RWANDA FURTHER ANALYSIS

Childhood Mortality in Rwanda: Levels, Trends, and Differentials

Further Analysis of the Rwanda Demographic and Health Surveys 1992-2007/08

Republic of Rwanda

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Rwanda Demographic and Health Surveys
1992–2007/08

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This report presents findings from a further analysis study undertaken as part of the follow-up to the 2007-08 Rwanda Interim Demographic and Health Survey (RIDHS). ICF Macro provided technical assistance for the project. This report is part of the MEASURE DHS program, which is designed to collect, analyze, and disseminate data on fertility, family planning, maternal and child health, nutrition, and HIV/AIDS. Funding was provided by the U.S. Agency for International Development (USAID) through the MEASURE DHS project (#GPO-C-00-03-00002-00). The opinions expressed herein are those of the authors and do not necessarily reflect the views of the USAID and other cooperating agencies.

Additional information about the RDHS can be obtained from the National Institute of Statistics of Rwanda, P.O. Box 6139, Kigali, Rwanda; telephone: (250) 571-037, E-mail: info@statistics.gov.rw, Internet: www.statistics.gov.rw. Information about the DHS program can be obtained from MEASURE DHS, ICF Macro, 11785 Beltsville Drive, Suite 300, Calverton, MD, USA; Telephone: 301-572-0200; Fax: 301-572-0999; E-mail: reports@orcmacro.com; Internet: http://www.measuredhs.com.

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ABSTRACT

Infant mortality rates (IMR) and under-five mortality rates (U5MR) are sensitive indicators of population and child health; and under-five mortality is one of the Millennium Development Goals (MDGs). IMR and U5MR have declined globally, but the degree of progress varies from country to country. Rwanda is a country where there is evidence of substantial decline in childhood mortality. This study analyzes the effects of several socio-demographic characteristics of children, mothers and households, as well as health and health care indicators on childhood mortality in Rwanda using data from the Rwanda Demographic and Health Surveys implemented in 1992, 2000, 2005, and 2007-08. The data are analyzed using synthetic cohort life tables and survival analysis methods.

The results show that infant and under-five mortality in Rwanda declined significantly in the past eight years, particularly from 2005 to 2007-08. This decline is likely the result of improvement in health and health care during that period. The main improvements have been increase in delivery assisted by a health professional, mother's use of contraceptive methods, and household possession of a mosquito net between 2005 and 2007-08, followed by a decline in short birth interval (<24 months), increase in antenatal care by a health professional and full immunization of children. Nonetheless, the decline in secondary education of mothers, increase in rural population, and increase in multiple births have offset some improvement in childhood mortality.

The analysis shows that multiplicity of birth, birth interval, antenatal care by a health professional, delivery by a health care professional, full immunization of children, mother's education, and urban/rural residence account for 52 percent of the overall decline in infant mortality between 2005 and 2007-08. During the same period, multiplicity of birth, birth interval, antenatal care by a health professional, delivery by a health care professional, full immunization of children, mother's education, mother's use of contraception, and household possession of a mosquito net account for 97 percent of the overall decline in under-five mortality. It is evident from this analysis that full immunization, contraceptive use, mosquito net distribution and professional health assistance at delivery should continue to be increased.

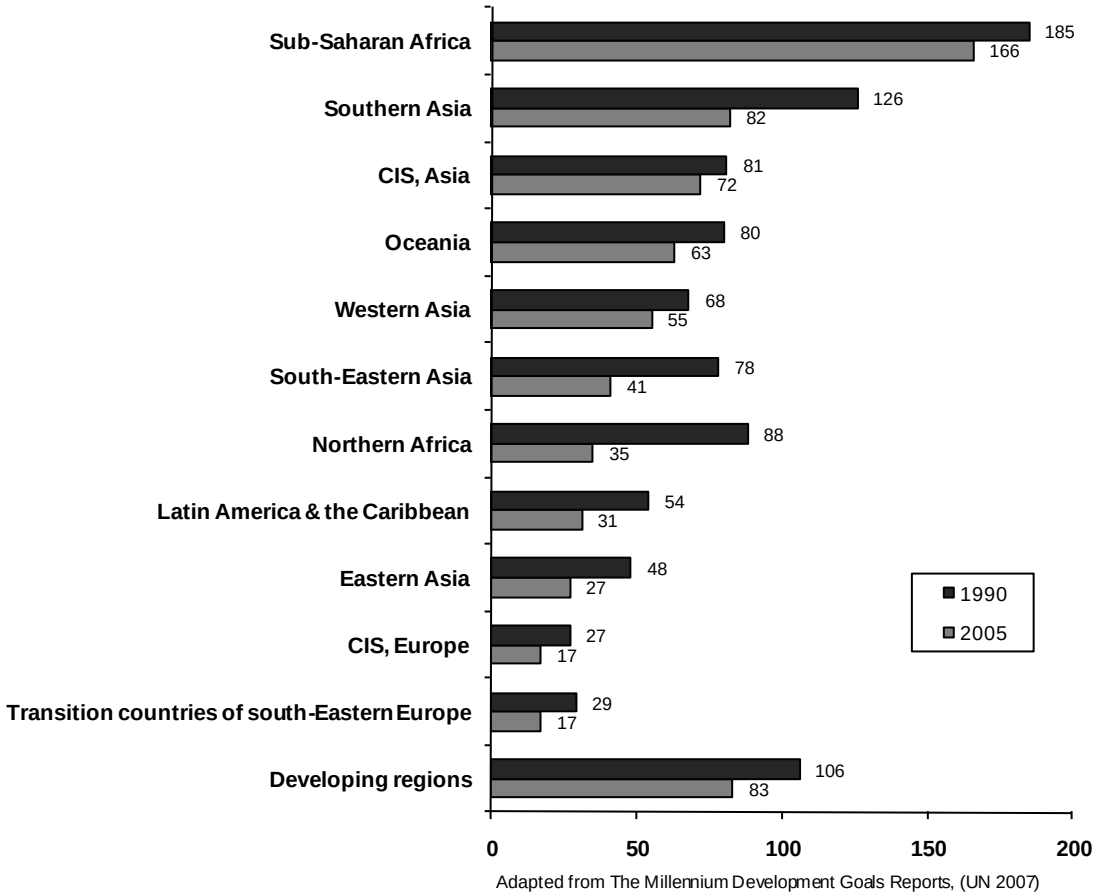
1 INTRODUCTION

1.1 Overview

Infant mortality and under-five mortality are regarded as highly sensitive indicators of population and child health. Reducing mortality and improving the health of young children are important goals for governments and the international community. Under-five mortality is one of the eight Millennium Development Goals (MDGs) that were adopted by the United Nations Member States in 2000. The Millennium Declaration set 2015 as the target date for most of the goals. Under-five mortality is targeted to be reduced by two-thirds, between 1990 and 2015 (United Nations 2008).

Although infant mortality rates (IMR) and under-five mortality rates (U5MR) have declined globally, the degree of progress varies across countries and regions. In developing regions, the U5MR has declined very slowly from 106 to 83 per 1,000 live births between 1990 and 2005. The rate is highest in sub-Saharan Africa where 185 and 166 per 1,000 children died before their fifth birthday in 1990 and 2005 respectively (Figure 1.1). Changes in the levels of infant and child mortality also differ widely by socioeconomic status of the household and level of education of the mother. Moreover, in many countries in sub-Saharan Africa, progress in reducing childhood mortality has been hindered by epidemics of HIV/AIDS and malaria or by war and conflicts, all of which have recently been among the leading causes of death among young children (United Nations 2007).

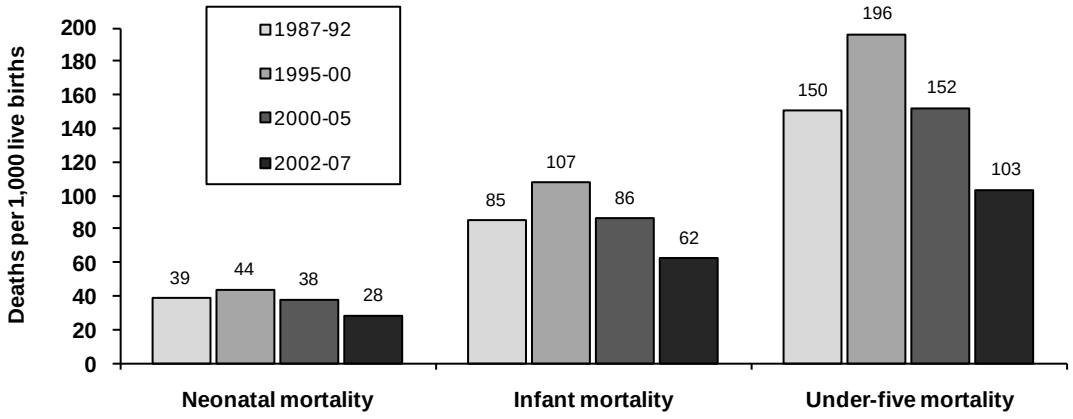
Figure 1.1 Under-five mortality rate per 1,000 live births, 1990 and 2005



Adapted from The Millennium Development Goals Reports, (UN 2007)

Levels and trends of infant and child mortality in Rwanda showed an increase in mortality rate during the 1990s and remained persistently high throughout that decade. From 2000 to 2004, the level of infant and child mortality had returned to pre-1990 levels and continued to decline to its lowest rate to date in 2007-08 (Figure 1.2).

