimates refer. This could suggest differential population coverage in the Census relative to the SHHS (e.g. among vulnerable population groups) in South Sudan.

Figure B1. Direct and indirect estimates of under-five mortality by region, 1965-2005

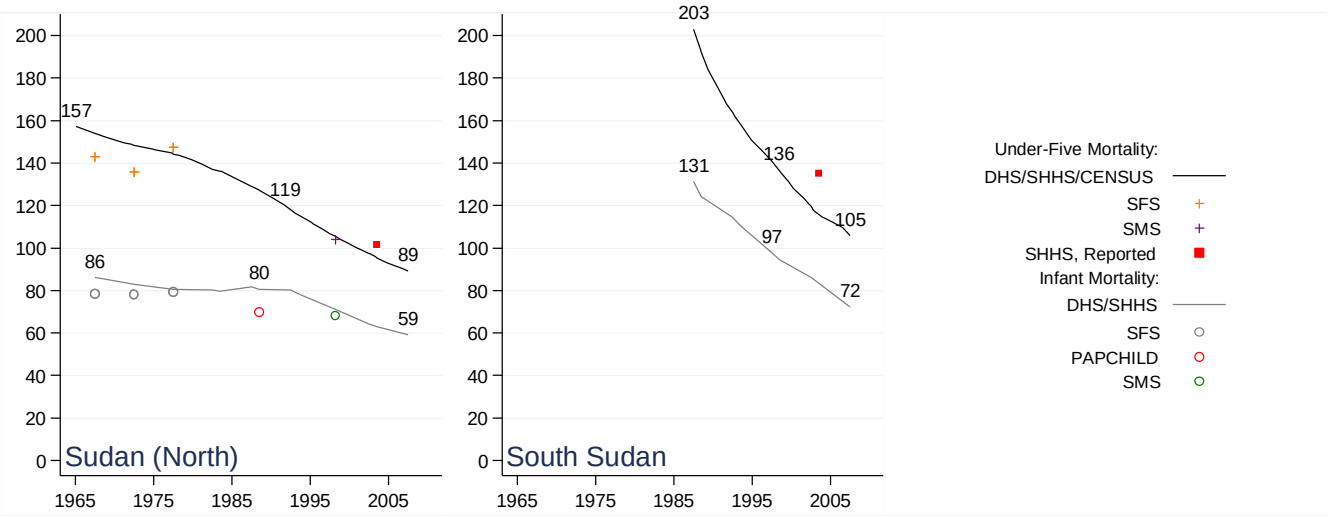


Source: Author's calculations using the 2006 and 2010 SHHS; 2008 Long Form Census and 1990 DHS.
Notes: Direct and indirect estimates are located at the mid-point of the period they correspond. For example mortality estimates that represent mortality risks from 2001-2006 are located at 2003.5. Fitted estimates are obtained from a locally weighted scatterplot smoothing procedure (lowess) that synthesizes the corrected direct and indirect estimates.

Figure B2 singles out the lowess estimates of the trends in under-five and infant mortality over time. Estimates available from the published reports of other population based surveys representative for Sudan are also provided. In addition, the under-5 mortality estimates presented in the official 2006 SHHS report are shown– these estimates were obtained using unspecified indirect methods (Central Bureau of Statistics and Southern Sudan Center for Census Statistics and Evaluation 2006).

Between 1965 and 2010, under-five mortality in Sudan declined from 157 to 89 under-five deaths per 1000 live births at an average annualized rate of 1.5 percent. While relatively stagnant between 1965 and 1975, improvements in child survival conditions in Sudan have been sustained since the early 1980s – with an annualized decline in mortality of 2 percent since 1980. Improvements in infant mortality between 1965 and 2010 by contrast were substantially slower, falling from 86 to 59 infant deaths per 1000 live births at an average annual rate of decline of 0.7 percent.

Figure B2. Under-five and infant mortality, Sudan (North) and South Sudan, 1965-2008

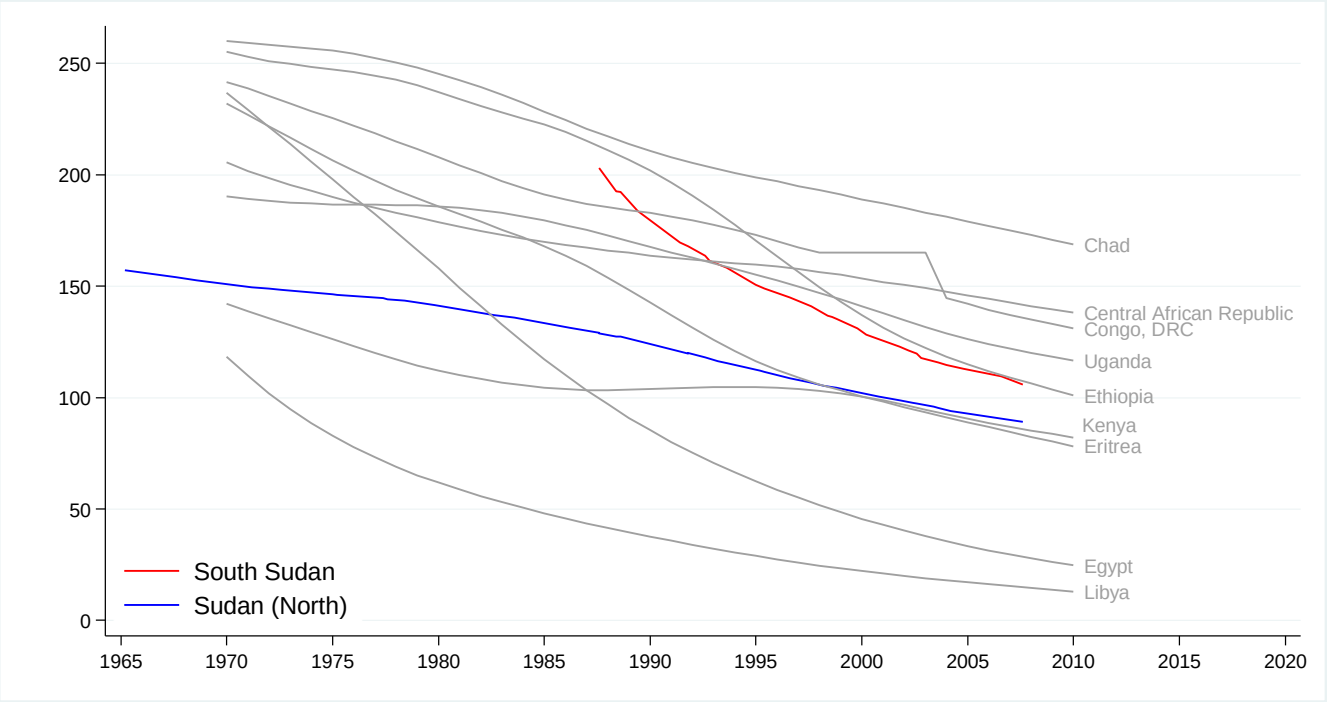


Source: Author's calculations using the 2006 and 2010 SHHS; 2008 Long Form Census and 1990 DHS.
Notes: The Under-Five mortality estimates labeled as DHS/SHHS/CENSUS correspond to the fitted estimates computed using a locally weighted scatterplot smoothing (lowess) procedure synthesizing direct and indirect estimates (also displayed in Figure B1). SFS = Sudan Fertility Survey (1978-1979), SMS = Safe Motherhood Survey (1999), PAPCHILD = Pan Arab Project for Child and Mother Health (1992-1993)

Figure B3 compares estimated under-five mortality levels and trends for Sudan with estimates available for neighboring countries. There is both wide variation in regional under-five mortality levels (ranging from a high of 170 in Chad to less than 25 in Egypt and Libya) and trends (Egypt, for example, reduced under five mortality by 6 percent per year on average between 1970 and 2010). By 2008, Sudan performs comparably to Kenya and Eritrea. The geographic variation in under-five mortality both regionally and globally is displayed in Figure B4. In 2009, under-five mortality among low and low-middle income countries was 117 and 90 deaths per 1,000 live births and for the WHO African region, under-five mortality in 2009 was 127 deaths per 1,000 live births (WHO 2011) – by comparison, Sudan's under-five mortality is at the level of low-middle income countries and 30 percent lower than the average for Africa.

Figures B5 and B6 display survey-specific and lowess region-level trends in under-five mortality between 1965 and 2010 for Sudan while Figures B7 and B8 provide trends for each state (as the DHS did not collect representative data at the state-level, these estimates are only available since 1985). At the regional level, Northern (comprised of Northern and River Nile States) has the best outcomes for children, while Kordofan (comprised of North and South Kordofan) has the worst outcomes for children. Figure B6 also shows evidence of recent deterioration in child survival conditions in Kordofan and Eastern regions. In Figures B7 and B8 states are ordered from lowest to highest according to average under-five mortality levels between 2005 and 2008 (Figure B6). All states show evidence of improved child survival conditions over the 25 year period (Figures B7, B8, B10) - with annualized rates of decrease in under-five mortality between 0.5 percent (Gadarif) to 3.5 percent (West Darfur). With an average of 124, 128 and 145 under five deaths per 1000 live births between 2005 and 2008 Gadarif, Blue Nile and South Kordofan stand out as having particularly poor child survival conditions. By contrast, with an average of 55 under-five deaths per 100 live births between 2005 and 2008, River Nile stands out has having relatively favorable child survival conditions (Figures B8, B10).

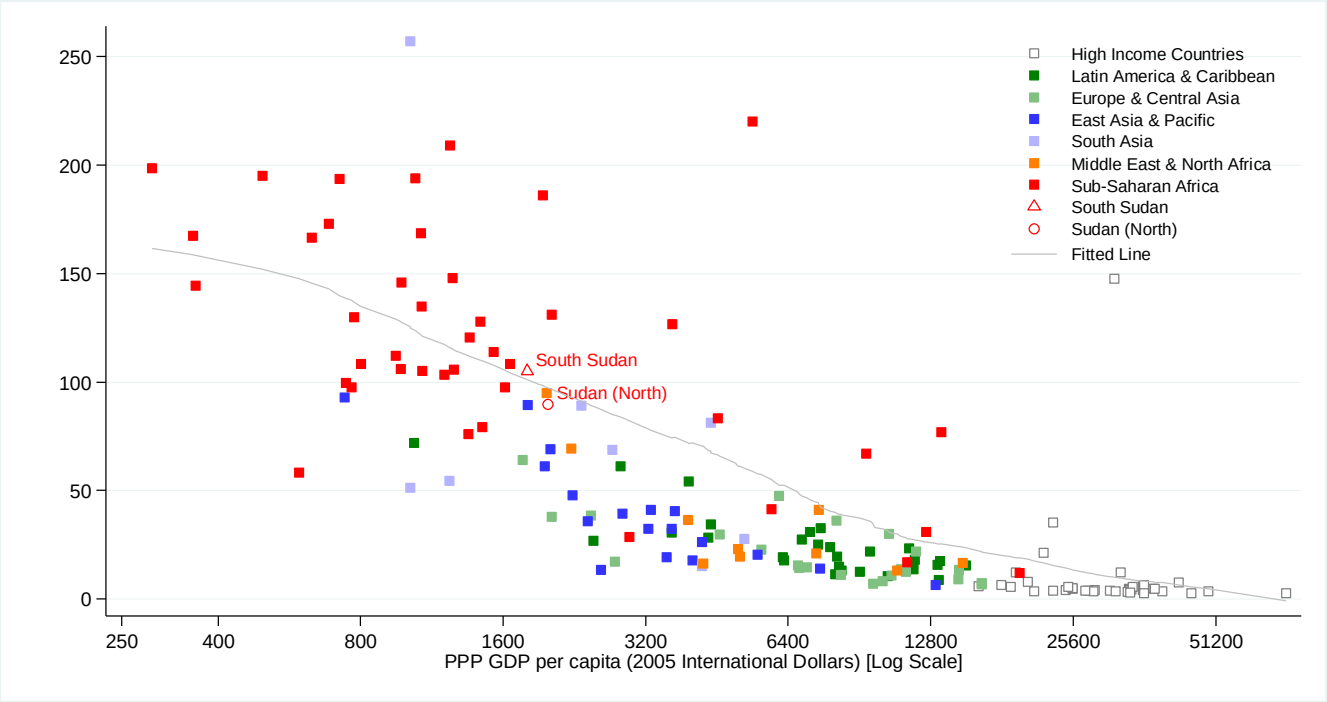
Figure B3. Under-five mortality, South Sudan, Sudan (North) and neighboring countries 1965-2010



Source: Institute for Health Metrics & Evaluation (Figure B3);

Notes: South Sudan and North Sudan's under-five mortality estimates pertain to the 2005-2010 period and are based on estimates made by this author using the 1989/1990 DHS, 2006, 2010 SHHS and 2008 Long Form Census. South Sudan's GDP is predicted using a linear regression of the logarithm of PPP GDP per capita and under-five mortality among all available countries. Sudan (North)'s GDP presumed to equal officially reported GDP estimates for Sudan.

Figure B4. Under-5 mortality (5q0) vs. GDP per capita, by country & region, 2008



Source: World Development Indicators 2010

Notes: Sudan, South Sudan and North Sudan's under-five mortality estimates pertain to the 2006-2010 period and are based on estimates made by this author using the 2006 and 2010 SHHS as well as the 2008 Census. South Sudan's GDP is predicted using a linear regression of the logarithm of PPP GDP per capita and infant mortality among all available countries. The infant mortality rate for South Sudan used for this prediction is 105 under five deaths per 1000 live births.

Figure B5. Direct and indirect estimates of under-five mortality by region, Sudan (North), 1965-2010

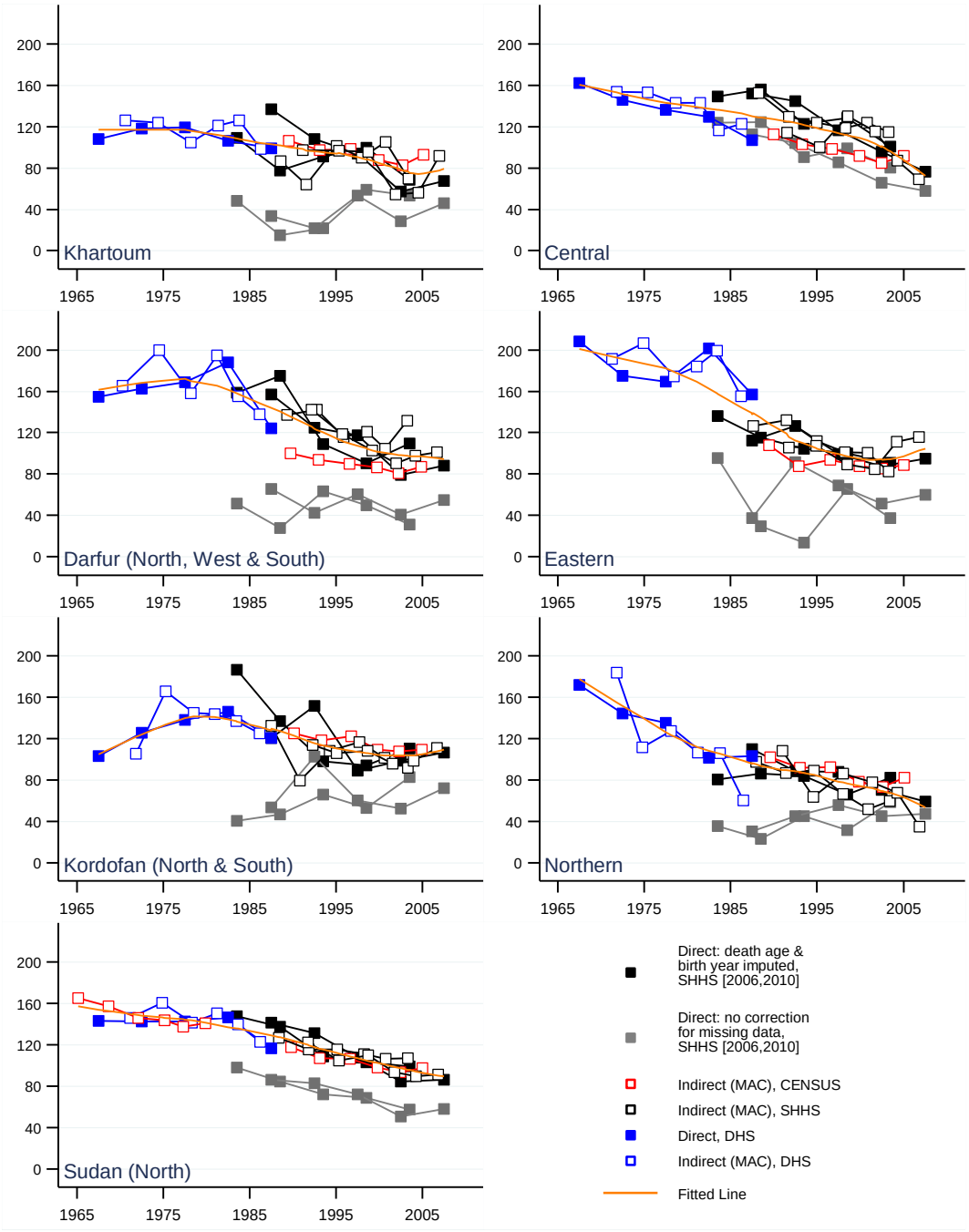
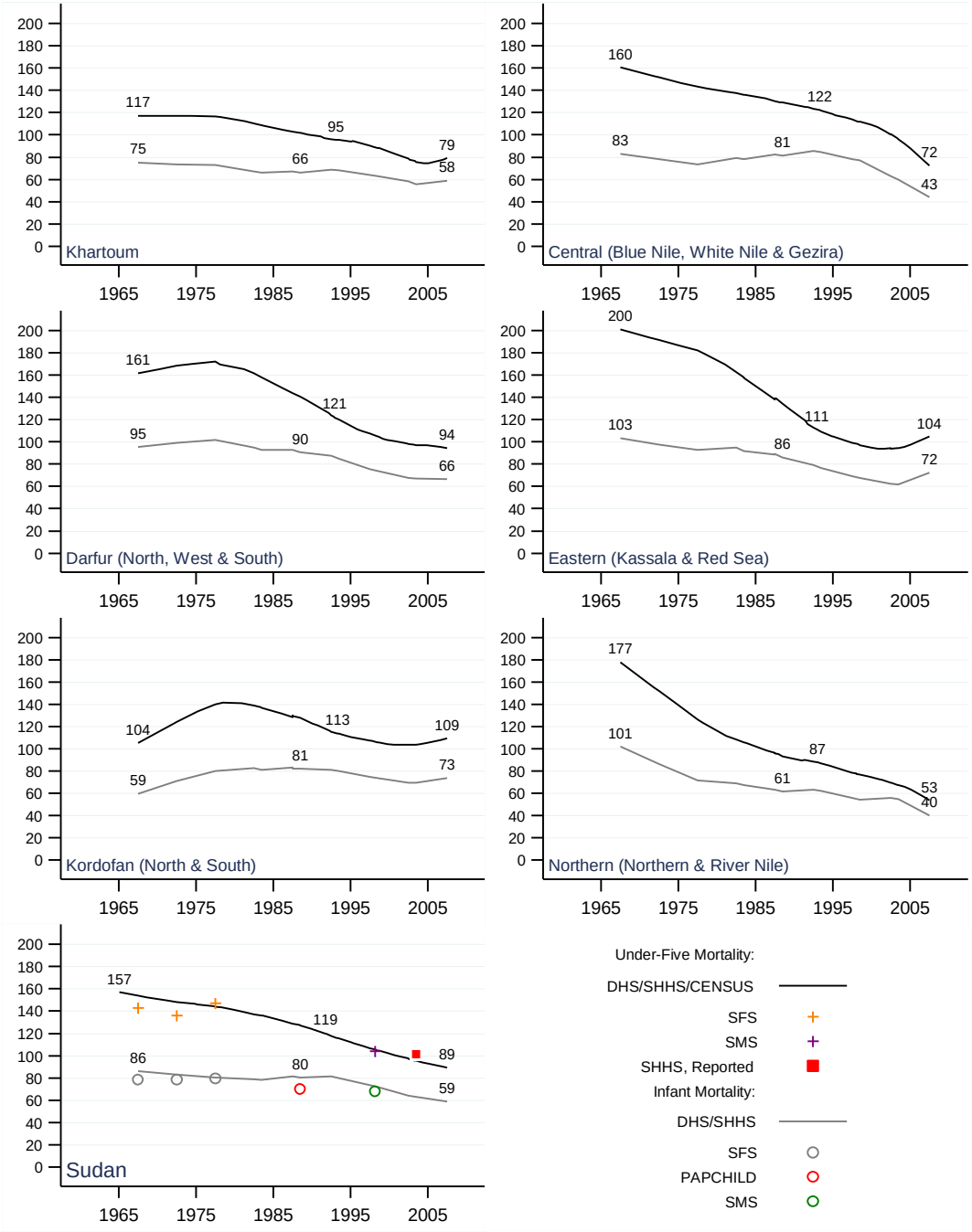


Figure B6. Under-five mortality by region, South Sudan, 1965-2010



Source: Author's calculations using the 2006 and 2010 SHHS and 2008 Long Form Census.

Notes: Direct estimates are located at the mid-point of the period to which they correspond. For example, mortality estimates the represent mortality risks between2001-2006 are located at 2003.5. Fitted estimates are obtained using a locally weighted regression (lowess) that combines the corrected direct and indirect estimates.

Figure B7. Direct and indirect estimates of under-five mortality by state, Sudan (North), 1980-2008

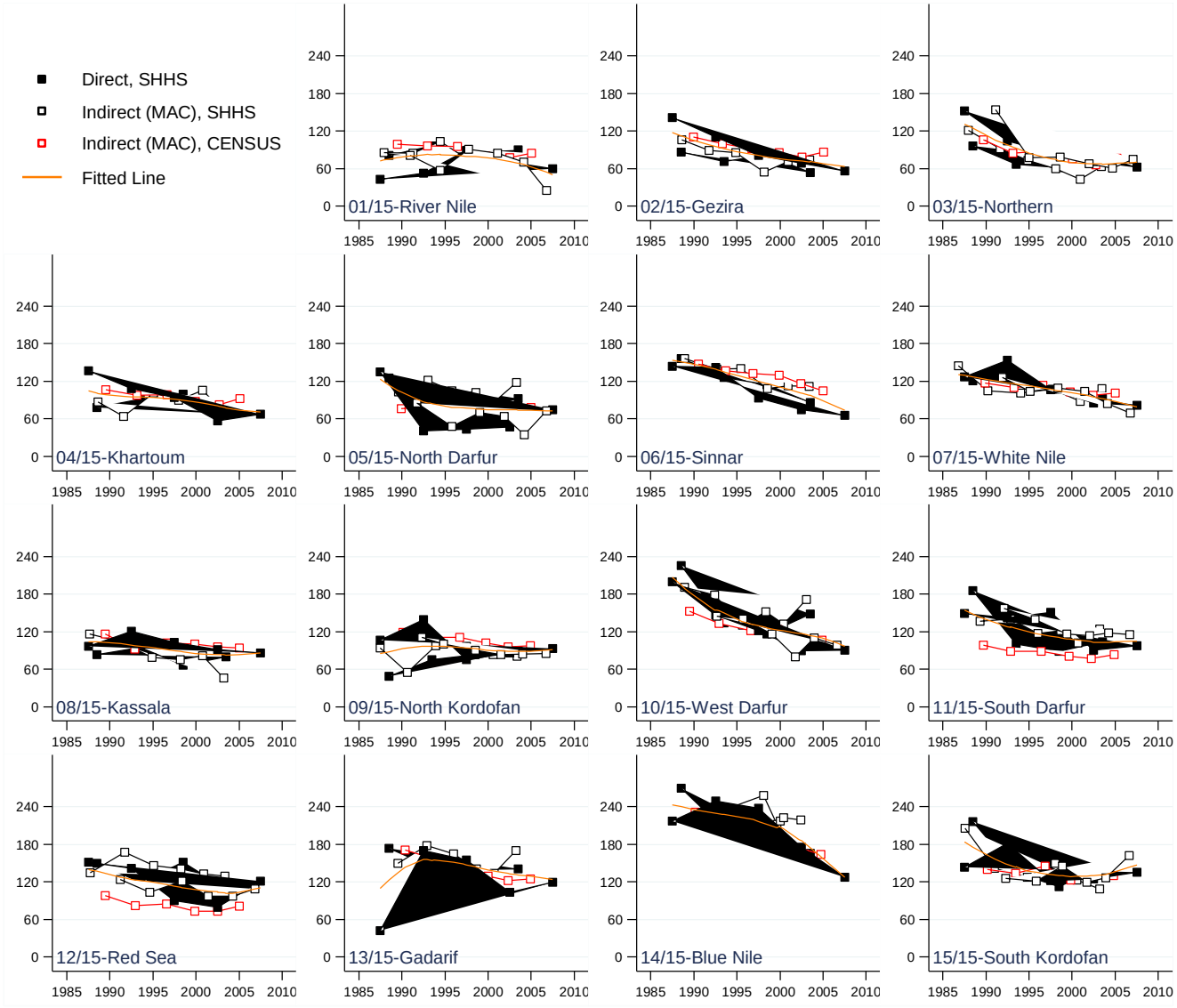
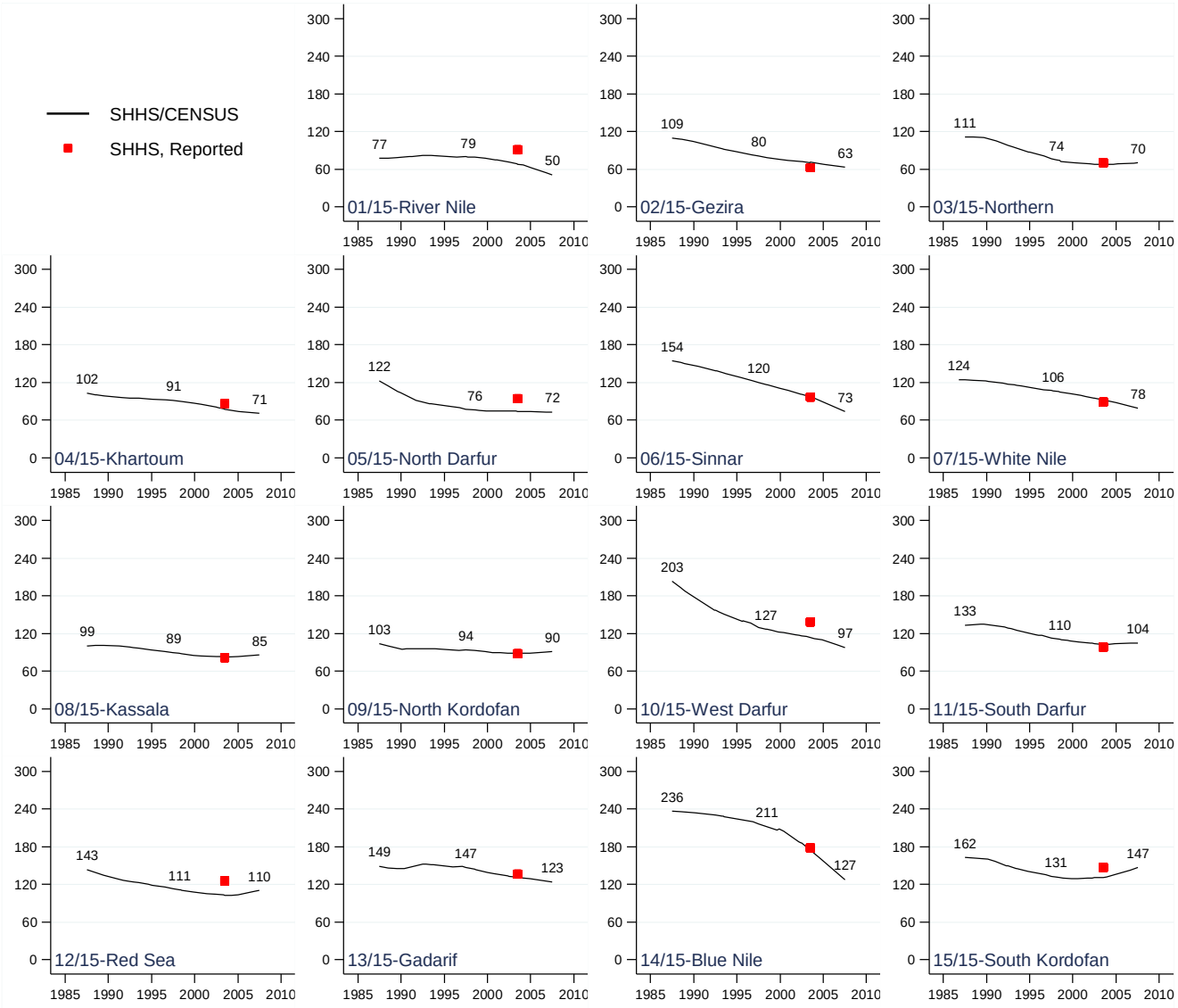


Figure B8. Under-five mortality by state, Sudan, 1980-2010

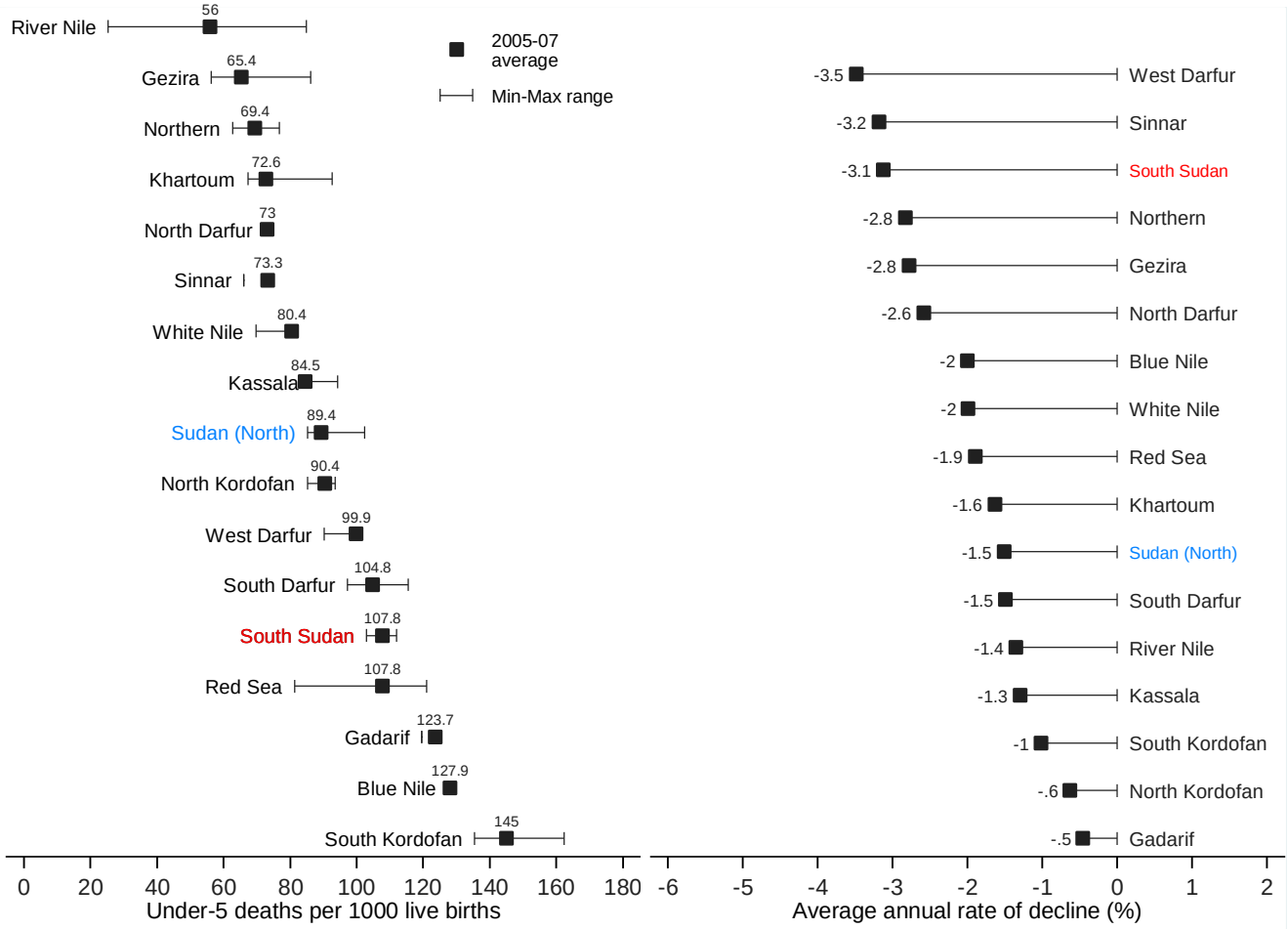


Source: Author's calculations using the 2006 and 2010 SHHS and 2008 Long Form Census.

Notes: States are ranked from lowest to highest mortality based on the fitted estimates in the 2005-2008 time range. Direct estimates are located at the mid-point of the period to which they correspond. For example, mortality estimates that represent mortality risks between 2001-2006 are located at 2003.5. Fitted estimates are obtained using a locally weighted regression (lowess) that combines the corrected direct and indirect estimates. Under-five mortality rates are labeled at the first point, mid-point and last point of the time series.

Figure B9. Average under-five mortality by state, Sudan (North), 2005-2007

Figure B10. Annualized percent change in under-five mortality by state, Sudan (North), 1984-2008



Source: Author's calculations using the 2006 and 2010 Sudan Household Health Survey and 2008 Long Form Census.
Notes: Under-5 mortality estimates are based on fitted estimates obtained using a locally weighted scatterplot smoothing procedure (lowess) that combines corrected direct and indirect mortality estimates. The average rate of decline for Sudan (North) in Figure B10 covers 1965-2008.

Determinants of under-five mortality

Key findings and discussion

- Heightened risk of under-five death associated with maternal age, birth order and birth interval suggest that educating adolescents on the importance of delaying first pregnancy and couples on spacing consecutive births by at least 2 years can have a large impact in reducing under-five mortality.

