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ABSTRACT

Most deaths of children under age five in sub-Saharan African and other developing countries have been linked to the household environment. This study, therefore, hypothesized that variations in household environments among sub-Saharan countries could affect children's survival chances. Using secondary data from Demographic and Health Surveys (DHS) in eight sub-Saharan countries, the study broadly categorized the selected countries into low and high under-five mortality groups. The study found that high-mortality countries are at a relative disadvantage on basic household environmental variables. There are significant relationships between the household environment and child survival. Some of the differences in childhood morbidity and mortality between low and high under-five mortality countries can be explained by levels of household environmental health hazards and by maternal socioeconomic status.

INTRODUCTION

This study systematically examines health hazards within the household environment as they affect child survival chances across sub-Saharan Africa. The distinctive physiological nature of children under age five predisposes them to a variety of health hazards within and around the household, including unsafe sources of water and poor sanitary conditions. Thus providing safe drinking water and access to improved sanitation within the household environment can reduce the risk of mortality and morbidity among children under age five (WHO, 2009). This fact has been demonstrated in some developed countries, where childhood mortality has declined through interventions such as the provision of safe drinking water and adequate sanitary facilities (Rutstein, 2000). Although some parts of the developing world are in the process of achieving substantial lower childhood mortality due to such interventions, the situation remains critical in sub-Saharan Africa, where about half of the population has no access to safe drinking water and improved sanitation (WHO, 2009).

Literature Review

Decline in under-five deaths in Africa has been slow, despite various approaches to improving child health (WHO, 2005). Although there are large variations across regions and countries in the developing world, mortality rates among children under age five in African countries are higher compared with other less developed societies. Out of 20 countries identified as having high under-five mortality, 19 are in sub-Saharan Africa (United Nations, 2002; Mutunga, 2004; Balk *et al*, 2004; Mason, 2004; WHO, 2005).

In developing countries maternal, demographic, and socioeconomic factors have been found to be important determinants of childhood mortality (Mosley and Chen, 1984; Mutunga, 2007; Rutstein, 2000; Gyimah and Fernando, 2002). Nutritional deficiencies, illnesses such as malaria, diarrhea, and acute respiratory infection (ARI), as well as vaccine-preventable diseases are also recognized as causes of under-five mortality in most countries in sub-Saharan Africa (Caldwell, 1979; Boerma and Bicego, 1992; Rutstein, 2000; Gyimah, 2002). Adetunji (2000) also observed a reversal of improvements in under-five mortality in countries with very high adult HIV prevalence (greater than 5%); mortality rates among children of HIV-positive mothers are much higher, by two to five times, than among children of HIV-negative mothers.

Most of the factors identified from various studies on childhood mortality in developing countries have followed the Mosley and Chen (1984) framework, which is based on the idea that the factors that affect childhood mortality work through a set of "proximate determinants." Five other premises were also suggested, along with the basic premises: (i) under optimal conditions, child survivability rates for newborn infants can be expected to reach 97 percent; (ii) in the real world, this rate is lowered by social, economic, biological, and environmental factors; (iii) socioeconomic determinants must operate through the proximate determinants in order to influence disease and disease processes; (iv) the proximate determinants can be indicated by the diseases and deficiencies of the surviving population; (v) child mortality is the result of the cumulative consequences of multiple disease processes.

Proximate determinants, as defined by Mosley and Chen (1984), are divided into five categories: maternal and demographic factors; environmental health factors; nutrient deficiency; injury; and personal illness control. Maternal factors include age of the mother, parity, and birth interval. The demographic factors include sex of child, multiple births, and previous child death. Household environmental factors include the house's construction material, sources of water, and presence/types of toilet facilities, as well as cooking facilities. In addition to the proximate determinants, Mosley and Chen posit that socioeconomic factors also affect childhood mortality. Manda (1999), however, has observed that the effect of the socioeconomic variables becomes greater as the child gets older.

Although several factors are responsible for the survival of children under age five in developing countries, studies reveal that some childhood diseases that often result in mortality can be explained by well-known health hazards within the child's household environment (Rutstein, 2000; United Nations, 2001). Indeed, environmental health hazards are threats to the health of millions of people in the settings where they live (World Bank, 2000; UNICEF, 2001). A variety of health hazards, including poor air quality, poor building standards, and contamination of water and food are present in the household environment (Racioppi, 2002). Studies have shown that sanitation, water supply, and hygiene are generally poor in developing countries; more than 1 billion people live without adequate shelter, about 1.4 billion people lack access to safe water, and over 2.9 billion people have no access to adequate sanitation (World Resources Institute, 1999; Rutstein, 2000; WHO, 2005; WHO, 2009).

Children under age five are in the dynamic stage of growth. Their immune, respiratory, and digestive systems are still developing. The impact of an unhealthy environment is felt among them because they are always close to the ground, where many contaminants settle (WHO, 2003; Mutunga, 2004). Unlike more developed countries, where health hazards from the child's household environment constitute little risk and hence cause little childhood mortality, developing countries still experience high childhood mortality due to diseases associated with poor water supply, sanitation, and personal and household hygiene (Woldemicael, 2000; Rutstein, 2000). The World Health Organization (WHO) (2003) reported that 75% of deaths from acute respiratory infections occur before the first birthday, and one-quarter of deaths among children under age five are linked to diarrhea. Studies in some developing countries have found a significant incidence of diarrheal diseases because of water shortage and contamination, early exposure to measles infections because of household crowding, and high risks of accidents or injury because of poor housing (Brockerhoff, 1995; Yassin, 2000; Macassa *et al*, 2004; Murray *et al*, 2007).

Women and young children are at high risk of exposure to the smoke emitted from burning coal, firewood, and other sources of fuel, due to women's traditional role in food preparation. Also, rapid urban growth often has outpaced the provision of safe water and sanitation, with crowded living conditions facilitating the spread of diseases that can affect child survival (Rutstein, 2000, Mishra and Retherford, 2007). Timaeus and Lush (1995) found that child morbidity and mortality have been strongly associated with household environmental conditions in urban areas of Ghana, Egypt, Brazil, and Thailand.