Figure 1.2 Neonatal, infant, and under-five mortality, five year rates, Rwanda 1992, 2000, 2005, and 2007-08 Demographic and Health Surveys



1.2 Objectives

The objective of this analysis is to assess and describe the levels and trends of infant and under-five mortality in Rwanda and present differentials in mortality rates by several key factors that are likely to influence mortality in children. This analysis also evaluates determinants associated with the probability of death before the age of one year (infant mortality) and before the age of 5 years (under-five mortality).

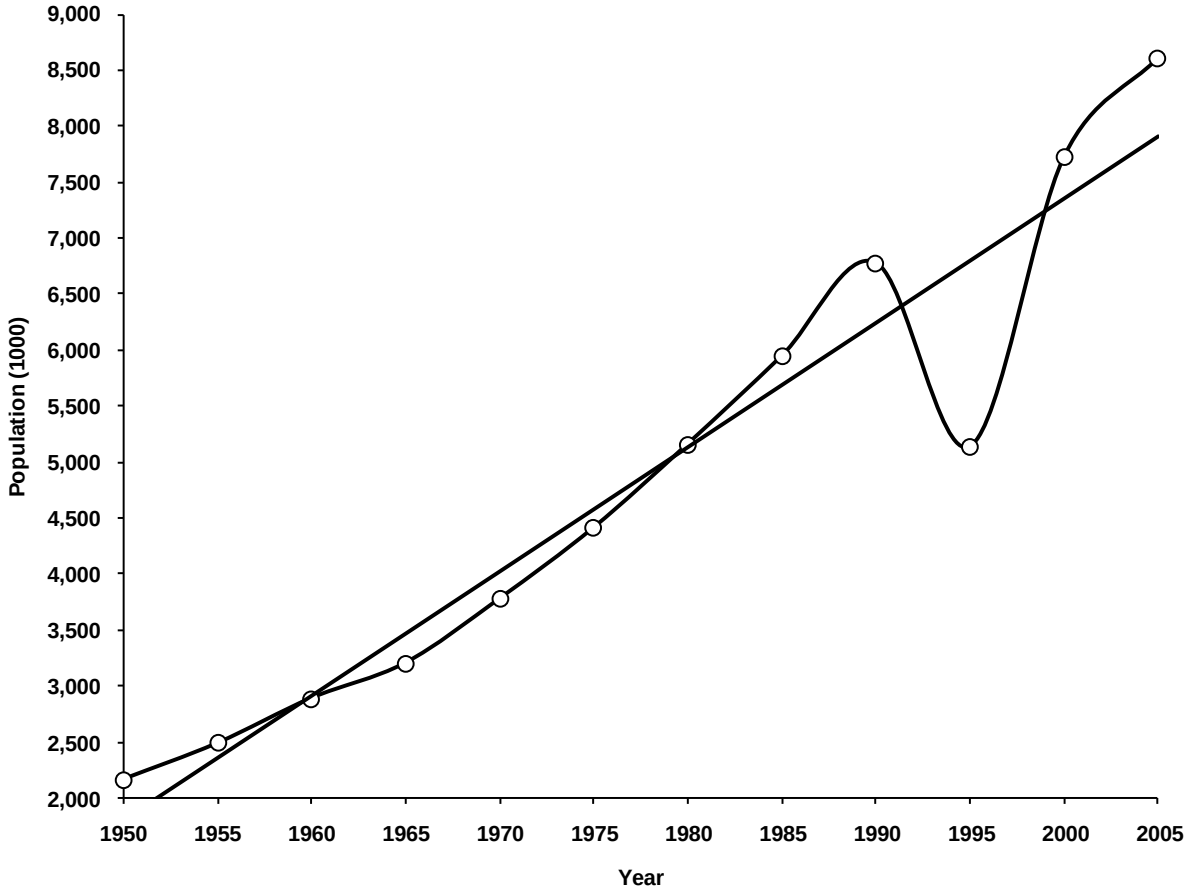
2 BACKGROUND

2.1 Population Policy

According to current estimates, as of mid 2008, the total population of Rwanda is about 10 million (UNFPA, 2009). The total population had increased steadily from about 2.1 million in 1952 to 6.8 million in 1990. In 1994, Rwanda suffered a major loss of more than one million people in a span of only 100 days as a result of one of the most brutal genocides in human history. The 1995 population was estimated at only 5.1 million. However, due to rapid demographic growth, the population has increased significantly and in 2002 it had reached 8.1 million.

Concerned about rapid population growth and improvement in the quality of life for all Rwandans, the government developed a new population policy in 2003. This policy emphasizes slowing population growth, food safety, access to primary and secondary education for all children, managing natural resources, good governance, equal opportunity, and participation in development by both women and men. Nonetheless, Rwanda is confronted with two goals today: rebuilding infrastructure and institutions ruined by war and conflicts a little more than a decade ago, and achieving rapid development and industrialization as a framework for the GOR's Vision 2020.

Figure 2.1 Total annual population of Rwanda



World Population Prospects: The 2008 Revision (UN Population Division, 2008)

Because Rwanda is the most densely populated country in Africa, the Rwandan people experience significant competition for the scarce resources available. Nevertheless, this situation offers an opportunity for provision of health services, since, on average, health care facilities are usually closer to the communities and households than in most parts of Africa.

2.2 Child Health

In 2005, responding to the alarming rates of childhood mortality, the Ministry of Health reorganized child health services by integrating them within the Maternal and Child Health unit in order to tackle child health problems specifically. Priority issues for this unit, stipulated in the 2005 Annual Report of the Ministry of Health, were those related to Integrated Management of Childhood Illnesses (IMCI). These include strengthening the skills of health care providers through pre- and in-service training, monitoring and evaluation, providing medicine and consumables, supervising, and expanding IMCI's community outreach (MOH 2005).

Results from the 2007-08 Rwanda Interim Demographic and Health Survey (RIDHS 2007-08) show that 80 percent of children age 12-23 months were fully immunized before the age of 12 months compared with only 69 percent in 2005 (RDHS 2005). However, this is still short of the EPI target of 90 percent (NISR and ORC Macro, 2006; MOH, NISR and ICF Macro, 2009). Findings from the RIDHS 2007-08 also show that only 28 percent of children suffering from symptoms of acute respiratory infection and 35 percent of children suffering from fever were taken to a health facility or provider for treatment. In addition, among children suffering from diarrhea, only 33 percent were taken to a healthcare provider for treatment (MOH, NISR and ICF Macro, 2009).

Malnutrition is an underlying factor in about 70 percent of the illnesses that cause death among children under age five. The RDHS 2005 found that 45 percent of children under age five in Rwanda are stunted, that is, too short for their age; 19 percent of them are severely stunted. About 23 percent are underweight, that is, too thin for their age. The prevalence of stunting is far higher among rural children (47 percent) than urban children (33 percent) (NISR and ORC Macro, 2006).

3 DATA AND METHODS

3.1 Sources of Data

Rwanda carried out three Standard DHSs in 1992, 2000, and 2005; and an Interim DHS in 2007-08. Data collected by the DHS program are of high quality and comparable across countries and over time because of meticulous design in sampling, methodology, protocol, and analysis. The first two DHSs were carried out by the *Office National de la Population* (ONAPO), whereas the last two surveys were carried out by the National Institute of Statistics of Rwanda (NISR). Technically these two institutions are the same, since NISR inherited the organizational structure, functions, and staff from ONAPO. Table 3.1 presents information on dates of fieldwork and sample sizes for the households and women interviewed.