- There is some evidence that births among mothers that have completed secondary education are substantially protected from childhood death. Given the strong association between educational attainment and wealth, however, it is difficult to gauge the degree to which this advantage is conferred through the improved child-care decisions made as a result of education or through improved living and nutritional conditions as a result of higher income.

- Boys are about 25 percent more likely than girls risk to die before the age of five, all else equal.

- No association is found between under-five mortality and the location of households in urban versus rural settings once characteristics of the household, mother and birth are taken into account.

- Wealth –a measure that largely reflects the living conditions of households (including access to improved drinking water and sanitation facilities) – is a significant determinant of under-five mortality. Children living in the most impoverished conditions are between 40 and 75 percent more likely to die before the age of five compared to children living in the wealthiest households, pointing to the importance of removing income related barriers to health care access as well as supporting improvements to housing, hygiene and sanitation as complementary and necessary inputs to public health efforts.

- The elevated risk of under-five mortality in individual states (relative to Khartoum) - most notably Blue Nile, West Darfur, Gadarif, and South Kordofan - controlling for specific characteristics of mothers, births and the economic status of the household – may point to areas with critically weak health services or recurrence of conflict. Children in Blue Nile, for example, are more than twice as likely to die before the age of five compared to children in Khartoum, all else equal.

Data and methods

Determinants of under-five mortality between 2001 and 2010 are studied using complete birth history data from the 2006 and 2010 SHHS, where each observation represents the live birth of a successfully interviewed woman between the ages of 15 and 49. Under-five mortality events are modeled in a proportional hazards regression (the details of this method are provided in Annex 3A).

Table B4 lists the risk factors (independent variables) included in the model as well as the mean and standard deviation of each taking into account the sampling methodology of the survey. The risk factors are classified broadly between socioeconomic attributes: maternal educational attainment (given the small number of

women with secondary education or higher in Sudan, mothers with primary and secondary education were grouped together), household wealth (Annex 3B provides details on how wealth is measured), the urban or

Table B4. Independent variables included in regression models

Attribute	Variable	Variable Categories	2006		2010	
			Mean	SE	Mean	SE
Socioeconomic Factors						
Mother's Educational Attainment		Never Attended [Ref]	0.52	0.016	0.48	0.016
	PRI	Primary Education	0.32	0.011	0.37	0.011
	SEC	Secondary or Higher	0.16	0.011	0.15	0.011
Household Wealth	WQ1	1st wealth quintile (poorest) [Ref]	0.19	0.012	0.21	0.014
	WQ2	2nd wealth quintile	0.22	0.010	0.23	0.012
	WQ3	3rd wealth quintile	0.20	0.009	0.20	0.009
	WQ4	4th wealth quintile	0.20	0.011	0.19	0.011
	WQ5	5th wealth quintile (richest)	0.19	0.016	0.17	0.015
Urban/ Rural Setting	Rural	Rural [Ref]	0.63	0.025	0.72	0.024
	Urban	Urban	0.37	0.025	0.28	0.024
State of Residence		Northern	0.02	0.003	0.01	0.003
		River Nile	0.03	0.005	0.03	0.006
		Red Sea	0.04	0.007	0.02	0.004
		Kassala	0.06	0.009	0.06	0.010
		Gadarif	0.05	0.008	0.05	0.009
		Khartoum [Ref]	0.16	0.023	0.14	0.022
		Gezira	0.10	0.015	0.12	0.019
		Sinnar	0.04	0.006	0.04	0.007
		Blue Nile	0.08	0.013	0.04	0.007
		White Nile	0.02	0.004	0.05	0.009
		North Kordofan	0.07	0.011	0.11	0.017
		South Kordofan	0.05	0.008	0.06	0.009
		North Darfur	0.09	0.014	0.07	0.012
		West Darfur	0.06	0.010	0.05	0.009
		South Darfur	0.15	0.022	0.14	0.022
Demographic/ Biological Factors						
Maternal Age (years)	MAB	Mother's Age at birth	27.38	0.108	27.17	0.104
	MAB2	(Mother's Age at birth)^2	793.93	6.144	783.28	5.879
	MAFB	Mother's Age at first birth	19.99	0.098	19.85	0.090
	MAFB2	(Mother's Age at first birth)^2	420.68	4.288	411.60	3.985
Sex of Child	Female	Female	0.48	0.005	0.49	0.005
	Male	Male	0.52	0.005	0.51	0.005
Single/ Multiple Birth	Single	Single Birth	0.96	0.003	0.97	0.003
	Multiple	Multiple Birth	0.04	0.003	0.03	0.003
Birth order/ interval (months)	BOI 1	First birth order	0.18	0.004	0.18	0.004
	BOI 2	2^{nd} – 4^{th} birth order, less than 2 yrs spacing	0.15	0.003	0.16	0.004
	BOI 3	2^{nd} – 4^{th} birth order, 2 yrs or more spacing	0.29	0.005	0.28	0.005
	BOI 4	5^{th} or higher birth order, less than 2 yrs spacing	0.12	0.004	0.13	0.004
	BOI 5	5^{th} or higher birth order, 2 yrs or more spacing	0.26	0.006	0.25	0.005
		Number of Observations	13,953		14,676	

*B=binary, C=continuous, [Ref] = Reference Category in regression

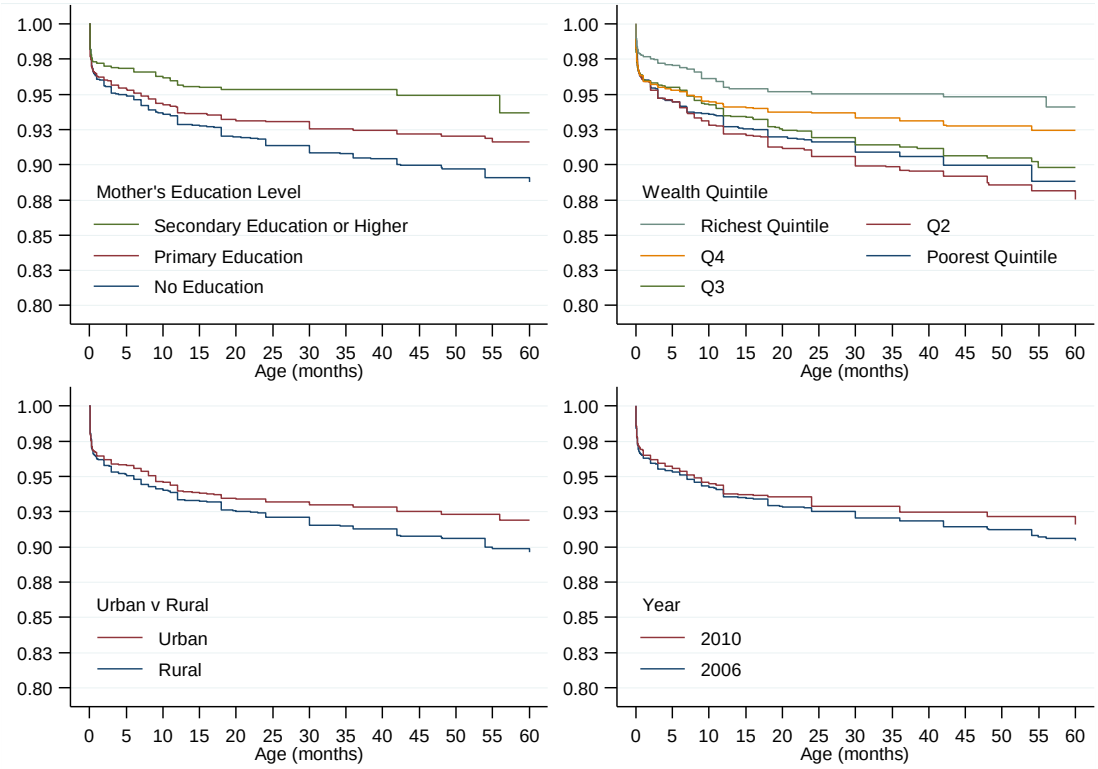
rural setting of the household, the state and region of residence; and demographic or biological attributes of the

mother and child: maternal age at the first and current birth as well as the sex, birth spacing and birth order of the child. Two additional variables were created: maternal age at first birth squared, and maternal age at current birth squared to capture the additional risk of mortality to births from relatively young and old mothers. As the first birth to every mother is not preceded by a birth, to avoid having missing values in the birth interval variable, a variable combining birth order and birth interval was created with five categories: (1) first order, (2) second to fourth birth order with less than two years of preceding spacing, (3) second to fourth birth order with two years or more of preceding spacing, (4) fifth or higher birth order with less than 2 years of preceding spacing, (5) fifth or higher birth order with two years or more of preceding spacing. Approximately 50 percent of the mothers interviewed never attended school, the average age at first birth is 20 years (the median is 19) and the median birth interval is 28 months or 2.3 years.

Results

Figures B9 and B10 display the cumulative survival probabilities (survivor curves) for children under-five for population sub-groups defined by the highest level of education attained by the mother, the wealth quintile of the household, the urban or rural setting of the household and the period of exposure: 2006 (2001-2006) and 2010 (2005-2010) for Sudan (North). A statistical procedure was conducted to test the equality of the survivor curves between each sub-group. Statistically significant advantages in survival were found for: (1) children whose mothers completed primary education over children whose mothers did not; (2) children whose mothers completed secondary education over children whose mothers completed primary education; (3) children living in the wealthiest households over children living in households belonging to any other wealth quintile; and (4) children living in urban areas over children living in rural areas.

Figure B9. Cumulative survival probability by age of child, 2001-2010, Sudan (North)



Source: Author's calculations based on 2006 and 2010 SHHS

Table B5. Determinants of under-five mortality (2001-2010), Sudan

	Model 1		Model 2		Model 3	
Attribute†	Hazard Ratio	Z-score	Hazard Ratio	Z-score	Hazard Ratio	Z-score
No Education			[Reference]			
Primary	0.866	(-1.77)	0.963	(-0.44)	1.021	-0.24
Secondary	0.650**	(-3.02)	0.827	(-1.21)	0.9	(-0.66)
MAB	0.901*	(-2.50)	0.904*	(-2.43)	0.906*	(-2.36)
MAB2	1.002***	-3.37	1.002***	-3.39	1.002***	-3.35
MAFB	0.922	(-1.78)	0.927	(-1.65)	0.934	(-1.47)
MAFB2	1.001	-0.85	1.001	-0.72	1.001	-0.66
Female			[Reference]			
Male	1.237**	-3.01	1.241**	-3.05	1.245**	-3.11
Single Birth			[Reference]			
Multiple Birth	2.408***	-7.03	2.432***	-7.1	2.373***	-6.9
BOI 1			[Reference]			
BOI 2	1.25	-1.71	1.22	-1.52	1.214	-1.49
BOI 3	0.676**	(-2.87)	0.667**	(-2.97)	0.666**	(-2.98)
BOI 4	1.272	-1.3	1.221	-1.07	1.217	-1.05
BOI 5	0.555**	(-3.02)	0.544**	(-3.14)	0.541**	(-3.15)
Urban	0.938	(-0.76)	1.095	-1.03	1.112	-1.21
2001-2006			[Reference]			
2005-2010	0.895*	(-2.13)	0.890*	(-2.23)	0.914	(-1.70)
Poorest			1.650**	-3.01	1.431*	-2.03
WQ 2			1.758***	-3.5	1.539*	-2.52
WQ 3			1.528**	-2.74	1.33	-1.76
WQ 4			1.238	-1.36	1.164	-0.96
Richest			[Reference]			
Northern					1.045	-0.18
River Nile					1.414	-1.54
Red Sea					1.406	-1.59
Kassala					1.067	-0.29
Gadarif					1.751**	-2.83
Khartoum			[Reference]			
Gezira					0.915	(-0.37)
Sinnar					1.218	-0.92
Blue Nile					2.010***	-3.58
White Nile					1.23	-0.98
North Kordofan					1.111	-0.48
South Kordofan					1.687**	-2.58
North Darfur					1.053	-0.24
West Darfur					1.764**	-2.77
South Darfur					1.405	-1.64
N	28,276		28,276		28,276	

Source: Author's calculation using 2006 and 2010 Sudan Household Health Survey.

Notes: †Abbreviation definitions are provided n Table B4. Significance levels correspond to the following: * p<0.05, ** p<0.01, *** p<0.001

Three different proportional hazards regression models are fit to describe under-five mortality. Table B5 displays the hazard ratios and z-scores resulting from the statistical test assessing whether the hypothesis of no association between under-five mortality and each covariate holds. Proportional hazards coefficients are always positive – a coefficient above 1 indicates elevated risk of death, a coefficient equal to 1 represents no difference in risk and a coefficient below 1 represents reduced risk between groups. The first model is the most parsimonious and includes the mother's educational attainment, the household setting and characteristics of the birth (maternal age, sex of child, birth order and interval); the second model adds household wealth quintiles and the third adds dummy variables for the state of residence. In this multivariate regression framework, the question of interest becomes whether significant differences in mortality risk are observed among children who are otherwise similar (as measured by attributes of the birth, the mother and the household).

Although not statistically significant in all models, there is some indication that secondary educational attainment of the mother confers benefits to children. In Model 1, the secondary education is associated with a 35 percent reduction in the likelihood of under-five mortality. Once the wealth of the household is included as a control in Model 2, however, the effect size declines to a 20 percent reduction in risk and loses

statistical significance. This result likely reflects the strong correlation between household wealth and mother's education. Wealth is strongly associated with reduced child mortality holding other factors constant: relative to children in the wealthiest quintile, children in progressively poorer wealth quintiles are between 40 and 75 percent more likely to die before the age of five.

Among birth characteristics - maternal age, birth order, birth interval, the sex of the child and twin birth – all have consistent effects on mortality. Maternal age during the current birth has a positive and non-linear association with under-five mortality suggesting for example, that births to mothers at 40 years of age carry more than twice the risk than births to mothers at age 20 years. While maternal age at first birth is associated with an 8 percent reduction in the risk of under-five mortality, this effect is not statistically significant.

Spacing consecutive births 2 or more years carries a significant protective effect (independent of the number of births a mother already has). Births with 2 or more years of spacing with the previous birth are between 35 percent (for births that are of a second, third or fourth birth order) and 45 percent (for births of a fifth or higher birth order) less likely to die before the age of 5 compared to first order births, all else equal.

There is strong evidence that boys are about 25 percent more likely than girls risk to die before the age of five. Studies have documented higher mortality of boys during the neonatal period and attribute differential mortality between the sexes early in life to biological factors (Naeye, Burt et al. 1971).

No statistical difference in mortality risk is evident for births in urban setting relative to those in rural settings holding other factors constant. Relative to Khartoum, Gadarif, Blue Nile, South Kordofan and West Darfur have significantly worse child survival conditions controlling for other factors. In Blue Nile, all else equal, births are about twice as likely to die before the age of five compared to births in Khartoum.

Comparing births occurring in the 2005-2010 period to births occurring in the 2001-2006 period, holding other factors constant provides an indication of whether average child survival conditions improved due to unobserved factors changing over the course of the ten years covered by the SHHS data used in the analysis. In Models 1 and 2, evidence indicates that children born in the 2005-2010 period were about 10 percent less likely to die before the age of five relative to those born 2001-2006 period, holding other factors constant. Once state fixed effects are included in the model, however, this result is no longer statistically significant.

Maternal and child survival strategies

Two of the millennium development goals relate directly to maternal and child health conditions: reducing child mortality and improving maternal health, reflecting the large burden of disease they suffer. In 2008, the Sudan census places approximately 18 percent of Sudan's population below the age of 5 – representing 5.5 million children. In Sudan close to 9 children out of every 100 born will not survive to their fifth birthday. As suggested by evidence from burden of disease estimates for eastern and Sub-Saharan Africa, most of these deaths are from preventable causes: diarrhea, pneumonia, measles, malaria, the underlying causes of under nutrition and a small group of causes leading to neonatal deaths. Women of reproductive age (ages 15-49) represent another vulnerable group due to the risks of pregnancy and childbirth. In Sudan, this group comprises approximately 24 percent of the population or 7.5 million women. A key challenge in Sudan is reaching these populations with key interventions as over 3 out of every 4 children and women of reproductive age live in rural areas.

Key findings and discussion

Maternal Health

- Complications during pregnancy affect four out of every five pregnant women, complications during labor affect one in every two pregnant women and complications up to six weeks after delivery affect two in three pregnant women. Approximately one in four female deaths occurs during pregnancy, delivery or two months after delivery. In this high risk setting, access to a continuum of effective antenatal, intrapartum and post-partum care for pregnant women is critical. In 2010, evidence-based maternal survival interventions (including professional antenatal and delivery care) cover only one in five women in need.

- Family planning and effective ante-natal care are among the maternal survival interventions with the lowest population coverage: In 2010, only 5 percent of married or cohabiting women used some form of contraception (which seems to be driven by limited access to- rather than low demand for- contraception).

- Total fertility rates have come down over time from 7.8 to 5.5 births per woman between 2000 and 2010 but remain higher than the average for Sub-Saharan Africa (5 births per woman).

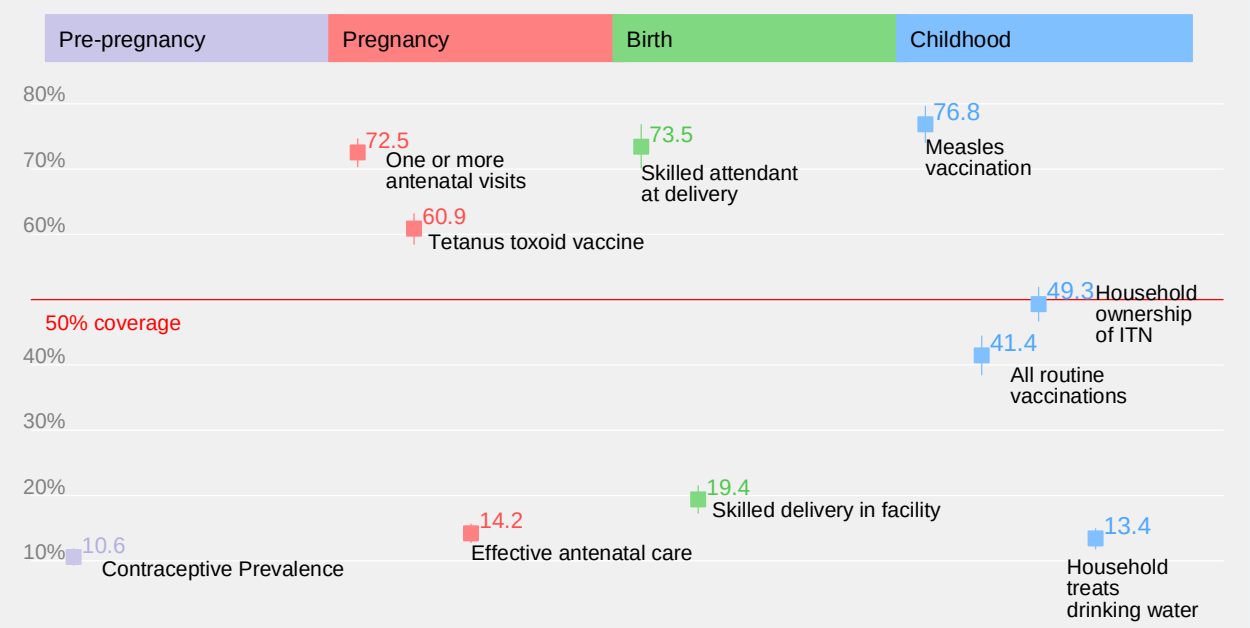
- While there is a tendency for women to marry early (close to 40 percent of women between the ages of 15 and 19 were married in 2010) adolescent fertility rates in South Sudan (at 40 births per 1000 women between the ages of 15 and 19 in the five years prior to the 2010 SHHS and 58 births per 1000 adolescent women in the five years prior to the 2006 SHHS) are more comparable to Middle East and North Africa (35 births per 1000 adolescent women) than Sub-Saharan Africa (110 births per 1000 adolescent women). Fertility is highest for women between the ages of 25 and 29 (225 live births per 1000 women).

- In the short run, family planning programs would do well by focusing on helping teenagers postpone pregnancies through contraceptive use, as well as helping older couples become familiar with modern contraceptive techniques. In the long run, broader efforts that foster social attitudes that value and provide economic opportunities for women will help create an environment that enables women to make the important decisions that affect their lives such as who to marry, when to marry and when to bear children.

- Between 2008 and 2010 only 3 percent of pregnant women reported receiving an effective package of antenatal services including four antenatal care visits, an assessment for blood pressure, urine screen for protein, a blood screen for anemia and two doses of tetanus toxoid vaccine.

- Among women of reproductive age with a pregnancy in the two years prior to the survey, skilled birth attendance (births attended by a doctor, nurse midwife or village midwife) increased from 41 percent of live births between 2004 and 2006 to 48 percent between 2008 and 2010 which was driven by an increase in the number of births delivered by nurse midwives, medical assistants and health visitors. The gains in professional support during childbirth, however, have been limited primarily to women in urban areas.

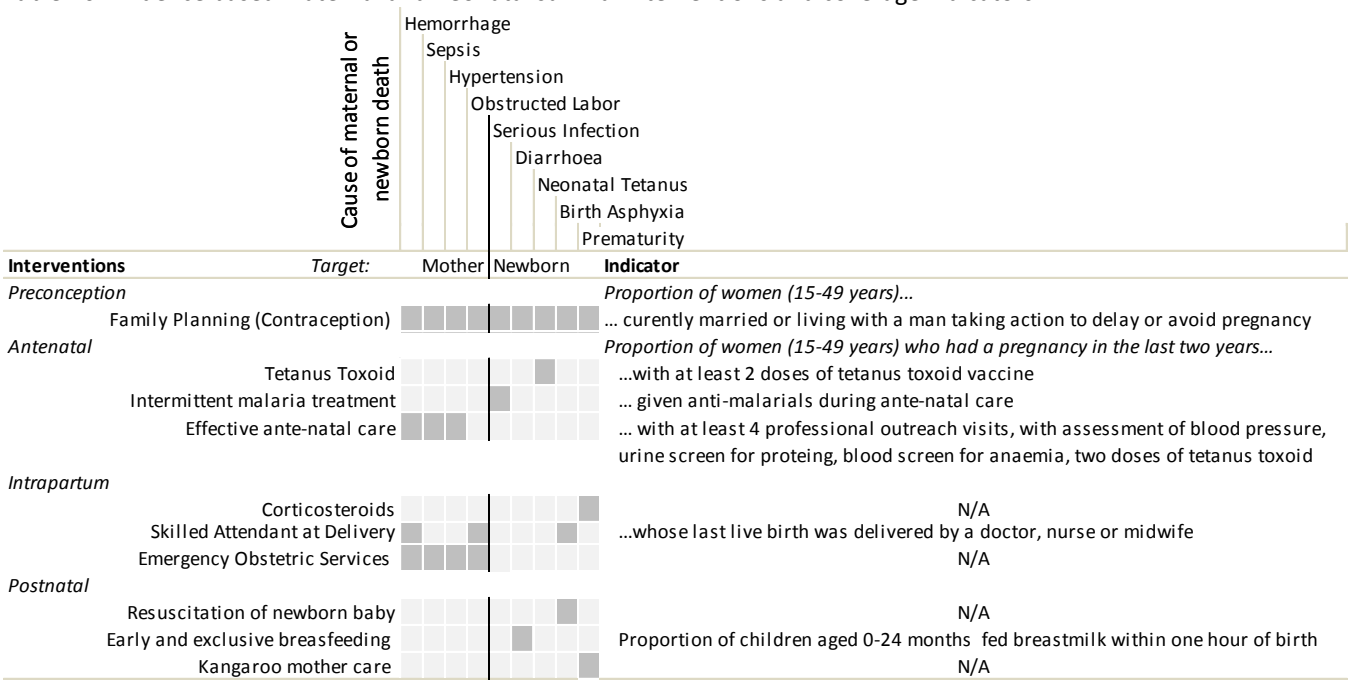
As births primarily occur in the home (in 2010, 85 percent of births occurred in the home) and close to 50 percent of births are delivered by traditional birth attendants, strategies to expand coverage of professional assistance during child birth need to take this into account. There is likely significant scope for training traditional birth attendants and providing them with safe delivery kits in the short run as a means to improve the conditions at birth for women and their newborns. A significant challenge in this setting, however, is to ensure women have access to emergency obstetric care if needed, which requires the availability of unscheduled 24 hour services close enough to the home to be able to respond during emergencies. As mobile phone penetration has increased significantly (ownership of mobile phones increased from less than 1 percent in 2006 to close to 20 percent in 2010 – with over half of households in urban areas owning a mobile phone in 2010) – there may be a role for leveraging this technology in areas with reliable reception to develop emergency obstetric response programs.



Data and methods

This section draws from the 2006 and 2010 SHHS as well as the 2009 NBHS and looks at the degree to which Sudanese mothers and their children across different sub-groups of the population receive preventive or treatment interventions - biological agents or actions intended to reduce morbidity or mortality. The interventions assessed are those with sufficient evidence of effectiveness in reducing cause-specific mortality and morbidity among mothers, newborns and children younger than five years in developing countries. Tables B6 and B7 display the evidence-based interventions included in this assessment, the diseases against which each intervention acts and the indicator used to measure the level of coverage for each. The interventions considered are not exhaustive. The prevalence of risk factors for each disease is also assessed where possible.

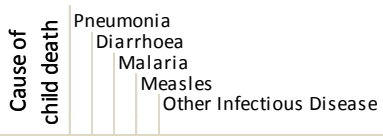
Table B6. Evidence based maternal and neonatal survival interventions and coverage indicators



Interventions	*Target:* Mother / Newborn	**Indicator**
Preconception		*Proportion of women (15-49 years)…*
Family Planning (Contraception)	Mother	… curently married or living with a man taking action to delay or avoid pregnancy
Antenatal		*Proportion of women (15-49 years) who had a pregnancy in the last two years…*
Tetanus Toxoid	Mother	…with at least 2 doses of tetanus toxoid vaccine
Intermittent malaria treatment	Mother	… given anti-malarials during ante-natal care
Effective ante-natal care	Mother	… with at least 4 professional outreach visits, with assessment of blood pressure, urine screen for proteing, blood screen for anaemia, two doses of tetanus toxoid
Intrapartum		
Corticosteroids	Newborn	N/A
Skilled Attendant at Delivery	Mother / Newborn	…whose last live birth was delivered by a doctor, nurse or midwife
Emergency Obstetric Services	Mother	N/A
Postnatal		
Resuscitation of newborn baby	Newborn	N/A
Early and exclusive breasfeeding	Newborn	Proportion of children aged 0-24 months fed breastmilk within one hour of birth
Kangaroo mother care	Newborn	N/A

Source: Adapted from (Dormstadt, Bhutta et al. 2005) and (Lawn, Zupan et al. 2006)

Table B7. Evidence based child survival interventions and coverage indicators



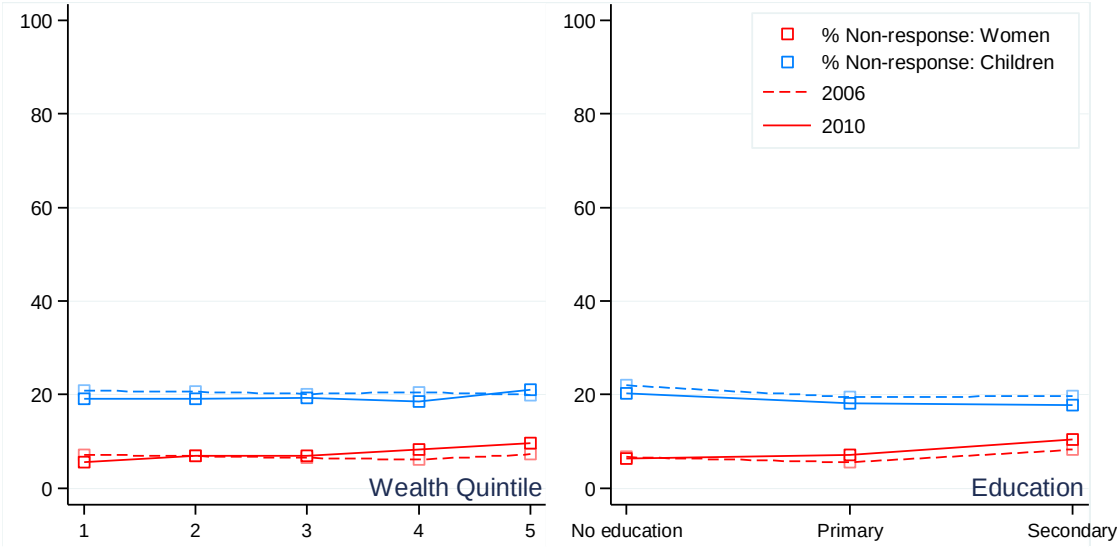
	Indicator
Breastfeeding initiation	Proportion of children (0-24 months) who were fed breastmilk within one hour of birth
Exclusive Breastfeeding	Proportion of children (0 -5 months) fed exclusively by mother's breastmilk in past 24 hours
Continued Breastfeeding	Proportion of children (12-15 months) with continued breastfeeding
Complementary feeding	Proportion of children (6-8 months) who received solid, semi-solid or soft foods in past 24 hours
Vitamin A	Proportion of children (5-59 months) receiving Vitamin A supplementation in last 6 months
Insecticide Treated Bednets	Proportion of households with at least one insecticide treated bednet
Water, Sanitation & Hygiene	Proportion of households with a protected source of water
Routine Immunizations	*According to immunisation card or mother's report:*
Measles	Proportion of children (12-23 months) with Measles (MMR) vaccine
BCG	Proportion of children (12-23 months) with Tuberculosis (BCG) vaccine
DPT3	Proportion of children (12-23 months) with 3 doses of Diptheria, Pertussis, Tetanus (DPT3) vaccine
Polio	Proportion of children (12-23 months) with at least 3 doses Polio (OPV) vaccine
Treatment Interventions	
Oral Rehydration Therapy	Proportion of children under 5 yrs with diarrhoea given oral rehydration salts or homemade fluid
Antimalarials	Proportion of children under 5 yrs with fever or malaria prescribed anti-malarials at health facility

Notes: Adapted from (Jones, Steketee et al. 2003)

To assess factors that are associated with access to care, a logistic regression is used to measure the relationship between the probability of receiving an intervention with characteristics of the household, mother and child: primarily education level, age, wealth and whether the household is an urban or rural setting. This analysis pools observations from the 2006 and 2010 SHHS and associations are summarized using the marginal effect of each covariate (for example, the marginal increase or decrease in probability that a mother will receive an intervention if she were in the richest wealth quintile rather than the poorest, all else equal), assessed against a "base" case: a women with no education, living in a rural household that classifies in the lowest quintile in the wealth distribution (Annex 4A explains in more detail the methods used).

Overall non-response among eligible women to the SHHS women questionnaire that provides the data for estimating coverage of key health interventions was 6.8 percent in 2006 and 7.7 percent in 2010 (Table B2) . If non-response is systematically associated with other attributes that influence intervention coverage (such as level of education or income, urban or rural household location, ethnicity) coverage estimates may suffer from a degree of selection bias depending on the strength of the association. Figure B11 shows the percentage of non-responding women and children under-five by household wealth and education of the mother. Interestingly non-response to the in-depth children's questionnaire was about twice as high as non-response to the women's questionnaire indicating that women withheld information about a subset of their children. There is not a strong association between the degree of non-response and household wealth in either the 2006 or 2010 SHHS women's or children's questionnaires for Sudan. There, is however, some indication that wealthier and more educated women, were slightly more likely to respond to the women's questionnaire than less educated women. The analysis presented in this section did not impute missing data and therefore assumes that missing data on interventions occur at random – that is children with missing data are equally likely to have received an intervention as not received an intervention. By state - as mentioned previously - overall non-response rates varied from 15 percent among women in Khartoum to 1 percent in Gezira in 2006, and 13 percent in Northern to 2.3 percent in Gezira in 2010. Assessing non-response rates by wealth status and education levels for each state reveals similar patterns as those observed for Sudan overall (Annex 4B provides a state by state display of non-response rates by education and wealth).

Figure B11. Non-response to women and under-five surveys, by wealth and education, Sudan



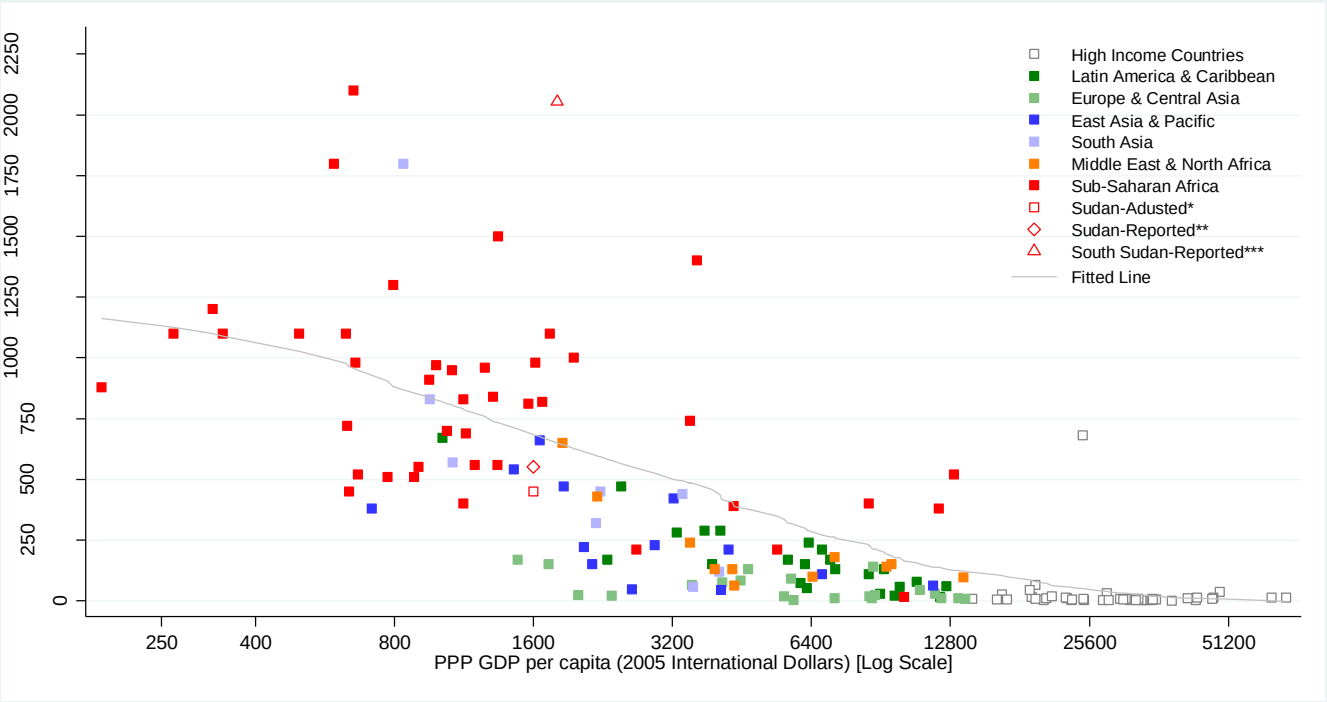
Source: Author's calculations based on 2006 and 2010 SHHS.
Notes: The education categories pertaining to children non-response rates reflect the educational levels of the head of the household in which the child resides.