Children in sub-Saharan Africa, as in other developing countries, are vulnerable to these health hazards from their household environment. According to World Health Statistics 2009 (WHO, 2009), the regional average of the under-five mortality rate (145 deaths per 1,000 live births) falls short of World Summit for Children national goal of reducing the infant mortality rate to 50/60 deaths per 1,000 live births, and reducing under-five mortality to 70/80 per 1,000. Although some countries within sub-Sahara Africa have reached this goal, others still lag behind. This study, therefore, examined differences in the household environmental health hazards between low and high under-five mortality countries, and their subsequent effect on child survival.

DATA AND METHODS

This comparative study examines secondary data from Demographic and Health Surveys (DHS) conducted between 2003 and 2008 in eight selected sub-Saharan African countries. The surveys provide up-to-date information on population and health in more than 80 countries. The DHS samples include data on birth history, household characteristics, health service usage, and child health, based on information collected from women at the time of the survey. The individual women's questionnaire was used to collect information from all women age 15-49. Birth files were generated from the eligible women's responses on their birth history.

The focus of this study is on how the differences in under-five mortality can be explained by household environments. Therefore, the selection for this study of eight countries is based on two criteria: the World Health Statistics 2003 to 2009 under-five mortality rates, and DHS surveys conducted between 2003 and 2008. Four of the selected countries are among the 2009 World Health Statistics countries with the lowest under-five mortality rates, while the other four countries are among those with the highest under-five mortality rates in sub-Saharan Africa. The selected period was recent enough to ensure that household characteristics do not differ widely from current situations. Also, births in the five years preceding the survey and births to mothers who are de jure[1] residents of the household were selected for study. Table 1 shows the breakdown of the selected low and high under-five mortality countries, with the number of sampled women and births within the five years preceding the survey[2].

[1] De jure residents are the usual residents in the household

[2] Information about detailed sampling procedures are in the individual country reports and can be requested/ordered from www.measuredhs.com

Table 1: Sample breakdown of the selected countries by region, U5 mortality rate and DHS year

Country	Region	WHO statistics U5 mortality rate	DHS recent survey year	Sampled women	Sampled births	DHS Births to de jure resident within 5yrs preceding survey
Low childhood mortality countries						
Namibia	Southern	68	2007	9,804	19,522	4,783
Lesotho	Southern	84	2004	7,095	14,708	3,464
Zimbabwe	Southern	90	2006	8,907	19,489	5.087
Swaziland	Southern	91	2006	4,987	11,410	2,730
High childhood mortality countries						
Niger	West	176	2006	9,223	34,378	9,830
Nigeria	West	189	2008	33,385	104,808	27,898
Burkina Faso	West	191	2003	12,477	41,520	10,667
Mali	West	196	2006	14,583	52,140	14,308

Source: DHS and World Health Statistics (2009)

Variable Measurement

The dependent variables for this study are under-five mortality and recent childhood morbidity. Childhood mortality is measured by the mother's response on whether a child born in the last five years is alive or dead. Childhood morbidities are measured by the occurrence of symptoms of diarrhea, fever, and acute respiratory infection (ARI) within two weeks preceding the survey. The household environmental variables include sources of drinking water, time to water source, types of toilet facilities, main flooring material of the household, type of cooking fuel, and use of mosquito nets in the household. The socioeconomic factor is measured with variables such as the mother's highest educational level, father's highest educational level, rural or urban residence, and household wealth index. The key variables were re-categorized from DHS data for this study.

Dependent Variables

- Childhood mortality (Yes, No) -

  Response to question: Child is alive?

- Childhood diarrhea (Yes, No) -

  Response to question: Had diarrhea in the last 2 weeks?

- Fever (Yes, No) -

  Response to question: Had fever in the last 2 weeks?

- ARI (Yes, No) -

  Response to questions: Had cough and had short rapid breathing in the last 2 weeks?

Socioeconomic Variables

- Mother's highest educational level (None, Primary, Secondary, Tertiary)
- Father's highest educational level (None, Primary, Secondary, Tertiary)
- Residence (Urban, Rural)
- Wealth index (Low, Middle, High)

  Low – lowest and second quintiles; high – highest and fourth quintiles

Household Environment Variables

Source of drinking water:

(1) Piped water - *piped into dwelling; piped into yard/plot; public tap or standpipe*

(2) Other improved sources - *protected dug well; protected spring; bottled water; rainwater; tube well/borehole*

(3) Unprotected dug well

(4) Other unimproved sources - *unprotected spring; cart with small tank/drum; tanker-truck; surface water*

Time to water source: Regrouped from actual values in minutes to

(1) On premises

(2) Less than 15 minutes

(3) 15-29 minutes

(4) 30 minutes and above

Toilet facility:

(1) Improved flush - *flush to piped sewer system; flush to septic tank; flush/pour flush to pit*

(2) Other improved facility - *composting toilet; VIP latrine; pit latrine with a slab*

(3) Unimproved facility - *flush/pour flush elsewhere; pit latrine without a slab/open pit; bucket; hanging toilet*

(4) No facility, or bush

Disposal of child's feces:

(1) Sanitary disposal - *child used toilet/latrine; feces put/rinsed into toilet or latrine; feces buried; used disposable diapers; used washable diapers*

(2) Unsanitary disposal - *feces put/rinsed into drain or ditch; thrown into garbage; rinsed away; left in the open*

Type of flooring material:

(1) Finished - *parquet; polished wood; vinyl/ asphalt strips; ceramic tiles; cement; carpet*

(2) Rudimentary - *wood plank; bamboo*

(3) Natural - *earth; sand; dung*

Type of cooking fuel:

(1) Biomass fuel - *wood; crop residue/dung cake; straw; lignite; charcoal*

(2) Non-biomass fuel - *electricity; LPG; biogas; kerosene*

Use of mosquito net for children under five years: (Yes, No)

Furthermore, an index of the status of household environmental health hazards is derived from the responses on some household environmental factors. The household environmental health hazard variable is defined below.

i. *Source of drinking water:*

Improved source of drinking water (scored 1)

Unimproved source of drinking water (scored 0)

ii. *Time to get to water source:*

On premise or less than 30 minutes (scored 1)

30 minutes and more (scored 0)

iii. *Type of toilet facility:*

Improved sanitation facility (scored 1)

Unimproved sanitation facility and no facility (scored 0)

iv. *Main flooring material:*

Finished flooring (scored 1)

Natural and rudimentary flooring (scored 0)

v. *Type of cooking fuel:*

Non-biomass fuel (scored 1)

Biomass fuel (scored 0)

The sum of the scores was further categorized into: non- health hazard (scored 5=2), low health hazard (scored 3-4= 1) and high health hazard (scored 0-2 = 0).