Table 3.1 Description of the Rwanda Demographic and Health Surveys (RDHS) included in the analysis

Year	Date of fieldwork	Implementing organization	Number of households interviewed	Number of women aged 15-49 interviewed
1992	June-October, 1992	ONAPO[1]	6,252	6,551
2000	June-November, 2000	ONAPO[1]	9,696	10,421
2005	February-July 2005	NISR[2]	10,272	11,321
2007-08	December 2007-April 2008	NISR[2]	7,377	7,313

[1]ONAPO: Office National de la Population

[2]NISR: National Institute of Statistics of Rwanda

Data from the 1992, 2000, 2005 RDHSs and 2007-08 RIDHS are used to assess and describe levels and trends of infant and under-five mortality in Rwanda and present differentials in mortality rates by several key indicators that are likely to affect mortality in children.

Data from the 2007-08 RIDHS are used to evaluate determinants associated with the probability of dying before the age of one year (infant mortality) and before the age of five years (under-five mortality).

3.2 Methods

Calculation of mortality: In the RDHSs, the Individual Questionnaire for eligible women age 15-49 includes questions on the total number of children ever born to a woman and a complete maternal birth history. Birth history questions include date of birth for every live birth,1 survival status, current age of surviving children, and age at death of deceased children. Data on age at death were collected in days for children who died with a month of birth, in months for children who died within 2-23 months of birth, and in complete years for children who died after 23 months of birth. All inconsistencies on birth history were checked and resolved by interviewers.

A synthetic cohort life table approach is used to calculate the probabilities of dying for small age segments based on real mortality experience. These mortality probabilities are then combined to estimate the more common and larger age segments. The small age segments adopted by DHS are 0, 1-2, 3-5, 6-11, 12-23, 24-35, 36-47, 48-50 months. The analysis of this report uses the following two indices of childhood mortality:

[1] Each live birth of a multiple birth is considered a separate live birth.

Infant mortality: the probability of dying between birth and exact age one year (1q0); and

Under-five mortality: the probability of dying between birth and exact age five years (5q0);

These calculations will be based on all birth data from the 1992, 2000, 2005, and 2007-08 surveys and will be used in descriptive statistics on levels, trends, and differentials of infant and under-five mortality.

Survival analysis: The data for all births in the last five years (2007-08 RIDHS) will be used to create a synthetic cohort life table for survival analysis using the Weibull Hazard function to estimate the risk of dying (expressed in Hazard Ratios with a significant level) before the age of one year (infant mortality) and before the age of 5 years (under-five mortality).

Limitations: Indicators related to health services/programs such as antenatal care, and delivery services were asked for births in the last five years.

Indicators other than health services/programs such as vaccinations were only asked for surviving children that were born in the last five years before the interview dates. Similarly, indicators related to health such as symptoms of acute respiratory infection (ARI), fever, and diarrhea; and their treatment by health facilities or providers were limited only to surviving children that were born in the last five years.

3.3 Data Quality

Data on birth history are retrospective and are subject to recall bias. The validity of mortality rate estimates depends on the quality of data. Recall biases that could affect time-dependent estimates such as mortality rates are omissions of birth and/or deaths, incomplete information on date of birth or death, displacement of events (birth or death) in time, and misreporting of age at death. These biases certainly occurred when data were retrospectively collected. However, whether or not the quality of data is significantly affected depends on the magnitude of these biases. The sections that follow will evaluate whether these biases were a substantial problem in the birth history data that are used in the analysis of this report (Johnson, Rutstein, and Govindasamy 2005).

3.3.1 Omissions of births/deaths

Bias due to omission of deaths or births can be assessed by examining the ratio of early neonatal mortality to all neonatal mortality, the ratio of neonatal mortality to infant mortality and the ratio of male to female births.

According to Sullivan et al. (1990), about 70 percent of neonatal deaths occurred during the first six days after birth or in the early neonatal period. If the ratio of early neonatal mortality to all neonatal mortality is less than 70 percent, it may indicate the omission of neonatal deaths. This ratio tends to decrease if overall mortality increases.

Table 3.2 Ratio of early neonatal (ENN) deaths to neonatal (NN) deaths for all Rwanda DHSs (weighted)

Year	ENN deaths	NN deaths	Ratio ENN:NN
1992	141	219	64.3
2000	249	352	70.7
2005	228	321	71.1
2007-08	111	160	69.5

Table 3.2 shows the number of both early neonatal and neonatal deaths for each survey year and the ratios of early neonatal to neonatal deaths. The ratio for 2000 and 2005 is 71 percent, very close to the expected ratio of 70 percent, and the ratio for 2007-08 is 70 percent. However, the ratio for 1992 is only 64 percent suggesting that there was some misreporting or under-reporting of neonatal deaths in the 1992 survey, although this was only slightly lower than the norm.

Table 3.3 Ratio of neonatal (NN) deaths to infant (INF) deaths for all Rwanda DHSs (weighted)

Year	NN deaths	INF deaths	Ratio NN:INF
1992	219	453	48.4
2000	352	818	43.0
2005	321	681	47.2
2007-08	160	324	49.3

Table 3.3 shows neonatal and infant mortality and the ratio of neonatal mortality to all infant mortality. This ratio decreases if overall mortality increases. The ratio deceases between 1992 and 2000 suggesting an increase in childhood mortality during that period. However it increases consistently with a decline in childhood mortality in Rwanda from 2000 to 2007-08.

Table 3.4 Ratio of male (M) births to 100 female (F) births for all Rwanda DHSs (weighted)

Year	M	F	Ratio M:F
1992	2,847	2,815	101.1
2000	4,122	4,066	101.4
2005	4,428	4,287	103.3
2007-08	2,860	2,796	102.3

The normal sex ratio of males to 100 females at birth varies from 103 to 107. Ratios significantly above or below this figure suggest that there are omissions. Table 3.4 shows that sex ratios at birth for males to 100 females in Rwanda for all four surveys are 101 to 103 and are slightly low but within the norm.

3.3.2 Incomplete information

A woman is likely to report all the births and all the deaths among her children, but she may not remember or be able to provide complete information on the exact dates of these births and deaths. DHS imputes the missing information when necessary. Table 3.5 shows that year and months of birth are reported in 98 percent of all births in the 1992 survey and almost 100 percent of all births in 2000, 2005, and 2007-08. There was only a very small percent of all births that required imputation.

Table 3.5 Completeness of reporting on data of births for all Rwanda DHSs (weighted)

	1992		2000		2005		2007-08	
Data reported	N	%	N	%	N	%	N	%
Month and year reported	5,392	97.9	7,895	99.7	8,641	99.9	5,624	99.4
Year and age reported, month imputed	46	0.8	1	0.0	—	—	22	0.4
Year and age reported, year ignored	—	—	12	0.2	—	—	—	—
Year reported, age and month imputed	67	1.2	13	0.2	5	0.1	7	0.1
Age reported, year calculated, month imputed	3	0.1	—	—	—	—	1	0.0
No data reported, all imputed	2	0.0	1	0.0	3	0.0	2	0.0
Total	5,510	100.0	7,922	100.0	8,649	100.0	5,656	100.0

3.3.3 Displacement of events in time

Displacement of an event in time such as birth date could be intentional so that eligible children will be moved outside the range of eligibility (children born within the past five years) for certain particular sections of the questionnaires, for example, the maternal and child health section. The motivation for reducing the number of eligible children is to decrease the workload in the process of collecting information from the mothers of those children.

Systematically displacing date of birth directly affects the calculation of mortality rates. This bias can be detected by calculating and analyzing the displacement ratio of births. This displacement ratio of births is represented by the following equation, where Bx is the number of births reported in year x. A ratio of less than 100 indicates that fewer births are reported for year x:

$$100 * (2B_x/(B_{x-1}+B_{x+1}))$$

In Table 3.6 calculation of displacement ratios for all births and births of deceased children are for the last year of the survey and for the year before the last year of the survey that a child is eligible for the maternal and child health sections. In all four RDHSs, the last year of eligibility is the full fifth year preceding the survey. If there is displacement out of the eligible date range then the ratio will be low for the last year of eligibility and high for the first year before the eligibility range. Table 3.6 shows evidence of displacement for all children and for dead children in all four surveys. The level of displacement for all children is greatest in the 2000 survey compared to the other surveys. The level of displacement for dead children is also greater in the 1992 and 2000 surveys than in the last two surveys. In the 2007-08 survey there is an overestimate of dead children.