Maternal and neonatal survival

The Maternal Mortality Ratio (MMR) (the number of maternal deaths per 100,000 live births) measures the level of obstetric risk - the probability women will die from direct or indirect causes once pregnant or 42 days after delivery. In 2005, the majority of global maternal deaths occurred in Sub-Saharan Africa (49 percent of all deaths) and South Asia (35 percent of all maternal deaths) (UN 2007). Sudan's MMR was estimated at 450[2] in 2005, compared to 900 for Sub-Saharan Africa and 200 for the Middle East and North Africa. As with under-five mortality, while large disparities in obstetric risk exist between countries at different stages of development (Figure B12), income levels alone do not fully explain the difference, especially among low and middle-income countries.

[2] The Maternal Mortality Ratio reported for Sudan is a model-based estimate derived from a regression model using information on fertility, birth attendants, and HIV prevalence. These estimates are developed by WHO, UNICEF, UNFPA and the World Bank.

Figure B12. Maternal mortality ratio (MMR) vs. GDP per capita, by country & region, 2005



Source: World Development Indicators 2010,
Notes: South Sudan's GDP is predicted using a linear regression of the logarithm of PPP GDP per capita and under-five mortality among all available countries. *Periodically, UNICEF, WHO, UNFPA and the World Bank evaluate nationally reported data and make adjustments to account for the well-documented problems of under-reporting and misclassification of maternal deaths and to develop estimates for countries with no data.** Reported by National Authority *** Reported in the 2006 SHHS report based on 2000 MICS2 survey data.

The lifetime risk of complications from pregnancy increases with the number of pregnancies and births experienced by women. Table B8 presents the distribution of women of reproductive age by number of children ever born according to five-year age groups for Sudan from most recent data sources. Data on the number of children ever born reflect the accumulation of births to women over their entire reproductive lifetime. Therefore, this measure does not necessarily reflect current fertility levels. In Sudan, the average age at first birth is 20 years old. Adolescent fertility rates in 2006, 2008 and 2010 (estimated from the 2006 SHHS, the census and 2010 SHHS) are estimated at 16,15 and 18 births for every 100 women between the ages of 15 and 19 (24 percent of adolescent women in 2010 were married). By age 20-24, around 50 percent of women has given birth. On average, women have given birth to three children by the time they are thirty and to about five children by the time they are forty. By the end of the childbearing period about one in ten women have never given birth.

Table B8. Percent of women by number of children ever born, Sudan

Proportion of Women by N° of Children Born	Mean N°	Mean N°	Mean N°	Conditional on

	Mother's Age Group	0	1	2	3	4	5	6 or more	of children ever born	of children surviving	of children deceased	at least one live birth: Proportion of children ever born, deceased at the time of survey
2006 SHHS												
Sudan	15-19	0.88	0.08	0.03	0.01	0.00	0.00	0.00	0.16	0.14	0.01	0.08
	20-24	0.55	0.17	0.15	0.08	0.03	0.01	0.00	0.92	0.83	0.08	0.09
	25-29	0.35	0.10	0.13	0.15	0.13	0.07	0.06	2.11	1.91	0.21	0.10
	30-34	0.22	0.07	0.10	0.12	0.13	0.14	0.22	3.36	3.02	0.35	0.10
	35-39	0.15	0.05	0.07	0.09	0.10	0.12	0.43	4.62	4.12	0.53	0.11
	40-44	0.10	0.04	0.04	0.08	0.10	0.12	0.52	5.44	4.81	0.71	0.13
	45-49	0.08	0.03	0.04	0.06	0.09	0.09	0.60	5.98	5.26	0.87	0.15
2008 Long Form Census												
Sudan	15-19	0.90	0.06	0.03	0.01	0.00	0.00	0.00	0.15	0.13	0.01	0.08
	20-24	0.62	0.12	0.13	0.07	0.04	0.01	0.01	0.87	0.80	0.07	0.08
	25-29	0.38	0.09	0.13	0.13	0.11	0.07	0.08	2.09	1.90	0.19	0.09
	30-34	0.29	0.06	0.09	0.11	0.12	0.11	0.22	3.13	2.84	0.30	0.10
	35-39	0.22	0.04	0.07	0.09	0.11	0.11	0.37	4.17	3.77	0.46	0.11
	40-44	0.20	0.04	0.06	0.08	0.10	0.10	0.43	4.62	4.16	0.60	0.13
	45-49	0.17	0.04	0.05	0.07	0.09	0.09	0.48	5.06	4.53	0.72	0.14
2010 SHHS												
Sudan	15-19	0.87	0.10	0.03	0.01	0.00	0.00	0.00	0.18	0.17	0.01	0.06
	20-24	0.50	0.19	0.17	0.10	0.04	0.01	0.00	1.02	0.94	0.08	0.08
	25-29	0.26	0.11	0.16	0.16	0.14	0.09	0.08	2.46	2.25	0.21	0.10
	30-34	0.19	0.06	0.11	0.13	0.13	0.13	0.26	3.60	3.27	0.33	0.10
	35-39	0.12	0.05	0.05	0.09	0.11	0.11	0.47	4.94	4.41	0.55	0.12
	40-44	0.08	0.05	0.05	0.06	0.09	0.11	0.56	5.66	5.07	0.70	0.13
	45-49	0.08	0.03	0.05	0.07	0.09	0.12	0.56	5.93	5.22	0.85	0.15

Source: Author's calculations using the 2006 and 2010 SHHS and 2008 Long Form Census.

Note: This analysis assumes that women without documented births who were unmarried at the time of interview have no children.

A rough measure of the risks of death from pregnancy is the age-specific proportion of all deaths ocurring during pregnancy, delivery or two months after pregnancy among women aged 15-49 (table B9). The age-weighted proportion of female deaths ocurring during the exposure period for pregnancy and post-delivery in Sudan in 2008 is 46 percent, with the highest percentage of pregnancy and delivery related deaths occuring between the ages of 20 and 24 years. Among states, the age weighted proportion of maternal deaths out of all female deaths is highest in North and South Darfur, Kassala, White Nile, Blue Nile and South Kordofan (above 50 percent) and lowest in Northern, River Nile and Gezira (below 30 percent).

Table B9. Percent of female deaths ocurring during pregnancy (in year prior to survey) by age at death, Sudan, 2008

Age at death	15-19	20-24	25-29	30-34	35-39	40-45	45-49
Percent of all reported female deaths (ages 15-49) ocurring during pregnancy, delivery or 2 months after delivery	42%	63%	44%	56%	38%	32%	17%
Proportion of population of reproductive age, by age group	11%	10%	9%	7%	6%	5%	3%

Source: Author's calculations based on 2008 long form census

The direct obstetric conditions that account for about 75 percent of maternal deaths are hemorrhage, sepsis, pregnancy-induced hypertension, obstructed labor and unsafe abortions; and for every death, around 16 or 17 pregnant women suffer long-lasting injuries or disabilities such as obstetric fistula, uterine prolapse, infertility and depression (Graham, Cairns et al. 2006). About 60 percent of perinatal deaths (including still births and neonatal deaths from any cause, during the perinatal period – 27 weeks of gestation to 28 days of life) are low birth weight (less than 2,500 grams), birth asphyxia and infection (neonatal sepsis, tetanus, congenital syphilis, HIV infection) (Graham, Cairns et al. 2006). Death to the mother and baby is highly concentrated near delivery, from the onset of labor or abortion to 48 hours postpartum or post abortion, highlighting the need for mothers to have professional care at the time of delivery. Mortality among babies is directly linked to complications experienced by mothers.

In Sudan, maternal conditions during pregnancy affect over one in three pregnant women (conditional on surviving pregnancy) and complications during labor or up to six weeks after delivery affect approximately one in every two pregnant women (table B10).

Table B10. Proportion of women experiencing obstetric complications, Sudan, 2006 and 2010

Conditional on women with pregnancy in 2 years prior to survey:	2006		2010	
	Mean	95% CI	Mean	95% CI
Complications during pregnancy (any)	0.60	(.576-.622)	0.36	(.335-.385)
Conditional on having reported at least one complication during pregnancy:*				
Hemorrhage (vaginal bleeding)	0.14	(.126-.155)	0.09	(.077-.1)
High Blood Pressure	0.25	(.228-.271)	0.09	(.078-.106)
Oedema (swelling of face or body)	0.30	(.279-.322)		
Severe headache	0.62	(.596-.645)		
High fever	0.63	(.606-.659)	0.58	(.547-.603)
Abdominal Pain	0.41	(.391-.438)	0.61	(.587-.631)
Convulsions	0.13	(.114-.153)	0.07	(.06-.085)
Painful urination	0.32	(.299-.347)	0.36	(.338-.384)
Jaundice	0.19	(.163-.214)	0.15	(.13-.179)
Severe breathlessness	0.26	(.232-.281)		
Vaginal discharge			0.21	(.184-.227)
Complications during labor/ postpartum (any)	0.45	(.42-.471)	0.55	(.526-.573)
Conditional on having reported at least one complication during labor:*				
Hemorrhage(vaginal bleeding)	0.28	(.249-.304)	0.14	(.123-.158)
High Blood Pressure			0.05	(.038-.059)
Oedema (swelling of face or body)	0.23	(.208-.26)	0.14	(.122-.16)
High fever	0.58	(.551-.611)	0.36	(.335-.385)
Abdominal Pain	0.48	(.455-.51)	0.37	(.348-.393)
Convulsions	0.16	(.13-.181)	0.07	(.052-.079)
Painful urination	0.32	(.296-.351)	0.20	(.182-.215)
Jaundice			0.04	(.036-.053)
Vaginal discharge	0.22	(.192-.24)	0.12	(.106-.135)
Prolonged labor (lasting more than 12 hours)	0.62	(.597-.648)	0.19	(.171-.213)
Swollen, painful breast	0.33	(.302-.36)	0.15	(.128-.171)
Dribbling of urine	0.09	(.066-.105)	0.03	(.021-.036)

Source: Author's calculations using 2006 and 2010 SHHS.

Notes: *Complication categories will not add up to 1 (100%) as women may experience more than one symptom concurrently.

Among women experiencing complications, ante-partum hemorrhage and hypertension (two of the most severe conditions) were cited by 14 percent of pregnant women in 2006 and 9 percent in 2010. Postpartum hemorrhage was reported among 28 percent of pregnant women in 2006 and 14 percent in 2010. In 2010, between 70 and 85 percent of interviewed women in South Darfur, White Nile, Blue Nile reported having complications during pregnancy; by contrast, in Red Sea and River Nile, reported rates of complication were much lower: at 28 and 33 percent, respectively.

Given the diversity of causes leading to maternal and perinatal conditions that threaten the health of women and newborns, there is no single intervention that warrants exclusive attention. Several opportunities and interventions exist to avert maternal and newborn mortality and morbidity that can be broadly grouped into three intervention pathways: preventing pregnancy, preventing complications and preventing death or disability from complications. The first pathway involves providing access to effective family planning; the second involves managing mild complications through quality antenatal, intra-partum and post-partum care while the third pathway involves providing effective, timely and appropriate emergency obstetric care (Graham, Cairns et al. 2006).

Population based interventions to reduce adverse outcomes for mothers and newborns include actions aimed at changing fertility behavior and those aimed at reducing the numbers of underweight and micronutrient deficient mothers. Malnourished women are more likely to deliver premature or small babies who are themselves more likely to die or suffer from suboptimal growth. Maternal nutritional status is usually measured using a reference body-mass index (BMI) of less than 18.5 kg/m^2 and a reference height of 145cm. Data on the height and weight of women of reproductive age is not available for Sudan from nationally representative surveys but as a reference, the percentage of women aged 15-49 with low BMI among neighboring countries with data ranges from a low of 0.6 percent in Egypt to a high of 38 percent in Eritrea. Short stature ranges from 0.6 percent of women in Chad to 2.6 percent in Tanzania (Black, Allen et al. 2008). Maternal short stature is a risk factor for complications at delivery and low maternal BMI is associated with intrauterine growth restriction (which refers to the poor growth of a baby while in the mother's womb during pregnancy). Assessing the extent of population-level nutritional interventions for girls, adolescents and women of reproductive age to address adverse maternal outcomes is beyond the scope of this current study. The provision of iron and folic acid supplementation during routine antenatal care at the primary level, however, is a recommended strategy for which there is data from the SHHS. In Sudan, the percentage of pregnant women (in the two years prior to the survey) taking iron supplementation was 49 percent in 2006 and 79 percent in 2010 - with all states, reaching over 65 percent of women in need in 2010. Effective nutritional strategies, however, need also address the long-term, chronic and intergenerational nature of undernutrition.

Evidence from this study and elsewhere links child mortality with the number, spacing and timing (in relation to mother's age) of pregnancies. In addition, unwanted or mistimed pregnancies brought about by lack of effective contraception carry risks for the mother – including unsafe abortion and sexually transmitted diseases. Effective family planning promotes delaying the age of first pregnancy to after 18 years of age, adequate spacing of births between 2 and 3 years and provides information, education and communication on contraceptive options. Here, contraceptive prevalence – the proportion of women of reproductive age currently married or living with a man using some form of contraception to delay or avoid pregnancy – is used as an indicator of the coverage of family planning services in Sudan.

Table B11. Marriage status and desire for children by women's age group, 2010, Sudan

	Urban		Rural	
Age	Mean	95% CI	Mean	95% CI
Married or living with other man				
15-19	14.63	(10.98-18.28)	28.2	(25.4-31.1)
20-24	42.49	(37.06-47.93)	62.3	(59.1-65.6)
25-29	67.6	(63.34-71.86)	79.7	(77.2-82.2)
30-34	78.91	(73.86-83.96)	82.5	(79.7-85.3)
35-39	80.9	(76.47-85.33)	85.5	(82.8-88.1)
40-44	84.95	(80.28-89.61)	84.4	(81.5-87.2)
45-49	85.69	(80.89-90.48)	80.3	(76-84.7)
Did not want previous birth (if women gave birth in past 2 years)				
15-19	82.5	(71.3-93.8)	90.2	(86.4-94)
20-24	79.2	(73.6-84.9)	88.8	(86.4-91.3)
25-29	75.3	(70.5-80)	87.7	(85.1-90.3)
30-34	74.8	(67.9-81.7)	84.1	(80.4-87.7)
35-39	78.2	(71.9-84.6)	81.5	(77.7-85.3)
40-44	67.3	(48.9-85.7)	78.1	(71.5-84.7)
45-49	87.7	(73.4-102.1)	76.9	(65.7-88.1)
Did not want current pregnancy (if pregnant)				
15-19	12.5	(0.7-24.2)	16.7	(7.1-26.3)
20-24	26.2	(14.1-38.2)	22.1	(16.7-27.5)
25-29	30.2	(20.2-40.1)	22.6	(17.6-27.5)
30-34	27.9	(16.9-38.9)	24.1	(16.2-32)
35-39	13.6	(3.9-23.4)	21.8	(14.1-29.5)
40-44	59.3	(25-93.5)	26.8	(13-40.6)
45-49	33.2	(-17.7-84.2)	17.2	(-9.7-44.1)
Does not want future pregnancy				
15-19	6	(1.9-10.1)	4.4	(2.4-6.4)
20-24	8	(4.1-11.8)	5.1	(3.7-6.6)
25-29	15.7	(11.9-19.5)	8.5	(6.4-10.7)
30-34	22.8	(17.2-28.4)	20.6	(17.5-23.7)
35-39	35.4	(30.3-40.5)	28.8	(25.1-32.6)
40-44	59	(50.6-67.5)	52.6	(48.1-57)
45-49	74.8	(67.7-81.9)	67.1	(61.5-72.7)
Contraceptive Prevalence				
15-19	14.1	(5.8-22.4)	4	(2-6.1)
20-24	18.9	(13-24.8)	6.1	(4.4-7.9)
25-29	23.2	(18-28.5)	7.2	(4.9-9.5)
30-34	22.1	(17.2-27)	7.8	(5.6-10)
35-39	22.3	(17.6-27.1)	7.4	(5-9.7)
40-44	22	(14.6-29.4)	6.3	(4.2-8.4)
45-49	11.8	(6.7-16.9)	2.7	(1.2-4.2)

Source: Author's calculations based on 2010 SHHS

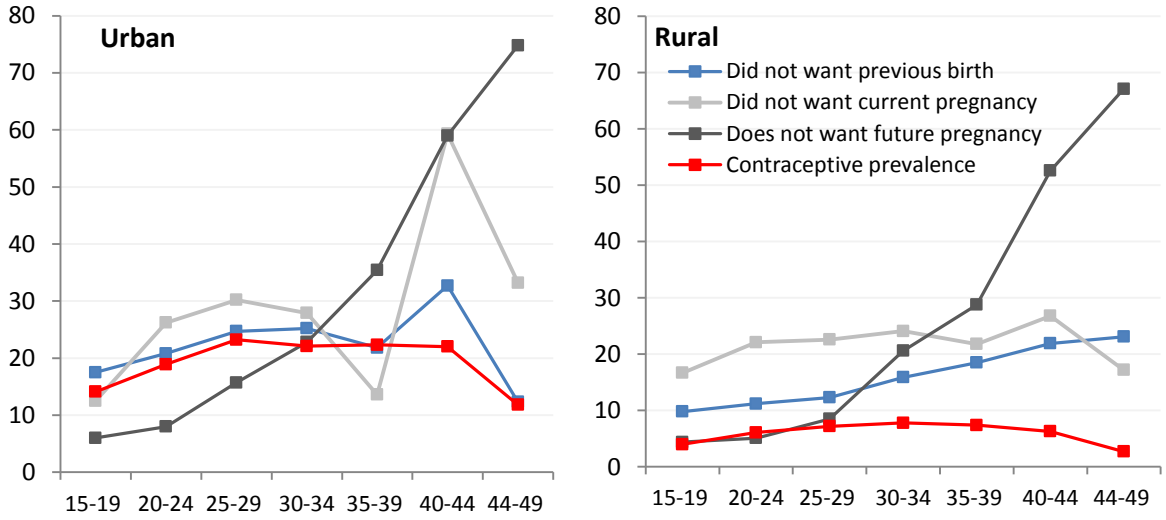
In 2010, 11 percent of married or cohabiting women used some form of contraception (Figure B14) – statistically indistinguishable from the contraceptive prevalence of in 2006 (9 percent). Statistically significant increases in the use of contraception are evident in three states between 2006 and 2010: West Darfur, South Kordofan and White Nile.

Contraceptive prevalence was 20 percent in urban areas versus 4.6 percent in rural areas and 3.3 percent among mothers with no education versus 25 percent among mothers with secondary education or higher. By comparison, contraceptive prevalence for Africa was 28 percent and for the Middle East and North Africa 54 percent between 2005 and 2009 (UNData 2012).

Exploring the reasons for low contraception use is important because low usage does not necessarily imply lack of access, and strategies for encouraging increased use of family planning methods need to be based on the reality of the decision-making process underlying fertility choices. The demand for contraception depends on whether women and their partners desire children and whether women have sufficient power (in cases where the fertility desires between men and women diverge) to influence decisions. Among women having had a live birth in the two years prior to the SHHS, in 2010, 23 percent in urban areas did not want their last birth compared to 14 percent in rural areas. A more prospective measure of the demand for contraception is the percentage of women not wanting to become pregnant in the future. In 2010, 29 percent of women in urban areas and 21 percent in rural areas did not want a future pregnancy. Table B11 disaggregates the marriage status, desire for pregnancy and use of contraception among women by their age group in 2010. Figure B13 displays these results graphically. Some salient observations are worth noting: (1) the percentage of married

women is lower in urban (57 percent) compared to rural (67 percent) settings suggesting greater economic or schooling opportunities for women in urban areas (Marriage rates did not change between 2006 and 2010). (2) Younger women (ages 15-30) reported not wanting previous or current pregnancies at a higher rate than future pregnancies relative to older women (ages 30-49) (Figure B13). One explanation may be that younger women who have given birth or are currently pregnant became pregnant sooner than desired and that older women are more likely to have already had their desired number of children. (3) In rural areas, use of contraception is generally lower than the demand for contraception (measured either by not having wanted a current pregnancy or a desire to avoid a future one) suggesting that barriers to access constrain contraceptive use – this is especially true for women past the age of 30, where the difference between demand for and actual use of-contraception is particularly large. In Urban areas on the other hand, the data suggests that much of the demand for contraception is met between the ages of 15 and 30.

Figure B13. Demand for contraception, by women's age group, Sudan, 2010



Source: Author's calculations based on 2010 SHHS

The use of modern contraception (injectable and oral hormones, implants, intrauterine devices, spermicides, condoms, diaphragms, female and male sterilization) expanded from 7.8 to 19 percent between 2006 and 2010 among women in urban areas. For women in rural areas, use of modern contraceptive increased from 3 to 5.6 percent between 2006 and 2010 and the use of traditional methods remained at 1 percent. The most commonly used methods for contraception in 2010 among couples using contraception were pills (73 percent), injectables (11 percent), lactational amenorrhea (5 percent) and periodic abstinence (4.5 percent). Less than 2 percent of women reported using male condoms as a form of contraception.

Compared to family planning and nutrition, which are interventions that can take a wider population-based approach, interventions directed at individuals require a continuum of care for the mother and baby in terms of time (before and after delivery), place (linking home and health services through effective referral) and person (the provider of care) (Graham, Cairns et al. 2006).

While the role of home-based and community care in Sudan is a necessary strategy to prevent adverse maternal and child outcomes (given that close to three in four births are delivered in the home (table B12)) these strategies are not sufficient. Home-based and community care is critical as a means to provide information, education and birth preparedness as well as promote male involvement to support care-seeking behavior. In addition involvement of the community in helping shape locally appropriate messages to promote health-seeking behavior and newborn care best practices can be effective. However, there is ample evidence that the chances of survival for mother and child are greatly improved if the mother can benefit from professional care (Koblinsky, Mathews et al. 2006). Child survival during the first 28 days of life requires a safe birth. A safe birth in turn, requires that women have access to a range of thoughtful and effective care: from routine antenatal care to delivery care to emergency obstetric services at the secondary level.

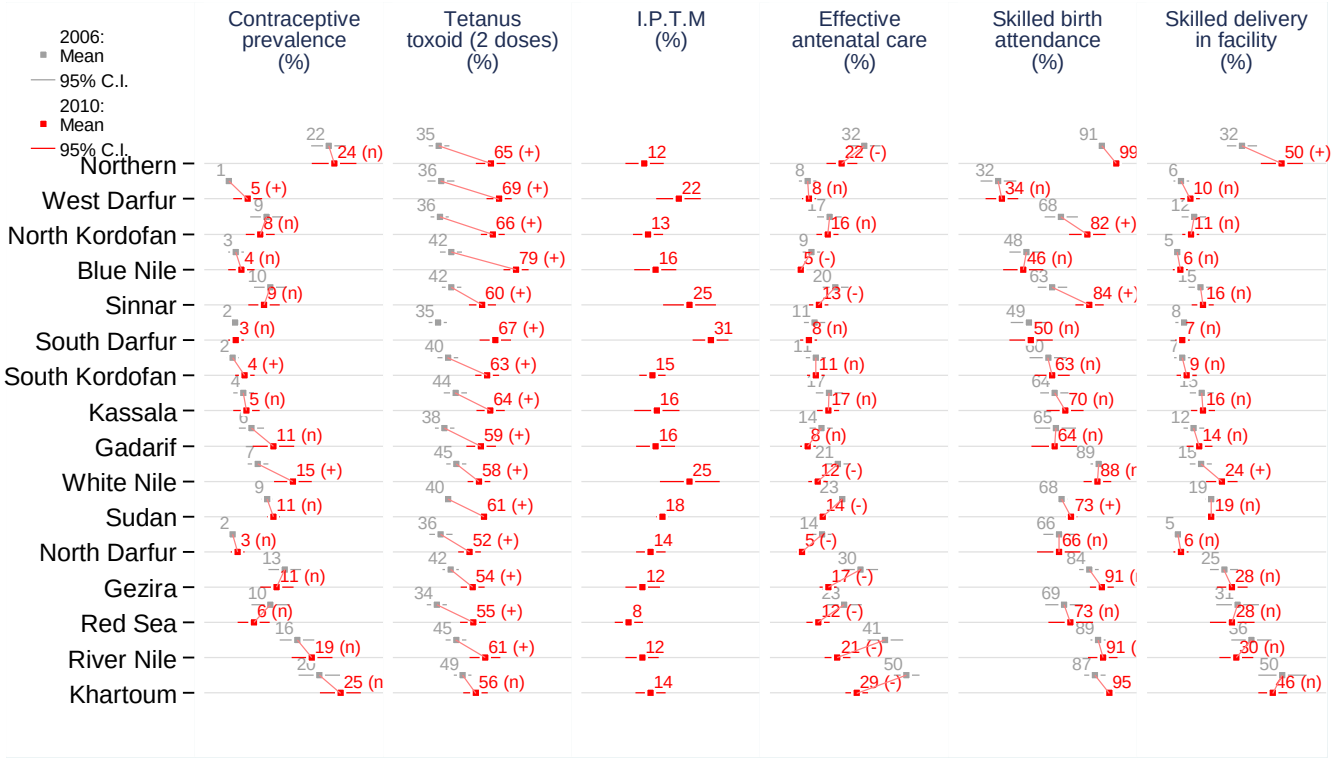
Table B12. Place of delivery among women giving birth in two years prior to survey, Sudan, 2006 & 2010

Place of Delivery	Year	Wealth Quintile		Mother's Education			Household Setting		Sudan
		Poorest	Richest	None	Primary	Secondary or Higher	Rural	Urban	
Home	2006	91.3	43.7	86.4	75.2	45.9	85.1	58.9	75.4
	2010	86.8	42.0	84.2	72.2	44.0	79.6	54.3	72.9
Hospital	2006	5.1	47.8	8.6	18.2	47.4	10.1	33.4	18.7
	2010	5.3	45.5	7.4	20.8	44.1	12.9	34.8	18.7
Primary Health Care Facility	2006	0.9	1.0	1.4	0.9	0.8	1.1	1.2	1.1
	2010	1.0	0.8	0.7	1.1	1.0	0.9	0.8	0.9
Other	2006	0.2	0.9	0.3	0.5	0.7	0.3	0.8	0.5
	2010	0.4	5.1	0.6	0.5	4.7	0.6	3.1	1.3

Source: Author's calculations based on 2006 and 2010 SHHS.

Five measures are used here to gauge the extent to which mothers have access to effective and skilled care (table B6): (1) coverage of tetanus toxoid vaccine among pregnant women (which is provided as a component of antenatal care); (2) coverage of intermittent presumptive treatment for malaria among pregnant women (3) coverage of effective antenatal care among pregnant women, defined as at least four outreach visits with a doctor, nurse or midwife, during which the women was given an assessment for blood pressure, a urine screen for protein and a blood screen for anemia as well as two doses of tetanus toxoid vaccination; (4) assistance during birth by a doctor, nurse or midwife and (5) assistance during birth by a doctor, nurse or midwife in a hospital or primary health care facility (used as a proxy to gauge the extent to which pregnant women have access to some level of emergency care in a clinical setting should the need arise).

Figure B14. Maternal and neonatal survival interventions



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: States or ordered based on largest average percentage point improvement in coverage between 2006 and 2010 across the five indicators. (+) Difference between means in 2010 and 2006 is positive and significant at the 95% level. (-) Difference between means in 2010 and 2006 is negative and significant at the 95% level. (nd) no evidence of statistical difference in means between 2006 and 2010. I.P.T.M = Intermittent Presumptive Treatment for Malaria

Maternal and neonatal tetanus (MNT) is a vaccine preventable disease that is a major cause of newborn death worldwide commonly resulting from unhygienic cutting of the chord or care of the chord stump. One of the key recommended strategies to reduce child deaths from tetanus is the provision of at least 2 doses of tetanus toxoid vaccine to women during pregnancy. Between 2005 and 2009, the percentage of women aged 15-49 having had a pregnancy in the 2 years prior to the survey with at least 2 tetanus toxoid vaccines increased from 40 to 61 percent (with increases in coverage occurring in all states).

Intermittent presumptive treatment for malaria (IPTM), a recommended antenatal intervention in malaria endemic areas, averaged 18 percent for Sudan in 2009, ranging from a high of 31 percent in South Darfur to a low of 8 percent in Red Sea. There were no data available from the 2006 SHHS to make comparisons over time. It is important to note that rather than only suggesting differences in the efficiency of treatment delivery, the degree of IPTM coverage also reflects different degrees of malaria endemicity, and therefore need, across Sudan's states.

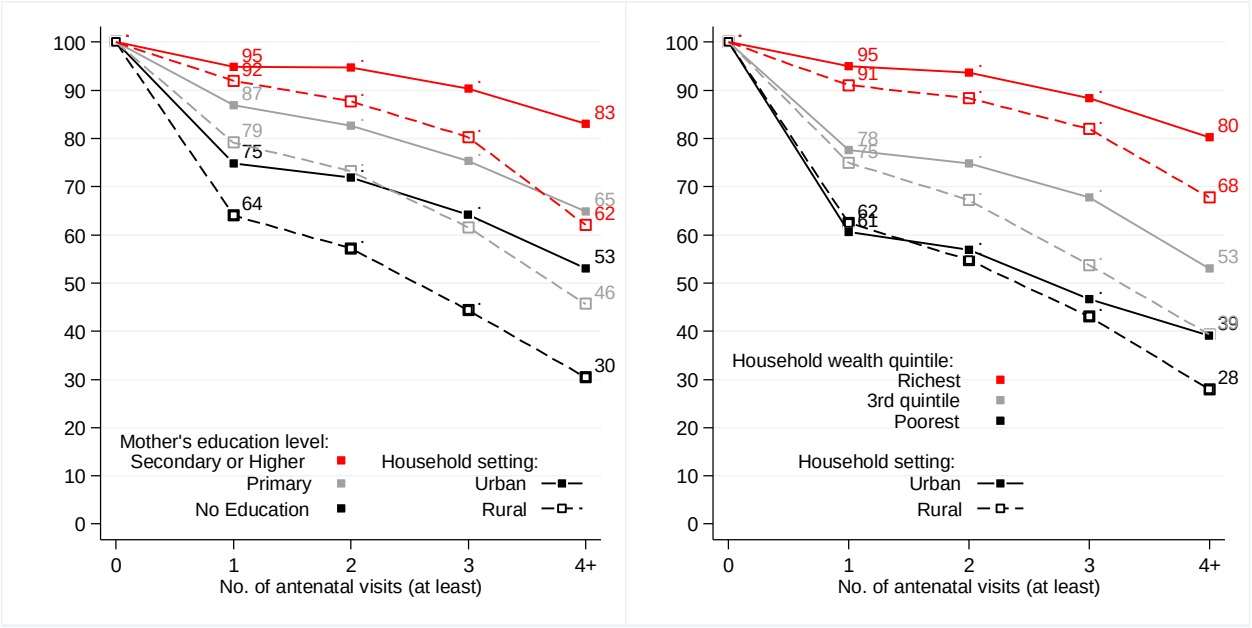
Relative to the provision of individual interventions, the health system performs poorly in delivering an overall package of effective antenatal care. Between 2004 and 2006 and 2008 and 2010, only 14 percent of pregnant women reported receiving an effective package of antenatal services.

The fact that so few women benefit from an effective package of antenatal care yet a relatively higher percentage benefit from individual interventions (such as iron supplementation or tetanus toxoid vaccines) reflects the additional challenge of delivering interventions that require repeated interactions and consistent engagement with the population. This difficultly likely reflects a mix of demand and supply side factors. For example, a pregnant woman in a rural household who is responsible for household tasks, tending to crops and caring for children might not prioritize visiting a clinic for a check-up until perceived benefits outweigh costs such as when something tangible is offered (like an injection or pill) or during an emergency. If the direct costs per facility visit are high, she may have to wait until she has saved sufficient cash to afford transportation to the clinic or to pay any associated fees at the point of care.

Figure B15 illustrates the effect of supply and demand factors in relation to antenatal care. The graph displays the percentage of women benefitting from at least zero (100 percent of pregnant women) to at least four antenatal visits during their last pregnancy (in the two years prior to the 2010 SHHS), in effect showing the points during the antenatal visit schedule at which pregnant women "drop out" of routine antenatal care. The left panel disaggregates this schedule by mother's education level and urban or rural household setting while the right panel disaggregates the schedule by the mother's wealth status and urban or rural household setting. Four observations are salient: (1) a significant number of the poorest (approximately 40 percent) and uneducated women (approximately 30 percent) never make it to a primary health care facility or hospital for a single antenatal visit (2) among women who do make it to a facility (regardless of education, wealth or household setting) for a first visit, between 45 and 84 percent return for a minimum of four visits, with the degree of attrition highest among the poor and uneducated (3) the demand for antenatal care increases with women's education and wealth (regardless of household setting) (4) households in rural settings have a more difficult time accessing care regardless of education or wealth.