The analysis involved the use of descriptive statistics to examine the distribution of household environmental health hazards in each country. Percentage distribution tables and graphs were used to provide a general overview of the different socioeconomic and demographic variables, household environment, and health hazards categories after weighing the samples. The

Kaplan-Meier method was used to estimate risk of childhood mortality by household environmental health hazards. This is a descriptive procedure for examining the distribution of time to an event variable; separate analyses by levels of a stratification variable were compared across the countries. The Cox proportional hazard model was further used to understand the effects of household environmental health hazard on childhood mortality in the selected countries. Various studies have shown that the Cox model gives estimates consistent with those produced by the logistic model and the more restricted hazard model. This proportional hazard model assumes that the underlying hazard rate is a function of the independent variables (covariates).

RESULTS AND DISCUSSION

Patterns of Household Environmental Health Hazards

The physiological characteristics of children place them at risk of death due to an unhygienic household environment. Therefore, this study examined the patterns of household environmental health hazards in the selected sub-Saharan countries. There are differences in the sources of drinking water for the eight selected countries, shown in Table 2. In countries with low under-five mortality, as in Namibia and Lesotho, the proportion of children living in households with an improved source of drinking water is greater than in countries in the high under-five mortality group. In Namibia, 71% of households, and in Lesotho 55% of households, access their drinking water from improved sources (piped, covered well, or borehole). Conversely, in countries with high under-five mortality at least 40% of children live in households with an open well or surface water as their source of drinking water.

The source of drinking water has a profound implication for the health outcomes of both mother and child. Improved sources of drinking water are less likely to be contaminated, while other sources, such as surface water and open wells, are more likely to carry disease-causing agents (NPC, 2004). The finding from this study corroborates several reports in developing countries on the relationship between household source of drinking water and childhood mortality; children under age five in households relying on open well/surface water have higher risks of death than those with piped water/borehole or covered well (Rutstein, 2000; Policy Project/Nigeria, 2002).

Although the source of water may be improved and made hygienic, timely access to the water is also very important. If the source of the water is more than 15 minutes away from the household, there may not be sufficient water from that source, and unsafe water might be consumed at times. The time to source of drinking water examined among the selected countries shows that at least half of children under age five in Namibia, Zimbabwe, Swaziland, Nigeria, Burkina Faso, and Mali live in households with access to drinking water on the premises or within 15 minutes of the household. Conversely, in Niger more than 50% of children live in households that fetch their drinking water from a source more than 15 minutes away.

Table 2: Household environment in sub-Saharan African countries with low and high levels of under-five mortality

Household environment variables	Low mortality countries					High mortality countries				
	Namibia	Lesotho	Zimbabwe	Swaziland	Average	Niger	Nigeria	Burkina Faso	Mali	Average
Source of drinking water										
Piped water	71.0	54.8	34.1	49.0	52.2	20.1	9.5	13.2	23.3	16.5
Other improved source	14.5	20.8	38.1	15.6	22.3	19.2	42.8	44.5	31.2	34.4
Unprotected dug well	4.0	22.1	16.1	10.7	13.2	59.2	23.0	28.5	41.6	38.1
Other unimproved source	10.5	2.3	11.7	24.6	12.3	1.6	24.6	13.9	3.9	11.0
Number of children	4,784	3,464	5,087	2,731		9,830	27,886	10,667	14,308	
Time to water source										
On premises	47.7	9.0	40.0	33.2	34.4	13.3	26.4	21.6	45.5	30.5
Less than 15 minutes	22.9	32.9	15.5	26.2	23.3	27.7	32.2	31.3	38.7	33.7
15-29 minutes	9.7	19.6	14.7	11.0	13.6	20.5	18.3	19.9	10.1	15.8
30 minutes or more	19.7	38.5	29.8	29.6	28.7	38.5	23.3	27.2	5.7	20.1
Number of children	4,720	3,455	5,071	2,724	15,971	9,804	27,574	10,643	14,289	
Toilet facility										
Improved flush toilet	32.2	1.0	28.5	12.5	17.3	0.8	12.8	1.2	1.6	3.6
Other improved facility	5.7	47.3	27.1	66.1	42.5	18.4	38.9	24.5	78.5	47.8
Unimproved facility	4.1	0.1	6.1	0.0	2.1	0.0	17.8	0.1	0.0	3.6
No facility	57.9	51.6	38.2	21.4	38.1	80.8	30.5	74.2	19.8	45.0
Number of children	4,783	3,458	5,078	2,727		9,824	27,769	10,651	14,274	
Disposal of child's feces										
Sanitary disposal	66.8	63.1	76.5	65.1	67.3	15.3	59.9	18.9	45.1	36.9
Unsanitary disposal	33.2	36.9	23.5	34.9	32.7	84.7	40.1	81.1	54.9	63.1
Number of children	3,971	3,074	4,503	2,349		9,274	25,338	10,088	13,299	

Cont'd..

Table 2: Cont'd

Household environment variables	Low mortality countries					High mortality countries				
	Namibia	Lesotho	Zimbabwe	Swaziland	Average	Niger	Nigeria	Burkina Faso	Mali	Average
Type of flooring material										
Finished	45.8	53.6	59.6	87.2	66.7	11.7	54.9	34.2	23.1	29.4
Rudimentary	0.5	0.1	0.2	0.1	0.2	0.0	1.0	0.0	0.0	0.2
Natural	53.7	46.4	40.2	12.7	33.1	88.3	44.1	65.8	76.9	70.4
Number of children	4,784	3,462	5,086	2,728		9,823	27,837	10,659	14,277	
Type of cooking fuel										
Non biomass fuel	32.3	17.9	26.8	24.9	25.4	0.3	1.2	0.9	0.1	0.5
Biomass fuel	67.7	82.1	73.2	75.1	74.6	99.7	98.8	99.1	99.9	99.5
Number of children	4,776	3,460	5,080	2,050		9,807	23,108	10,635	14,284	
Use of mosquito net										
Yes	15.5	NA	7.9	0.9	6.3	18.0	14.4	24.1	48.7	30.8
No	84.5	NA	92.1	99.1	93.7	82.0	85.6	75.9	51.3	69.2
Number of children	4,232	NA	4,762	2,487		9,568	26,712	10,318	13,701	
Household environmental health hazard										
Non potential	26.9	11.8	26.1	21.2	21.4	0.2	0.9	0.8	0.1	0.4
Low potential	20.9	37.2	28.5	48.9	36.9	15.3	46.0	28.5	50.9	38.3
High potential	52.2	51.0	45.4	29.9	41.7	84.5	53.1	70.7	49.0	61.3
Mean (of 5 indicators)	2.8	2.6	2.8	3.3	2.9	1.3	2.4	1.9	2.5	2.1