Table 3.6 Displacement of events: displacement ratios of all birth, and births for children who died (Displacement ratio = $100*(2B_x/(B_{x-1}+B_{x+1}))$

	x=Last year of eligibility		x=Year before last year of eligibility	
Year	All births	Births of children who died	All births	Births of children who died
1992	101.0	86.8	106.9	123.6
2000	78.5	59.1	128.0	108.8
2005	107.0	100.9	111.4	113.1
2007-08	96.0	107.1	107.0	93.0

3.3.4 Misreported age at death

Data on age at death for deceased children were asked to mothers in days for children who died within a month of birth, in months for children who died within 2-23 months of birth, and in complete years for children who died after 23 months of birth. Mothers, however, may report the age at death in days or months by rounding them to an approximate higher level of time unit rather than the exact number. For example, mothers may report the age at death as 7 days (one week), 30 days (one month), and 12 months (one year). This misreporting of age at death is called heaping, which is particularly serious when it happens at the age of 12 months. In the DHS, the infant mortality rate is calculated based on deaths between 0-11 months, while deaths at 12 months belong to the calculation of child mortality rates. Rounding-up or heaping-up the reported age at death from 10 or 11 months to 12 months underestimates the calculation of infant mortality rates, while heaping-down from 14 or 13 months to 12 months has no implication for the calculation of child mortality rates.

This misreporting of age at death can be examined by calculating the heaping ratio. This ratio is represented by the following equation, where Dx is the total number of deaths reported at the age in months x:

$$3D_x/(D_{x-1}+D_x+D_{x+1})$$

Table 3.7 Heaping of reported age at death from month 12 (Heaping ratio=$3*D_{12}/(D_{11}+D_{12}+D_{13})$)

Year	Heaping ratio
1992	2.6
2000	2.3
2005	2.1
2007-08	2.6

Table 3.7 presents the heaping ratios for heaping on reported age at death in months 12 (x=12 months). There is evidence of heaping on reported age at death in all four surveys, ranking from 110 percent to 160 percent. Nonetheless, the misreporting of age has not significantly impacted the estimates of infant mortality for the following reasons: 1) A shift from 13 to 12 months does not affect the calculation of infant mortality. 2) Some excess deaths at 12 months are due to reporting of age at death as one year (rounding) rather than 14, 15, … 21, 22, and 23 months, none of which affects the calculation of infant mortality. 3) A majority of infant mortality is concentrated in the earlier months of life with fewer deaths at age 11 and 12 months. Indeed, a decrease in mortality for these ages makes the heaping ratio more sensitive to small numbers. Studies have shown that the effect of heaping at 12 months lowers the infant mortality rate by less than 5 deaths per thousand live births. Therefore, there appears to be little change in the quality of age at death information with little impact on infant mortality trends. Heaping at 12 months has no impact on estimates of under-five mortality.

4 TRENDS OF SOME SOCIOECONOMIC AND HEALTH INDICATORS

Some socioeconomic status and health indicators are believed to have an impact on mortality in children. This chapter looks at trends of some socioeconomic and health indicators from 1992 to 2007-08. Socioeconomic indicators include household availability of improved toilet facilities, access to safe drinking water, improved sources of water, and women's education. Health indicators include health status and health services. Health status indicators include prevalence of diarrhea and ARI among children, nutritional status of children and women, and birth intervals. Health service indicators are child immunization coverage, modern contraceptive prevalence, treatment of diarrhea and ARI among children, antenatal care, delivery assistance, household possession of mosquito nets, and mosquito net usage. Household possession of mosquito nets is classified as a health service indicator because mosquito nets were distributed in Rwanda during vaccination campaigns, ANC visits, etc. However, some households bought mosquito nets from a shop, in which case net possession could also be classified as a socioeconomic indicator.

Table 4.1 presents a list of these indicators (and their indicated denominators) as well as their levels according to the four surveys.

Results show that the proportion of households with access to improved toilet facilities has increased dramatically, from 9 percent in 2000 to 56 percent in 2007-08. Access to safe drinking water improved between 1996 and 2000, but dropped slightly in 2005. Only 41 percent of households currently have access to safe drinking water. Lack of access to safe drinking water and proper sanitation facilities increased exposure of Rwandans to the risk of diarrhea and other water- and food-borne infections. The education level of women had improved substantially between 1992 and 2000, but has not changed very much since then. Only slightly more than one in ten women had secondary education or higher in 2007-08.

With regard to health status, results show that the percentage of children who had diarrhea or ARI within two weeks before the survey has gradually improved over the years. Nutritional status of children has also improved slightly over the period. The proportion of children with chronic malnutrition (who were stunted) in 1992, 2000, and 2005 was 48 percent, 43 percent, and 45 percent respectively. The proportion of under-weight children was 29 percent, 24 percent and 23 percent during the same periods.

Short birth intervals are associated with increased risk of mortality. The interval with the highest risk is less than two years, while the most favorable is four or more years. Results show that the birth interval < 24 months increased from 21 percent in 1992 to 24 percent in 2000. This may reflect a population replenishing effect after the tragic events in 1994. However, the proportion of births with short birth intervals has decreased to 23 percent in 2005 and 22 percent in 2007-08.

Immunization is a simple, safe, and effective way of providing children with protection for specific infections. The World Health Organization recommends that all children be immunized against at least six common childhood infections: tuberculosis, diphtheria, whooping cough, tetanus, polio, and measles. The health authority in a country may choose to add one or two additional vaccines into its immunization program such as hepatitis B or hemophilus influenza, based on its specific disease profile and needs.

Table 4.1 Trend in selected health and socioeconomic indicators that could have influenced early childhood mortality, Rwanda 1992-2007/08

	Denominator	Percent				Number			
		1992	2000	2005	2007-08	1992	2000	2005	2007-08
Socioeconomic indicators									
Access to improved toilet[1]	Households	na	9	29	56	6,252	9,696	10,272	7,377
Access to safe drinking water[2]	Households	23	40	34	41	6,252	9,696	10,272	7,377
Access to improved source of water[3]	Households	77	82	67	67	6,252	9,696	10,272	7,377
Primary education	Women aged 15-49	54	65	67	66	6,551	10,421	11,321	7,313
Secondary or higher education	Women aged 15-49	8	11	10	12	6,551	10,421	11,321	7,313
Health indicators									
Had diarrhea in past 2 weeks	Children <5 years (women's birth history)	22	17	14	14	4,994	7,033	7,797	5,241
Had ARI in past 2 weeks	Children <5 years (women's birth history)	33	21	17	15	4,994	7,033	7,797	5,241
Stunting (height-for age < -2SD)	Children <5 years (household schedule)	48	43	45	na	4,363	6,490	3,859	na
Wasting (weight-for height < -2SD)	Children <5 years (household schedule)	4	7	4	na	4,363	6,490	3,859	na
Underweight (weight-for age < -2SD)	Children <5 years (household schedule)	29	24	23	na	4,363	6,490	3,859	na
BMI (<18.5 kg/m^2)	Women aged 15-49 (exclude pregnant)	na	9	10	na	na	8,968	5,100	na
Birth interval < 24 months	Births in the last 5 years (exclude 1st born)	21	24	23	22	4,621	6,521	7,074	4,434
Birth interval 24-35 months	Births in the last 5 years (exclude 1st born)	45	37	41	38	4,621	6,521	7,074	4,434
Birth interval >35 months	Births in the last 5 years (exclude 1st born)	34	40	36	41	4,621	6,521	7,074	4,434
Health service indicators									
Fully immunized	Children age 12-23 months	87	76	75	80	1,010	1,330	1,626	1,226
Modern contraceptive prevalence	Married women (15-49)	13	6	10	27	3,385	5,052	5,510	3,888
Diarrhea: taken for treatment	Children with diarrhea	23	13	14	33	1,089	1,186	1,103	719
ARI: taken for treatment	Children with ARI	30	15	27	28	1,628	1,490	2,450	796
Antenatal care from health care professional	Women (15-49) with live birth (last 5 years)	94	94	94	96	3,616	5,141	5,425	3,658
2+ tetanus toxoid injections	Women (15-49) with live birth (last 5 years)	62	32	22	31	3,409	4,755	5,124	3,431
Delivery by health care professional	Births in the last 5 years	26	31	39	52	5,612	8,188	8,715	5,656
Delivery in health care facility	Births in the last 5 years	25	27	28	45	5,612	8,188	8,715	5,656
Possession of mosquito nets	Households	na	na	18	59	na	na	10,272	7,373
Slept under a mosquito net previous night	Children <5 years (household schedule)	na	na	16	60	na	na	7,534	5,414

na = not applicable
[1] Including flush toilet, ventilated/improved latrine or toilet
[2] Including piped water, protected wells, and piped wells/boreholes
[3] Including piped water, protected wells, piped wells/boreholes, spring, and rain water

To be considered to have been fully immunized in Rwanda, a child should have received one dose of BCG vaccine (for tuberculosis), three doses of DPT vaccine (for diphtheria, whooping cough, and tetanus), three doses of polio vaccine, and one dose of measles vaccine. Data show that full immunization coverage was high in 1992 (87 percent). It declined significantly in 2000 (76 percent) and 2005 (75 percent). In 2007-08 the full immunization rate recovered to 80 percent.