Expanding preventive antenatal care for women hinges importantly on stimulating demand for care – through education, communication, improving the quality of care and reducing financial barriers at the point of care – as well as targeting investments in remote rural communities without ready access to primary health care facilities. This may include expanding health worker training, providing affordable transportation to health centers, improving roads and improving drug supply chains.

Figure B15. Number of antenatal visits, by education, wealth and household setting, Sudan, 2010



Source: Author's calculations based on 2010 SHHS

In 2000, approximately 50 percent of women in all low and middle-income countries were able to access professional care at childbirth. In Sub-Saharan Africa and the Middle East and North Africa, large discrepancies in coverage exist between women living in rural areas (30 percent coverage) and women living in urban areas (70 percent coverage). In Sudan– among women of reproductive age with a pregnancy in the two years prior to the survey - skilled birth attendance (births attended by a doctor, nurse midwife or village midwife) covered 68 percent of live births between 2004 and 2006 and 73 percent between 2008 and 2010. Across states, skilled birth attendance ranges from a high of 99 percent in Northern to a low of 34 percent in West Darfur. Coverage improved in four states between 2006 and 2010: Khartoum, North Kordofan, Northern and Sinnar.

In urban settings, skilled birth attendance increased from 82 percent in 2006 to 92 percent in 2010, while in rural settings coverage was 60 percent in 2006 and 67 percent in 2010. By comparison, in-facility births attended by a professional did not change during the 4 year period (19.4 percent of pregnant women gave birth with the help of a professional in a facility in 2006 and 2010). Among women in urban and rural areas, skilled deliveries in facilities were 35 and 14 percent in 2010, respectively. Delivery by a doctor is primarily the experience of educated women in wealthy, urban households; for uneducated mothers in poor and rural households, auxiliary midwives, traditional birth attendants and community health workers play a much larger role (Table B13).

While assessing the degree of coverage of professional staff is important, it is also critical for the Ministry of Health and health worker training institutions to assess the degree to which these providers are adequately trained to provide effective care such as identifying high-risk pregnancies and to perform simple – potentially life-saving procedures – at the time of delivery.

Table B13. Assistance at delivery, Sudan, 2006 & 2010

Person assisting at delivery		Year	Wealth Quintile		Mother's Education			Household Setting		Sudan
			Poorest	Richest	No Education	Primary	Secondary or Higher	Rural	Urban	
Professional Cadres	Doctor	2006	3.5	36.6	5.0	13.1	36.3	7.1	23.9	13.3
		2010	3.8	39.5	4.8	15.0	37.1	9.1	28.2	14.2
	Nurse Midwife	2006	11.4	37.8	16.1	29.1	36.5	19.4	32.2	24.1
		2010	3.3	12.4	4.2	8.4	12.8	5.8	11.3	7.3
	Auxiliary/ Village Midwife	2006	28.0	38.8	33.5	45.6	38.7	37.0	41.2	38.5
		2010	40.2	45.6	45.2	60.4	48.2	50.8	53.7	51.6
	Medical Assistant	2006	Category not used in 2006							
		2010	0.0	0.0	0.2	0.2	0.1	0.2	0.3	0.2
	Health Visitor	2006	Category not used in 2006							
		2010	1.1	8.2	1.4	3.9	8.0	2.4	6.5	3.5
	Traditional Birth Attendant	2006	44.1	4.1	34.2	14.5	3.7	29.5	9.6	22.1
		2010	46.9	0.8	37.1	11.2	1.3	27.4	3.6	21.1
	Other	2006	11.3	6.1	12.8	9.4	5.1	11.4	8.5	10.3
		2010	2.9	0.8	2.7	2.0	1.0	2.2	1.9	2.1
	No Assistance	2006	6.4	4.6	7.0	3.9	3.1	5.1	5.5	5.2
		2010	3.6	0.4	6.3	2.7	0.1	4.2	3.0	3.9

Source: Author's calculations based on 2010 SHHS

Notes: Other includes community health workers, relatives and other

With the exception of effective intermittent presumptive treatment for Malaria, the educational attainment of mothers is positively associated with contraceptive use and professional maternal antenatal and delivery care. Holding other factors constant, the education effect is largest for skilled birth attendance (mothers with primary and secondary education are 18 and 27 percentage points more likely to be assisted at birth compared to mothers without education) and smallest for contraception (mothers with primary and secondary education are 4 and 7 percentage points more likely to use contraception relative to mothers without education). Household wealth is associated with all maternal care interventions (with the exception of intermittent presumptive therapy for Malaria, which is expected as Malaria is not endemic across all of Sudan). Holding other factors constant, the wealth effect is largest for skilled birth attendance (mothers in the richest households are 30 percentage points more likely than mothers in the poorest households to be assisted during delivery) and smallest for contraception (where mothers in the richest households are 11 percentage points more likely than mothers in the poorest households to deliver in a facility). Mothers in urban areas are more between 6 and 8 percentage points more likely to receive professional antenatal care and care during delivery than mothers in rural areas, holding other factors constant, suggesting a shortage of professional care staff in rural areas. These results are summarized in table B14.

Table B14. Marginal effects for the association between maternal intervention coverage and select demographic variables

	Contraception		Tetanus Toxoid (2 doses)		Intermittent Preventive Therapy for Malaria		Effective Ante-natal care		Skilled Birth Attendance		Skilled Delivery in Facility	
	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t

Mother's Education												
None						[reference]						
Primary	0.05	7.05	0.09	5.21	0.01	0.33	0.07	5.02	0.18	8.84	0.03	2.17
Secondary or Higher	0.08	8.04	-0.01	-0.64	0.01	0.26	0.17	7.50	0.27	11.38	0.16	7.00
Mother's Age *												
Household Setting	0.00	1.78	0.05	9.90	0.00	0.28	0.01	2.12	0.01	1.40	0.01	1.36
Rural						[reference]						
Urban	0.01	1.06	0.03	1.77	0.01	0.70	0.07	3.76	0.06	2.20	0.08	4.09
Household Wealth												
Poorest						[reference]						
2nd quintile	0.01	1.05	0.06	2.31	0.02	1.20	0.06	3.41	0.09	3.34	0.03	1.68
3rd quintile	0.03	3.88	0.11	3.79	-0.01	-0.53	0.12	6.54	0.19	5.92	0.04	2.12
4th quintile	0.06	5.74	0.12	4.29	-0.02	-0.67	0.20	9.83	0.27	8.28	0.11	5.04
Richest	0.11	8.75	0.14	4.16	-0.03	-0.95	0.29	12.20	0.30	7.97	0.25	7.88
Year												
2006						[reference]						
2010	0.01	2.57	0.22	13.5	N/A		-0.07	-7.02	0.07	3.54	0.02	1.84
N	20,658		10,964		5,740		11,798		11,357		11,796	

Source: Author's calculations based on 2006 and 2010 SHHS.

Notes: *Mother's age represents five year age groups, so the marginal effects should be interpreted as the change in probability of coverage associated with a 5 year increase in the mother's age.

Nutritional status and infant and young child feeding

Under nutrition encompasses stunting, wasting and deficiencies of essential vitamins and minerals. Stunting and wasting is characterized by comparing the weights and heights (lengths) of children of a certain age and sex to the weight and heights of healthy children (of the same age and sex) from a reference population[3]. These comparisons yield z-scores – the difference between a child's weight or height and the median value at that age and sex in the reference population divided by the standard deviation in the reference population. Stunting (a height for age z-score that is less than 2 standard deviations below the median of the reference population), wasting (a weight for height z-score that is less than 2 standard deviations below the reference median) and underweight (a weight for age z-score that is less than 2 standard deviations below the reference median) are three common indicators used to measure undernutrition in a population. Monitoring stunting and wasting is more useful as underweight encompasses the effects of both and the determinants of stunting and wasting may be different and respond to different interventions.

Growth faltering

Stunting generally results from chronic undernutrition whereas wasting results from poor nutrition in the short term. Prior studies have noted the role of food insecurity (infrequent meals, lack of food variety and lack of meat) and an inadequate social and care environment (women's heavy workloads that prevent good feeding practices, limits on food intake during pregnancy and lactation) in preventing good nutrition (Theuri 2007), broader nutritional assessments underscore the role of infectious disease in children which worsens malnutrition, the

[3] Currently, two reference standards are in use: one from the World Health Organization (WHO) and the other from the National Center for Health Statistics (NCHS). The WHO standards are used in this report to measure stunting, wasting and underweight.

role of traditional beliefs and customs which are at odds with feeding best practices and the inequitable distributions of food within the household (Harvey and Rogers-Witte 2007). In addition, the causes of undernutrition are varied, depending on geographic or livelihood area (which will moderate the availability and access to food through climactic and soil conditions) and ethnic group. Income poverty – the lack of employment, poor living conditions, savings and access to capital is also a major underlying cause of under nutrition.

Childhood malnutrition has significant long-term effects, including diminished adult intellectual ability, work capacity and productivity which ultimately lead to economic hardships for individuals and their families. For children of school-age, poor nutrition limits cognitive ability and school readiness. From a health standpoint, under-nutrition increases vulnerability to disease and the likelihood of death from disease. Worldwide, 19 percent of under-5 deaths are directly attributable to being underweight. Even children who are mild to moderately underweight (weight-for-age less than 1 standard deviation below the reference mean) are at increased risk of death. In Sub-Saharan Africa, an estimated 1.3 million deaths are attributable to undernourished children (weight-for-age less than 1 standard deviation below the reference mean). In addition, there is growing evidence that early malnutrition is a risk factor for developing chronic diseases later in life such as diabetes, hypertension, renal disease and cardiovascular disease which are costly to manage. Infants and young children falter in their growth due to inadequate diets and recurrent illness which reduce appetite, increase metabolic requirements and increase nutrient loss (Caulfield, Richard et al. 2006).

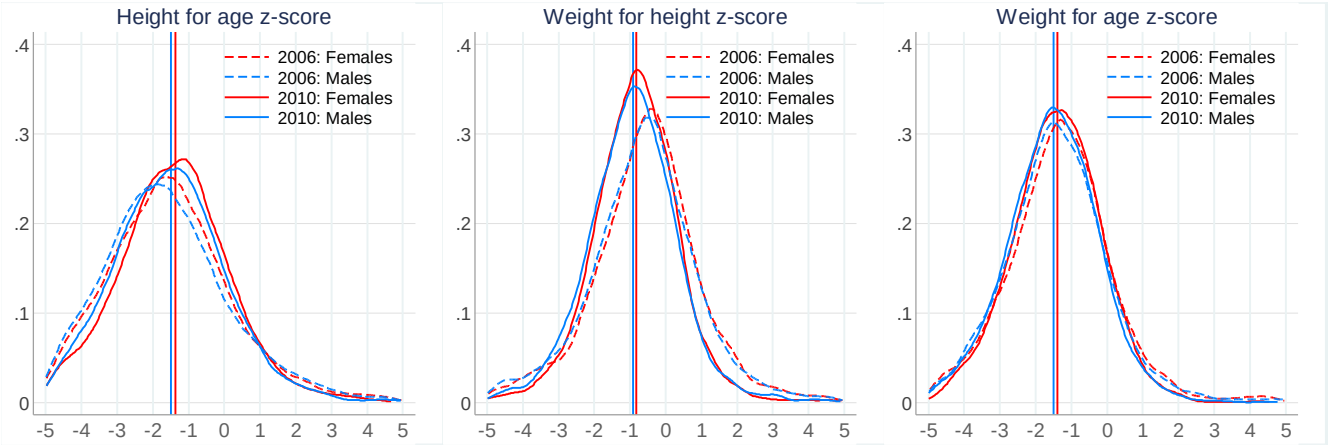
In 2010, the prevalence of underweight, stunted and wasted children under the age of five in Sudan was 28, 35 and 13 percent, respectively (table B15 to B17). By comparison, regional estimates of underweight, stunting and wasting prevalence in 2010 place Eastern Africa at 22, 45 and 9 percent, respectively, and North Africa at 8, 22 and 10 percent, against a backdrop of stagnant rates in Africa as a whole, where – since 1990 - underweight prevalence has remained at 20 percent, stunting prevalence at close to 40 percent and wasting prevalence at close to 10 percent (Onis, Blossner et al. 2011) (Department of Nutrition 2011). Since 2006, as measured by weight-for-age, the overall nutritional status of Sudan's children has not improved on average. While stunting prevalence fell from 40.6 in 2006 to 34.7 percent in 2010, wasting prevalence remained in the from 12 to 13 percent range. Severe wasting over this time period declined from 4.5 to 3.3 percent.

On average, female children have better nutritional outcomes than males. Figure B16 shows the distribution of height for age, weight for height and weight for age z-scores for males and females. In each case, the mean z-score for females is greater than the mean z-score for males. This result is also apparent when comparing the prevalence of underweight, stunted and wasted females in males in tables B15 through B17.

Stunting prevalence shows a discernible age-pattern (figure B17). Children between the ages of 6 to 23 months are about 50 percent less likely to be stunted relative to children between the ages of 0-5 months and 24-60 months of age. Of note, is that the decline in stunting prevalence between 2006 and 2010 occurs across all age groups. The observed age-pattern may suggest that children are born with a nutritional disadvantage (possibly resulting from maternal malnutrition and low birthweight) but gain nutritional advantage in the first year of life with good breastfeeding practices. Nutritional outcomes subsequently deteriorate, possibly as a result of inadequate transition to other foods that may be insufficient in quantity or lacking in key nutrients and as a result of more exposure to the environment, increasing their likelihood of illness. This hypothesis is supported by studies have established the relationship between episodes of diarrhea and increased odds of stunting at 24

months of age (Black, Allen et al. 2008). The age pattern for wasting (Figure B18) suggests that the nutritional risks causing reduced weight climb and then decline with age (children between 1 and 3 years of age have the highest wasting prevalence). Figure B19 displays the evolution of the average weight for age, height for age and weight for height z-scores with age for each state in Sudan. While there is significant variation by state, the general pattern that emerges is that nutritional outcomes measured by the height-for-age z-score drops sharply after birth, with average z-scores approaching and often falling below the -2 standard deviation mark by 40 months of age. Average weight for height z-scores on the other hand are more uniform over age and tend to remain close to the -1 standard deviations mark.

Figure B16. Wasting prevalence by sex, age group and year, Sudan



Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.
Notes: The 2010 mean z-values are represented as vertical lines.

Table B15. Underweight and severe underweight prevalence by age, sex and year (all ages), Sudan

	2006				2010			
	Severe underweight		underweight		Severe underweight		underweight	
	% < -3SD	(95% CI)	% < -2SD	(95% CI)	% < -3SD	(95% CI)	% < -2SD	(95% CI)
Both Sexes	9.7	(8.8- 10.7)	27	(25.6- 28.4)	9	(8.3- 9.8)	28.1	(26.9- 29.4)
Males	10.3	(9.2- 11.4)	28.1	(26.4- 30)	9.7	(8.8- 10.6)	29.4	(27.9- 30.9)
Females	9.2	(8.2- 10.3)	25.8	(24.4- 27.3)	8.2	(7.4- 9.1)	26.8	(25.4- 28.3)

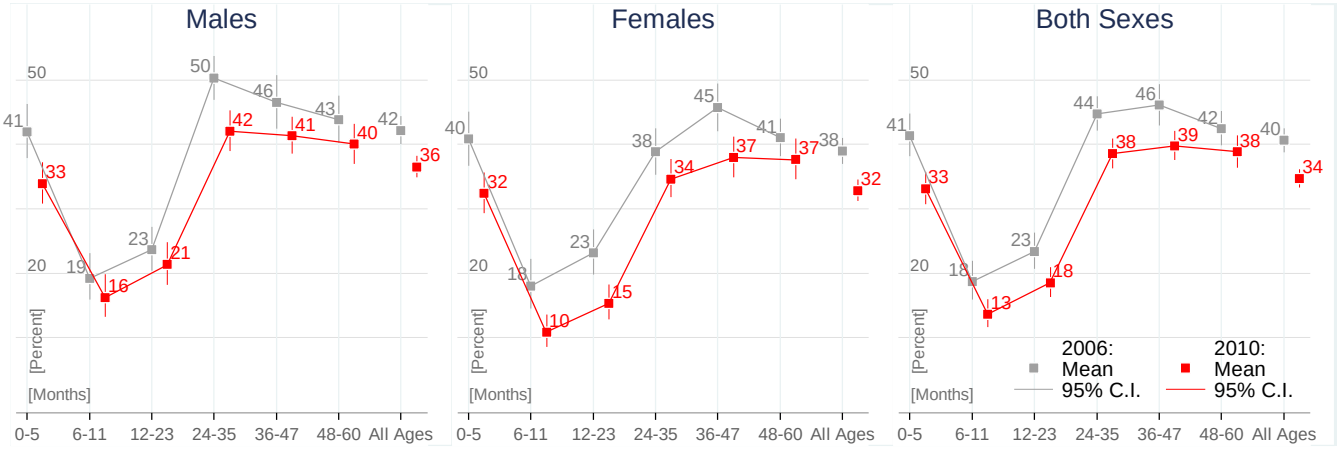
Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Table B16. Stunting and severe stunting prevalence by sex and year (all ages), Sudan

	2006				2010			
	Severe stunting		Stunting		Severe stunting		Stunting	
	% < -3SD	(95% CI)	% < -2SD	(95% CI)	% < -3SD	(95% CI)	% < -2SD	(95% CI)
Both Sexes	20.4	(19.2- 21.6)	40.6	(38.7- 42.4)	15.1	(14.1- 16.2)	34.7	(33.3- 36.1)
Males	21	(19.6- 22.4)	42.1	(40- 44.3)	16.3	(15.1- 17.6)	36.5	(34.9- 38.1)
Females	19.8	(18.5- 21.2)	38.9	(37- 40.9)	13.9	(12.8- 15.1)	32.8	(31.2- 34.5)

Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Figure B17. Stunting prevalence (percentage of stunted children under-five) by sex, age group and year, Sudan



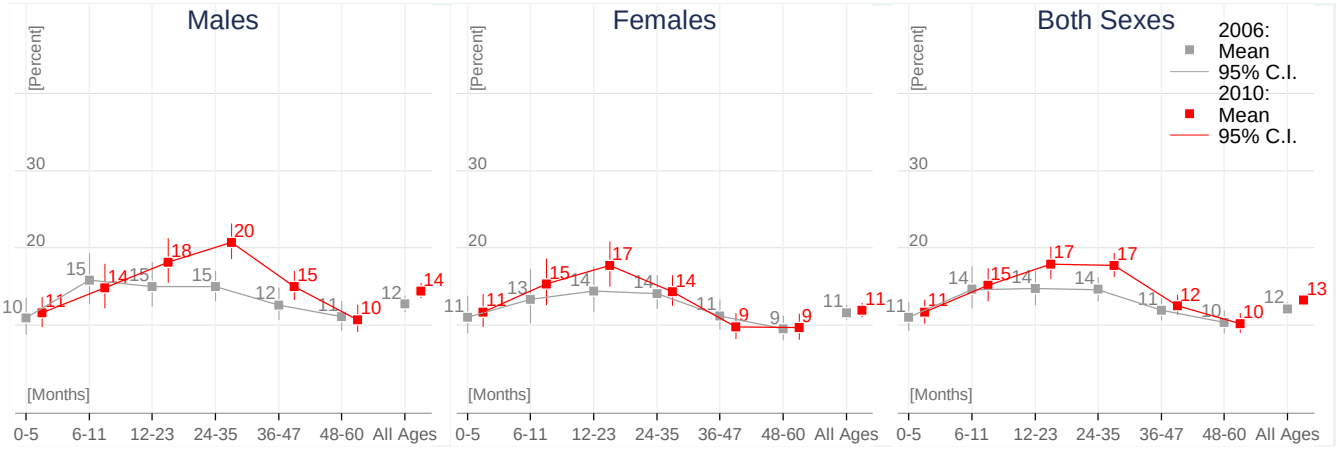
Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Table B17. Wasting and severe wasting prevalence by sex and year (all ages), Sudan

	2006				2010			
	Severe wasting		wasting		Severe wasting		wasting	
	% < -3SD	(95% CI)	% < -2SD	(95% CI)	% < -3SD	(95% CI)	% < -2SD	(95% CI)
Both sexes	4.5	(4.1- 5.1)	12.1	(11.4- 12.9)	3.3	(2.9- 3.6)	13.2	(12.5- 13.9)
Males	4.7	(4.1- 5.4)	12.7	(11.7- 13.7)	3.8	(3.3- 4.3)	14.4	(13.5- 15.4)
Females	4.4	(3.8- 5)	11.6	(10.7- 12.6)	2.7	(2.3- 3.2)	11.9	(11- 12.8)

Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Figure B18. Wasting prevalence by sex, age group and year, Sudan

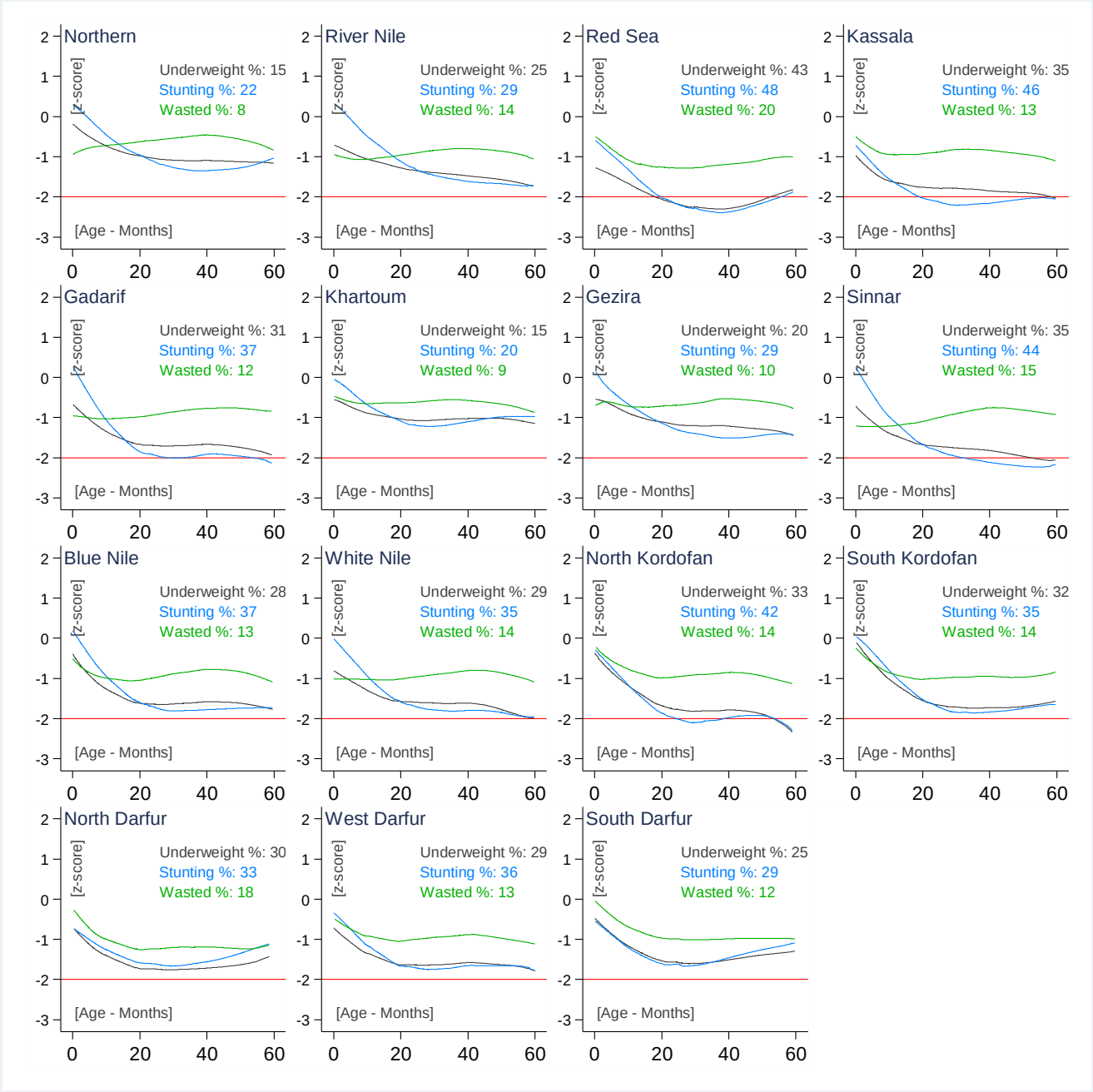


Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Nutritional outcomes vary widely across states. With 15 percent of under-five children underweight, Northern and Khartoum stand out has having relatively favorable nutritional outcomes for children. On the other hand, with stunting prevalence over 40 percent, Red Sea, Kassala, Sinnar and North Kordofan have very poor

nutritional outcomes. Wasting prevalence is highest in Red Sea (20 percent) and North Darfur (18 percent) and lowest in Northern (8 percent) and Khartoum (9%).

Figure B19 Weight for age, height for age and weight for height z-scores versus age, by state, 2010



Source: Author's calculations based on 2006 & 2010 SHHS, WHO's Anthro software v3.2.2 and WHO growth standards.

Central to interventions aimed at preventing under nutrition is the promotion of optimal feeding practices of infants and young children. Among these practices, exclusive breastfeeding is recommended beginning immediately after birth until six months of age – other liquids such as oral rehydration salts, drops or syrups for vitamins, minerals or medicines are allowed at this time (WHO).

The coverage of exclusive breastfeeding through 6 months of age in Sudan was 42 percent, representing a statistically significant increase since 2006 when exclusive breastfeeding coverage stood at 36 percent (Figure B19). Another recommended action for mothers is to continue frequent and on-demand breastfeeding until their child reaches two years of age or beyond. In Sudan, continued breastfeeding – defined as the percentage of children between the ages of 12-15 months who continue to be breastfed was 93 percent in 2010 (not statistically different from the 91 percent coverage rate in 2006) (Figure B19). Gains in breastfeeding are distributed across all states with women in North Darfur and Northern more commonly practicing exclusive and continued breastfeeding, in 2010 compared to 2006. Breastfeeding promotion strategies include influencing hospital policies and practices to encourage breastfeeding and discourage bottle feeding, counseling and education provided by peers or health workers, mass media and community education and support groups. Given the increase in breastfeeding practice, there is an opportunity to identify and further scale specific approaches that have been effective in conveying public health messages related to breastfeeding. Interestingly, there isn't an association between wealth and breastfeeding practice (table B18), but mothers with secondary education are about 14 percent more likely to exclusively breastfeed their children. There is an important exception to breastfeeding which involves women who are HIV-positive due to the risk of transmitting HIV to the infant. For these women, the WHO currently recommends affordable and safe replacement feeding. When replacement feeding is not possible alternatives exist such as heat-treated breast-milk, HIV-negative wet nurses, uncontaminated donor milk or exclusive breastfeeding for six months and rapid discontinuation thereafter(WHO 2003).

When breast milk alone cannot satisfy all of a child's nutritional requirements, complementary foods and liquids (alongside breast milk) are needed to meet nutrient and energy demands starting at 6 months of age. Without adequate complementary foods – even with optimum breastfeeding – children will become stunted (Black, Allen et al. 2008). For Sudan the introduction of complementary foods - measured as the percentage of infants between the ages of 6-8 months who were fed solid, semi-solid or soft foods in the 24 hours prior to the survey – covered 48 percent of the infants in 2010 down from 63 percent in 2006. Adequate complementary feeding ranged from 23 percent in West Darfur to 83 percent in Northern. Complementary feeding is a significantly more common practice among women with secondary education (compared to women without formal education) (table B18). While monitoring whether a child is being given solid, semi-solid or soft foods is important, feeding practices related to hygiene, food handling, the quantity of food given and the frequency and diversity of meals is also critical as a strategy to prevent repeated infection and illness which can worsen a child's nutritional outcomes.

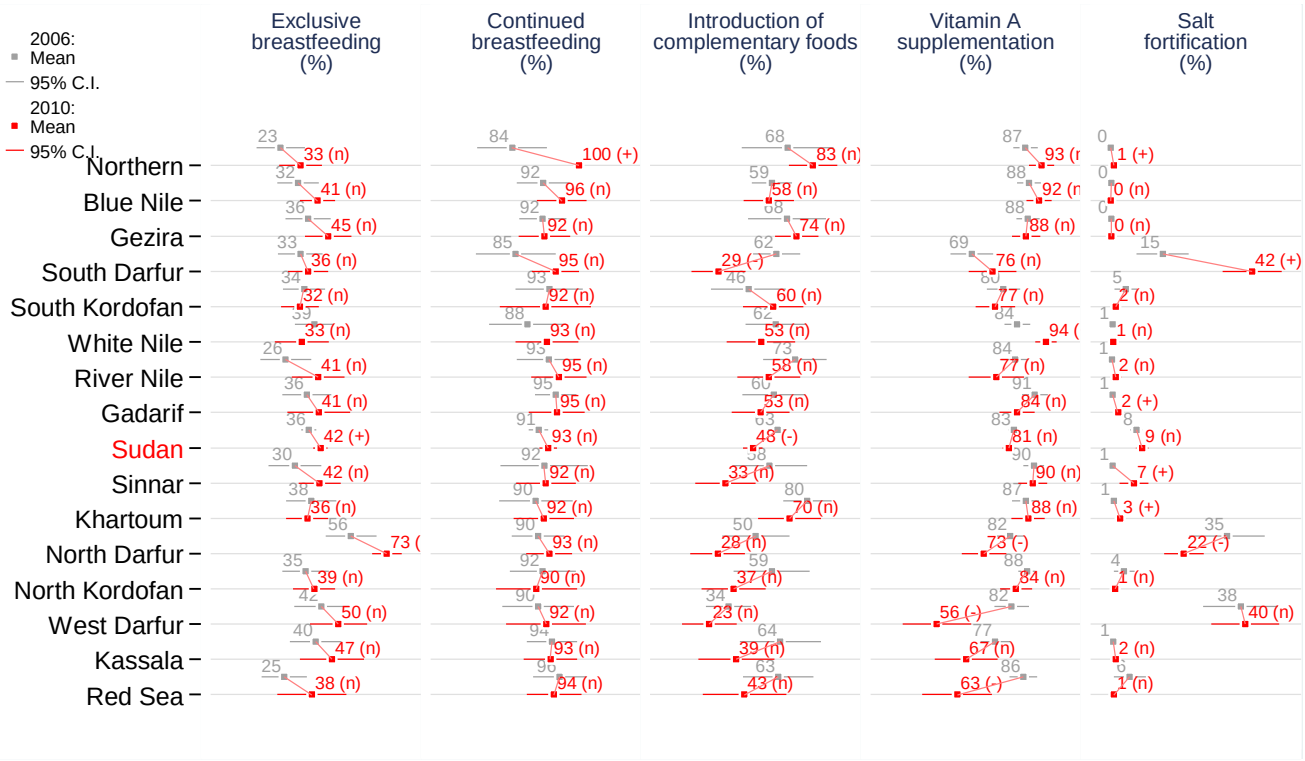
Micronutrient deficiencies

Vitamin A deficiency (causing an estimated 383 thousand deaths annually in Sub-Saharan Africa and affecting 32 percent of children ages birth through four in the region) is a preventable cause of blindness and a risk factor for infectious disease and mortality, most likely due to weakened immune system. The underlying causes of Vitamin A deficiency include low intakes of animal foods that provide vitamin A (such as milk and eggs), inadequate intakes of non-animal sources of carotenoids (dark green leafy vegetables, non-citrus fruits and other vegetables such as pumpkins and squash) and inadequate intakes of fat which facilitate the absorption of carotenoids. Vitamin A supplementation, given as an oral capsule, is an effective way to reduce blindness and mortality. Other approaches such as fortification and dietary diversification have been pursued to increase intake of

Vitamin A. In Sudan, the percentage of under-five children older than 6 months receiving oral Vitamin A capsules was 81 percent – no different than overall coverage in 2006 (figure B19). Declines in the coverage of Vitamin A supplementation are evident in North Darfur, West Darfur and Red Sea.

Iodine is required for thyroid hormones which regulate growth, development and metabolism and prevent goiter and cretinism. Inadequate intake can result in impaired intellectual development and physical growth, the range of conditions resulting from iodine deficiency are known as iodine deficiency disorders and can include fetal loss, stillbirth, congenital anomalies and hearing impairment, however, the main burden of insufficient iodine is reduced mental capacity which carries long-term economic consequences. An indirect proxy for the prevalence of iodine deficiency in the population is the prevalence of goiter - in Sudan, estimates from a 1997 national study place the prevalence of goiter at 22 percent (UNICEF 2007).

Figure B19. Infant and young child feeding interventions, by state, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: States or ordered based on largest average percentage point improvement in coverage between 2006 and 2010 across the five indicators. (+) Difference between means in 2010 and 2006 is positive and significant at the 95% level. (-) Difference between means in 2010 and 2006 is negative and significant at the 95% level. (nd) no evidence of statistical difference in means between 2006 and 2010.

Large scale salt fortification is the primary strategy for preventing iodine deficiency because of the nearly universal consumption of salt regardless of socioeconomic status and the fact that supplementation with iodine does not cause an effect on taste, consistency or color (Caulfield, Richard et al. 2006). In Sudan, a declaration in 2003 under the Public Health law of 1975 provided for blending salt with potassium iodate, calling on producers to begin this process within six months but with limited production capacity, lack of a ban on non-iodized salt,

unclear role for inspectors and sanctions for non-compliant salt producers, little progress was made initially (UNICEF 2007). Between 2006 and 2010, iodized salt consumption at the recommended level of 15 or more parts per million remained unchanged at a relatively low level - between 8 and 9 percent between 2006 and 2010 (figure B19). The populations of South Darfur, North Darfur and West Darfur, however, benefit from iodized salt at a much higher rate: between 20 and 40 percent of households had access to iodized salt in 2010, possibly resulting from the focus of international humanitarian assistance in this region since 2004.