An examination of the sanitary facilities within the household reveals that the use of flush toilet facilities is very low in all the selected countries, with Lesotho, Niger, Mali, and Burkina Faso at less than 2%. Although in Zimbabwe and Namibia more than 25% of children live in households with a flush toilet, this figure is still lower than might be expected. Except for Mali and Swaziland, about five in ten households in all the surveyed countries use unimproved toilet facilities, or have no toilet facility.

Because lack of availability of a sanitary facility can be a public health concern and can have adverse implications for child health, the proper disposal of feces is also crucial. A large proportion of households in the selected low-mortality countries dispose of children's feces properly. Conversely, most of the households in high-mortality countries, except for Niger, dispose of children's feces in an unsanitary manner. Several studies in sub-Saharan countries on childhood mortality have found that improper disposal of excreta was definitely related to high incidence of childhood morbidity. There is increased prevalence of diarrhea and cholera in such households, which could contribute to childhood mortality (Ayeni and Oduntan, 1980; Tankins, 1981; Trussell and Hammerslough, 1983; Obungu, Kizito, and Bicego, 1984; Jinadu *et al*, 1991; Rutsein, 2000).

It has been observed that the type of materials used for flooring is an indicator of the economic situation of households and a source of exposure to disease-causing agents (NPC, 2004). This study therefore examined the main flooring materials in households of mothers who gave birth within the five years before the survey. The results show that, although there are slight variations in the type of flooring material among the selected low-mortality countries, on average about 67% live in households with finished flooring material such as cement, carpet, or rug. While very few children in low-mortality countries live in households with natural or rudimentary flooring, most households in Niger, Burkina Faso, and Mali use natural flooring material, which is common among rural dwellers. The natural flooring materials include earth and sand, which could have an adverse effect on the health of children under age five, especially those who are still crawling.

The type of cooking fuel used in the household is an important variable, as many children are exposed to toxic pollutants from the use of unprocessed biomass fuel from wood, charcoal, straw, and dung. Unprocessed biomass fuels have a high level of toxic indoor air pollutants that

have been linked to reduced birth weight, ARI, nutrition deficiency, and child mortality (Mishra and Retherford, 2007). Studies have shown that mothers and their young children are at high risk of exposure to the smoke emitted from burning of coal, firewood, and other sources of fuel because of women's traditional role in the preparation of food and childcare practices while cooking (Rutstein, 2000). More than 65% of children in the selected countries live in households where their mothers cook with firewood, charcoal, or straw.

Malaria-carrying mosquitoes are another health hazard, responsible for many deaths, and the groups most vulnerable are children under age five and pregnant women (NPC, 2004). The DHS asked respondents about the use of mosquito nets by household members in the previous night before the interview. Despite high awareness of malaria prevention using mosquito nets for children under age five, findings show that such use was low among all the selected countries. Use of mosquito nets for children under age five is more prevalent in high under-five mortality countries than in low under-five mortality countries, with the highest level (48.7%) in Mali, a high-mortality country, and the lowest level (0.9%) in Swaziland, a low-mortality country.

Overall, the results from the study show that in low under-five mortality countries 27%, 12%, 26%, and 21% of children in Namibia, Lesotho, Zimbabwe, and Swaziland, respectively, live in a household environment classified as having non- health hazard. Though these proportions are quite low, they are much higher than the proportions in the high under-five mortality countries studied, where negligible numbers live in households with non- health hazard—about 0.2% in Niger, 0.9% in Nigeria, 0.8% in Burkina Faso, and 0.1% in Mali. Moreover, except for children in Swaziland, more than four in ten children under age five live in households classified as having high health hazard. This is unacceptably high and raises a serious concern about public health in Africa, especially for the four high-mortality countries studied, where about 99% of the children are exposed to at least one health hazard in the household.

These results indicate that low-mortality countries have a higher proportion of households with improved sources of drinking water, improved toilet facilities, sanitary disposal of children's feces, finished flooring, and use of non-biomass fuel for cooking. Countries in the high-mortality group are more exposed to the risk of under-five deaths in the household. A substantial proportion of households in high-mortality countries have unimproved sources of drinking water, lack basic sanitary facilities, and use more biomass fuel for cooking. This is

reflected in the overall score of household health hazards. In the selected countries with high childhood mortality, 64% of sampled children live in households with high health hazards, compared with 42% in countries with low childhood mortality.

Household Environmental Health Hazards and Background Characteristics

There are significant associations between household environmental health hazards and background characteristics such as maternal education, paternal education, and rural or urban residence, as well as household wealth. Further measures of association for categorical rank variables—Spearman rank correlations—also show the magnitude and direction of these relationships (Table 3). As expected, the level of parental education is closely related to the household environments in this study; in all the selected countries, more than 90% of children whose mothers have tertiary education live in households with low or non- health hazards. In all the selected countries, the higher the parent's educational level, the lower the likelihood of a health hazardous household environment for children under age five ($p<0.001$). It is of note that, among the high under-five mortality countries, while all the children of mothers with tertiary education in Niger, Burkina Faso, and Mali live in a presumably safe environment, 8% of their counterparts in Nigeria live in households with high health hazards.

This study also buttresses the association found in various publications on urbanization and household environment; it is evident in the literature that urban-rural residence influences good sanitation and housing environments (Woldemicael, 2000; Balk *et al*, 2004; Macassa *et al*, 2004). The significant positive relationship observed in this study among all the selected countries implies that those living in urban areas are much less likely to have health hazards in their household environment. However, the pattern of household environmental health hazards differs among the low and high under-five mortality countries for both rural and urban areas. More than 9 in 10 children in urban Swaziland, Lesotho, and Zimbabwe live in households with non- or low health hazards. Children under age five living in rural areas in Africa are likely to be more exposed to household health hazards because of lack of basic infrastructure and amenities. The highest proportion is found in rural Niger, a high-mortality country, while the lowest proportion is found in rural Swaziland, a relatively low-mortality country.