Diarrhea and ARI are major causes of childhood morbidity and among the leading causes of mortality if they do not receive proper medical attention. In 1992 only a small proportion of children with diarrhea (23 percent) and ARI (30 percent) were taken for treatment. Unfortunately, these indicators substantially decreased in 2000 and 2005 compared to 1992. However, in 2007-08 the situation had improved slightly, and the proportions of children treated for diarrhea and ARI were 33 percent and 28 percent, respectively.

The major objective of antenatal care is identification and treatment of problems during pregnancy such as anemia and infections. During antenatal care visits pregnant women receive screening for complications and advice on a range of issues including place of delivery and referral should complications occur. DHS results indicate that practically all women in Rwanda received antenatal care (94 percent in 1992, 2002, 2005 and 96 percent in 2007-08).

Neonatal tetanus is common among newborns in developing countries where many deliveries are not conducted at a health care facility, but in poor hygienic conditions where implements used to cut the umbilical cord are not properly sterilized. Tetanus toxoid (TT) immunization is given to pregnant women in order to prevent neonatal tetanus. For full protection, a pregnant woman needs at least two doses of TT injections. If a woman has been immunized before she became pregnant, she only needs one dose of TT. For a woman to have lifetime protection she must receive a total of five doses. In Rwanda, the 1992 RDHS shows that 62 percent of pregnant women received two or more TT injections. This proportion declines by almost 50 percent in 2000 (32 percent) and further declines in 2005 (22 percent). However, according to the 2007-08 RIDHS, it has now increased to 31 percent.

Assistance during delivery is an important indicator influencing delivery outcome and health of the mother and infant. Overall, the 1992 survey indicates that only one in four births (26 percent) in the five years preceding the survey was assisted by a health professional during delivery. The proportion increased to 31 percent in 2000 and to 39 percent in 2005; in 2007-08 it continued to increase even more, reaching a proportion of 52 percent. However, some women only go to seek delivery assistance from a health professional when they have complications. For these women, having an assisted delivery is associated with an increased risk of neonatal mortality. Similar levels and trends were observed in the proportion of births occurring in a health care facility.

Malaria is one of the major public health concerns in Rwanda. It is one of the leading causes of morbidity and mortality. The disease especially affects children under 5 years of age and pregnant women. In such a situation, the use of mosquito nets is an important protection against the bite of the Anopheles mosquitoes that carries the malaria parasite and transmits the disease. Data on the possession and use of mosquito nets were collected in the 2005 and 2007-08 surveys. Table 4.1 shows that 18 percent of households had mosquito nets in 2005. Three years later, the proportion increased to 59 percent. With regard to use of mosquito nets, the data show that 16 percent of children under age five slept under a mosquito net the night before the survey in 2005, while in 2007-08 this figure increased to 60 percent.

5 LEVELS, TRENDS, AND DIFFERENTIALS

Table 5.1 presents the five-year rate for early childhood mortality in Rwanda from 1992 to 2007-08. All early childhood mortality rates from 1992 to 2007-08 display similar trends: starting from reasonably low rates during the calendar period 1987-1991 (1992 survey), the rates jumped drastically during the calendar period 1995-1999 (2000 survey). Five years later, during the calendar period 2000-2004 (2005 survey), they declined to the level of the 1992 survey, and continued to drop further and faster during the period 2003-2007 (2007-08 survey).

Table 5.1 Trends in neonatal, infant, and under-five mortality rates, Rwanda 1992-2007/08 (five-year rates)

Year	Approximate calendar period	Neonatal mortality (NN)	Post neonatal mortality (PNN)	Infant mortality (1q0)	Child mortality (4q1)	Under-five mortality (5q0)
1992	1987-1991	39	46	85	72	150
2000	1995-1999	44	64	107	100	196
2005	2000-2004	37	49	86	72	152
2007-08	2003-2007	28	34	62	43	103

The levels and trends of infant mortality and under-five mortality from the four surveys are also presented by different determinants or risk/protecting factors to provide differentials in childhood mortality. These determinants are also used in the multivariate analysis.

The determinants or risk/protecting factors are:

Child's characteristics:

- Child's sex: whether the child is a boy or girl.
- Whether the birth was multiple or single—multiple births are known to have very high risks of mortality especially during the neonatal period. Singleton births are taken as the reference category.
- Birth order—whether the child is first or second born, third born, or fourth or higher born. Birth order is expected to have a U-shaped relationship with mortality. Birth orders one and two are taken as the reference category in multivariate analysis.
- Prior birth interval—studies have shown that length of prior birth interval is strongly related to the risk of infant and child mortality, births occurring less than 36 months after the prior birth are at increased risk of mortality and the shorter the interval, the higher the risk. Births were classified into those occurring less than 24 months after the prior birth, 24 to 35 months, and 36 or more months. In order to include all children in the analysis, the category of first-born children needed to be included since these births have no preceding interval. This category is taken as the reference in multivariate analysis.

Health and health and care indicators:

- Antenatal care—Whether or not the mother received one or more antenatal check-ups from a healthcare professional during the pregnancy of the specific child. The reference category in multivariate analysis is those who did.

- Tetanus toxoid vaccination during the pregnancy of the specific child. Children whose mothers received two or more vaccinations are the reference category in multivariate analysis.
- Delivery by health care professional—Children whose birth was attended by a health care professional are the reference category in multivariate analysis.
- Full immunization—Since the immunization of dead children was not ascertained, information on the immunization status of living siblings under age five (and of the children themselves if living) was used as a proxy. Children for whom some or all of their siblings including themselves had received full immunization are taken as the reference category.

Mother's characteristics:

- Mother's age at birth—The age of the mother at the birth of the child has a U-shaped relationship with mortality. Especially at risk are births which occur when the mother is less than 18 years of age or older than 40 years. To represent mother's age at birth, three categories are used: less than 18 years (the reference category), 18 to 34 years and 35 or more years.
- Marital status—It is expected that children whose mothers are in a stable relationship (currently in union) have lower risks of mortality than those whose mothers are not married. Marital status is measured at the time of the survey and may not necessarily have been the same since the child's birth. Single (not currently in union) is taken as the reference category.
- Mother's level of education—As mother's level of education increases, the risk of mortality is expected to decrease. The categories are: no education (reference), primary education whether incomplete or complete, and secondary or higher.
- Mother's use of contraceptives—The risk of mortality is expected to decrease if the mother uses contraceptives. The categories are: never used, ever used but not currently using, currently using.

Household characteristics—all measured at the time of the survey:

- Type of area of residence—Urban or rural. Urban is the reference category.
- Household wealth index tricile—Low, Middle, High. Low is the reference category. It is expected that the risk of mortality is lower among households with a high wealth index.
- Improved sources of drinking water—Divided into improved sources and non-improved sources. Piped water, protected wells, piped wells/boreholes, spring, and rain water are considered as improved sources and are taken as the reference category.
- Improved toilet facilities—Divided into households with an improved toilet (flush toilet, ventilated/improved latrine or toilet) and rudimentary toilet/no toilet; with improved toilet as the reference category in multivariate analysis.
- Possession of a mosquito net—Households with at least one mosquito net of any type. In Rwanda almost all mosquito nets are impregnated with insecticide.
- Mother slept under a mosquito net—Mothers of children in the analysis slept under a treated net or under a non-treated net. Without a net or did not sleep under a net is a reference category in multivariate analysis.

Table 5.2 Infant mortality rate (ten-year rate) preceding the surveys, by selected characteristics, Rwanda 1992-2007/08

Background characteristic	IMR per 1000 live births			
	1992	2000	2005	2007-08
Child characteristic				
Child's sex				
Boy	98	123	106	83
Girl	82	112	99	71
Multiple birth				
Single	84	112	97	72
Multiple	383	317	301	254
Child's birth order				
1	100	115	113	77
2	91	108	100	70
3	82	110	98	66
4+	89	124	101	85
Prior birth interval				
First born	102	116	117	79
< 2 years	159	186	149	132
2 years	62	106	88	62
3+ years	56	77	74	54
Health and health care indicator				
Mother received prenatal care from health professional (last birth)[1]				
Yes	82	72	52	29
No/not by health professional	82	115	95	66
Mother received tetanus injections (last birth)[1]				
2+ doses	73	65	46	29
1 dose	101	79	52	26
No	84	81	62	31
Delivery by health care professional[1]				
Yes	88	98	69	38
No	101	112	89	48
Siblings (and themselves if living) were fully immunized				
All or some	64	81	71	58
None	125	130	127	76
No living sibling under-five	191	187	170	136
Mother characteristic				
Mother's age at childbirth				
<18	112	171	154	138
18-34	91	113	101	75
>34	87	126	101	77
Mother's marital status				
Not currently in union	111	123	115	89
Currently in union	87	116	100	75
Mother's education				
No education	97	135	117	100
Primary	85	114	101	73
Secondary or higher	65	60	64	23

To be continued...