Iron deficiency anemia affects about 60 percent of children between birth and age four in Sub-Saharan Africa and causes about 21 thousand deaths annually in the region (Caulfield, Richard et al. 2006) and is caused by insufficient absorption of iron or excess loss (occurring mainly from blood loss) and can result in neurological impairment and decreased immune function. Zinc deficiency results from inadequate intakes (which comes mainly from animal meat and shellfish) and excess losses (for example during diarrheal illness) and in severe cases, can result in growth retardation, impaired immune function, skin disorders and anorexia among others. Mild to moderate deficiency reduces immune function, increasing susceptibility to infection. In Sub-Saharan Africa, Zinc deficiency is estimated to affect 50 percent of children ages birth through four and cause 400 thousand deaths annually. Unfortunately, there is no data available to assess the degree of iron and zinc deficiency among children in Sudan from the household surveys used in this study.

Table B18. Marginal effects for the association between intervention coverage and select demographic variables

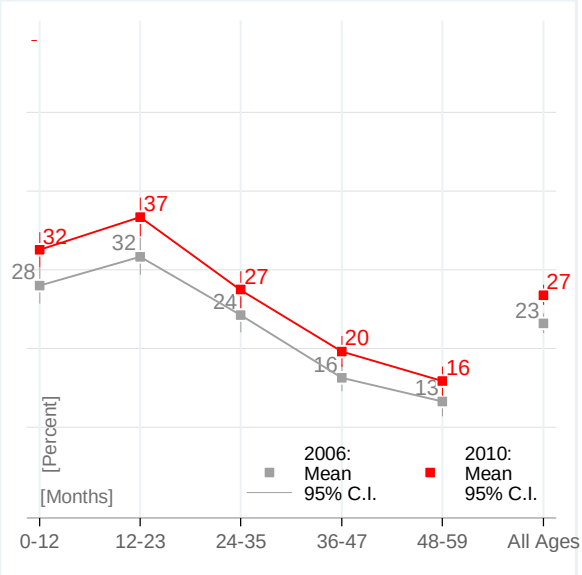
	Exclusive Breastfeeding		Continued Breastfeeding		Complementary Feeding		Vitamin A supplementation		Salt fortification with iodine	
	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t
Education[ǂ]										
None	**[Reference]**									
Primary	0.03	0.92	0.03	0.82	0.07	1.10	0.04	3.35	0.00	-0.03
Secondary +	0.14	2.36	0.02	0.41	0.27	3.44	0.06	3.48	0.02	1.65
Setting										
Rural	**[Reference]**									
Urban	-0.03	-0.83	-0.01	-0.43	-0.01	-0.19	-0.03	-1.23	0.03	2.04
Wealth										
Poorest	**[Reference]**									
2nd quintile	0.08	1.79	0.00	-0.03	0.01	0.07	0.06	3.32	0.02	0.85
3rd quintile	0.02	0.47	-0.03	-0.78	0.03	0.41	0.08	3.45	-0.02	-0.72
4th quintile	0.00	-0.04	-0.05	-1.24	0.21	2.41	0.12	5.20	-0.09	-4.17
Richest	0.06	0.86	0.01	0.19	0.15	1.40	0.11	4.27	-0.10	-4.14
Year										
2006	**[Reference]**									
2010	0.05	2.07	0.02	1.67	-0.14	-3.51	-0.02	-1.36	0.02	1.42

Source: Author's calculations based on 2006 and 2010 SHHS.

Notes: [ǂ] Education levels refer to the highest education level achieved by the mother, with the exception of education levels associated with salt fortification which correspond to the household head

Diarrhea: Risk factors, prevention and care

Figure B20. Diarrhea prevalence by age, Sudan, 2006 and 2010



Source: Author's calculation based on 2006 & 2010 SHHS

Diarrheal diseases are a leading cause of preventable death and morbidity among children under-five years of age worldwide. In Sudan, in the two weeks prior to the survey, diarrhea affected 27 percent of children under-five in 2010, up from 23 percent in 2006 (figure B20). The frequency and severity of diarrhea is associated with housing conditions, access to clean water, sanitary disposal of fecal waste, cohabitation with domestic animals and lack of refrigerated storage. These factors, including inadequate personal hygiene are responsible for an estimated 90 percent of childhood diarrhea (Keusch, Fontaine et al. 2006).

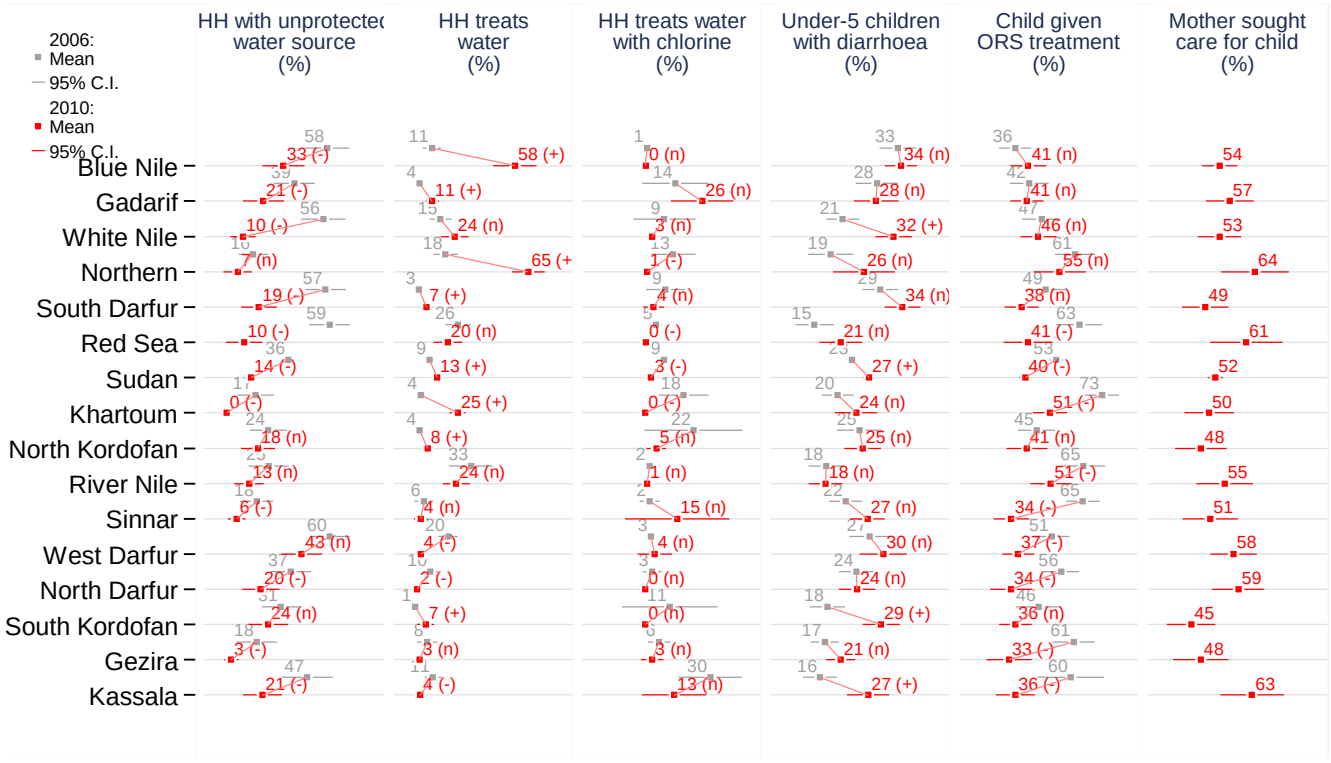
About 14 percent of households in Sudan rely on an unprotected water source for drinking (including unprotected wells or springs and unfiltered open water from rivers, streams and ponds). Approximately 13 percent of households treats their drinking water; of those that do 3 percent use chlorine (figure B21). Among households, the most common means of treating water is to let it stand and settle (two in three households use this method) and to strain it through a cloth (27 percent of households use this method). Between 2006 and 2010 among households who are treating their water, the use of chlorine decreased from 9 percent in 2006 to 3 percent in 2010. Relative to the poorest households, wealthier households are substantially more likely to treat their water (table B19), controlling for other factors. In terms of sanitation, 34 percent of households in 2010 do not have any formal facility for disposing solid waste. Given the association between poverty and housing conditions, children in the richest households are 7 percentage points less likely to suffer from diarrhea compared to children in the poorest households (table B19). Children whose mothers have secondary education are 4 percentage points less likely to contract diarrhea relative to children whose mothers have no education, all else equal. The association between education and reduced diarrheal incidence is likely mediated through improved feeding and care practices as mother's education is also associated with increased likelihood of exclusive breastfeeding, complementary feeding and vitamin A supplementation (table B18).

The prevalence of diarrhea is slightly higher among children between the ages of 12 and 23 months relative to other age groups (figure B20) and prevalence drops steadily after 2 years of age. While it is difficult to draw conclusive inferences about the experience of children as they grow older from a cross sectional survey, the age pattern suggests that behaviors starting around 12 months increase children's vulnerability to diarrhea. As mentioned earlier, early childhood diarrhea during periods of critical postnatal development adversely affects the growth and nutritional status of children.

Promoting exclusive breastfeeding (which by eliminating the intake of food or drink other than breast milk significantly reduces a transmission pathway; breast milk also contains antimicrobial agents) is one key strategy for controlling diarrheal diseases. One observational study suggests that breastfed children are 6 times less likely to die of diarrhea compared to infants who are not breastfed (Keusch, Fontaine et al. 2006). Other key prevention strategies include improving complementary feeding practices to avoid microbial contamination of food, improving diets during and after episodes of diarrhea, and measles immunization (measles predisposes individuals to diarrheal disease). Improving hygiene practices such as hand washing, for example, has also been shown to reduce diarrhea incidence substantially, however this requires availability of water and soap. Other observational studies have demonstrated an association between improved access to sanitation facilities and reductions in child mortality (Esrey, Potash et al. 1991). The impact of sanitation will likely have greater impact in areas with high population densities and when an entire community, rather than single households adopts the intervention (Keusch, Fontaine et al. 2006).

Two strategies are available to manage diarrheal disease: Oral rehydration solution (ORS) and zinc supplementation in combination with exclusive breastfeeding and proper nutrition. In Sudan, among children who had diarrhea in the weeks before the 2010 SHHS, 52 percent were taken for care and 40 percent were treated for diarrhea with an ORS packet or a recommended homemade solution (figure B21). Children whose mothers with formal education (relative to no education) and living in wealthier households (relative to the poorest households) were more likely to have received treatment all else equal (Table B18).

Figure B21. Diarrhea risk factors, prevention and care, by state, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: States ordered based on largest average percentage point improvement in coverage between 2006 and 2010

across the treatment indicators. (+) Difference between means in 2010 and 2006 is positive and significant at the 95% level. (-) Difference between means in 2010 and 2006 is negative and significant at the 95% level. (n) no evidence of statistical difference in means between 2006 and 2010.

Table B19. Marginal effects for the association between select diarrhea risk factors and treatment indicators and select demographic variables

	Household with unprotected Water Source		Household treats water		Child has diarrhea		Child given ORS		Child taken for care	
	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t
Education ǂ										
None	[reference]									
Primary	-0.04	-2.85	0.01	1.41	0.00	-0.16	0.05	1.64	-0.04	-1.33
Secondary +	-0.08	-3.69	0.02	1.91	-0.04	-2.59	0.09	1.90	0.04	0.84
Setting										
Rural	[reference]									
Urban	0.02	0.39	0.01	0.69	-0.02	-1.74	0.06	1.73	0.04	1.38
Wealth										
Poorest	[reference]									
2nd quintile	-0.04	-1.54	0.02	1.97	0.00	0.04	0.06	1.99	0.04	1.39
3rd quintile	-0.05	-1.48	0.02	1.69	-0.01	-0.38	0.10	2.63	0.04	1.20
4th quintile	-0.17	-4.39	0.03	1.78	-0.04	-2.61	0.18	4.52	0.09	2.15
Richest	-0.36	-10.05	0.02	1.16	-0.07	-3.62	0.16	3.32	0.05	0.95
Year										
2006	[reference]								[NA]	
2010	-0.21	-10.12	0.04	3.99	0.03	3.57	-0.13	-6.84		

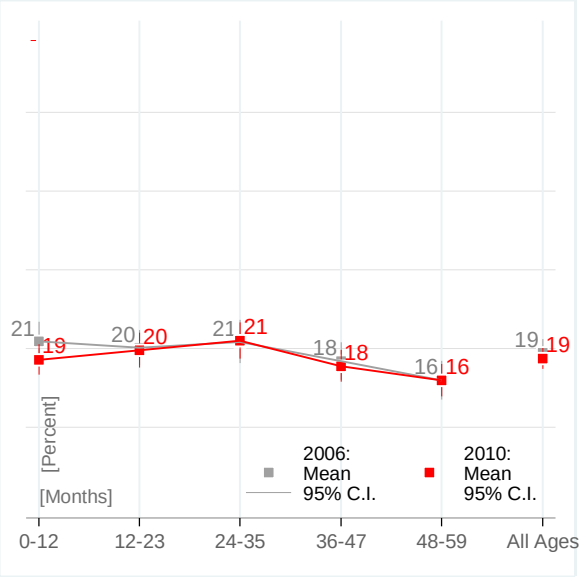
Source: Author's calculations based on 2006 & 2010 SHHS

Notes: ǂ Education levels refer to the highest education level achieved by the mother, with the exception of education levels associated with unprotected water source and treats water

Acute respiratory infections: risk factors and care

Acute respiratory infections (ARIs) in children fall into two broad categories, those affecting the upper respiratory (URI) tract (more common) – such as rhinitis, sinusitis, ear infections, pharyngitis and laryngitis - and those affecting the lower respiratory (LRI) tract (more severe) – such as pneumonia, bronchiolitis and to a lesser extent influenza. ARIs are a major cause of under-five mortality past the neo-natal period and are responsible for nearly 20 percent of all child deaths (Simoes, Cherian et al. 2006). Clinical signs of acute lower respiratory infections include coughing and rapid breathing; lower chest wall indrawing identifies the presence of more severe disease. In Sudan, 19 percent of under-five children showed signs of ARIs in 2006 and 2010 in the weeks prior to the survey (figure B22, B23). The age pattern of ARIs is uniform over children's first five years of life (figure B22) and episodes are less frequent among children in relatively wealthier families (table B21).

Figure B22. ARI prevalence by age, Sudan, 2006 and 2010



Source: Author's calculation based on 2006 and 2010 SHHS

Table B20. Place of care for ARI, Sudan, 2006 & 2010

Place of Care	Year	Mean (%)	95% C.I.
Public Facility	2006	68.3	(63.8 - 72.8)
	2010	69.3	(65.2 – 73.4)
Private Facility	2006	16.3	(13.2 – 19.3)
	2010	20	(16.4 – 23.5)
Other (religious healer, traditional healer, relatives)	2006	7.1	(5.1 – 9.2)
	2010	5.2	(3.7 – 6.7)

Source: Author's calculations based on 2006 & 2010 SHHS Notes: Table does not include category for cases with missing values

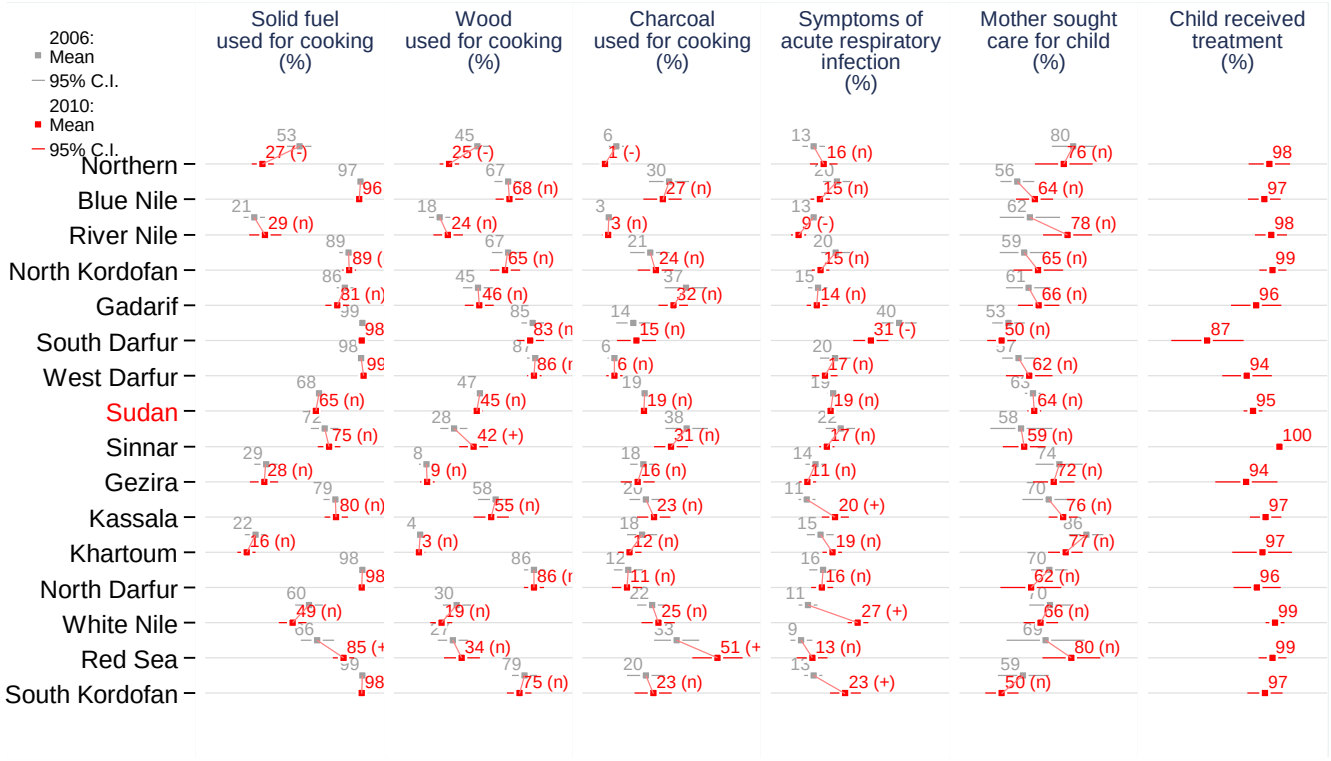
Exposure to indoor air pollution from solid fuel use has been established as a risk factor for acute lower respiratory infection in children under five, including evidence linking higher concentrations of particulate matter with more severe ARI (Ezzati and Kammen 2002). The majority of exposure for women and children in the developing world occurs in the kitchen during cooking. In Sudan, biomass (wood, charcoal, grass, crop residues and dung) is used by two-thirds of all households as the primary fuel for cooking (figure B23) and use of solid fuel is much less likely among wealthier households (table B21). While biomass is the predominant fuel used by households overall, there is wide variation across states. In South, West and North Darfur, nearly all households rely on biomass, whereas in Khartoum only 16 percent of households rely on biomass – these patterns are likely related to the percentage of households living in cities versus more isolated rural villages. After wood, gas is the most common fuel used for cooking (used by 30 percent of households) followed by charcoal (use by 19 percent of households). Approximately 76 percent of households in 2010 reported cooking was done indoors either in the house or in a separate building used specifically as a kitchen.

Interventions to control ARI's include immunization against specific pathogens, early diagnosis and treatment, improvements in nutrition and safer environments. Vaccines against measles, diphtheria, pertussis, Hib (*Haemophilus inluenzae* type b) and influenza can reduce the incidence of ARIs in children. The coverage of these vaccines is covered in the section on vaccine preventable disease. Effective case management of ARIs involves accurately detecting pneumonia and severe pneumonia based on respiration rate and lower chest wall indrawing based on WHO recommended guidelines. If pneumonia cases are detected, timely oral treatment options are recommended and for severe pneumonia, intramuscular antibiotics are recommended as well as the provision of oxygen.

The effectiveness of early case detection and management depends on the mother's awareness of danger signs and ability to seek care if needed. In both 2006 and 2010, 64 percent of children displaying symptoms of acute ARI were taken for care. Care-seeking behavior is strongly associated with mother's education and household wealth (table B21). Children with ARI symptoms whose mother has a primary or secondary education, were 10 and 13 percentage points more likely to be taken for care relative to children whose mothers have no formal

education, all else equal. Children from households with progressively greater wealth are increasingly likely to be taken for care. The independent and significant effects of education and household wealth suggests that some education is critical in order for mothers to recognize and respond to illness, but that barriers related to wealth also play a strong role (possibly income and access to social networks and support). Whether a family lives in an urban or rural setting seems to have no bearing on whether the mother's child accesses care when needed.

Figure B23. Acute respiratory infections: risk factors, prevalence and care, by state, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: States ordered based on largest average percentage point improvement in coverage between 2005 and 2009 across the five indicators. (+) Difference between means in 2009 and 2005 is positive and significant at the 95% level. (-) Difference between means in 2010 and 2006 is negative and significant at the 95% level. (nd) no evidence of statistical difference in means between 2006 and 2010.

When children are taken for care, they are primarily taken to a public health facility (69 percent of children with ARI symptoms in 2010) or a private facility (20 percent of children with ARI symptoms in 2010) (table B20). In 2010, the percentage of children visiting traditional or religious healers declined from was 5.2 percent with some evidence of a shift away from informal care towards private care between 2006 and 2010. For a finer disaggregation, in 2010, about 43 percent of children with ARI symptoms taken for care visited a public primary care facility (health center or post), 23 percent of children went to a public hospital, 3.4 percent went to a private hospital, 7 percent went to a private physician and 7 percent went to a private pharmacy. Among children in urban areas, 30 percent were taken to public hospitals, 37 percent to public primary care facilities, 7 percent to private hospitals, 12 percent to private pharmacies and 9 percent to private pharmacies. Among rural

areas, 20 percent were taken to public hospitals, 45 percent to public primary care facilities, 7 percent to private pharmacies and 4 percent to private physicians. Not surprisingly, rural mothers rely much more on primary health care facilities than hospitals for their child's health care, which also means they are less likely to get needed clinical care for more severe cases of ARI.

In 2010, among children who were taken for care, 95 percent received treatment (in both rural and urban areas). Of those receiving treatment, approximately 86 percent were given antibiotic pills, 13 percent an injectable antibiotic and 7 percent acetaminophen. The high rate of treatment in both urban and rural areas suggests that the health system responds effectively to ARI.

Table B21. Marginal effects for the association between select ARI related indicators and select demographic variables

	Household uses solid fuel for cooking		Child has ARI symptoms		Child taken for care [if child has ARI symptoms]		Child received treatment for ARI [if taken for care]	
	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t
Education ǂ								
None	[reference]							
Primary	-0.07	-7.25	0.01	0.92	0.10	3.89	0.01	0.82
Secondary +	-0.16	-7.11	-0.02	-1.10	0.13	2.52	0.06	2.17
Setting								
Rural	[reference]							
Urban	0.07	2.72	-0.01	-0.75	0.01	0.21	0.00	0.09
Wealth								
Poorest	[reference]							
2nd quintile	-0.04	-5.54	0.01	0.36	0.06	1.44	-0.02	-1.22
3rd quintile	-0.15	-9.93	-0.01	-0.42	0.16	3.90	-0.02	-0.77
4th quintile	-0.42	-17.64	-0.05	-2.55	0.22	4.80	-0.04	-1.75
Richest	-0.80	-37.96	-0.07	-3.20	0.26	4.91	-0.03	-1.14
Year								
2006	[reference]							
2010	-0.05	-2.40	-0.01	-0.69	0.01	0.31	[omitted]	

Source: Author's calculations based on 2006 & 2010 SHHS

Notes: ǂ Education levels refer to the highest education level achieved by the mother, with the exception of education levels associated with unprotected solid fuel for cooking which refer to those of the household head.

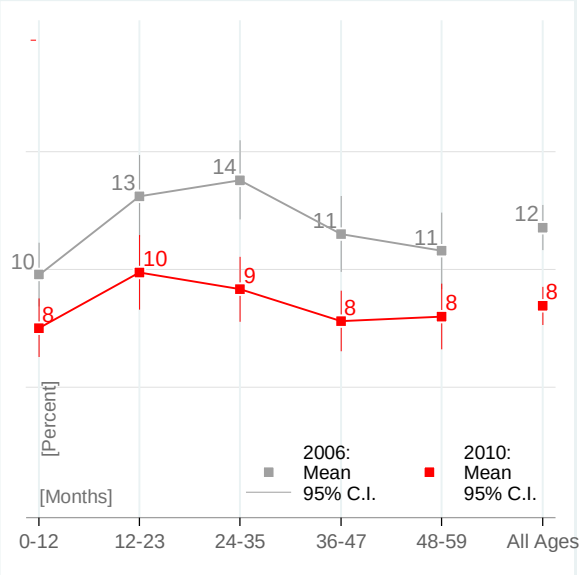
Malaria: prevention and treatment

Malaria is estimated to cause about 8 percent of all child deaths, primarily as a result of *Plasmodium falciparum* that is transmitted through female anopheline mosquitos (Breman, Mills et al. 2006). In a 2002 national burden of disease study focusing on malaria in Sudan, of approximately 9 million episodes of malaria, 44 thousand resulted in deaths, with the highest mortality among children under-five (Abdalla, Malik et al. 2007). Only certain areas of Sudan has stable endemic *plasmodium falciparum* - as measured by the parasite rate (the proportion of people sampled showing detectable parasites) (Hay, Guerra et al. 2009) – meaning that transmission occurs regularly year-round. Sudan's endemic areas lie along the border with Sudan, encompassing most of West Darfur, South Darfur, South Kordofan, White Nile, Blue Nile, Sinnar, Gadarif and Gezira as well as

the southern parts of North Darfur, Northern Kordofan, Khartoum and Kassala. Populations along the river Nile and certain parts of the coast of Red Sea state are also at risk of Malaria transmission (Hay, Guerra et al. 2009). Estimates indicate that in areas of stable malaria risks 4.9 episodes of malaria are experienced per person per year (Snow, Newton et al. 2003).

In settings with stable malaria, morbidity and mortality is high during early childhood, but for survivors, some immunity is acquired so that infections at older ages are usually asymptomatic. Anemia among children is common in stable transmission areas and among pregnant women falciparum malaria is associated with anemia and low birth weight. If uncomplicated malaria is treated promptly, mortality is very low but mortality rises sharply with more complicated cases. The most common causes of malaria-related death are from cerebral malaria, severe malaria anemia (hemoglobin levels of less than 5 gm/dl in association with malaria parasites), respiratory distress, hypoglycemia (low blood sugar) and low birthweight. Long term morbidity after severe malaria can include neurological conditions affecting hearing, eyesight, speech and behavior (Breman, Mills et al. 2006).

Figure B24. Malaria (or fever) prevalence by age, Sudan, 2006 and 2010



Source: Author's calculation based on 2006 and 2010 SHHS

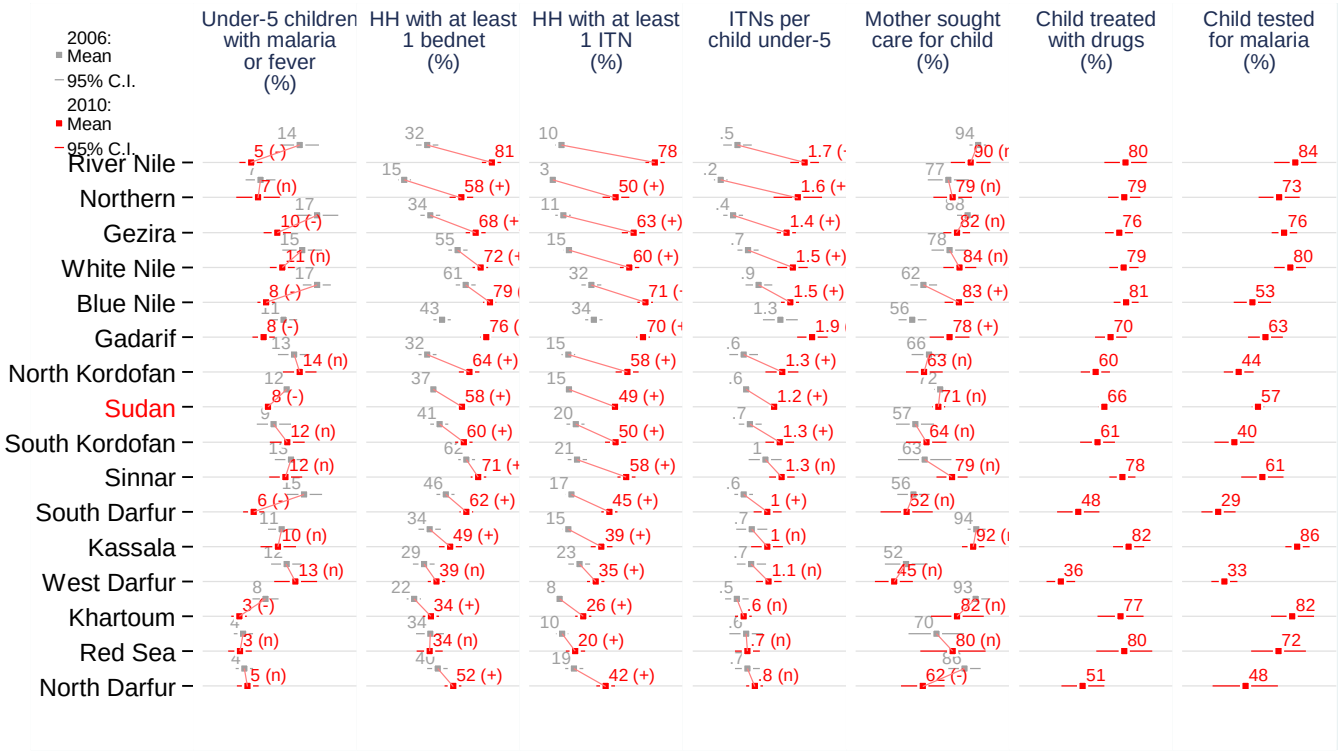
In the two weeks prior to the 2010 SHHS, 8 percent of children under-five had a presumptive diagnosis of malaria (compared to 12 percent in 2006) – which includes reported episodes of fever. In 2010, the states with over 10 percent of presumptive malaria diagnoses were White Nile, North Kordofan, South Kordofan, Sinnar and West Darfur (Figure B25). The sharp 30 percent reduction in reported malaria cases between 2006 and 2010 is notable and may suggest the effectiveness of malaria prevention efforts (Figure B23). It is important, however, to recognize that while fever is the primary clinical manifestation of malaria in the non-immune and has dominated the diagnosis and management of the disease, not all fevers result from malaria and thus diagnosis of malaria as a distinct clinical entity is difficult (Snow, Newton et al. 2003). The age-pattern of malaria illness is relatively uniform, with the exception of children between the ages of 1 and 3 years of age for which there is some evidence of increased risk of malaria.

Evidence-based interventions to reduce infection and the adverse outcomes of malaria infection include the use of insecticide treated nets (ITNs), indoor residual spraying with long lasting insecticides, effective disease management - including early diagnosis and treatment with proper drugs as well as intermittent presumptive treatment in pregnancy and infancy.

A recent study of the effectiveness of ITNs in Sub-Saharan Africa found that household ownership of at least one ITN was associated with a relative reduction in mortality among children of ages 1 month to 5 years of 23 percent (Lim, Fullman et al. 2011). Given the rapid expansion of ITN's in the past decade in the region, this

finding – consistent with previous findings of ITN efficacy – is encouraging and supports further efforts to increase ITN coverage. ITNs reduce malaria transmission through a barrier effect that prevents blood feeding by mosquitos and an insecticide effect which kills and repels mosquitos. In Sudan, ownership of at least 1 ITN increased from 15 percent in 2006 to 49 percent of households in 2010, with substantial increases in ownership occurring across all states (figure B25). That not all of Sudan's population is at risk for Malaria suggests that bednet distribution efforts are coming increasingly close to covering all households at risk; however, without more detailed information on household location relative to known areas of malaria transmission makes it hard to gauge how close.

Figure B25. Malaria prevalence, prevention and care, by state, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: States or ordered based on largest average percentage point improvement in prevention or treatment coverage between 2006 and 2010. (+) Difference between means in 2010 and 2006 is positive and significant at the 95% level. (-) Difference between means in 2010 and 2006 is negative and significant at the 95% level. (nd) no evidence of statistical difference in means between 2006 and 2010.

Among households with at least one ITN and at least one under-five child, the average number of ITNs owned is 2.7 (or 1.6 per under-five child) in 2010 - households that do acquire at least one bednet acquire enough to at least provide for all under-five children in addition to some older children or adults. Of the most recently purchased ITN, 70 percent were purchased in the year prior to the 2010 survey (March 2009 to March 2010 approximately), 16 percent between one and two years prior, 14 percent more than two years prior.

While scaling the coverage of ITNs is critical, fostering proper use and maintenance for durability is important as well. Whether households re-treat nets with insecticide in a timely way determines efficacy, low re-treatment rates have been attributed to the additional cost and effort required by net owners and the perception that it is the physical barrier and not the insecticide that provides protection (Lindblade, Dotson et al. 2005). Given the difficulty of promoting net re-treatment, longer lasting insecticide treated nets (LLITNs) have been developed – these and are being increasingly distributed globally through donor financing – in 2010, LLITNs comprised 46 percent of all ITNs in circulation and 30 percent of households owned at least 1 LLITN. Even with these newer technologies, the degree to which LLITNs retain insecticide over time has been shown to vary widely by brand (Lindblade, Dotson et al. 2005), and factors such as the frequency and method of washing and drying, also moderate their effectiveness (Atieli, Munga et al. 2010). In 2010, only 16 percent of households reported sleeping under a bednet the night prior to the survey – underscoring the need to understand determinants of use and not just ownership.