Table 3: Background characteristics and household environmental health hazards in low and high under-five mortality countries in SSA

	Low mortality countries									
	Namibia		Lesotho		Zimbabwe		Swaziland		Overall	
Characteristics	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**
Maternal highest education										
None	22.7	77.3	18.0	82.0	21.3	78.7	52.7	47.3	29.2	70.8
Primary	28.8	71.2	40.9	59.1	32.1	67.9	60.5	39.5	38.6	61.4
Secondary	58.7	41.3	67.2	32.8	69.9	30.1	76.8	23.2	67.0	33.0
Higher	91.7	8.3	96.6	3.4	96.6	3.4	96.9	3.1	94.5	5.0
Spearman rank correlation	0.345**		0.298**		0.387**		0.250**		0.331**	
Paternal highest education										
None	24.7	75.3	21.4	78.6	20.3	79.7	47.9	52.1	26.0	74.0
Primary	32.9	67.1	49.1	50.9	29.2	70.8	56.4	43.6	41.2	58.8
Secondary	62.1	37.9	70.0	30.0	64.0	36.0	78.7	21.3	66.2	33.8
Higher	86.0	14.0	94.3	5.7	97.6	2.4	97.2	2.8	93.5	6.5
Spearman rank correlation	0.330**		0.353**		0.371**		0.327**		0.353**	
Place of residence										
Rural	21.9	78.1	41.8	58.2	36.0	64.0	62.1	37.9	38.8	61.2
Urban	85.1	14.9	92.7	7.3	100.0	0.0	98.0	2.0	92.5	7.5
Spearman rank correlation	0.528**		0.404**		0.569**		0.356**		0.485**	
Wealth Index										
Poor	1.8	98.2	8.6	91.4	11.9	88.1	43.7	56.3	13.5	86.5
Middle	49.6	50.4	60.7	39.3	73.0	27.0	79.1	20.9	63.6	36.4
Rich	98.9	1.1	92.6	7.4	98.8	1.2	94.3	5.7	96.7	3.3
Spearman rank correlation	0.837**		0.768**		0.793**		0.515**		0.752**	

Cont'd..

Table 3: Cont'd

	High mortality countries									
	Niger		Nigeria		Burkina Faso		Mali		Overall	
Characteristics	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**	**N/LPHH**	**HPHH**
Maternal highest education										
None	11.3	88.7	29.9	70.1	24.8	75.1	24.8	75.2	29.9	70.1
Primary	34.8	65.2	47.0	53.0	52.1	47.9	52.1	47.9	49.5	50.5
Secondary	77.2	22.8	69.2	30.8	87.6	12.4	87.6	12.4	71.7	28.3
Higher	100.0	0.0	91.8	8.2	100.0	0.0	100.0	0.0	92.2	7.8
Spearman rank correlation	0.396**		0.341**		0.290**		0.204**		0.329**	
Paternal highest education										
None	11.0	89.0	27.1	72.9	23.8	76.2	45.7	54.3	28.3	71.7
Primary	28.5	71.5	45.4	54.6	50.6	49.4	58.5	41.5	46.3	53.7
Secondary	57.6	42.4	62.8	37.2	81.7	18.3	83.1	16.9	65.3	34.7
Higher	91.0	9.0	77.3	22.7	98.8	1.2	92.8	7.2	79.1	20.9
Spearman rank correlation	0.367**		0.367**		0.338**		0.281**		0.340**	
Place of residence										
Rural	4.6	95.4	33.2	66.8	20.4	79.6	39.2	60.8	27.0	73.0
Urban	78.0	22.0	79.1	20.9	91.5	8.5	83.1	16.9	81.1	18.9
Spearman rank correlation	0.762**		0.406**		0.537**		0.396**		0.471**	
Wealth Index										
Poor	0.0	100.0	15.1	84.9	0.0	100.0	31.2	68.8	13.9	86.1
Middle	0.0	100.0	52.5	47.5	17.6	82.4	40.3	59.7	34.6	65.4
Rich	39.8	60.2	86.0	14.0	75.7	24.3	78.5	21.5	74.7	25.3
Spearman rank correlation	0.570**		0.628**		0.692**		0.416**		0.544**	

** p<0.001; * p<0.05; HEHH: Household environmental health hazards;

N/LPHH: Non/Low Potential health hazards; HPHH: High Potential health hazards

The household wealth index, categorized into highest, middle, and lowest, is another background characteristic examined in this study. It has been established in demographic studies that the wealth index is a good indicator of the influence of social class on the health of mother and child (NPC, 2004). The higher the wealth index, the greater is the likelihood of a good household health environment. Therefore, children from lower social classes may be more likely to be subject to ill health due to household environmental health hazards. For this study, there is a significant strong inverse relationship between being in households in the highest wealth index quintile and living in a poor environment, for all the selected countries. In Lesotho, Namibia, Zimbabwe, Niger, Nigeria, and Burkina Faso, over 80% of children living in households in the lowest wealth index quintile are exposed to high household environmental health hazards. However, in Swaziland 44% of children in poor households are in a non- or low health hazard environment.

In addition, within the high wealth index category, there are substantial differences among the selected countries in the percentages with household environmental health hazards. The percentages of the high wealth index group living in a high health hazard environment are 60%, 24%, 22%, and 14% in Niger, Burkina Faso, Mali, and Nigeria, respectively. Conversely, in this same wealth index group only 1% in Namibia and Zimbabwe, 6% in Swaziland, and 7% in Lesotho are in a high health hazard environment. Among the low-mortality countries, Lesotho has the largest percentage of the high wealth index group living in a more hazardous environment, while among the countries with high under-five mortality, the largest percentage is in Niger.

Household Environmental Health Hazards and Childhood Morbidity

Figure 1 shows the patterns of childhood morbidity in the selected countries. Three major patterns of childhood morbidity that were experienced in the two weeks preceding the survey were examined: diarrhea, fever, and ARI. Dehydration from diarrhea has been identified as one of the causes of death among children under age five. Among the analytical sample, data on childhood diarrhea in the last two weeks preceding the survey show that in Burkina Faso and Niger children under age five have the highest incidence of diarrhea. Two low-mortality countries, Swaziland and Lesotho, however, have a higher prevalence of childhood diarrhea than

Nigeria, in the high-mortality group. Further examination of the household risk factor on childhood diarrhea using logistic regression (Table 4) reveals that the source of drinking water and the type of cooking fuel have a significant effect on diarrhea for the two mortality groups. However, type of toilet facility and flooring material are also significant household environment risk factors that can affect diarrhea in the high-mortality countries.