Table 5.2 --- Continued

Background characteristic	IMR per 1000 live births			
	1992	2000	2005	2007-08
Mother's use of contraceptive				
Never use	105	125	115	91
Ever used	79	114	85	75
Currently use	70	85	78	64
Household characteristics				
Residence				
Urban	88	78	69	40
Rural	90	124	108	82
Household wealth status				
Low	86	127	115	87
Middle	101	123	98	80
High	85	98	94	62
Access to improved sources of water				
Yes	84	111	98	77
No	105	147	111	76
Access to improved toilet facility				
Yes	na	83	97	82
No	na	121	105	71
Possession of mosquito nets				
No	na	na	60	109
Yes at least one	na	na	53	68
Mother slept under mosquito net previous night				
No net/not slept	na	na	105	96
Slept under treated net	na	na	92	70
Slept under non-treated net	na	na	94	38

na = not applicable
[1] Data are available for five-years rates

Table 5.3 Under-five mortality rate (ten-year rate) preceding the surveys, by selected characteristics, Rwanda 1992-2007/08

Background characteristic	U5MR per 1000 live births			
	1992	2000	2005	2007-08
Child's characteristic				
Child's sex				
Boy	177	215	187	146
Girl	149	198	177	123
Multiple birth				
Single	157	203	177	130
Multiple	441	371	370	288
Child's birth order				
1	170	206	190	144
2	164	203	177	127
3	158	192	193	124
4+	161	213	178	137
Prior birth interval				
First born	172	206	194	146
< 2 years	243	299	245	210
2 years	137	192	170	114
3+ years	111	145	140	92
Health and health care indicator				
Mother received antenatal care from health professional (last birth)[1]				
Yes	149	120	99	36
No/not by health professional	156	189	156	95
Mother received tetanus injections (last birth)[1]				
2+ doses	138	122	96	38
1 dose	174	115	100	30
No	180	134	110	40
Delivery by health care professional[1]				
Yes	150	162	124	58
No	195	198	159	67
Siblings (and themselves if living) were fully immunized				
All or some	126	151	134	107
None	183	209	203	129
No living sibling under-five	314	325	285	215
Mother's characteristic				
Mother's age at childbirth				
<18	240	278	238	224
18-34	162	209	181	133
>34	153	199	174	122
Mother's marital status				
Not currently in union	205	220	203	164
Currently in union	156	202	178	129
Mother's education				
No education	177	233	210	174
Primary	152	200	179	127
Secondary or higher	94	117	95	43

To be continued...

Table 5.3 --- Continued

Background characteristic	U5MR per 1000 live births			
	1992	2000	2005	2007-08
Mother's use of contraceptive				
Never use	189	226	202	162
Ever use	147	195	159	134
Current use	117	147	130	103
Household characteristic				
Residence				
Urban	155	141	123	78
Rural	163	216	192	142
Household wealth status				
Low	160	229	206	152
Middle	169	205	181	135
High	157	182	154	108
Access to improved sources of water				
Yes	154	199	175	133
No	183	247	192	132
Access to improved toilet facility				
Yes	na	144	158	142
No	na	214	189	121
Possession of mosquito nets				
No	na	na	190	176
Yes at least one	na	na	146	120
Mother slept under mosquito net previous night				
No net/not slept	na	na	187	159
Slept under treated net	na	na	151	124
Slept under non-treated net	na	na	153	78

na = not applicable
[1] Data are available for five-years rates

As indicated earlier, levels of childhood mortality have declined rapidly in the last 7-8 years, from the 2000 RDHS to 2007-08 RIDHS, and reached a record low that is lower than those observed in the 1992 survey. The 2005 RDHS data show that levels of childhood mortality had returned to the levels found in the 1992 RDHS. Table 5.1 shows that infant mortality and under-five mortality levels in the 2007-08 RIDHS represent an almost 28 percent and 32 percent decrease respectively from the level of 86 deaths per 1,000 live births and 152 deaths per 1,000 live births observed in the 2005 RDHS.

Differentials in infant and under-five mortality rates by selected variables for children, mothers, health, health care and households are presented in Tables 5.2 and 5.3. The bivariate analysis indicates that differences in mortality rates by child's and mother's characteristics are relatively large, in particular those related to multiplicity of birth, birth interval, mother's age at child's birth, mother's education, and mother's use of contraceptives. For example, infant mortality for children of mothers with a secondary education or higher was always lower than for children whose mothers had never attended school. In the 2000 RDHS children of mothers with a secondary education or higher had an infant mortality rate of 60 per 1,000 live births compared to 135 per 1,000 live births for children of mothers who had never attended school. In the 2007-08 RIDHS, infant mortality rates for children of mothers with a secondary education or higher was 23 per 1,000 live births, while it was 100 per 1,000 live births for children whose mothers had never attended school. In another example, infant mortality for children of mothers who

currently use contraceptive methods is always lower than for children of mothers who have never used contraceptives.

Data in tables 5.2 and 5.3 also show that antenatal care, assistance during delivery by a health professional, full immunization, possession of a mosquito net, and mother slept under net have a large impact on mortality decline. For example, regarding possession of a mosquito net, results show that levels of under-five mortality among children from households without mosquito nets compared to households with a mosquito net in the 2005 RDHS were 190 per 1,000 live births and 146 per 1,000 live births, respectively. In the 2007-08 RIDHS, the under-five mortality rate among both groups of children had declined; but there was still a gap between them. These data from the 2007-08 RIDHS result in levels of under-five mortality among children from households without mosquito nets and from households with a mosquito net of 176 per 1,000 live births and 120 per 1,000 live births, respectively.

6 RESULTS OF THE MULTIVARIATE ANALYSIS

To determine which among the possible characteristics for children and mothers, health and health care indicators, and household characteristics are most responsible for changes in infant and under-five mortality seen in Rwanda in 2007-08, multivariate analysis is required to sort out the overlapping effects of many of the potential variables and eliminate confusion.

The procedure for determining how much change in mortality between surveys is due to measured characteristics is as follows. First a multivariate analysis of mortality is produced using data from the 2007-08 survey. Then changes in the distribution of indicators or covariates between surveys are multiplied by the coefficients of variables from the multivariate analysis. These products are then summed and this sum is exponentiated to get the change in mortality due to changing health conditions between surveys. An alternative procedure is to multiply each coefficient by the percentage in each category of the variable, sum these products along with the constant to produce a likelihood ratio of mortality and finally the mortality rate itself.

The dependent variables for mortality analyses are infant and under-five mortality during the five-year period prior to the surveys. Not all children born during the period have been exposed to the risk of death for the whole time since some may have been born later in the period. Therefore, the Weibull hazard regression (a multivariate life-table procedure) was used to adjust for the incomplete exposure to mortality.

For both infant and under-five mortality, the covariates of interest regarding children and mothers, health and health care, and households are those discussed in the preceding section.

Results of the multivariate analyses for infant and under-five mortality are presented in Tables 6.1 and 6.2 as exponentiated coefficients or hazard ratios. The hazard ratio is the percentage increase or decrease in the risk of dying entailed by the specific category of variable when compared to the reference category for that variable.

Table 6.1 shows both the unadjusted (univariate) and adjusted (multivariate) hazard ratios for each of the variables as well as the p-value. A p-value of less than 0.050 is considered to be statistically significant (i.e. not the result of random chance). In the adjusted model, for the children's characteristics, the model reveals that being a child from a multiple birth substantially increases the risk of mortality. Birth order and birth interval are not significant. For health and health care indicators, antenatal care provided by a health professional, delivery assisted by a health professional, and being fully immunized lower the risk of mortality. Tetanus injection is not significant. For mother's characteristics, mother's current use of contraception decreases the risk of mortality, but not significantly. Mother's age at childbirth, marital status, and education are not significant. Among household characteristics, household wealth status, water, toilet, possession of a mosquito net, and mother slept under either a treated or non-treated net are not significant. Rural children are at higher risk than urban children but not significantly. Household possession of a mosquito net decreases the risk of infant mortality but not significantly.