Table B23. Marginal effects for the association between malaria related indicators and select demographic variables

	Mother sought care for child [if ill with malaria]		Child given treatment for malaria or fever [if taken for care]		Child tested for malaria	
	dy/dx	t	dy/dx	t	dy/dx	t
Education						
None	[reference]					
Primary	0.13	3.60	0.00	0.16	0.06	1.21
Secondary +	0.16	2.63	0.03	2.65	0.15	1.74
Setting						
Rural	[reference]					
Urban	0.05	1.44	0.01	0.61	0.13	2.21
Wealth						
Poorest	{reference]					
2nd quintile	0.06	1.30	0.01	0.40	-0.03	-0.61
3rd quintile	0.13	2.75	0.01	0.35	0.12	2.27
4th quintile	0.16	3.04	0.04	1.44	0.30	4.32
Richest	0.30	5.82	0.00	-0.01	0.60	5.32
Year						
2006	[reference]					
2010	0.01	0.24	-0.25	-5.85	[NA]	

Source: Author's calculations based on 2006 & 2010 SHHS

Notes: ᵗ Education levels refer to the highest education level achieved by the mother, with the exception of education levels associated with ITN ownership which refer to those of the household head.

Indoor residual spraying (IRS) is a well-established method for controlling the transmission of malaria. The insecticide - which is applied to internal walls and ceilings - can kill a mosquito any time it enters a house for a blood meal. The challenges of implementing a widespread IRS strategy include the need to build public acceptance of spraying, the need for trained staff and well maintained equipment as well as adequate supervision to ensure adherence to application procedure and financial support (Malaria Consortium). No data was available in the household surveys to assess the degree to which IRS is used in Sudan.

In addition to cost-effective population preventive measures – such as ITNs and IRS (and the communication and outreach strategies that accompany them) – early diagnosis and effective treatment can cure infection, prevent morbidity by halting progression to more severe disease and reduce transmission. Accurately diagnosing malaria depends on laboratory detection of the parasite (using a blood smear or a rapid diagnostic test) or a clinical diagnosis based on observed symptoms. In diagnosed cases, treatment using appropriate anti-malarial drugs should be prompt and in areas with resistance to single drugs, combination treatments are recommended, preferably using artemisinin combination therapy (ACT).

Effective diagnosis and treatment requires caregivers to recognize and respond to symptoms. In 2006 and 2010, the mothers of about 70 percent of the under-five population in need (children with malaria or fever) sought care for their child (Figure B25). In 2010, among children who were taken for care about 66 percent received drugs, so that 46 percent of children with malaria or fever were treated with drugs. Treatment rates (among children taken for care) were highest in Kassala (82 percent) and lowest in West Darfur (36 percent). Disparities in access to care are significant (Table B23): children with signs of illness whose mothers have primary or secondary education were 13 and 16 percentage points more likely to have been taken for care compared to mothers without education, all else equal; and children from the wealthiest households were 30 percentage points more likely to have been taken for care compared to children in the poorest households. While wealth is associated with access, once at a facility, children from wealthier households are no more or less likely to receive treatment .

Among children taken for care during an episode of malaria or fever, 71 percent were taken to a public facility (36 percent visited health centers or units and 26 percent public hospitals), 21 percent to a private facility (2 percent to a private hospital, 13 percent to a private physician and 14 percent to a pharmacy) and less than 1 percent to a traditional or religious healer. In urban areas, children were equally as likely to visit a public facility as a private facility relative to rural areas.

Current WHO treatment guidelines for uncomplicated *plasmodium falciparum* malaria recommend artemisinin-based combination therapies (ACTs) for first and second line treatment (WHO 2010). Of the children taken for care (in case of malaria or fever) and receiving treatment in 2010, the most commonly given anti-malarial was chloroquine (about one in three children taken for care received the drug), followed by an artimisinin combination (received by 29 percent of children taken for care) and SP (received by 16 percent of children taken for care) (Table B24). Between 2006 and 2010, among children being treated, the use of chloroquine fell significantly alongside increases in the use of artemisinin which suggests that adherence to treatment guidelines and availability of first line drugs is improving. The increase in reported treatment in SP between 2006 and 2010, reflects its use with Artemisinin in combination therapies.

Table B24. Percentage of children with fever or malaria, taken for care and receiving treatment, by drug given for treatment

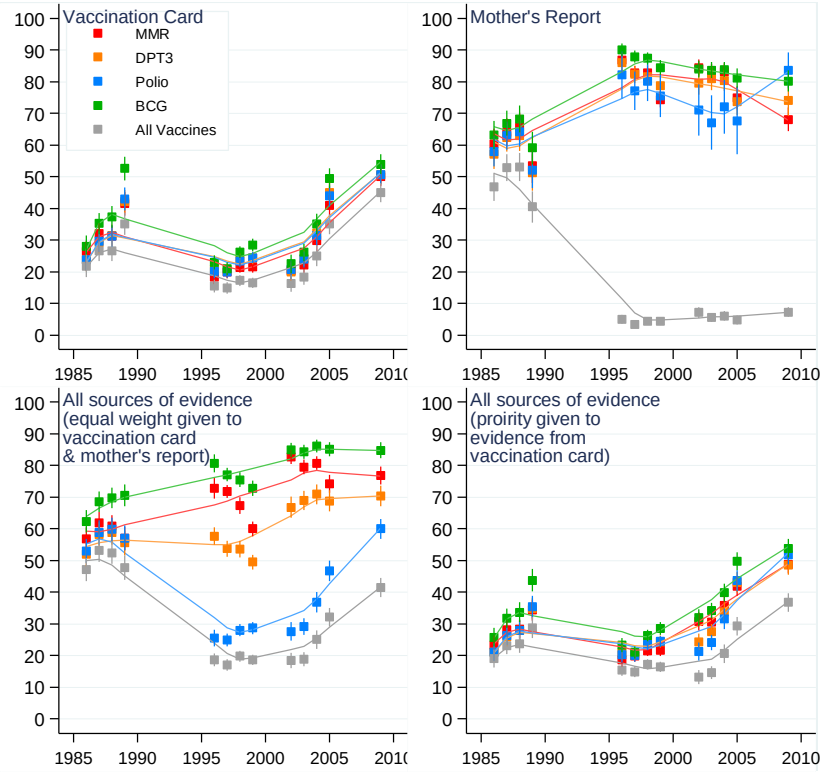
Drug Given	2006		2010	
	Mean	95% CI	Mean	95% CI
Chloroquine (Oral or Injection)	74.4	(70.3 – 78.4)	33.8	(29.1-38.6)
Paracetamol, Acetaminophen, Aspirin or Ibuprofen	29.3	(25.1 - 33.5)	25.4	(21.3 – 29.6)
Sulphadoxine-Pyrimethamine (SP) / Fansidar	7.7	(5.66 – 9.88)	16.1	(12.8 – 19.4)
Amodiaquine (Oral or Injection)	2.24	(0.8 – 3.68)	2.78	(0 - 1.05)
Quinine (Oral or injection)	2.18	(1.04 – 3.31)	2.69	(1.39-3.99)
Artemisinin combination	9.77	(7.11 – 12.4)	28.8	(24.2-33.5)
Metacalfin (Oral)	0.15	(0 – 0.38)	0.51	(0 – 1.05)
Other	11.6	(8.89 – 14.4)	11.5	(8.81 – 14.2)

Source: Author's calculations based on 2006 and 2010 SHHS
Notes: Categories do not add up to 100% as multiple drugs could be given to children

Vaccine Preventable Disease: Coverage of routine immunizations

Vaccination against childhood communicable diseases through WHO's expanded program on immunization (EPI) is recognized as one of the most cost-effective public health interventions (Brenzel, Wolfson et al. 2006). The vaccines originally included under EPI were BCG (targeting tuberculosis), diphtheria-tetanus-pertussis (DTP), oral polio and measles, often given as a measles-mumps-rubella (MMR). Since 1999, GAVI – a public private partnership – has raised significant resources to help countries improve access to new and under-used vaccines including hepatitis B (HepB) and haemophilus influenza type b (Hib).

Figure B28. Percentage of children between the ages of 12-23 months vaccinated against MMR, DPT, Polio and BCG, Sudan, 2002-2009



Source: Author's calculations based on 1989/90 DHS, 200 MICS2, 2006 and 2010 SHHS. *Notes:* In 2009, Hib and HebB are provided with DPT as a pentavalent vaccine.

Figure B28, displays the coverage of DTP-3 (3 doses of DTP vaccine), polio (4 doses), MMR and BCG in Sudan among children between the ages of 12 and 23 months from two sources of evidence: a vaccination card if available and the mother's recollection (the bottom two panels of Figure B28 show coverage trends based on combining the evidence from the vaccination card and mother's reports – explained in further detail below). By 2010, two additional vaccines were rolled in with the DTP vaccine – HepB and Hib (which follow the same immunization schedule as DTP). In the DHS, MICS2 and SHHS, as the vaccination status for all children under five years of age was recorded, coverage estimates were placed in time as follows: children ages 12-23 years are placed at 1 year before the survey (2005), those with ages 24-35 months at 2 years before the survey (2004), those with ages 36-47 months at 3 years before the survey (2003) and those with ages 48-59 months at 4 years before the survey (2002). In the 2010 SHHS, vaccination status was recorded only for children between the ages of 12-23 months (corresponding to the 2009 calendar year).

The percentage of children under-five with a vaccination card remained at 61 percent between 2006 and 2010 (figure B29). Compared to evidence from vaccine cards, mother's reports yield substantially higher coverage estimates. Across all available years and vaccines, the ratio of vaccine coverage based on mother's reports to coverage based on vaccination cards averaged 2.15 (in 2009, that ratio fell to 1.2). Two very different trends emerge depending on whether vaccination coverage rates are based on evidence from vaccination cards or the

mother's report. Evidence from vaccination cards indicate a decline in coverage between the late 1980s to the mid-1990's followed by a steady increase to the 40 to 50 percent coverage range in 2009. Evidence from the mother's report indicates a rapid increase in coverage from the 50 to 70 percent range between 1985 and 1990 to the 75 to 90 percent range in the mid to late 1990s followed by a steady decline in the 2000s. These observations put into doubt the accuracy of mother's recollection vis-à-vis the documentation on available cards. Nonetheless, over the 25 year time horizon covered by the data, vaccination coverage has increased steadily over the 25 years covered by the data (table B25).

To consolidate these two sources of evidence into a single coverage indicator, two approaches were used. The first gives equal weight to the vaccination card and the mother's report so that a child is considered vaccinated if either a vaccination card was seen and displayed a date associated with the vaccination or the mother reported that the child had been vaccinated. The second approach, gives priority to the vaccine card so that the mother's report is only considered in cases where no information was available from the vaccine card. Overall levels of coverage are sensitive to the method used to consolidate vaccination reports from cards and mothers.

Using the first approach (giving equal weight to vaccination reports from a card and mother), overall coverage of BCG, MMR, DPT-3 and Polio in 2009 was 84.7, 76.8, 70.3 and 60.3 percent with 41.4 percent of children between the ages of 12 and 23 months having the complete set of immunizations. The fact that levels of BCG and MMR coverage are higher than Polio and DPT3 coverage suggests platforms of service delivery that perform relatively well at delivering single-dose vaccinations and less well at delivering vaccines that require multiple doses and consistent engagement with the population.

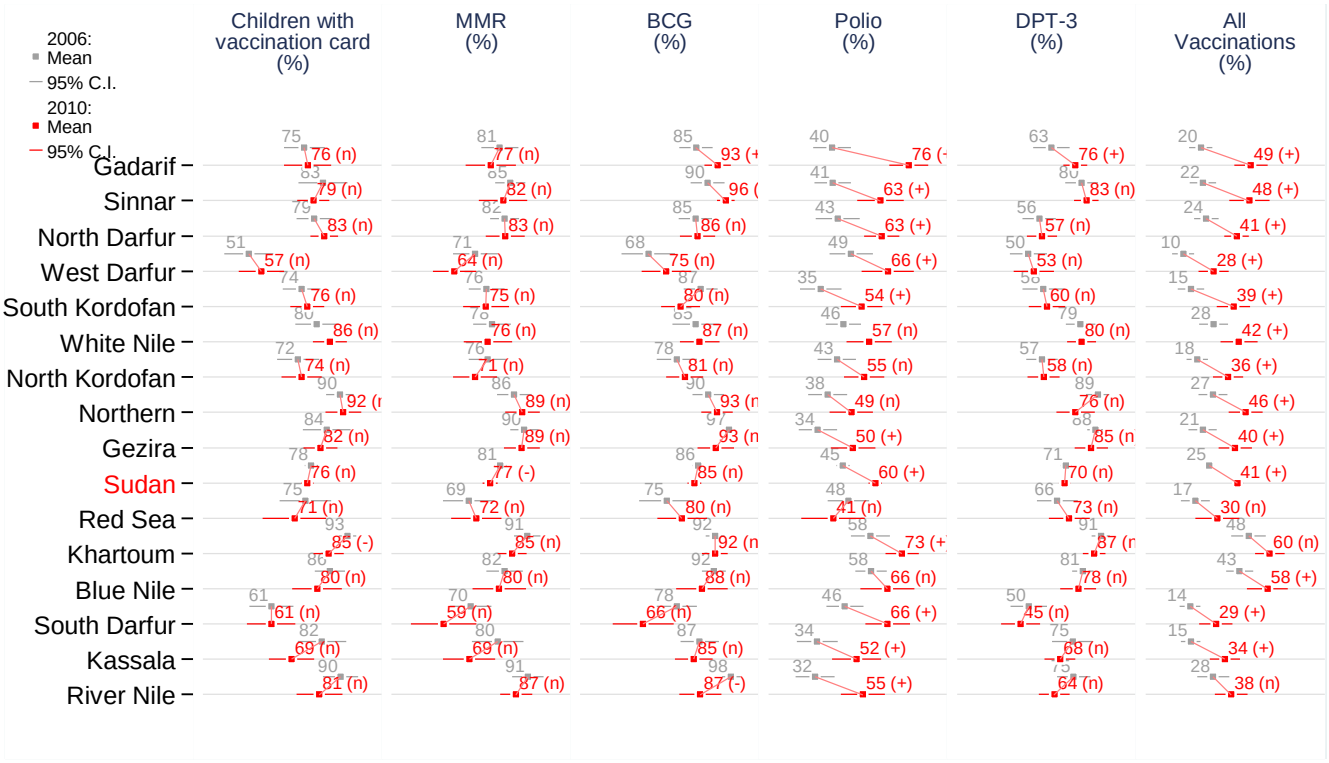
Table B25. Average annualized percent change in vaccination coverage between 1985 and 2009

Vaccine	Vaccination Card	Mother's Report	Combined (Equal weight given to both vaccination card and mother's report)	Combined (Priority given to evidence from vaccination card)
MMR	+0.33	+1.25	+1.49	+1.81
DPT-3	+0.91	+1.53	+1.13	+1.86
Polio	+0.84	+1.2	-1.75	+1.65
BCG	+0.35	+1.37	+1.27	+1.61
All vaccines	+0.39	-10.4	-2.96	+0.13

Source: Author's calculations based on 1990 DHS, 2000 MICS2, 2006 and 2010 SHHS

Vaccination coverage by state during 2005 and 2009 is presented in Figure B29. In 2009, MMR vaccination rates range from 59 percent in South Darfur to 89 percent in Northern and Gezira; BCG vaccination rates range from 66 percent in South Darfur to 96 percent in Sinnar; Polio vaccination rates range from 41 percent in Red Sea to 76 percent in Gadarif and DPT-3 vaccination rates range from 45 percent in South Darfur to 85 percent in Gezira. The percentage of children who received all recommended vaccines was highest in Khartoum (60 percent) and lowest in South Darfur (29 percent).

Figure B29. Vaccination coverage by state, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: Estimates of coverage give equal weight to evidence of vaccination from cards and mother's reports. States ordered based on largest average percentage point improvement in coverage between 2005 & 2009 across the five indicators. (+) Difference in means between 2005 & 2009 is positive and significant at the 95% level. (-) Difference in means between 2005 & 2009 is negative and significant at the 95% level. (n) no evidence of a difference in means between 2005 & 2009.

Disparities in vaccine coverage across socio-economic indicators follow patterns similar to those observed with other child survival interventions. With the exception of Polio, children whose mothers completed primary education are between 7 and 13 percentage points more likely to be inoculated compared to children whose mothers have no formal education, all other factors equal (table B26). Children living in urban areas are no more likely to have received vaccines compared to children living in rural areas suggesting that immunization efforts are not biased towards areas that are easier to access geographically; and children from successively wealthier households are consistently more likely to have received vaccines compared to children from the poorest households.

Table B26. Marginal effects for the association between vaccination outcomes and select demographic variables

	Child has vaccination card		MMR vaccine		BCG vaccine		Polio vaccine		DPT-3 vaccine		All vaccines	
	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t	dy/dx	t
Education												
None	[reference]											
Primary	0.12	9.02	0.07	4.88	0.07	5.88	0.03	1.5	0.10	5.72	0.05	3.83
Secondary +	0.14	7.04	0.09	4.43	0.09	5.28	0.03	1.3	0.13	5.69	0.05	2.56
Setting												

Rural	[reference]											
Urban	0.03	1.78	0.00	-0.28	0.01	0.64	0.03	1.51	0.00	0.14	0.02	0.97
Wealth												
Poorest	[reference]											
2nd quintile	0.08	3.66	0.04	1.78	0.05	2.35	0.08	4.23	0.09	3.83	0.04	3.30
3rd quintile	0.15	5.67	0.08	3.56	0.10	4.34	0.11	4.92	0.15	5.84	0.09	5.42
4th quintile	0.21	7.96	0.12	4.73	0.13	5.63	0.14	5.81	0.23	8.52	0.12	6.22
Richest	0.29	11.55	0.14	5.08	0.17	6.70	0.17	5.46	0.28	8.88	0.16	6.50
Year												
2006	[reference]											
2010	0.02	1.62	0.11	6.94	0.03	2.17	0.25	13.51	0.08	4.16	0.21	12.42

Source: Author's calculations based on 2006 & 2010 SHHS

Notes: ǂ Education levels refer to the highest education level achieved by the mother.

Composite coverage of maternal and child interventions

To obtain an overall assessment of the degree to which health service delivery performance has progressed between 2006 and 2010, disease specific maternal and child interventions that were available from both the 2006 and 2010 SHHS were averaged to generate a year and state specific composite index for maternal and child interventions. The composite index can roughly be interpreted as the proportion of the target population (pregnant women or children under-five years of age, for example) receiving evidence-based care. Coverage estimates for the following maternal interventions were averaged: contraceptive prevalence, tetanus toxoid vaccines, effective antenatal care and skilled birth attendance. Coverage estimates for the following child survival interventions were averaged: exclusive breastfeeding, continued breastfeeding, introduction of complementary foods, vitamin A supplementation, insecticide treated net presence in home, treatment of diarrhea with ORS or appropriate homemade solution, measles vaccine, BCG vaccine, polio vaccine (4 doses) and DPT vaccine (3 doses). This simple averaging procedure implicitly weights each intervention equally. The levels of composite coverage for 2006 and 2010, along with the percent change occurring over these two time points is shown in Table B27 for each state.

Overall, access to evidence based maternal or child survival interventions in Sudan have increased (Table B27), with gains in service delivery made across most states. In 2010, close to 40 percent of women and 65 percent of children under-five years of age received evidence-based care when needed. Coverage of maternal health interventions in 2010 was lowest in West Darfur (29 percent) and highest in Northern (52 percent). A hopeful indication is that gains in access to maternal interventions between 2006 and 2010 were greatest in the states with lowest overall coverage: West Darfur, North Kordofan, South Darfur and Blue Nile. Coverage of childhood health interventions was lowest in West Darfur and South Darfur (55 percent coverage) and highest in Northern (72 percent coverage). The states making the greatest progress in expanding child interventions between 2006 and 2010 were Northern and Blue Nile.

Table B27. Composite index of intervention coverage by state, Sudan, 2006 and 2010.

	Maternal Interventions			Childhood Interventions		
State	2006	2010	Percent Change	2006	2010	Percent Change
West Darfur	0.19	0.29	51.6	0.54	0.55	2.1
North Kordofan	0.32	0.43	33.0	0.56	0.62	10.7
South Darfur	0.24	0.32	32.4	0.52	0.56	6.0
Blue Nile	0.25	0.33	31.5	0.56	0.71	26.0
South Kordofan	0.28	0.35	23.9	0.53	0.62	16.0
Sinnar	0.34	0.41	22.4	0.59	0.67	13.0
Kassala	0.32	0.39	20.2	0.58	0.59	2.3
Northern	0.45	0.52	16.1	0.55	0.72	31.8
Gadarif	0.31	0.35	15.5	0.59	0.71	19.0
Sudan	0.35	0.40	13.5	0.57	0.65	13.5
North Darfur	0.30	0.32	7.4	0.59	0.63	7.3
Red Sea	0.34	0.37	7.0	0.57	0.57	-1.1
White Nile	0.41	0.43	6.9	0.56	0.68	21.5
Gezira	0.42	0.43	2.7	0.59	0.71	20.0
River Nile	0.48	0.48	1.1	0.58	0.69	18.8
Khartoum	0.51	0.51	-0.5	0.63	0.70	11.5

Source: Author's calculations based on 2006 and 2010 SHHS.

Notes: States are ordered in terms of the percent change in composite coverage of maternal survival interventions between 2006 and 2010.

While identifying and understanding the underlying factors contributing to the overall increase in population coverage of health services is beyond the scope of this study, it is worth noting several salient contextual economic and policy factors that have plausibly played an supporting role during the 2005 – 2010 timeframe:

(1) The implementation in 2008 of the Government of National Unity's free health care initiative for under-five children and pregnant women.

(2) Increased funding from external partners (assistance for health has primarily been driven by disease-specific programs – primarily HIV/AIDS, Malaria and TB – and humanitarian assistance for conflict-affected areas).

(3) Increased levels of real government health spending per capita (see next section on health financing)

However, it is also important to acknowledge the external and domestic risks that threaten the continued facilitation of access to life-saving interventions:

(1) Tightening of fiscal policy resulting in reduced government spending in response to slower economic growth, shortfalls in revenues and reduced foreign financing inflows (Sudan's economy and public sector depends heavily on the oil sector).

(2) Renewed conflict and instability (as is evidenced by the recent resurgence of fighting along border states, in particular Kordofan and Blue Nile).

Figures B30 and B31, summarize disparities in access to care for mothers and children resulting from economic differences (the wealthiest compared to the poorest households) and geographic differences (urban compared to rural households). Without adjusting for differences in other factors such as education, differences in access to care are on the order of 10 to over 200 percent. Gaps in access have saliently fallen over time for three of interventions: effective antenatal care (although the disparities here remain very large), household ownership of ITNs and tetanus toxoid vaccination. Interventions that benefit poor households with relatively equal likelihood as the wealthiest households involve breastfeeding (which to some degree is not surprising as these interventions do not require out of pocket payments, are controlled by mothers and can be performed from the home). Wealth is strongly associated with access to professional attention prior to and during birth, access to contraception and the practice of appropriate feeding practices for infants passed the age of 6 months. These patterns also hold for disparities between rural and urban settings although the magnitudes of the gaps are smaller presumably as geographic barriers are surmountable with wealth.

Figure B30. Wealth disparities in coverage: the ratio of intervention coverage between the wealthiest and poorest households, Sudan, 2006 and 2010

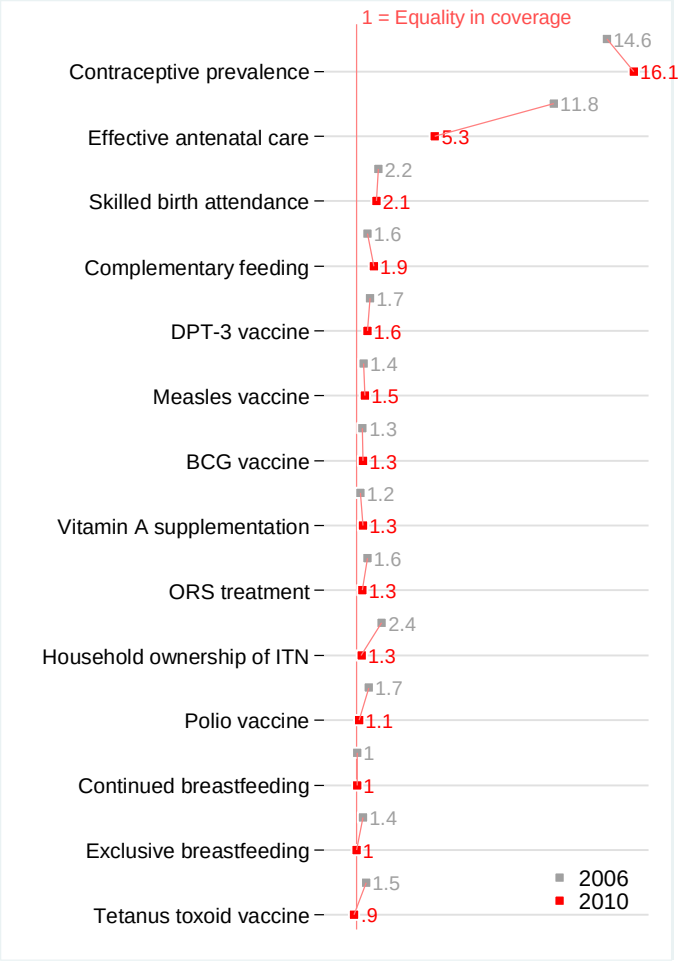
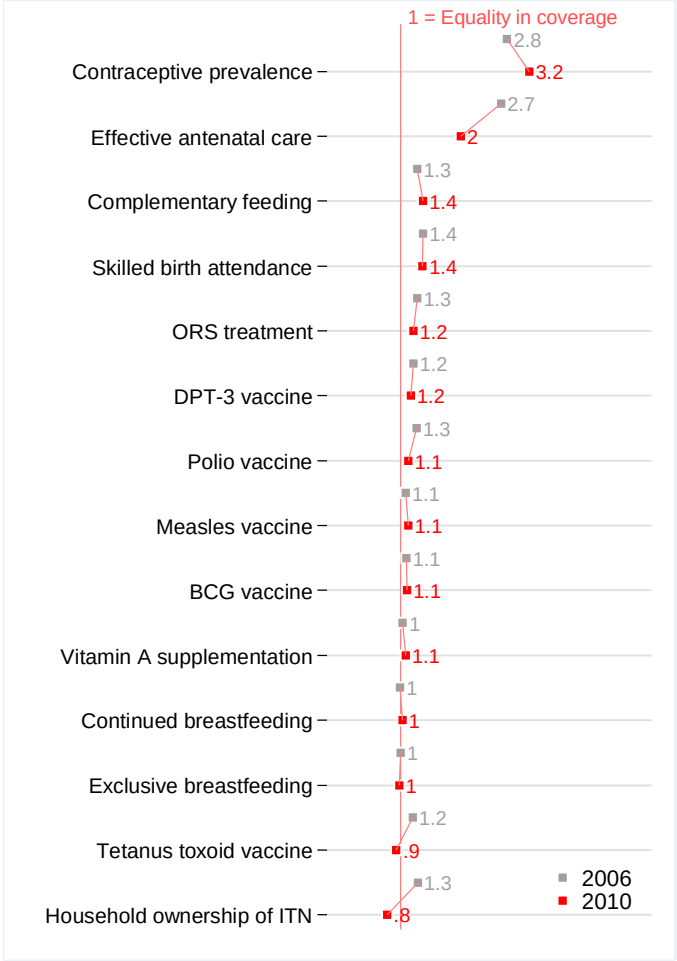


Figure B31. Urban-Rural disparities in coverage: the ratio of intervention coverage between urban and rural households, Sudan, 2006 and 2010



Source: Author's calculations based on 2006 and 2010 SHHS.
Notes: Households are ordered from high to low based on the ratio of coverage in 2010.

C. HEALTH FINANCING

Key findings and discussion

- Over 90 percent of households reported purchasing health services in the month prior to the National Baseline Household Survey in 2008, reflecting a relatively high degree of access to, willingness or ability to pay for - health care. On average, households paid 10 SDG per person per month for health care, representing 6.3 percent of total monthly consumption.

- The high level of out-of-pocket health payments in Sudan is consistent with the high proportion of revenues raised by state government through non-tax instruments - including user charge fees for health services (In 2009, non-tax revenues made up 80 percent of state's own revenues) as well as findings from National Health Accounts estimates which place out-of-pocket health payments at 70 percent of total health spending – the largest share among countries at similar levels of development.

- Measures of economic hardship resulting from out-of-pocket payment for health care are high in Sudan relative to other countries. The prevalence of catastrophic health spending in Sudan is 14.5 percent – among the highest worldwide.

- Severe health shocks affect Sudanese citizens with relatively equal likelihood across groups defined by wealth and urban or rural dwelling. Given that families devote considerable private resources to cope with these shocks (on average 115 percent of the value of yearly consumption, and up to two times the value of yearly consumption among the poorest households) demonstrates that people care significantly about their health.

- When affected by health shocks, families in Sudan draw from a variety of strategies to cope: approximately three in five households either sells assets, borrows or relies on social assistance to overcome the financial barriers to care. Since borrowing and selling assets threatens the future economic status of households (through interest payments or reduced ability to generate earnings through livelihood activities), severe health shocks may be a mechanism that makes it more difficult for families to escape poverty. The relatively large share of families relying on social assistance or charity may in part reflect the importance of Al Zakat as a form of insurance.

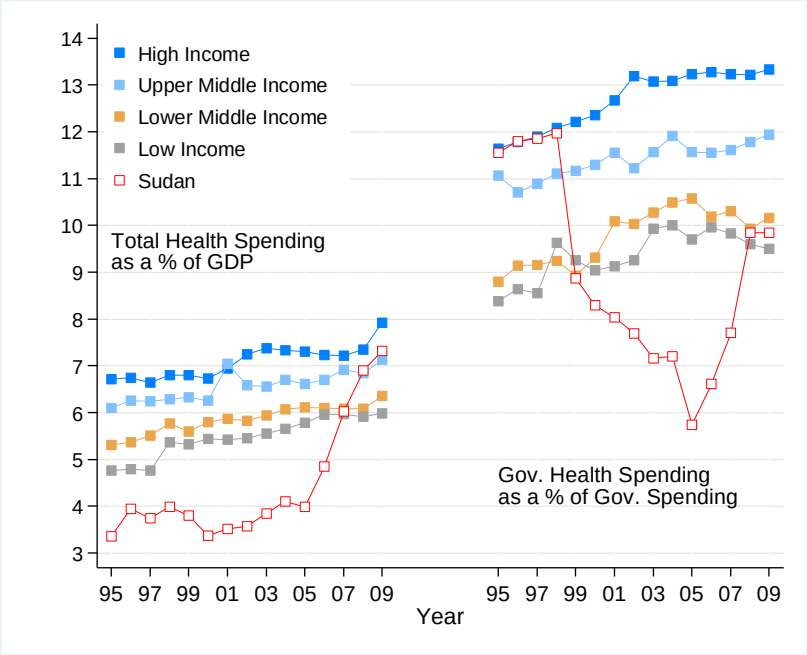
Introduction

Health financing is the process by which revenues are collected, accumulated in fund pools and allocated through purchasing to specific health actions. A well-functioning health financing system contributes to health system goals - primarily improved population health - by generating enough resources to adequately finance the health system (collecting), motivating actors in the system through financial incentives to work towards common goals (purchasing), and protecting individuals from the economic costs of health care by spreading risks over larger population groups (pre-payment and pooling). A key challenge in structuring health financing systems is expanding access to high quality health services while simultaneously protecting users from financial hardship resulting from healthcare.

In 2009, according to WHO National Health Accounts (NHA) estimates, total spending on health in Sudan was USD 95 (SDG 213) per person, lower than the average for lower-middle-income countries which stands at USD 153 but higher than the USD 44 per capita cost estimate of providing key health services by the WHO high-level task force on Innovative Financing for Health Systems. Figure C1 displays the evolution of total health expenditure as a percent of GDP– a measure of the importance of health care in the overall economy – and general government health expenditures as a percent of general government expenditures – a measure of the degree to which the government prioritizes health care in the national budget.

The share of health expenditure in GDP increased significantly from 4 percent on average between 1995 and 2005 to 7.2 percent in 2009, placing Sudan at spending levels slightly higher than the average upper-middle-income country. While general government health expenditures as a fraction of GDP increased steadily from a low of 0.5 percent of GDP to a high of 2.3 percent of GDP in 2008, the main driver of increased health spending was private health expenditures (primarily direct out-of-pocket spending) which increased from 2.6 percent of GDP in the 2005 to 5.3 percent of GDP in 2009.

Figure C1.

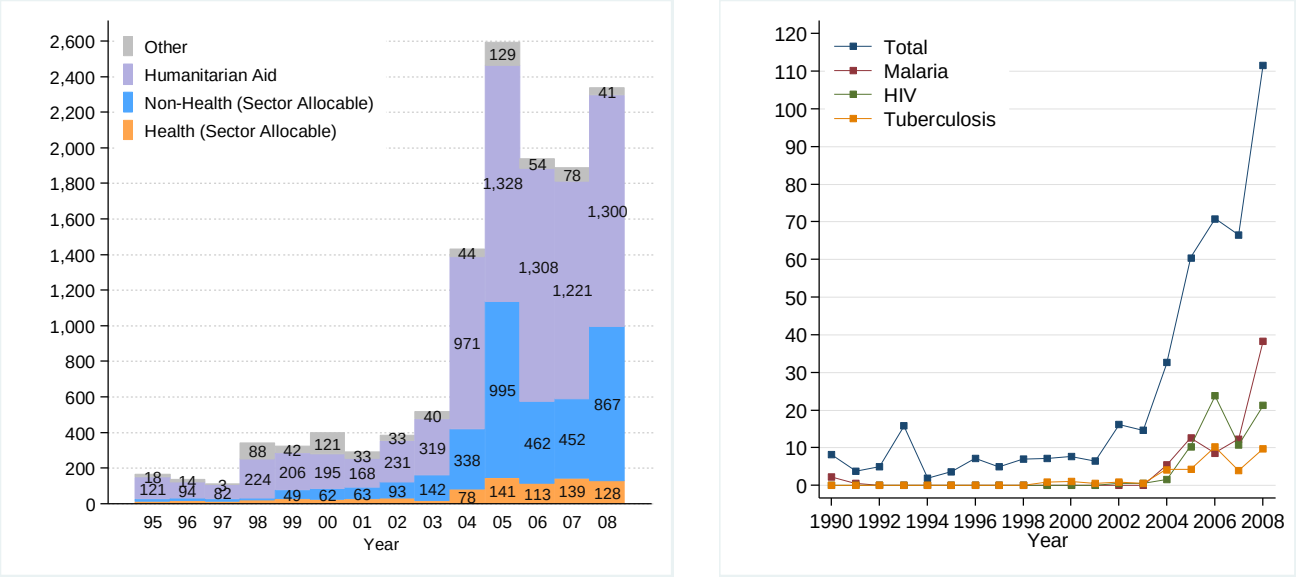


Source: World Health Organization, NHA Database

Between 1998 and 2004 the share of government health spending in total government expenditures fell from approximately 12 percent to 5.7 percent but recovered to 9.9 percent in 2009 – slightly above the average for low-income countries but below the average for lower-middle-income countries. It is important to note that these figures include contributions from external sources channeled through the government budget.