Figure1: Prevalence of diarrhea, fever, and ARI in the past 2 weeks among children under age five in sub-Saharan Africa

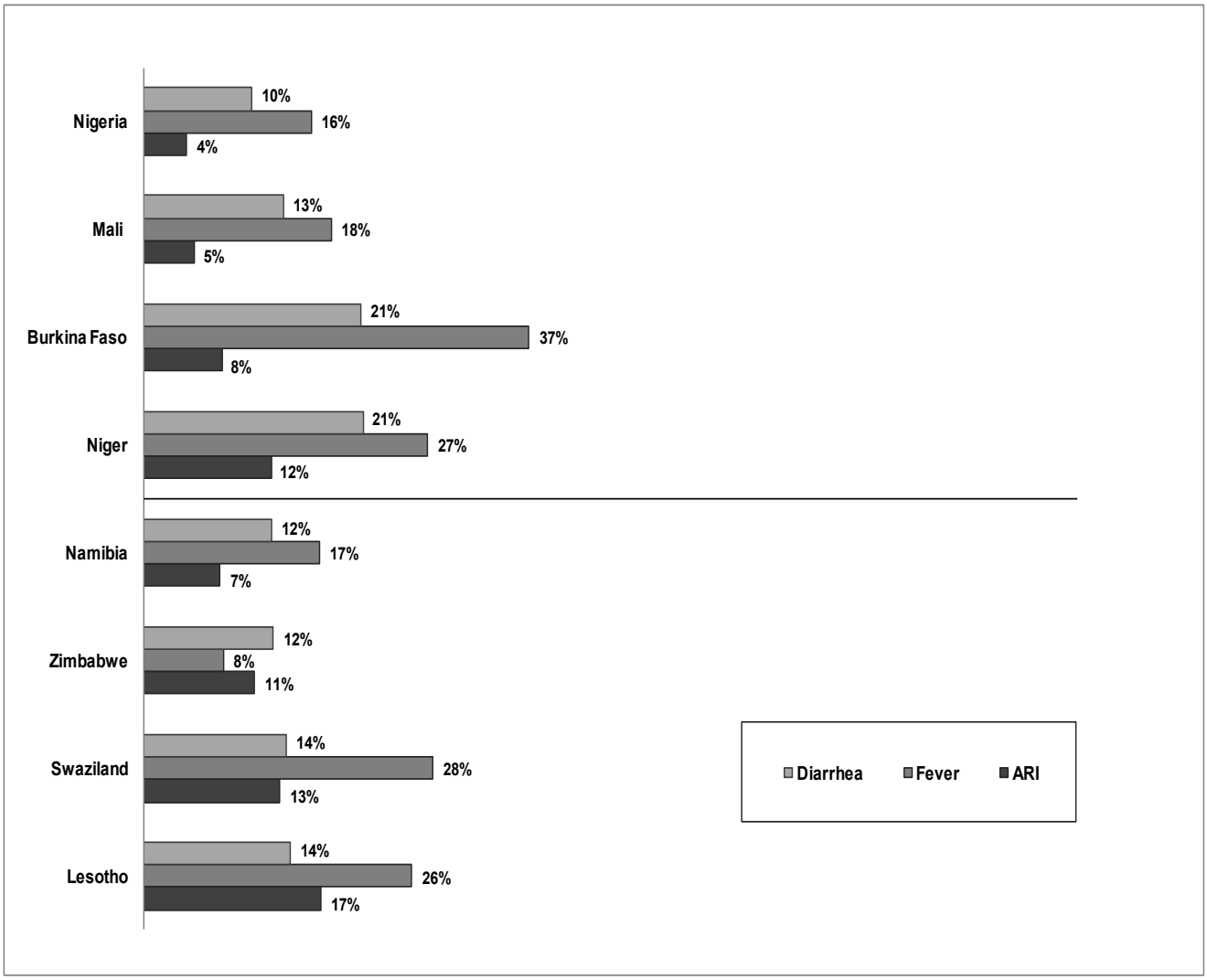

Table 4: Risk of childhood morbidity by household environmental factors in low and high under-five mortality countries in SSA

	Diarrhea		Fever		ARI	
	Low U5 mortality group	High U5 mortality group	Low U5 mortality group	High U5 mortality group	Low U5 mortality group	High U5 mortality group
Source of drinking water - Improved source	0.815*	0.946*	0.886*	1.084*	0.847*	1.120*
Time to water source - On premises/less than 30 minutes	0.971	0.968	0.838*	0.916**	0.773**	0.771**
Toilet facility - Improved toilet facility	0.965	0.889**	1.066	0.800**	1.061	0.750**
Flooring material - Finished flooring	1.038	0.598**	1.206*	0.824**	0.951	0.818**
Type of cooking fuel - Non-biomass fuel	0.798*	0.622*	0.780**	1.124	0.621**	0.721
Disposal of child's feces - Sanitary disposal	0.966	1.040	0.780**	0.839**	0.870*	0.836**

** p<0.001; * p<0.05

It is evident in this study that if the drinking water of a household in the low under-five mortality group is from an improved source, the risk of diarrhea significantly decreases by 11%, while for the high under-five mortality group the risk decreases by 6%. Although there is a decrease in childhood diarrhea if the household drinking water is from an improved source, the expected high effect of source of drinking water on childhood diarrhea is likely to be distorted by other factors, such as fetching, storage, and treatment of the drinking water. Also, the high incidence of childhood diarrhea in Lesotho might be a result of other causes, since the country has the highest proportion of those with an improved source of drinking water.

In a household where the cooking fuel is non-biomass, the risk of childhood diarrhea significantly decreases by 20% for the low-mortality group, and 38% for the high-mortality group, compared with households that use biomass fuel such as charcoal, firewood, and straw. Therefore, for all the selected countries a change in the household cooking fuel to non-biomass, such as electricity, gas, and kerosene, can reduce the risk of childhood diarrhea, especially among the high under-five mortality group.