Table 6.2 is similar to table 6.1 but for under-five mortality. Under-five mortality includes infant and child mortality at ages 1 to 4 years. As in infant mortality, children from multiple births have higher mortality risks. Other child characteristics are not significant. Receiving antenatal care from a health professional, delivery assisted by a health professional, and being fully immunized substantially decrease the risk of mortality. Mother's tetanus injection is not significant. Mother's current use of contraception is significantly associated with a lower risk of mortality. Other maternal characteristics are not significant. Household possession of a mosquito net decreases the risk of under-five mortality but not significantly.

Other household characteristics are not significant. However, similar to infant mortality, rural children are at significantly higher risk of under-five mortality than urban children.

Table 6.1 Effects of selected factors associated with infant mortality among children who were born in the five-year period preceding the survey, by selected characteristics, Rwanda 2007/08

	Unadjusted		Adjusted	
Background characteristic	Hazard ratio	P-value	Hazard ratio	P-value
Child's characteristic				
Child's sex				
Boy	1.00	—	1.00	—
Girl	0.77	0.031	0.83	0.164
Multiple birth				
Single	1.00	—	1.00	—
Multiple	4.59	0.000	3.08	0.000
Child's birth order				
1-2	1.00	—	1.00	—
3	0.76	0.158	0.94	0.809
4+	1.03	0.834	1.21	0.358
Prior birth interval				
First born	1.00	—	1.00	—
< 2 years	1.44	0.041	1.41	0.136
2 years	0.71	0.059	0.85	0.502
3+ years	0.84	0.303	0.84	0.472
Health and health care indicator				
Mother received antenatal care from a health professional (last birth)				
Yes	1.00	—	1.00	—
No/not by health professional	3.34	0.000	2.88	0.000
Mother received tetanus injections (last birth)				
2+ doses	1.00	—	1.00	—
1 dose	1.03	0.863	0.96	0.807
No	1.41	0.030	0.94	0.722
Delivery by health care professional				
Yes	1.00	—	1.00	—
No	2.11	0.000	1.65	0.001
Siblings (and themselves if living) were fully immunized				
All or some	1.00	—	1.00	—
None	6.29	0.000	6.26	0.000
Mother's characteristic				
Mother's age at childbirth				
<18	1.00	—	1.00	—
18-34	0.58	0.122	0.59	0.130
>34	0.63	0.208	0.67	0.310
Mother marital status				
Not currently married	1.00	—	1.00	—
Currently married	0.91	0.593	1.03	0.854
Mother's education				
No education	1.00	—	1.00	—
Primary	0.88	0.345	1.09	0.560
Secondary or higher	0.35	0.002	0.55	0.099

To be continued...

Table 6.1 --- Continued

Background characteristic	Unadjusted		Adjusted	
	Hazard ratio	P-value	Hazard ratio	P-value
Mother's use of contraceptive				
Never use	1.00	—	1.00	—
Ever use	1.04	0.810	1.13	0.425
Current use	0.69	0.010	0.79	0.142
Household characteristic				
Residence				
Urban	1.00	—	1.00	—
Rural	1.86	0.001	1.45	0.075
Household wealth index				
Low	1.00	—	1.00	—
Middle	0.78	0.085	0.94	0.711
High	0.79	0.115	0.93	0.703
Access to improved sources of water				
Yes	1.00	—	1.00	—
No	0.88	0.330	0.83	0.192
Access to improved toilet facility				
Yes	1.00	—	1.00	—
No	0.85	0.201	1.08	0.638
Possession of mosquito nets				
No	1.00	—	1.00	—
Yes, at least one	0.63	0.000	0.81	0.362
Mother's slept under a mosquito net				
No net/not slept	1.00	—	1.00	—
Yes, treated net	0.76	0.027	1.04	0.859
Yes, non-treated net	0.38	0.011	0.72	0.428
Number of children	5,489		5,455	

Table 6.2 Effects of selected factors associated with under-five mortality among children who were born in the five-year period preceding the survey, by selected characteristics, Rwanda 2007/08

Background characteristic	Unadjusted		Adjusted	
	Hazard ratio	P-value	Hazard ratio	P-value
Child's characteristic				
Child's sex				
Boy	1.00	—	1.00	—
Girl	0.77	0.015	0.82	0.091
Multiple birth				
Single	1.00	—	1.00	—
Multiple	3.86	0.000	2.84	0.000
Child's birth order				
1-2	1.00	—	1.00	—
3	0.78	0.150	0.99	0.966
4+	0.93	0.541	1.10	0.594
Prior birth interval				
First born	1.00	—	1.00	—
< 2 years	1.32	0.078	1.36	0.126
2 years	0.71	0.030	0.88	0.547
3+ years	0.73	0.038	0.76	0.186
Health and health care indicator				
Mother received antenatal care from a health professional (last birth)				
Yes	1.00	—	1.00	—
No/not by health professional	3.82	0.000	3.38	0.000
Mother received tetanus injections (last birth)				
2+ doses	1.00	—	1.00	—
1 dose	0.99	0.936	0.95	0.717
No	1.32	0.049	0.91	0.578
Delivery by health care professional				
Yes	1.00	—	1.00	—
No	2.08	0.000	1.56	0.000
Siblings (and themselves if living) were fully immunized				
All or some	1.00	—	1.00	—
None	6.21	0.000	6.00	0.000
Mother's characteristic				
Mother's age at childbirth				
<18	1.00	—	1.00	—
18-34	0.69	0.268	0.75	0.404
>34	0.70	0.297	0.92	0.819
Mother marital status				
Not currently married	1.00	—	1.00	—
Currently married	0.88	0.367	0.96	0.819
Mother's education				
No education	1.00	—	1.00	—
Primary	0.79	0.055	0.96	0.760
Secondary or higher	0.38	0.001	0.56	0.063
Mother's use of contraceptives				
Never use	1.00	—	1.00	—
Ever use	1.02	0.912	1.12	0.411
Current use	0.58	0.000	0.68	0.009

To be continued..

Table 6.2 --- Continued

Background characteristic	Unadjusted		Adjusted	
	Hazard ratio	P-value	Hazard ratio	P-value
Household characteristic				
Residence				
Urban	1.00	—	1.00	—
Rural	1.72	0.001	1.35	0.096
Household wealth index				
Low	1.00	—	1.00	—
Middle	0.74	0.022	0.93	0.649
High	0.78	0.062	0.95	0.780
Access to improved sources of water				
Yes	1.00	—	1.00	—
No	0.84	0.135	0.79	0.069
Access to improved toilet facility				
Yes	1.00	—	1.00	—
No	0.81	0.066	1.03	0.843
Possession of mosquito nets				
No	1.00	—	1.00	—
Yes, at least one	0.61	0.000	0.66	0.058
Mother’s slept under a mosquito net				
No net/not slept	1.00	—	1.00	—
Yes, treated net	0.76	0.015	1.27	0.278
Yes, non-treated net	0.35	0.003	0.78	0.522
Number of children	5,483		5,455	

To view the impact of changing health conditions on infant and under-five mortality, backward stepwise hazard regressions were performed to remove one non-significant variable at each step and apply coefficients (converted from hazard ratios) of significant characteristics to changes in the distributions. The results are shown in Table 6.3 for infant mortality and 6.4 for under-five mortality. Reference categories with coefficients equal to one are not included; they are not presented in the coefficient column. Also non-significant results are omitted from the coefficient columns.

For infant mortality, multiplicity of birth, birth interval, antenatal care by a health professional, delivery by a health care professional, full immunization of children, mother's education, and urban/rural residence are significant predictors of the risk of dying under age 12 months. Between 2005 and 2007-08, decrease in short birth intervals, increase in antenatal care by a health professional, delivery assisted by a health care professional, and fully immunized children, are related to a substantial decrease in infant mortality. This reduction in infant mortality is offset by increases in multiple births, rural residence, and a decrease in secondary education of mothers. Together, these characteristics account for about a 14 percent reduction in overall infant mortality between 2005 and 2007-08. From Table 5.1 the overall reduction between 2005 and 2007-08 was about 28 percent. Thus the model explains about 52 percent of the overall reduction. These characteristics account for a 24 percent reduction in overall infant mortality between 2000 and 2007-08, during which the overall reduction was 42 percent. Thus the model explains about 57 percent in the overall reduction.