An important driver of increasing government health expenditures is increasing funding of health programs by the international community since 2005 – which as a fraction of total health expenditures averaged 5.7 percent between 2004 and 2009 compared to 2.5 percent between 1995 and 2003. Total disbursements for the health sector from the development partners (bilateral and multilateral) totaled USD 112mn in 2008 up from less than USD 10mn in 2000. A large portion (approximately 63 percent of total disbursements in 2008) of this scale up in funding is focused on Malaria, HIV and Tuberculosis. Between 2004 and 2011, GFATM disbursed USD 294mn (of which 139.7mn was for Malaria, 104.5mn for HIV/AIDS, and 49.4mn for Tuberculosis). Between 2004 and 2009, PEPFAR disbursed USD 26mn for HIV/AIDS prevention, treatment and care, and the two Multi-Donor Trust Funds (one for conflict affected areas in Northern Sudan and the other for South Sudan) managed by the World Bank have disbursed approximately 120mn for the health sector since 2006 (primarily through funds from the Netherlands, Norway, UK and Canada).

Figure C2 Development assistance, Sudan (North & South) (Commitments, left panel; Disbursements, right panel)



Source: OECD, DAC (left panel); Institute for Health Metrics and Evaluation (right panel)
Notes: Health (Sector Allocable) includes projects and programs targeted to general and basic health, population programs and reproductive health. Non-Health (Sector Allocable) includes projects and programs targeted to economic infrastructure, productivity (e.g. agriculture) and non-health social sectors (e.g. education, water and sanitation). Other includes ODA designated for debt relief, commodity aid, general budget support, donor administrative costs and unidentified ODA.

Government Health Spending

In Sudan, total government health spending (including Federal level and State level spending that is enabled both by federal transfers and each state's own revenue raising strategies) in nominal terms increased on average by 25 percent per year from SDG 129.7mn in 2000 to SDG 981.9mn in 2009, outpacing consumer

inflation (averaging 8.7 percent over the same period) and population growth (averaging 2.4 percent over the same period). In real terms – total government health spending per capita increased by 14 percent per year between 2001 and 2009, reaching SDG 31 in 2009 (approximately USD 13.5). It is important to note that the expansion in funds observed in the 2000s followed a period of contraction of social sector spending in the 1990s.

Table C2 compares the level of general government spending on health per capita and the share of government health spending in all government spending for Sudan and South Sudan, as well as neighboring countries and other conflict affected states in the region.

Table C2. General Government Health Expenditures (2009) among neighboring countries and other conflict affected states

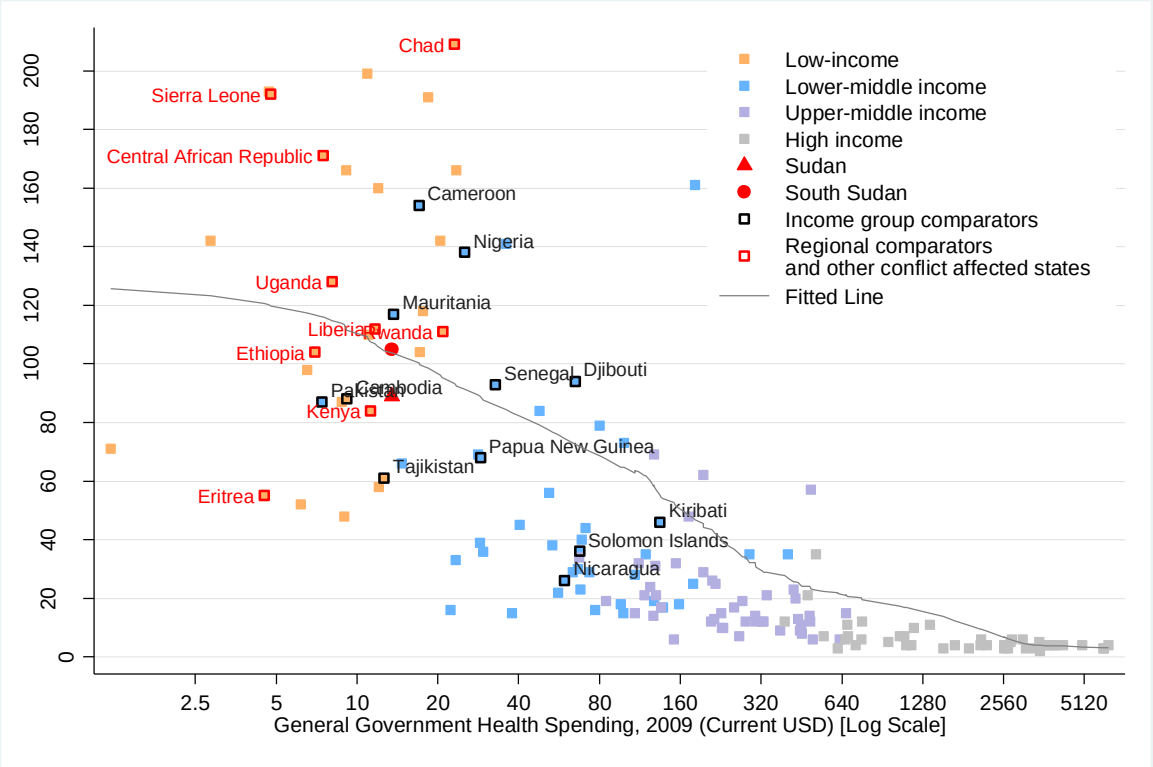
Country	General government expenditure on health per capita 2009 (Current USD)	General government expenditure on health per capita 2009 (International USD)	General government expenditure on health as a fraction of total government expenditure (%)	Under Five Mortality (probability of death between age 0 and age 5 per 1000 live births)
Chad	23.1	52.1	13.8	209
Rwanda	20.8	44.1	16.8	111
Mozambique	20.4	41.4	14.2	142
Sudan*	13.5	23.0	N/A	89
Republic of South Sudan*	13.5	23.0	4.9	105
Côte d'Ivoire	11.7	18.2	5.1	119
Liberia	11.6	20.8	17.2	112
Kenya	11.2	23.0	5.4	84
Uganda	8.1	21.8	11.6	128
Democratic Republic of the Congo	7.9	15.5	17.0	199
Central African Republic	7.5	12.5	11.0	171
Ethiopia	7.0	19.0	11.4	104
Sierra Leone	4.8	11.6	6.4	192
Eritrea	4.5	6.0	3.1	55

Source: WHO National Health Accounts Database, World Bank PETS, GoSS Annual Budgets
Notes: *Numbers for Sudan and South Sudan are based on author's estimates using World Bank PETS and Goss Annual Budgets all other data are from the WHO NHA database. *The estimates of general government health expenditure for Southern Sudan, assumes that 30% of donor funding goes through the government budget.

Figure C3 provides a broader view of the relationship between government expenditures on health and population health (as summarized by the under-five mortality rate). There is a strong negative relationship – countries that spend more on health care per citizen, have on average better health outcomes. At the lower end of the spending distribution (primarily low income countries), there is a very wide range of health outcomes suggesting other factors are at play (the prevalence of violent conflict or the degree of private spending, for example, but also how money is spent may be more important than how much is spent when resources are scarce). Among all low income countries, the average general government health spending per capita in 2009 was USD 11 placing Sudan and South Sudan just above the average. Among the low income group, only four countries have spending levels above USD 20 per capita: Chad, Rwanda, Mozambique and Burkina Faso. Although all of these countries have relatively high levels of government health spending, only Rwanda has

better child health outcomes than the average for low income countries (120 deaths per 1000 live births). Other countries in the same region or income group as Sudan that have significantly better outcomes than would be expected by their spending levels are Eritrea, Bangladesh, Madagascar, Tajikistan, the Democratic Republic of Korea, Myanmar and Kyrgyz Republic. Among lower-middle income countries average spending on health per capita in 2009 was USD 79.8 and average under-five mortality was 53.4 deaths per 1000 live births.

Figure C3. Under Five Mortality and General Government Health Spending by Income Groups, 2009

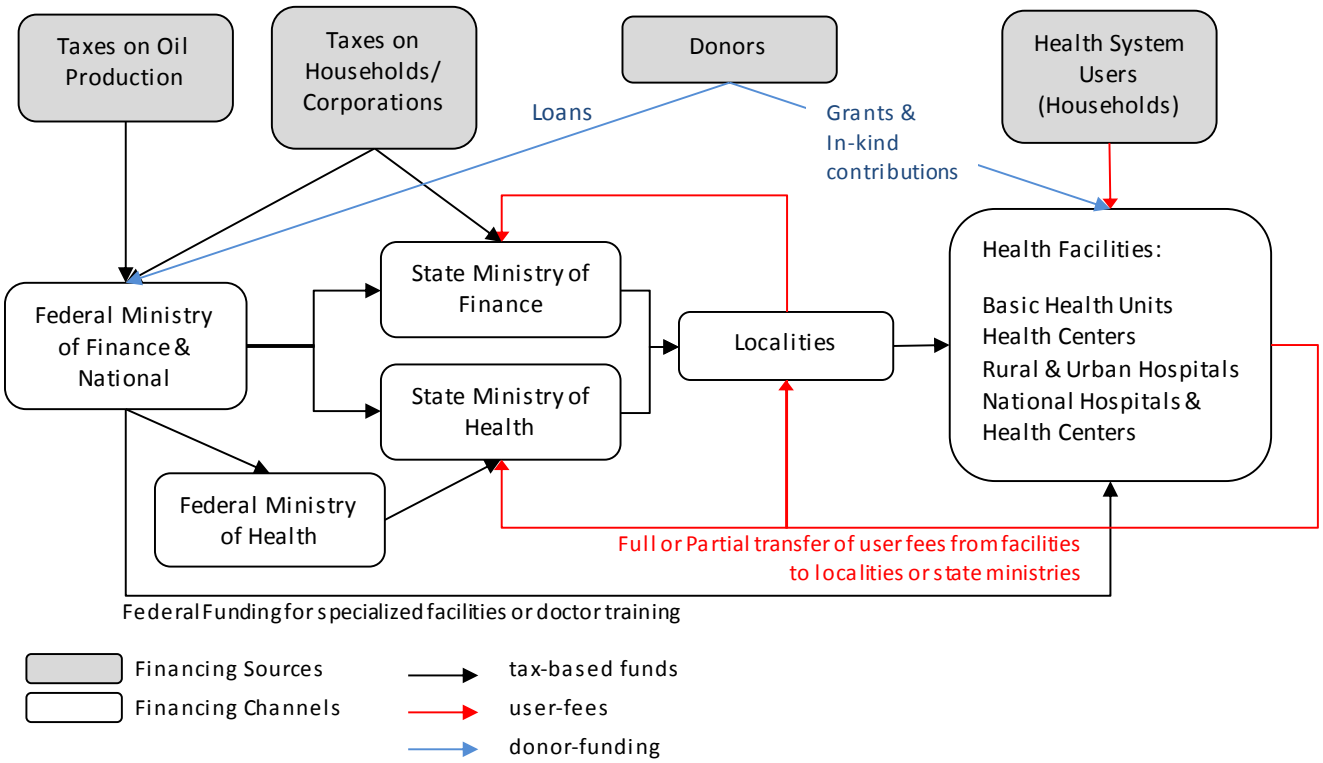


Source: WHO National Health Accounts Database, World Bank PETS, GoSS Annual Budgets

Assessing the effectiveness of government health spending – the degree to which public financing mechanisms promote better population health - requires understanding not only the level of donor and public spending but also understanding how funds flow through the health system and are translated into services. Decentralization – as a means to provide greater fiscal and decision-making authority to subnational governments – is a guiding principle for the structure of Sudan and South Sudan's health services. In this setting, states assume the primary role of basic health service management and provision. In Sudan, increasing responsibility over providing services at the state-level has also been accompanied by significantly increased transfers from the Federal Ministry of Finance and National Economy. In 2009, transfers to Northern states from the federal government in the form of block and earmarked grants represented 62 percent of aggregate state's revenue, up from 31 percent in 2000. Tax and non-tax revenues make up the remainder of funds available at the state level. In 2009, tax revenues represented a minor share (20 percent) of state's own revenues, while non-tax revenues (user-fees, state licenses and state enterprises among others) made up the remaining 80 percent (World Bank 2011). Figure C4 provides a simplified schematic of how funds flow from the major sources of financing to health service providers in Sudan - the majority of tax-based funding flows from the federal level to states (via monthly

bulk transfers), then to localities and finally to facilities. User-fees which comprise an important share of state's own revenues are collected at facilities from patients and then transferred in part or in full to localities or state ministries. On average, across the six PETS focus states - Blue Nile, Kassala, Khartoum, North Kordofan, Red Sea and South Kordofan – 19, 16 and 65 percent of total expenditures were executed at that state, locality and facility level, respectively.

Figure C4. Overview of health system funding structure, North Sudan

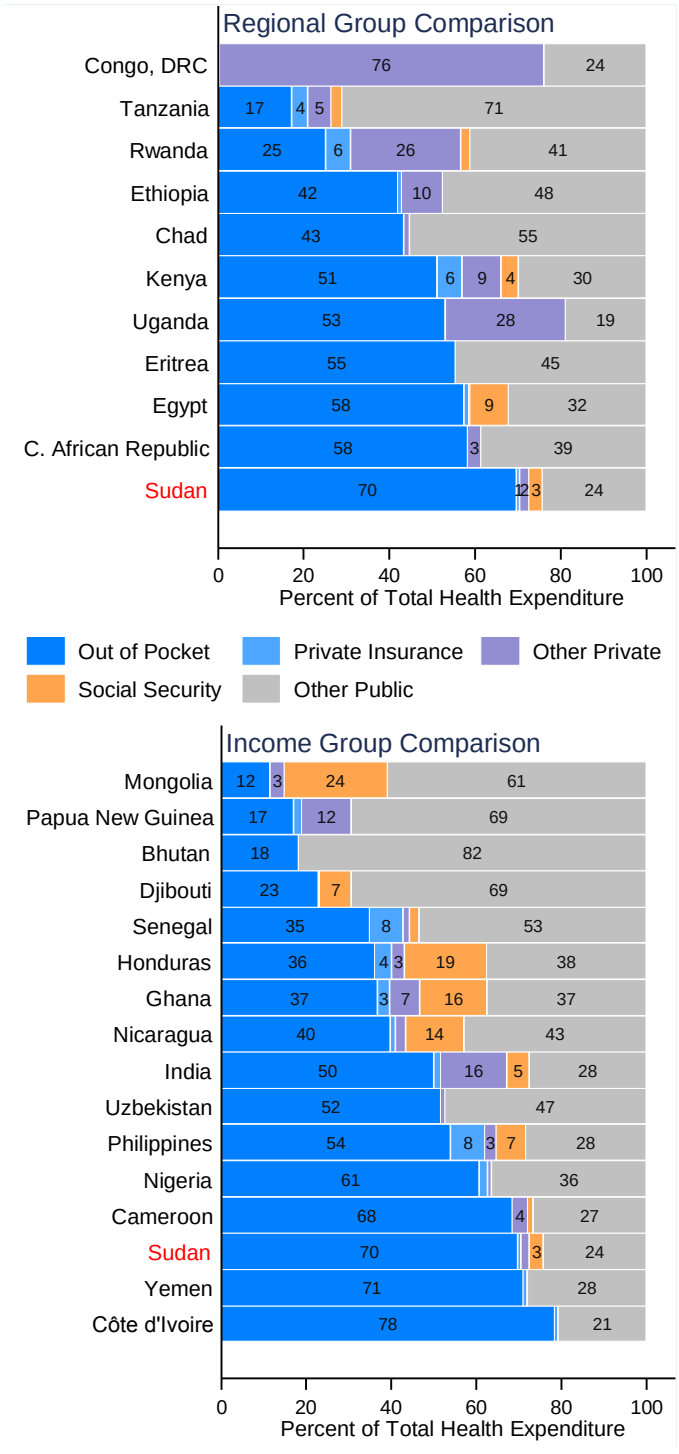


Source: Adapted from the World Bank Public Expenditure Tracking Survey (PETS), 2011

Recent studies (Witter 2010; World Bank 2011) looking at the health financing in Sudan have identified several challenges with the decentralized structure of Sudan's health system. Among these, states have a weak ability to raise tax revenues (a result of both having a narrow tax base and limited tax instruments at their disposal); federal development transfers for health have a low budget execution (and therefore credibility) and low predictability, complicating state-level planning; given the dependence on federal transfers for capital improvements, there is a very low level of investment (84 percent of all health spending is made up by current spending); and the allocation of health spending across states is not rationalized with need (for example, poverty rates or burden of disease). The institutionalization of national policies (such as the free health care initiative for children under-five and pregnant women) when there are multiple actors and weak central monitoring and evaluation mechanisms is also difficult.

Out-of-pocket health spending & user-fees

Figure C3. Disaggregation of Total Health Expenditures, 2009



Source: World Health Organization, NHA Database

Figure C3 displays the breakdown of total health expenditure from private sources: out-of-pocket payments, private health insurance and other sources as well as public sources – social security and general tax-based public funding for Sudan, neighboring countries and countries with a similar per-capita income level in 2009. With out-of-pocket expenditures at 70 percent of total health expenditures, Sudan stands out as having the highest proportion of out of pocket health spending in total health spending among neighboring countries and the third highest (behind Ivory Coast and Yemen) among countries with similar income levels. Tax-based government spending, representing 24 percent of total health spending, is the next largest component. At less than 4 percent of total health spending, formal insurance mechanisms – voluntary private insurance schemes and tax-funded social security – play a very minor role in health financing.

One component of out-of-pocket spending are the user fees charged at public and private health facilities. Despite having offered free public health care after independence, the government of Sudan introduced user fees for services and drugs in public health facilities in 1991-1992 as a part of the Health Salvation programs and Sudan National Strategy for Health (Mohamed 2007) (Abdu, Mohammed et al. 2004). In recognizing the threats to access imposed by user-fees, several policy responses were ensued: in 1995 the National Health Insurance Fund (NHI) was created, in 1996 a presidential declaration establishing free emergency care and select specialist services was established and most recently, in 2008, the Government of National Unity of Sudan agreed on an initiative to provide free health care to under-five children and pregnant women (Witter 2010).

Interestingly, the Sudan Interim National Constitution of 2005 encodes both the right to free health care and the right of states to collect revenues through local taxes and charges. State and facility level data from the World Bank PETS focused on Northern Sudan reveal that in 2009, the fees received from facilities as a source of state revenue amounted to SDG 283.4mn or 46 percent of total state level expenditure on health. At the facility level, 32 percent of the funding available for financing service delivery in Northern States is from retained user fees (those not transferred to the State Ministry of Finance of Localities). The value of these fees in 2009 was SDG 258.2mn. Based on these numbers, the estimated total revenue raised from user-fees in Northern Sudan was SDG 546.7mn representing approximately 55 percent of total spending on health by the state and federal government. Evidence from PETS suggests that user fees serve a variety of purposes: to supplement shortfalls in transfers from the state and federal level, to pay salaries and allowances and to purchase drugs and medical consumables. One driver for the relative importance of fees as a source of revenue in the financing system, is the decreasing ability of states to raise taxes through productive instruments such as agricultural or sales tax, creating pressure on state governments to search for other sources of revenue. Another reason is that it may be a way to balance the uncertainty in the timing and levels of federal transfers.

The PETS study also provides an indication of the relative importance of insurance mechanisms in health financing. Data from facilities suggests that health insurance accounts for 4.7 percent of all funds collected for facility level expenditures – although this is likely an underestimate as the PETS did not track reimbursements from the insurance provider. Another source of insurance is Al Zakat- a religious-based social protection mechanism overseen by the Ministry of Welfare and Social Development. Zakat accounted for less than 0.01 percent of facility funding, likely reflecting that most of Zakat funding is received directly by beneficiaries who might then use the funds to access health care.

The NHA and PETS data point to a health system relying heavily on direct spending by health care users at the place and moment of service delivery. While it is unclear precisely the degree to which user-fees drive total out-of-pocket spending in Sudan, previous studies have documented two negative aspects with out-of-pocket spending associated with user fees (WHO 2010). Firstly, user fees can discourage health seeking behavior (in particular for promotion and prevention services) and delay treatment especially for the poor. In the PETS, out of 371 facilities surveyed in six focus states: Blue Nile, Kassala, Khartoum, Northern Kordofan, Red Sea and Southern Kordofan 45 percent responded that patients could not pay for services, suggesting that user-fees risk allocating health care along the lines of ability to pay rather than need. In this setting, the majority of the facilities citing the unaffordable levels of user-fees reported they still provide services to individuals who cannot pay.

Secondly, user-fees hurt household finances. By exposing individuals to the financial risk of illness, even small payments can hurt poor households by forcing them to reduce basic payment on food, shelter or their children's education. Large, unexpected health care payments can also hurt richer households (Xu, Evans et al. 2007). When the costs of health care exceeds a household's income or capacity to pay, households may resort to borrowing, selling assets or taking their children out of school to cope. Additionally, user fees may cause inefficiency and inequity in the way resources are used. People who can afford to make direct payments, may overuse services, while those who can't (usually those who can't afford payments are also those with greatest need) will under-use or not use them at all.

While policies that implicitly recognize the negative consequences of user-fees have been adopted and are attempting to shift the burden of financing health care from individuals to the state (through user-fee exemptions) (Witter 2010), recent findings suggest that the implementation of these policies has been uneven and not able to significantly reducing the financial burden on users. In a review of the implementation of the free care for pregnant women and under-fives initiative, the study authors found that the policy was not clearly defined and communicated to states and localities, federal funding and drug supplies were inadequate and unpredictable (i.e. not sufficient to cover all intended beneficiaries and procedures) and communities had relatively low awareness of the initiative (although there is some evidence that utilization for child care services increased during the implementation period) – limiting the degree of public accountability. Faced with funding shortfalls, facilities participating in the program partially or fully reintroduced fees, effectively undermining the objective of the policy. In exit interviews with the caregivers of ill children under-five – less than 2 percent reported receiving free care (Witter 2010).

The section below takes a closer look at the distribution of out-of-pocket payments and their effects on financial hardship and impoverishment among households in Sudan.

Economic hardship & health care spending

Data and Methods

This section draws on household consumption data from the 2009 National Baseline Household Survey (Table C1) to measure out-of-pocket spending on health and the extent to which those payments contribute to economic hardship. The analysis that follows is restricted to households who sought care and reported paying for care in the 4 weeks prior to the survey, thus focusing on the financial consequences of paying for care rather than on the financial consequences on households who could not afford or access health care.

Table C1. NBHS Sample Characteristics

	Sudan	South Sudan
No of households	7,913	4,969
Male (%)	82.3	67.8
Average Age	45.8	42.2
Education		
No schooling (%)	47.5	71.1
Primary (%)	30.1	17.8
Secondary or Higher (%)	22.4	11.2

Source: Author's calculations using 2009 NBHS

Table C2. Health Spending Items in NBHS

Medicines and Drugs
- Cough Syrup medicine (cold)
- Drug tabs and roots for reducing fever and malaria
- Antibiotics
- Other pharmaceutical products

Equipment for Curative Services
- Medical eye glasses
- Hearing aid

Medical Doctoral Services
- Specialist and general doctors
- Medical consultation at hospital
- Planning blood vessels

Medical Dental Services
- Filling and treatment of teeth

Medical Tests and Others
- Malaria blood testing
- Other tests (blood, urine, feces)
- x-ray test
- Physiotherapy

Other hospital and healer services
- Birth in general hospital
- Operations in hospital
- Government hospital
- Private hospital
- Traditional healers fee/medicine

Source: NBHS Questionnaire

Private out-of-pocket spending on health is measured using consumption spending captured in the NBHS using an aggregation of the items shown in Table C2. For each item, households were asked how much was spent in the month and year prior to the time of the survey. The preferred recall period used for the construction of non-food consumption measures was the last month. The annual consumption amount was used if the household did not report the last month but reported in the last year. Adjustments for price differences in urban and rural settings were made so the consumption expenditure is in real terms. In addition, consumption measures are presented on a per-capita basis to adjust for household size. Total household spending is constructed by aggregating monthly expenses on education, health, clothing, utilities, transportation and communication, personal care, maintenance, utensils and accessories for the house and entertainment and leisure.

In addition to measuring the levels of out-of-pocket health spending and the share of health spending in the overall household consumption budget, three measures were constructed to gauge the extent to which households face economic hardship as a result of out-of-pocket payments for health care:

(1) Catastrophic Expenditure: The percentage of households incurring catastrophic health expenditures where catastrophic expenditure is defined as out-of-pocket health payments exceeding 40% of a household's capacity to pay for health services (defined as total household spending minus subsistence spending defined by the poverty line) (Xu, Evans et al. 2003). For households whose total consumption spending is below the poverty line, capacity to pay is defined as the observed level of non-food spending.

(2) I**mpoverishment:** The percentage of households pushed below the poverty line due to out-of-pocket health payments.

(3) Hardship Financing: The percentage of households having to borrow or sell assets to financially cope with the severe illness or accident of a household member (Kruk, Goldmann et al. 2009). Unpredictable illness or accidents that diminish the health status of individuals have two important economic consequences, firstly they are often associated with the need for hospitalization that require payments of large sums of money in a short period of time and secondly they bring about loss of income to the household due to the temporary or prolonged disability of a wage earner. Assessing the coping mechanisms used by households to respond to health shocks is important as it can shed light on how health payments affect future welfare (Leive and Xu 2008). Table C3 displays the coping strategies captured by the NBHS among households reported to have been severely affected by the illness or accident of a household member in the five years prior to the survey. For purposes of analysis, the coping strategies were aggregated to seven categories: savings, sale of assets, borrowing, income or labor allocation, social assistance or charity, consumption reduction and other. In addition, the NBHS captures the estimated value of the health shocks to households; however, it does not capture the proportion recovered by the coping strategy.

Several advantages are associated with using the extent of borrowing and selling assets to measure the economic hardship associated with health payments including its ability to distinguish between affordable and less-affordable payments that might have negative long-term consequences for households by increasing their exposure to debt or ability to generate revenue in the long term. In addition, this measure can also take into account non-financial costs such as those associated with travel to a facility or income loss (Kruk, Goldmann et al. 2009).

Table C3. Coping Categories/ Strategies

Savings
- Spent Cash Saving

Sale of assets
- Sold assets (tools, furniture etc.)
- Sold farm land
- Sold animals

Borrowing
- Borrowed money from relatives
- Borrowed money from money lender
- Borrowed money from institutions (banks)

Income/ Labor allocation
- Rented out farm
- Sold more crops
- Worked more/ longer hours
- Other household members who weren't working went to work
- Removed children from school to work
- Went elsewhere to find work for more than a month
- Started a new business

Social Assistance/ Charity
- Received help from religious institutions
- Received help from local NGO
- Received help from international NGO
- Received help from Government
- Received help from family/friends

Consumption reduction
- Reduced food consumption
- Consumed lower cost, but less preferred foods
- Reduced non-food expenditures

Other
- Sent Children to live with relatives
- Spiritual help – prayers, sacrifices, consulted diviner, etc.

Limitations

Measuring out-of-pocket spending directly from surveys has limitations resulting from sampling error and non-sampling error. Sampling error results both from the inherent variation between individuals and households in the population (random error) as well as factors related to the sampling design (fixed error). Fixed sampling error related to health care spending can arise if sub-groups of the population are not surveyed – such as groups living in institutions (hospitals and prisons for example). However, in the case of North and South Sudan – this group is not likely to represent a large portion of the population. Fixed sampling error can also result from

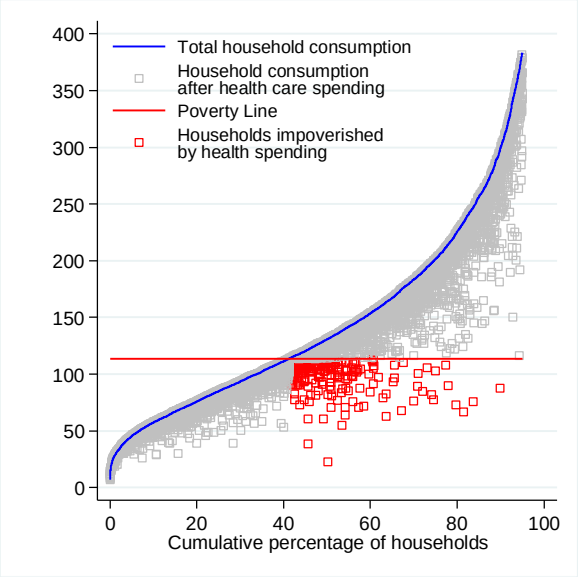
seasonal variations in health care use and expenditure. Non-sampling errors on the other hand – rather than resulting from the sampling design – result from issues in the design and implementation of the survey and from characteristics of human behavior under survey conditions. One notable issue is recall bias – individuals are rarely able to accurately recall the full details and timing of events in the past. In addition, as household surveys (including the NBHS) rely on proxy respondents to obtain information, there is a larger chance that that the respondent will not recall important events if they did not experience it directly. For example, relative to mothers, adult male respondents are likely to be less familiar with expenditures involving their children. In addition, deliberate errors might be introduced by respondents in order to conceal sensitive information and in the case of very long surveys, some respondents may simply omit responses in order to complete the interview more quickly (Rannan-Eliya 2008).

Relative to surveys that are specialized to collect health care spending, surveys conducted to collect data on all items of household consumption – like the NBHS – tend to underestimate health spending. Excluding non-financial costs from survey questionnaires – such as transportation to access health facilities and health services provided at home, will also tend to underestimate health-care related consumption – especially for households in isolated settings.

Results

In Sudan, 91 percent of households reported purchasing health care services or products in the month prior to the survey with out-of-pocket payments, reflecting a relatively high degree of access, ability or willingness to pay for services. Out-of-pocket health spending averaged SDG 10 per person per month (or SDG 120 per person per year), representing 6.3 percent of total consumption. By comparison, expenditures by the state governments on health in 2009 was SDG 18.5 per capita per year (World Bank 2011) – reinforcing the system-wide picture provided by NHA data in Figure C3 that a large majority of total health spending is made by individuals at the point of care. Although health spending is greater in urban relative to rural areas, health spending in rural areas captures a higher share of total consumption (6.7 percent in rural areas versus 5.6 percent in urban areas). At 24 SDG per capita per month, health spending among the richest households is eight times as large as spending by the poorest households (SDG 3 per capita). As a share of total consumption, health care payments rise from 5.5 percent among the poorest households to 7.4 percent among the richest suggesting that the demand for health care rises with income.

Figure C4. Impoverishment from health spending, Northern Sudan



Source: Author's calculations using 2009 National Baseline Household Survey

Overall, 14.5 percent of households in Northern Sudan incurred catastrophic health payments, and 8.6 percent were impoverished as a result of those payments. Prior research has found the prevalence of catastrophic

spending among low income countries to range from less than 1 percent up to 10 percent (among middle income countries the distribution ranges from less than 1 to 7 percent) (Xu, Evans et al. 2007). The findings from this analysis, suggests that Sudan has among the highest levels of catastrophic spending worldwide. The prevalence of catastrophic spending for health care is more pronounced for rural households (16.3 percent) compared to urban households (11.3 percent). There is a sharp increase in vulnerability to economic hardship from health spending among households in the third wealth quintile, where 38 percent of households incurred catastrophic health expenditures compared to an average of 6.7 percent among the majority of the poor (1st and 2nd wealth quintiles) and 5.7 percent among the richest households. Over 29 percent of households in the third wealth quintile were impoverished by out-of-pocket health payments. Figure C4 conveys the concentration of impoverishment among households in the middle of the consumption distribution, although it is important to note that impoverishment affects even households located at the upper end of the distribution.