Children under age five in the high-mortality countries that live in households with an unimproved toilet, such as open pit, bucket, hanging toilet, pit latrine without a slab, or with no

facility are significantly more likely to have episodes of diarrhea than others with an improved toilet facility. An unimproved toilet facility that is not constantly clean is a route for infection and germs that could affect young children. Likewise, children under age five in the high-mortality countries living in households with natural and rudimentary flooring have higher risk of diarrhea than those in households with finished flooring, with particular consequences for the health of toddlers, who are likely to crawl and pick up dirty things on the floor.

World Health Statistics 2009 (WHO, 2009) estimates that fever is a common childhood illness in developing countries, especially in sub-Saharan Africa, where about 15 of every 1,000 children born die from malaria before age five. Consistent with the WHO report, this study found that, in seven of the eight selected countries, fever is the most common childhood illness within the two weeks preceding the DHS survey (Figure 1). The exception is Zimbabwe, where the prevalence of fever is only 8% in the two weeks preceding the survey. However, in Lesotho and Swaziland prevalence of fever is relatively high compared with the other two countries in the low-mortality group.

In this study the prevalence of fever is highest in Burkina Faso. Burkina Faso also has the highest prevalence of childhood diarrhea. This is consistent with the assumption that a child that has diarrhea might likely have fever, because of lower immunity from dehydration. Another factor that might be responsible for this high prevalence is the overall low usage of mosquito nets, in spite of malaria awareness and prevention campaigns. Although all these household risk factors affect the incidence of fever, the level of exposure varies from one country to another.

Acute respiratory infection, characterized by coughing and short rapid breaths, is also one of the major causes of childhood mortality in developing countries. Figure 1 shows that the prevalence of ARI is higher in the low-mortality countries, as measured within the two weeks preceding the survey. For example, 17% of children in Lesotho have symptoms of ARI, the highest prevalence among countries in this study, while Nigeria has the lowest prevalence of ARI, at 4%. Further analysis in Table 4 shows a similar pattern for fever and diarrhea on household risk factors that can predispose a child to ARI.

Household Environmental Health Hazards and Childhood Mortality

Table 5 shows the risks of childhood mortality according to household environmental health hazards. The findings reveal that in the group of countries with low under-five mortality, with the exception of Swaziland, there is increased risk of under-five mortality by the level of household environmental health hazards. Although the differences are not significant, the finding implies that, keeping all other factors constant, at the end of five years in low-mortality countries 92% of children living in non- health hazard environments will survive, while 91% of those living in high health hazard environment will survive.

Table 5: Risk of under-five mortality based on household environmental health hazard

Country	Non HEHH	Low HEHH	High HEHH
Low childhood mortality	**92**	**91**	**91**
Namibia	95	92	92
Lesotho	90	88	88
Zimbabwe	93	92	92
Swaziland	89	89	89
High childhood mortality **	**96**	**87**	**84**
Niger**	95	90	85
Nigeria**	97	87	84
Burkina Faso**	95	87	84
Mali*	93	85	83

** $p<0.001$; * $p<0.05$; HEHH: Household environmental health hazards

Whereas, overall, the high-mortality group shows a 96% chance of children surviving to age five in non- health hazard household environments, children in high health hazard environments have an 84% survival chance. It is clear from these findings that children under age five in non- health hazard environments among the high-mortality group have more chance of survival than their counterparts in the low-mortality group of countries. Within a country, differences in household environmental health hazards and survival of children under age five are more distinct in the high-mortality group than the low-mortality group. In Mali, for instance, there is a 93%, 85%, and 83% chance of survival for non-, low, and high health hazard environments, respectively.

Table 6 presents further analysis using the Cox hazard regression model. The regression analysis was based on the independent effect of the household environment on under-five mortality and an adjusted household score, after controlling for the background characteristics (education, residence, and wealth index) that could influence the level of exposure of children to household environmental health hazards, such that the actual household health hazards index is an intermediate variable—that is, household environmental health hazards are not independent of some background variables. The adjusted household environmental score as independent variable would reveal the effect on childhood mortality of the background variables, working through the household environmental health hazards.

Table 6: Relative hazards of under-five mortality in selected SSA countries

Country	HEHH	Adjusted HEHH
Low childhood mortality	**0.974**	**0.956**
High childhood mortality	**0.913***	**0.799****
Namibia	0.941	0.922
Lesotho	1.015	1.034
Zimbabwe	0.944	0.909
Swaziland	1.002	1.056
Niger	0.919**	0.866**
Nigeria	0.892**	0.776**
Burkina Faso	0.903**	0.836**
Mali	0.905**	0.787**

** p<0.001; * p<0.05; HEHH: Household environmental health hazards;
Adjusted HEHH: Household environment after controlling for education, wealth and residence

The result from the multivariate analysis shows that there is a significant effect of household environmental health hazards on under-five mortality for high childhood mortality countries. A unit increase in the household environment score will significantly decrease the relative hazard of under-five deaths by 9% (relative hazard-0.91), while a unit increase in the adjusted household environment score will significantly decrease the relative hazard of under-five deaths by 20% (relative hazard-0.80)[3]. There is a similar pattern in all four of the selected

[3] Hazard rate percentage calculated by {[(E(b) – 1.0)/1.0]*100}

high-mortality countries. The independent effect of household environment in this study will reduce the relative hazards of under-five deaths in Burkina Faso, Niger, Nigeria, and Mali by 10%, 8%, 11% and 10% respectively. However, when maternal education, residence, and wealth index is controlled on the household environment score, the relative hazards of death significantly reduce to 16%, 13%, 22%, and 16% in Burkina Faso, Niger, Nigeria, and Mali, respectively.

CONCLUSIONS

Disparities exist in the household environment of children in the selected sub-Saharan African countries; the high under-five mortality groups are at a relative disadvantage on basic household environmental variables that affect hygiene. There are also significant relationships between household environment and child survival in sub-Saharan Africa. Some of the differences in childhood morbidity and mortality in low and high under-five mortality countries can be explained by levels of household environmental health hazards. Socioeconomic status of mothers is salient in the reduction of childhood morbidity and mortality from health hazards within the household.