Table 6.4 presents the results for under-five mortality. For under-five mortality, multiplicity of birth, birth interval, antenatal care by a health professional, delivery by a health care professional, full immunization of children, mother's education, mother's use of contraception, and household possession of a mosquito net are significant predictors of the risk of under-five mortality. Between 2005 and 2007-08,

decrease in short birth intervals, increase in antenatal care by a health professional, delivery assisted by a health care professional, fully immunized children, mother's use of contraception, and household possession of a mosquito net are related to a substantial decrease in under-five mortality. This reduction in under-five mortality is offset by an increase in multiple births and a decrease in secondary education of mothers. Together, these characteristics account for about a 31 percent reduction in overall under-five mortality between 2005 and 2007-08; thus the model explains 97 percent of the 33 percent decline in under-five mortality between the two surveys. The model therefore accounts for a 42 percent reduction in overall under-five mortality between 2000 and 2007-08, which was about 48 percent in all. Thus the model explains about 89 percent of the overall decline in under-five mortality between the two surveys.

Table 6.3 Expected change in infant mortality rate

	Proportions			Change in proportions		Coefficients	IMR by change in proportions	
Characteristic	2007/08	2005	2000	2007/08-2005	2007/08-2000	Infant mortality 2007/08	2007/08-2005	2007/08-2000
Girl	0.4943	0.4924	0.5008	0.0019	-0.0065			
Multiple birth	0.0284	0.0252	0.0249	0.0032	0.0035	1.1147800	0.0035673	0.0039017
Birth order 3rd	0.1649	0.1598	0.1491	0.0051	0.0158			
Birth order 4th+	0.4414	0.4812	0.4633	-0.0398	-0.0219			
Birth with birth interval<24 months	0.1711	0.1885	0.1882	-0.0174	-0.0171	0.4562487	-0.0079387	-0.0078019
Birth with birth interval 24-35 months	0.2949	0.3303	0.2905	-0.0354	0.0044			
Birth with birth interval >35 months	0.3180	0.2929	0.3177	0.0251	0.0003			
Mother did not receive antenatal care by health professional for last birth	0.0420	0.0560	0.0770	-0.0140	-0.0350	1.0568440	-0.0147958	-0.0369895
Received 1 dose of TT	0.3999	0.4111	0.2171	-0.0112	0.1828			
Did not receive TT	0.3049	0.3597	0.5932	-0.0548	-0.2883			
Delivery was not assisted by health care professional	0.4793	0.6140	0.6870	-0.1347	-0.2077	0.5187787	-0.0698795	-0.1077503
None of the siblings was fully immunized	0.2708	0.3153	0.3537	-0.0445	-0.0829	1.8790310	-0.0836169	-0.1557717
Mother age 18-34 at childbirth	0.7669	0.7461	0.7267	0.0208	0.0402			
Mother age >34 at childbirth	0.2120	0.2400	0.2537	-0.0280	-0.0417			
Married mother	0.8607	0.8665	0.8317	-0.0058	0.0290			
Primary	0.6705	0.6326	0.5579	0.0379	0.1126			
Secondary	0.0725	0.0840	0.1019	-0.0115	-0.0294	-0.7577525	0.0087142	0.0222779
Mother ever used contraceptive	0.2009	0.1713	0.2393	0.0296	-0.0384			
Mother currently uses contraceptive	0.3714	0.1671	0.1273	0.2043	0.2441			
Rural residence	0.8803	0.8591	0.8525	0.0212	0.0278	0.3744241	0.0079378	0.0104090
Middle wealth tercile	0.3531	0.3483	0.2813	0.0048	0.0718			
Higher wealth tercile	0.2816	0.3033	0.3212	-0.0217	-0.0396			
No access to improved sources of water	0.3400	0.6618	0.1863	-0.3218	0.1537			
No access to improved toilet facility	0.4309	0.7187	0.9109	-0.2878	-0.4800			
Household with mosquito net	0.7916	0.2376	0.0817	0.5540	0.7099			
Mother slept under treated net	0.6377	0.1528	na	0.4849	na			
Mother slept under non-treated net	0.0535	0.0326	na	0.0209	na			
Constant						-6.3767470		
						sum	-0.156011673	-0.271724755
						exp(sum)=RR	**0.855549203**	**0.762063986**

Note: Reference categories are not presented.

Table 6.4 Expected change in under-five mortality rate

Characteristic	Proportions			Change in proportions		Coefficients	IMR by change in proportions	
	2007/08	2005	2000	2007/08-2005	2007/08-2000	Under-five mortality 2007/08	2007/08-2005	2007/08-2000
Girl	0.4943	0.4924	0.5008	0.0019	-0.0065			
Multiple birth	0.0284	0.0252	0.0249	0.0032	0.0035	1.095632	0.0035060	0.0038347
Birth order 3rd	0.1649	0.1598	0.1491	0.0051	0.0158			
Birth order 4th+	0.4414	0.4812	0.4633	-0.0398	-0.0219			
Birth with birth interval<24 months	0.1711	0.1885	0.1882	-0.0174	-0.0171	0.478792	-0.0083310	-0.0081873
Birth with birth interval 24-35 months	0.2949	0.3303	0.2905	-0.0354	0.0044			
Birth with birth interval >35 months	0.3180	0.2929	0.3177	0.0251	0.0003			
Mother did not receive antenatal care by health professional for last birth	0.0420	0.0560	0.0770	-0.0140	-0.0350	1.215506	-0.0170171	-0.0425427
Received 1 dose of TT	0.3999	0.4111	0.2171	-0.0112	0.1828			
Did not receive TT	0.3049	0.3597	0.5932	-0.0548	-0.2883			
Delivery was not assisted by health care professional	0.4793	0.6140	0.6870	-0.1347	-0.2077	0.462753	-0.0623328	-0.0961138
None of the siblings was fully immunized	0.2708	0.3153	0.3537	-0.0445	-0.0829	1.811183	-0.0805976	-0.1501471
Mother age 18-34 at childbirth	0.7669	0.7461	0.7267	0.0208	0.0402			
Mother age >34 at childbirth	0.2120	0.2400	0.2537	-0.0280	-0.0417			
Married mother	0.8607	0.8665	0.8317	-0.0058	0.0290			
Primary	0.6705	0.6326	0.5579	0.0379	0.1126			
Secondary	0.0725	0.0840	0.1019	-0.0115	-0.0294	-0.612686	0.0070459	0.0180130
Mother ever used contraceptive	0.2009	0.1713	0.2393	0.0296	-0.0384			
Mother currently uses contraceptive	0.3714	0.1671	0.1273	0.2043	0.2441	-0.403974	-0.0825319	-0.0986101
Rural residence	0.8803	0.8591	0.8525	0.0212	0.0278			
Middle wealth tercile	0.3531	0.3483	0.2813	0.0048	0.0718			
Higher wealth tercile	0.2816	0.3033	0.3212	-0.0217	-0.0396			
No access to improved sources of water	0.3400	0.6618	0.1863	-0.3218	0.1537			
No access to improved toilet facility	0.4309	0.7187	0.9109	-0.2878	-0.4800			
Household with mosquito net	0.7916	0.2376	0.0817	0.5540	0.7099	-0.248808	-0.1378399	-0.1766291
Mother slept under treated net	0.6377	0.1528	na	0.4849	na			
Mother slept under non-treated net	0.0535	0.0326	na	0.0209	na			
Constant	1.0000	1.0000	1.0000	0.000	0.000	-5.772941		
						sum	-0.37809845	-0.55038249
						exp(sum)=RR	**0.68516304**	**0.57672917**

Note: Reference categories are not presented.

7 CONCLUSIONS

Both infant and under-five mortality in Rwanda declined substantially from 2000 to 2005 and fell even further in 2007-08. Evaluation of the data quality used for calculating mortality rates shows no reason to doubt that there has been a decline. There have been substantial health improvements from 2000 to 2007-08 and particularly from 2005 to 2007-08. Leading improvements have been the increase in delivery assisted by a health professional, mother's use of contraceptive methods, and household mosquito net possession between 2005 and 2007-08, followed by the decline in short birth interval (<24 months), the increase in antenatal care by a health professional and in full immunization of children. However, the decline in secondary education of mothers, increase in rural population, and increase in multiple births have all offset to some extent the drop in mortality due to improvements in other health conditions. The analysis shows that variables included in the final models account for 52 percent and 97 percent of the overall decline in infant and under-five mortality between 2005 and 2007-08, respectively. Other socioeconomic and health conditions may also explain some of the remaining overall declines but were not included in the analysis due to lack of data (e.g. changes in mortality due to violence and accidents) or inappropriate timing of data (e.g. fever, diarrhea, and ARI treatment, which are measured for the two-week period preceding the survey). Of course some of the unexplained decline may still be due to sampling variability and changes in data quality. It is evident from this analysis that full immunization, contraceptive use, mosquito net distribution and professional health assistance at delivery should continue to be increased.

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