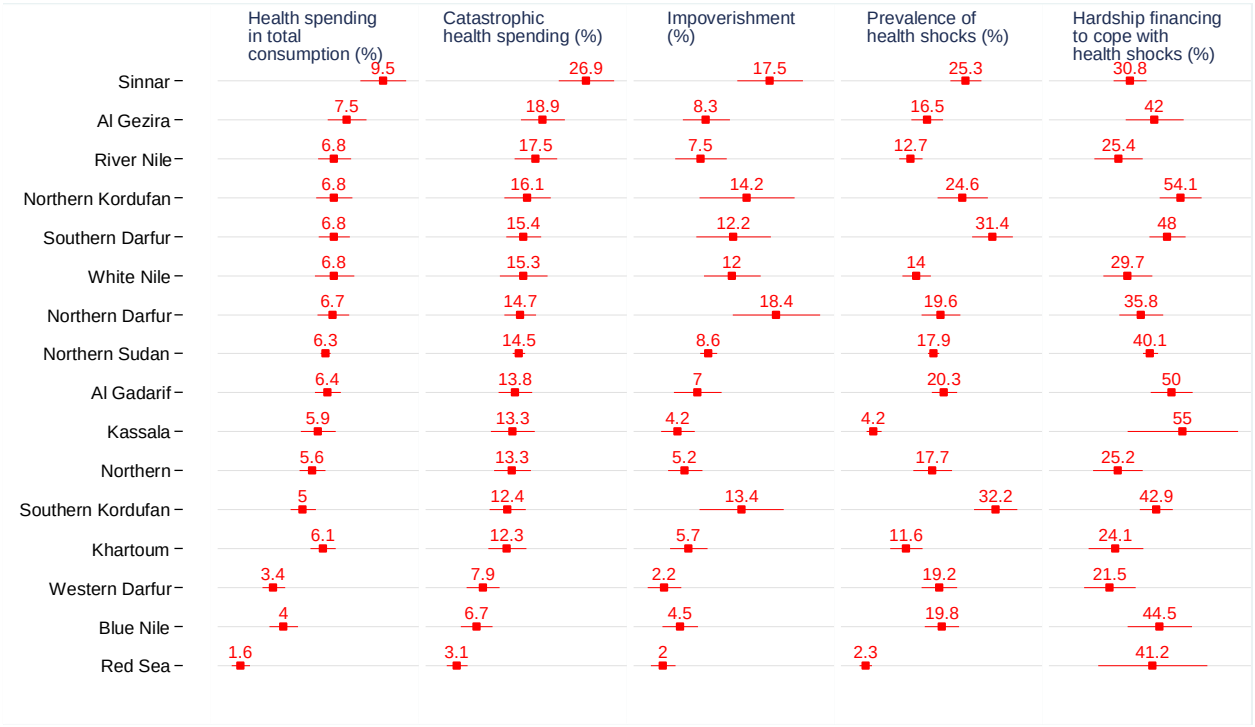
Table C4. Health spending, exposure to health shocks and measures of economic hardship, Sudan

	Urban	Rural	Poorest	2nd wealth quintile	3rd wealth quintile	4th wealth quintile	Richest	Sudan (North)
Consumption per capita per month (SDG)								
Food	113.3	77.8	31.7	54.6	77.1	107	181.9	90.4
Education	7.3	1.7	1.1	1.7	2.4	3.5	9.9	3.7
Health	12.1	9	2.9	5.1	7.5	11.2	24	10.1
Total Consumption	196.6	121.6	50.7	86.5	120.8	169.6	314	148.3
Households reporting health spending in past month (%)	92.9	90.1	82.2	89.8	93	94.6	95.8	91.1
Consumption per capita per month (SDG)								
Food (%)	59.8	63.8	62.3	63.1	63.9	63.1	59.5	62.4
Education (%)	3.4	1.6	2.1	1.9	2	2.1	3	2.2
Health (%)	5.6	6.7	5.5	5.9	6.1	6.6	7.4	6.3
Share of Health Spending in Non-Subsistence Spending (%)	22.6	50	13.4	14.6	138.8	21.7	12.6	40.2
Poverty								
Poverty headcount (%)	26.5	57.6	100	100	32.7	0	0	46.5
Exposure to health shocks and coping strategies								
Households faced with severe health shock (%)	15.8	19.1	18	17.4	18.4	18.1	17.6	17.9
Value of Health Shock (SDG)	2,682	1,763	1,204	1,740	1,619	2,009	3,117	2,050
Households affected with health shock by coping strategy:								
Savings (%)	25	11.5	4.7	12.9	9.8	17	27.4	15.7
Sale of assets (%)	13.1	25.1	23.9	28.9	23.2	20.6	14.3	21.3
Borrowing (%)	21.4	17.6	18.6	14.7	18.4	23.4	17.9	18.8
Income/Labor Allocation (%)	6.9	11.5	9.1	9.4	13	10.8	8.3	10.1
Social Assistance/ Charity (%)	22.1	19.8	28	21.4	19	17	19.4	20.5
Consumption reduction (%)	3	1.5	2.8	1.2	3.2	1	2	2
Other (%)	8.6	13	12.9	11.7	13.3	10.1	10.7	11.6
Measures of economic hardship from health spending								
Catastrophic Health Expenditures (%)	11.3	16.3	6.6	6.8	38.8	14.8	5.7	14.5
Impoverishment (%)	4.8	12.3	--	--	29.3	2.9	0.4	8.6
Hardship financing (%)	34.5	42.7	42.5	43.5	41.7	44	32.2	40.1

Source: Author's calculations using 2009 National Baseline Household Survey

About 18 percent of all households were affected by the severe illness or accident of a family member in the five years prior to the survey. In these cases, the average reported value of these health shocks was SDG 2,050 – larger than the annual value of total consumption for the average person (SDG 1780). Health shocks are more common in rural than urban households, but equally likely across wealth quintiles – the financial impact of these events on the poorest, however, are relatively more significant since the value of reported health shocks among the poorest was almost double the value of their yearly consumption. The rate of borrowing or selling assets to cope with health shocks among affected households is 40 percent, higher among rural than urban households but equally likely across wealth quintiles, except for the wealthiest quintile whose members were more likely to draw from savings to cope with severe health shocks. Of the households who borrowed money, over 50 percent borrowed from relatives, about 40 percent from a money lender and less than 7 percent borrowed money from formal institutions. When households sold assets, over 60 percent sold animals, the remainder sold consumer durables and less than 2 percent sold land. Social assistance is another prominent strategy for coping with health shocks among households in Sudan, by far the most dominant form of this assistance was support from family or friends. The high level of reliance on relatives for money and support highlights the critical role of informal social networks as a means to cope with shocks.

Figure C5. Health spending, exposure to health shocks and measures of economic hardship, North Sudan, by State



Source: Author's calculations using 2009 National Baseline Household Survey
Notes: States are ranked from highest to lowest in terms of catastrophic health spending

Across states, Khartoum has the highest level of health spending per person per month (SDG 13.7) while Red Sea has the lowest (SDG 2.8). Relative to total household consumption, health spending is largest in Sinnar where it makes up 9.5 percent of total consumption and lowest in Red Sea. Measures of economic hardship resulting from out-of-pocket payments for health care are also high in Sinnar, which has the highest prevalence of catastrophic health spending (26.9 percent) and the second highest rate of impoverishment (14.2 percent). At 18.4 percent, Northern Darfur has the highest rate of impoverishment as a result of health spending, with Northern and Southern Kordofan, Southern Darfur and White Nile showing rates of impoverishment above 10 percent. States with the highest reported exposure to health shocks are Southern Kordufan (32.2 percent),

Southern Darfur (31.4 percent), Sinnar (25.3 percent) and Northern Kordufan (24.6 percent). The percentage of households borrowing or selling assets to cope with these shocks was highest in Kassala (55 percent), Northern Kordufan (54.1 percent), Al Gadarif (50 percent) and Southern Darfur (48 percent). It is important to note that differences between individual states may not be statistically significant due to sampling variation.

Works Cited

Abdalla, S. I., E. M. Malik, et al. (2007). "The burden of malaria in Sudan: incidence, mortality and disability - adjusted life - years." Malaria Journal **6**(97).

Abdu, Z., Z. Mohammed, et al. (2004). "The impact of user fee exemption on service utilization and treatment seeking behaviour: the case of malaria in Sudan." International Journal of Health Planning and Management **19**(S95-S96).

Atieli, F. K., S. O. Munga, et al. (2010). "Wash durability and optimal drying regimen of four brands of long-lasting insecticide-treated nets after repeated washing under tropical conditions." Malaria Journal **9**(248).

Black, R. E., L. H. Allen, et al. (2008). "Maternal and child undernutrition: global and regional exposures and health consequences." The Lancet **371**: 243-260.

Brass, W. and A. J. Coale (1968). Methods of analysis and estimation. The Demography of Tropical Africa. Princeton, New Jersey, Princeton University Press.

Breman, J. G., A. Mills, et al. (2006). Conquering Malaria. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Brenzel, L., L. J. Wolfson, et al. (2006). Vaccine-Preventable Diseases. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Caulfield, L. E., S. A. Richard, et al. (2006). Stunting, Wasting, and Micronutrient Deficiency Disorders. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Central Bureau of Statistics and Southern Sudan Center for Census Statistics and Evaluation (2006). Sudan Household Health Survey. Khartoum/ Juba, Government of National Unity (GONU), Government of South Sudan (GOSS).

Department of Nutrition, W. (2011). "Estimated prevalence of wasted preschool children 1990-2010 with 95% confidence intervals by UN regions and subregions." from http://www.who.int/nutgrowthdb/wasting_p1990_2010.pdf.

DHS (1991). Sudan Demographic and Health Survey 1989/1990. Khartoum/ Columbia, Department of Statistics, Ministry of Economic and National Planning, Institute for Resource Development/ MACRO International.

Dormstadt, G. L., Z. A. Bhutta, et al. (2005). "Evidence-based, cost-effective interventions: how many newborn babies can we save? ." Lancet **365**: 977-988.

Esrey, S. A., J. B. Potash, et al. (1991). "Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma." Bulletin of the World Health Organization **69**(5): 609-621.

Ezzati, M. and D. M. Kammen (2002). "The Health Impacts of Exposure to Indoor Air Pollution from Solid Fuels in Developing Countries: Knowledge, Gaps, and Data Needs." Environmental Health Perspectives **110**(11): 1057-1068.

Feeney, G. (1980). "Estimating Infant Mortality Trends from Child Survivorship Data." Population Studies **34**(1): 109-128.

Graham, W. J., J. Cairns, et al. (2006). Maternal and Perinatal conditions. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank Oxford University Press.

Harvey, P. and B. Rogers-Witte (2007). Nutrition Status and its Determinants in Southern Sudan: A summary of available data. Washington DC, Academy for Educational Development.

Hay, S. I., C. A. Guerra, et al. (2009). "A World Malaria Map: Plasmodium falciparum Endemicity in 2007." PLoS Med **6**(3): 0286-0302.

Jones, G., R. W. Steketee, et al. (2003). "How many child deaths can we prevent this year? ." Lancet **362**: 65-71.

Keusch, G. T., O. Fontaine, et al. (2006). Diarrheal Diseases. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Koblinsky, M., Z. Mathews, et al. (2006). "Going to scale with professional skilled care." The Lancet.

Kruk, M. E., E. Goldmann, et al. (2009). "Borrowing And Selling To Pay For Health Care in Low- And Middle-Income Countries." Health Affairs **28**(4): 1056-1066.

Lawn, J. E., J. Zupan, et al. (2006). Newborn Survival. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Leive, A. and K. Xu (2008). "Coping with out-of-pocket health payments: empirical evidence from 15 African countries." Bulletin of the World Health Organization **86**: 849-856.

Lim, S. S., N. Fullman, et al. (2011). "Net Benefits: A Multicountry Analysis of Observational Data Examining Associations between Insecticide-Treated Mosquito Nets and Health Outcomes." PLoS Med **8**(9).

Lindblade, K. A., E. Dotson, et al. (2005). "Evaluation of long-lasting insecticidal nets after 2 years of household use." Tropical Medicine and International Health **10**(11): 1141-1150.

Malaria Consortium. Retrieved September, 2011, from http://www.malariaconsortium.org/articles.php?coid=8.

Mohamed, G. K. (2007). "Financing health care in Sudan: Is it a time for the abolishing of user charges? ." Sudanese Journal of Public Health **2**(1): 38-45.

Naeye, R. L., L. S. Burt, et al. (1971). "Neonatal Mortality, The Male Disadvantage." Pediatrics **48**(6): 902-906.

Onis, M. d., M. Blossner, et al. (2011). "Prevalence and trends of stunting among pre-school children, 1990-2020." Public Health Nutrition.

Preston, S. H., P. Heuveline, et al. (2001). Demography: Measuring and Modeling Population Processes. Oxford, Blackwell.

Rajaratnam, J. K., L. N. Tran, et al. (2010). "Measuring Under-Five Mortality: Validation of New Low-Cost Methods." PLoS Med **7**(4).

Rannan-Eliya, R. P. (2008). National Health Accounts Estimation Methods: Household Out-of-pocket Spending in Private Expenditure, Monograph prepared for WHO/NHA Unit, Geneva, Switzerland.

Simoes, E. A. F., T. Cherian, et al. (2006). Acute Respiratory Infections in Children. Disease Control Priorities in Developing Countries, 2nd Edition. D. T. Jamison, J. G. Breman, A. R. Meashamet al. New York, The World Bank and Oxford University Press.

Snow, R. W., C. R. J. C. Newton, et al. (2003). The Public Health Burden of Plasmodium falciparum Malaria in Africa: Deriving the Numbers. Working Paper No. 11, Disease Control Priorities Project. Bethesda, Fogarty International Center, National Institutes of Health.

Sudan National Aids Program (2009). Review of the HIV Epidemic in Northern Sudan: Situation Analysis. Khartoum, Sudan National Aids Program.

Theuri, T. (2007). "Summary of a report on the underlying causes of malnutrition in Twic county, Warrap State, South Sudan." Southern Sudan Medical Journal **1**(3).

UN (2007). Maternal Mortality in 2005: Estimates developed by WHO, UNICEF, UNFPA and the World Bank. Geneva, WHO.

UNAIDS (2008). Epidemiological Fact Sheet on HIV and AIDS, Sudan. Geneva, UNAIDS/ WHO Working Group on HIV/AIDS and STI.

UNData (2012).

UNICEF (2007). Technical Briefing Paper 2: Universal Salt Iodisation. Khartoum, UNICEF.

United Nations (1983). "Manual X: Indirect Techniques for Demographic Estimation." Population Studies **81**.

WHO Indicators for assessing infant and young child feeding practices: conclusions of a consensus meeting held 6-8 November 2007 in Washington D.C., USA, Washington D.C., USA, World Health Organization.

WHO (2003). HIV and Infant Feeding - Framework for Priority Action. Geneva, WHO.

WHO (2010). "Guidelines for the treatment of malaria."

WHO (2010). The world health report: the path to universal health coverage.

WHO (2011). World Health Statistics, WHO.

Witter, S. (2010). Free health care for under-five children and pregnant women in Northern Sudan: Progess so far and recommendations for the future, Federal Ministry of Health.

World Bank (2011). Public Expenditure Tracking Survey (PETS) for Northern Sudan (Draft).

Xu, K., D. B. Evans, et al. (2007). "Protecting Households From Catastrophic Health Spending." Health Affairs **26**(4): 972-983.

ANNEXES

Annex 2. Under-Five Mortality Estimates

A. Direct Methods

Producing estimates of under-five mortality using complete birth histories relies on the use of survival models that are characterized by two features of survival data:

(1) The outcome of interest is the time until the occurrence of a well-defined event – in this case the death of a child before his or her first or fifth birthday.
(2) Observations are censored: for some children, the event of interest has not occurred at the time the survey was collected.

In addition, survival models can be used to assess the relationship between variables of interest and time until death.

In the setting of under-five mortality, the outcome of interest (survival time) can be modeled as follows: **T** represents a non-negative continuous random variable representing the time until death which has a probability density function, $f(t)$ and a cumulative distribution function, $F(t) = \Pr\{T \leq t\}$ which gives the probability that the event has occurred by duration t.

The survival function gives the probability that a child is alive by duration (age) t, which is the complement of the probability that the child has died by duration t:

$$S(t) = \Pr\{T > t\} = 1 - F(t) = \int_t^{\infty} f(x)dx$$

The additional feature in survival models that must be taken into account is that at the time of the survey, some children have died and their survival time is known, while others are still alive and their survival times are not known. A key underlying assumption is that the children who are censored (resulting from the cross-sectional nature of the survey) are no more or less likely to survive beyond the censoring time than those who are not censored – that is, the censoring mechanism is non-informative.

B. Assessment of under-reporting of early neonatal and neonatal deaths, South Sudan

Table A2.1 displays the ratio of early neonatal deaths (0-6 days) to all neonatal deaths (0-30 days) as well as the ratio of neonatal deaths to all infant deaths (0-12 months) by region, the sex of the child and the calendar year of death.

Table A2.1 Assessment of under-reporting of child deaths, Sudan (North)

Calendar Year of Death	Ratio of Early Neonatal Deaths to All Neonatal Deaths		Ratio of Neonatal Deaths to all Infant Deaths	
	SHHS (2006)	SHHS (2010)	SHHS (2006)	SHHS (2010)
(2005-2010]	--	0.721	--	0.585
(2001-2006]	0.726	0.661	0.645	0.530
(1996-2001]	0.659	0.687	0.590	0.531
(1991-1996]	0.685	0.597	0.534	0.483
(1986-1991]	0.634	0.540	0.595	0.545
(1981-1986]	0.631	--	0.549	--

Source: Author's calculations from 2006 and 2010 SHHS.

The proportion of neonatal deaths reported during the first week of life ranges from 0.63 to 0.73 in the 2006 SHHS and 0.54 to 0.72 in the 2010 SHHS. Comparing these observations to other data sources, the ratio of early neonatal to all neonatal deaths ranges from 0.65 to 0.77 in the 1990 DHS (Northern States) and 0.685 to 0.701 in the 2005 Ethiopia DHS. Overall, there does not seem to be strong evidence for systematic under-reporting of early neonatal deaths. However, for the most recent cohort of children (regardless of the survey), there is a higher proportion of early neonatal deaths compared to earlier cohorts. This may suggest that mothers under-report early neonatal deaths that occur farther in the past.

The proportion of neonatal deaths occurring in the first year of life ranges from 0.534 to 0.645 in the 2006 SHHS and 0.483 to 0.585 in the 2010 SHHS. Compared to other data sources the ratio of neonatal to infant deaths ranges from 0.45 to 0.66 in the 1990 DHS and 0.498 to 0.528 in the 2005 Ethiopia DHS.

C. Imputing of missing birth dates and ages at death for estimating under-five mortality using the direct method

For children missing the month of birth only, a month is randomly selected from a uniform distribution of numbers between 1 and 12 (representing January through December) for years of birth during or before 2005 and 2009 (corresponding to the year before the 2006 and 2010 SHHS survey interview). For children born in 2006 or 2009 (the years of the 2006 and 2010 SHHS survey interview), a month is randomly selected between January and the month of the interview date. Months are randomly selected within several logical constraints. Firstly, for mothers with multiple children, the randomly selected month preserves a minimum distance of 9 months between births. Secondly, for children belonging to a multiple birth, the birth with the missing month is assigned the same month of birth as the twin. For children still alive at the time of the survey with a missing birth month and year but non-missing age, the date of birth is imputed by subtracting the age from the date of the survey interview.

Three imputation strategies to estimate the birth dates for children with missing year of birth were attempted:

(1) Logical imputation assuming that the reported birth order (as listed in the birth history) is correct: If children with missing dates of birth have a younger and older sibling with known dates of birth, the value is imputed by randomly selected a date of birth 9 months after the younger sibling's birth and 9 months before the older sibling's birth. For children with missing birth dates and only a single sibling, or the children who are the first or last in the reported birth order, a set of intervals using logical constraints is created for child's birth date using the earliest possible childbearing date as a lower limit and the date of the interview as the upper limit. These intervals are further narrowed by dividing the possible range of months over which the birth could have occurred, by the number of children with missing birth dates per mother, so that imputed birth dates are evenly spaced over the range of all possible birth dates and at least 9 months apart from each other. Imputed birth dates are randomly selected from a uniform distribution of birth dates between the lower and upper limit of the intervals. This procedure assumes that all missing cases belong to single births.
(2) Logical imputation ignoring reported birth order. In this case, the dates of birth for children with missing information were imputed using the strategy for terminal births explained above. A correction procedure was applied to ensure that neighboring births are at least 9 months apart.
(3) Imputation using multivariate regression: missing dates of birth are predicted using information on the age of the mother at the time of the survey, the age of the mother at first birth, total number of children and the birth space between the current and last birth. Two different regressions were tried, one that used reported birth order as a predictor and another that did not.

Missing ages at death are imputed by randomly selecting from a log-uniform distribution of death ages bounded by the minimum death age observed for all deaths (with known death ages) of the same birth order and the maximum death age observed for all births (with known death ages) of the same birth order. If the upper bound death age exceeded the age the child would have been at the time of the survey, the upper bound is replaced by the child's hypothetical age at the time of the survey. After imputation of birth dates and ages at death, 26,456 live births from the 2006 SHHS and 28,720 live births from the 2010 SHHS were used to measure under-five mortality for South Sudan using the direct method.

Annex 3. Determinants of Under-5 mortality

A. Methods

Proportional hazards regression is a framework that takes into account the feature of the data that children who have not yet reached their fifth birthday by the time of the survey have not been fully exposed to the risk of under-five death. In other words, some measurements of death are known exactly, and others are only known to exceed the date of the survey interview. Data in this setting are represented by two variables: An observation time, which identifies the time to death or censoring (whichever comes first) and an event indicator, which

identifies actual death. The proportional hazards model (Equation 1) describes the hazard (the instantaneous risk of death) for individuals with a certain set of characteristics (x_i). This approach estimates a baseline hazard function $\lambda_0(t)$ that describes the risk of death at each time among individuals with $x_i = 0$ and the relative risk - $e^{x_i'\beta}$ - associated with the specific set of characteristics x_i. Proportional hazards models assume that relative risk is constant in time between two groups and treats the survival distribution within a group semi-parametrically. The model estimates the relative risk of death (measured by the hazard ratio) between groups of individuals defined by an attribute (such as the education or age of the mother), controlling for other attributes.

$$\lambda_i(t|x_i) = \lambda_0(t)e^{x_i'\beta} \qquad \text{(Equation 1)}$$

B. Measuring Wealth

In order to assess inequalities in health outcomes or health services associated with economic status, a measure of household wealth is needed. In the absence of monetary measures of household wealth such as income or expenditure, a wealth or asset index can be constructed using observations on household asset ownership (such as consumer durables) and housing characteristics (such as availability of piped water or a flush toilet). Table A3.1 provides an overview of the types of assets captured in the SHHS as well as the mean ownership of each asset across households in 2006 and 2010. To aggregate the assets into an index, a linear combination of the available asset variables is constructed as follows (Equation 2):

$$A_i = b_1 a_{1i} + b_2 a_{2i} + \cdots + b_k a_{ki} \qquad \text{(Equation 2)}$$

Where A_i the asset is index for household i, a_{ki} are indicators of asset ownership and household characteristics and $b_k$are the weights used to aggregate the indicators into an index. While there are several approaches to estimate the weights the statistical method of principal components is used. The asset index can be best interpreted as a measure of a household's long-run economic status. Five different asset groupings were used to generate candidate asset indices (these are described below). For variables describing household characteristics, two approaches were tried. The first approach incorporated the variables dichotomously in the principal components model. The second approach allowed for more parsimonious modeling, by grouping together similar household features into a single continuous variable.

Asset group 1: consumer durables, dichotomous water and sanitation variables, dichotomous household structure variables, [No livestock**] Asset group 2**: consumer durables, continuous water and sanitation variables, continuous household structure variables, [No livestock] **Asset group 3**: only livestock ownership variable. **Asset group 4**: consumer durables, continuous water and sanitation variables, continuous household structure variables and livestock variables. **Asset group 5**: land ownership and livestock ownership variables. The resulting distributions of the asset indices are displayed in Figure A3.1. Given the non-smooth distributions of the wealth indices produced by asset group 3 and 5, these were not considered. To choose among the remaining three asset indices, the correlation of the index with other proxies of economic status, such as the education of the household head and the employment status of the household head was used. Using these criteria, asset group 2 was chosen.

Table A3.1. Household ownership of assets (proportion of households), South Sudan, 2006 & 2010

Asset	2006			2010		
	South Sudan	Rural	Urban	South Sudan	Rural	Urban
Consumer Durables						
Electricity						
Radio						
Television						
Mobile Phone						
Non-Mobile Phone						
Refrigerator						
Computer						
Internet						
Watch						
Bicycle						
Motorcycle or Scooter						
Animal Drawn Cart						
Car or Truck						
Boat with motor						
Water & Sanitation						
Source of Drinking Water						
Piped (Into dwelling, yard or plot) or bottled						
Public tap/ standpipe or borehole						
Protected well or spring						
Unprotected well or spring						
Delivered by tanker or truck						
Surface Water						
Other						
Type of Toilet Facility						
Flush System						
Latrine						
No Facilities						
Other						
Household Structure						
Number of Rooms/ Tukuls						
Type of Floor						
Earth, Grass, Mud						
Rudimentary - Wood planks, Palm, Bamboo						
Finished - Parquet, polished wood, vinyl, ceramic,						
Type of Roof						
Natural, no roof, thatch, grass						
Rudimentary - Palm, bamboo, wood planks, animal skin						
Finished - Metal, wood, ceramic, cement, shingles						
Land Ownership						
Member of Household owns land for farming, grazing or						
Member of household uses land for farming						

Annex 4. Maternal and child survival strategies

A. Logistic regression to assess factors associated with disease and uptake of interventions

The following is the functional form of the logistic regression used to explore factors associated with coverage of key maternal and child interventions (y_i), where x_i represents characteristics of the mother, child or household:

$$Pr(y_i = 1|x_i) = \frac{e^{x_i'\beta}}{1 + e^{x_i'\beta}}$$

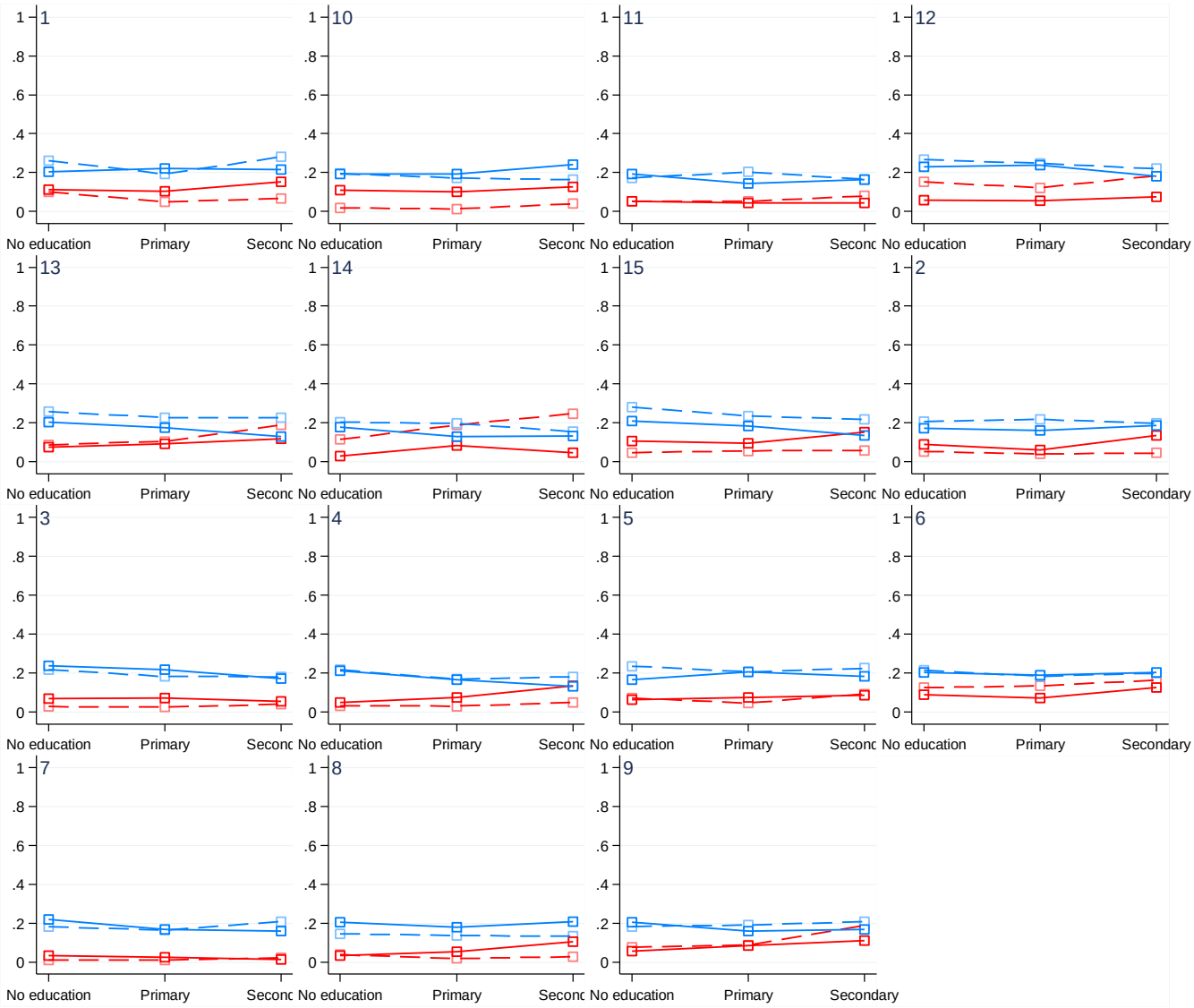
In order to compute the increase in probability of receiving an intervention associated with a marginal increase in a characteristic of the mother, child or household (for example, the increase in probability of receiving tetanus toxoid vaccine associated with an increase in mother's education from none to primary), the partial derivative is needed:

$$\frac{dy}{dx} = \beta e^{x_i'\beta}\left(1 + e^{x_i'\beta}\right)^{-2}$$

Since the marginal effect ($\frac{dy}{dx}$) varies with the value of the explanatory variables x_i, they are assessed at the average values of the explanatory variables.

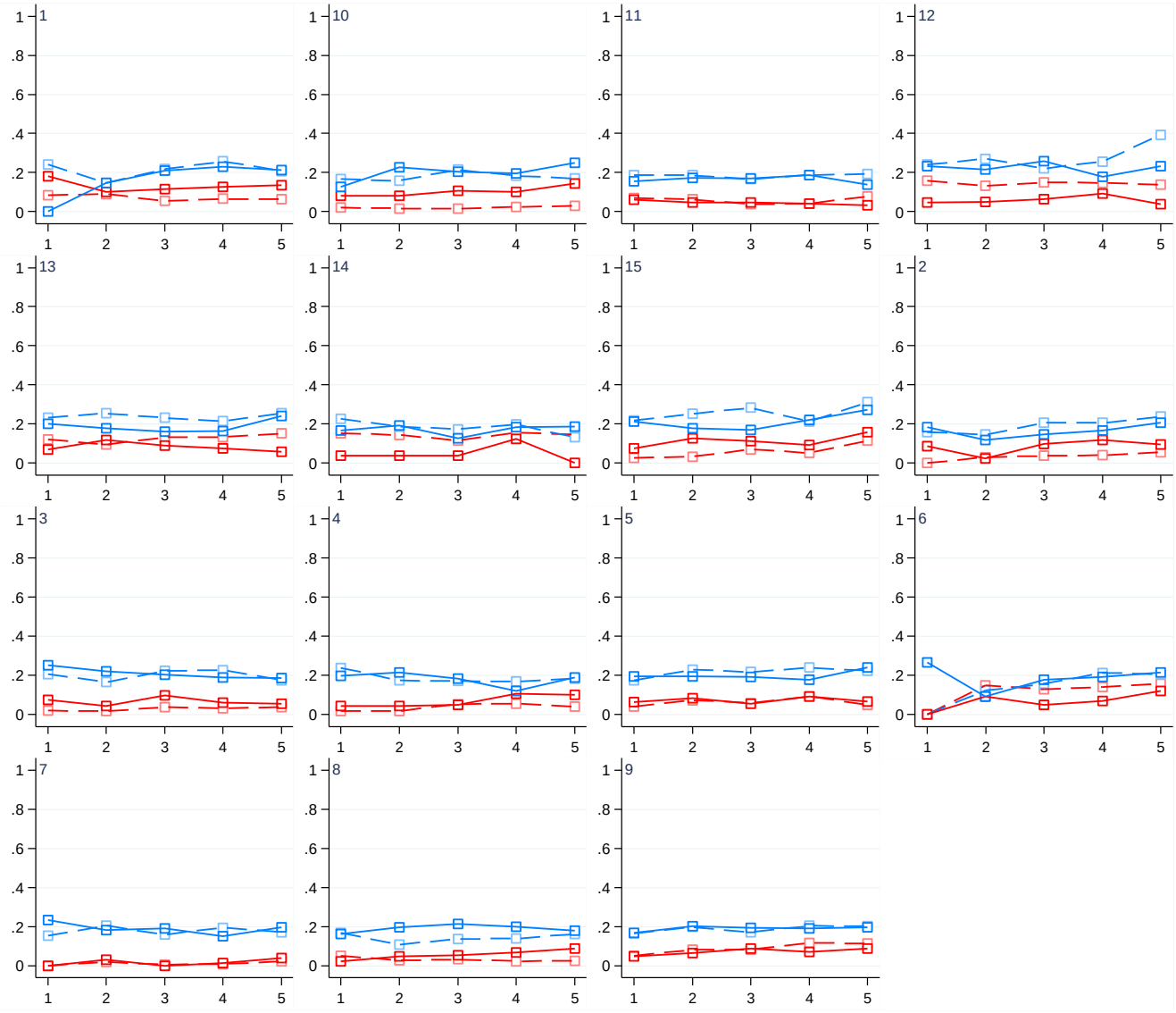
B. Non-response by wealth, education and state

Figure A4B.1. Non –response by mother's education and state



Source: Author's calculations based on 2006 and 2010 SHHS
Notes: Y-axis (percent)
State Codes: 1= Northern , 2 = River Nile , 3 = Red Sea , 4 =Kassala, 5 =Gadarif, 6 =Khartoum, 7 = Gezira, 8 = Sinnar, 9 = Blue Nile, 10 = White Nile, 11 = North Kordofan, 12 = South Kordofan, 13 = North Darfur, 14 = West Darfur, 15 = South Darfur

Figure A4B.2. Non –response by household wealth & state



Source: Author's calculations based on 2006 and 2010 SHHS

Notes: Y-axis (percent), X-axis (household wealth quintiles where 1 = Poorest and 5 = Richest)

State Codes: 1= Northern , 2 = River Nile , 3 = Red Sea , 4 =Kassala, 5 =Gadarif, 6 =Khartoum, 7 = Gezira, 8 = Sinnar, 9 = Blue Nile, 10 = White Nile, 11 = North Kordofan, 12 = South Kordofan, 13 = North Darfur, 14 = West Darfur, 15 = South Darfur