In order to meet Millennium Development Goal 4—to reduce under-five mortality by two-thirds between 1990 and 2015—prompt attention should be given to various factors affecting the equal distribution of resources and facilities to every part of sub-Saharan Africa, especially the high-mortality countries. Policy should be redirected to programs that encourage household hygiene and sanitation. Interventions on water accessibility and basic sanitation should be jointly provided by different sectors, especially for countries where under-five mortality rates are high. Government, non-governmental organizations, and the private sector should seek to invest in programs that promote a healthy and hygienic household environment and increase access to clean water and good sanitation as part of community development efforts in sub-Saharan Africa. Women should also have more access to education and information on best childcare practices in the household environment, irrespective of their place of residence.

REFERENCES

Adetunji, J. 2000. Trends in Under-5 Mortality Rates and the HIV/AIDS Epidemic. *Bulletin of the World Health Organization* 78: 1200-1206.

Ayeni, O. and S.O. Oduntan. 1980. Infant Mortality Rates and Trends in a Nigerian Rural Population. *Journal of Tropical Pediatrics and Environmental Child Health* 26(1): 7-10.

Balk, D., T. Pullum, A. Storeygard, F. Greenwell, and M. Neuman. 2004. A Spatial Analysis of Childhood Mortality in West Africa. *Population, Space and Place* 10: 175-216.

Boerma, J.T. and G.T. Bicego. 1992. Preceding Birth Intervals and Child Survival: Searching for Pathways of Influence. *Studies in Family Planning* 23(4): 243-256.

Brockerhoff, M. 1995. Child Survival in Big Cities: The Disadvantages of Migrants. *Social Science and Medicine* 40: 1371-1388.

Caldwell, J.C. 1979. Education as a Factor in Mortality Decline: An Examination of Nigerian Data. *Population Studies* 33(3): 395-414.

Gyimah, S.O. 2002. Ethnicity and Infant Mortality in Sub-Saharan Africa: The Case of Ghana. Population Studies Centre Discussion Paper Number 02-10. The University of Western Ontario: London, Ontario, Canada.

Gyimah, S.O. and R. Fernando. 2002. The Effects of Infant Deaths on the Risk of Subsequent Birth: A Comparative Analysis of DHS from Ghana and Kenya. *Social Biology* 49: 44-57.

Jinadu, M.K., S.O. Olusi, J.I. Agun, and A.K. Fabiyi. 1991. Childhood Diarrhea in Rural Nigeria: Studies on Prevalence, Mortality and Socio-Environmental Factors. *Journal of Diarrhea Diseases Research* 9(4): 323-327.

Macassa, G., G. Ghilagaber, E. Benrhardt, and B. Burston. 2004. Contribution of Household Environment Factors to Urban Childhood Mortality in Mozambique. *East African Medical Journal* 81(8): 408-414.

Manda, S.O.M. 1999. Birth Intervals, Breastfeeding and Determinants of Childhood Mortality in Malawi. *Social Science and Medicine* 48: 301-312.

Mason, B. 2004. *World Health Report: Life Expectancy Falls in Poorest Countries*. International Committee of the Fourth International (ICFI). Retrieved on October 21, 2005 from http://www.wsws.org/articles/2004/jan2004/whor-j12.shtml

Mishra, V. and R.D. Retherford. 2007. Does Biofuel Smoke Contribute to Anaemia and Stunting in Early Childhood? *International Journal of Epidemiology* 36: 117–129.

Mosley, W.H. and L.C. Chen. 1984. An Analytical Framework for the Study of Child Survival in Developing Countries. *Child Survival: Strategies for Research, Supplement to Population and Development Review* 10: 25-45.

Murray, C.J.L., T. Laakso, K. Shibuya, K. Hill, and A.D. Lopez. 2007. Can We Achieve Millennium Development Goal 4? New Analysis of Country Trends and Forecasts of Under-5 Mortality to 2015. *The Lancet* 370: 1040-1054.

Mutunga, J.C. 2004. Environmental Determinants of Child Mortality in Urban Kenya. Discussed in an informal workshop held at the Abdus Salam ICTP: Trieste, Italy.

National Population Commission (NPC) [Nigeria] and ORC Macro. 2004. *Nigeria Demographic and Health Survey 2003.* Calverton, Maryland: National Population Commission and ORC Macro.

Obungu, W., P.M. Kizito, and C. Bicego. 1994. *Early Childhood Mortality in Kenya.* DHS Further Analysis Studies No. 12. Calverton, Maryland: Macro International Inc.

POLICY Project/Nigeria. 2002. *Child Survival in Nigeria: Situation Response and Prospect: Key Issue*. Abuja: POLICY Project.

Rutstein, S.O. 2000. Factors Associated With Trends in Infant and Child Mortality in Developing Countries during the 1990s. *Bulletin of the World Health Organization* 78: 1256-1270.

Timaeus, I.M. and L. Lush. 1995. Intra-Urban Differentials in Child Health. *Health Transition Review* 5: 163-190.

Trussell, J. and C. Hammerslough. 1983. A Hazard Model of the Covariates of Infant and Child Mortality in Sri Lanka. *Demography* 20: 1-26.

UNICEF. 2001. *The State of World's Children*. UNICEF: New York, New York.

United Nations. 2001. *Population, Environment and Development: The Concise Report.* New York: United Nations Publication.

United Nations. 2002. *World Population Prospects: The 2000 Revision to Volume III Analytical Reports.* New York: United Nations Publication.

Woldemicael, G. 2000. Effects of Water Supply and Sanitation on Childhood Mortality in Urban Eritrea. *Journal of Biosocial Science* 32: 207-227.

World Bank. 2000. *The World Development Indicators*. The World Bank Online Database, Washington, D.C.

World Bank. 2001. Health and Environment. Background paper for the World Bank Environment Strategy, Washington, D.C

World Health Organization (WHO). 2003. The Physical School Environment: An Essential Element of a Health-Promoting School. The World Health Organization's information series on school health.

World Health Organization (WHO). 2005. *World Health Report: Make Every Mother and Child Count.* Geneva: The World Health Organization.

World Health Organization (WHO). 2009. *World Health Statistics 2009.* Geneva: The World Health Organization.

WRI (World Resources Institute). 1999. *World Resources (1998-99): Environmental Change and Human Health*. New York: Oxford University Press.

Yassin, K. M. 2000. Indices and Socio-Demographic Determinants of Childhood Mortality in Rural Upper Egypt. *Social Science and Medicine* 51: 185-197.