Kingdom of Cambodia

# Factors Associated with the Decline of Under-Five Mortality in Cambodia, 2000-2010

## Further Analysis of the Cambodia Demographic and Health Surveys

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USAID

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This report presents findings from a further analysis study undertaken as part of the follow-up to the 2010 Cambodia Demographic and Health Survey (CDHS). ICF International 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 USAID and other cooperating agencies.

Additional information about the survey may be obtained from the National Institute of Statistics (NIS) of Cambodia, (#386, Monivong Blvd, Phnom Penh, Cambodia. Telephone/Fax: 855-23-213-650, Email: hdarith@nis.gov.kh, internet: http://www.nis.gov.kh/). Additional information about the DHS project may be obtained from ICF International, 11785 Beltsville Drive, Calverton, MD 20705 USA; Telephone: 301-572-0200, Fax: 301-572-0999, E-mail: reports@measuredhs.com, Internet: http://www.measuredhs.com.



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## EXECUTIVE SUMMARY

This further analysis of data from the Cambodia Demographic and Health Surveys (CHDS) conducted in 2000, 2005, and 2010 examines the determinants of under-five mortality. Although the level of under-five mortality in Cambodia has declined, it remains among the highest in the Asian region. The study analyzes the relationship between under-five mortality and several socio-demographic characteristics of children, mothers, and households, as well as health and health care indicators. The analysis uses both descriptive methods and multivariate survival analysis. Mortality data are derived from the retrospective cohort life table of all live births five years and ten years preceding the surveys.

The results show a substantial decline in under-five mortality in Cambodia during the ten years from 2000 to 2010. This decline is likely the result of improvements in health status and health care, particularly in maternal and child health services. There has been an increase in antenatal care by qualified health professionals and an increase in tetanus toxoid injections given to pregnant women during antenatal visits. Also, an increase in women's use of contraception both between 2000 and 2005 and between 2005 and 2010 was followed by a decline in higher-order births and multiple births, an increase in the proportion of long birth intervals (36 months or more), and a decline in the proportion of women bearing children at higher-risk ages (“too young” or “too old”).

The analysis shows that 84 percent of the overall decline in under-five mortality between 2000 and 2010 can be attributed to multiple births, birth order, birth interval, age of the mother at mother’s use of contraception, antenatal care, tetanus toxoid injection, and geographic region. Between 2005 and 2010 this group of determinants together was responsible for 67 percent of the overall decline in under-five mortality. The effect of geographic region may be less important than the effects of health status and health care indicators for public health policies and programs. Overall, the study demonstrates that maternal and child health programs as well as reproductive health and family planning programs have had a positive impact on child survival in Cambodia in the past decade.

# 1. INTRODUCTION

Cambodia has experienced a steady decline in infant mortality and under-five mortality during the past decade. Data from the 2000, 2005, and 2010 Cambodia Demographic and Health Surveys (CDHS) show that infant mortality decreased more than 50 percent, from 95 deaths per 1,000 live births in 2000 to 45 deaths per 1,000 live births in 2010. Similarily, during the same period under-five mortality declined from 124 deaths per 1,000 live biths to 54 deaths per 1,000 live births, a decline of 56 percent.

This report of further analysis of the CHDS initially examines the quality of the data collected for the calculation of childhood mortality. In a discriptive analysis it examines the trend of under-five mortality from 2000 to 2010 at the national level and differentials according to several socio-demographic characteristics of the child, mother, and housheold. A multivariate analysis is conducted to identify the factors associated with these declines.

## 2. DATA AND METHODS

### 2.1. Sources of Data and Methods

Cambodia has conducted three DHS surveys, in 2000, 2005, and 2010. Data collected by the DHS are comparable over time because the sampling design, questionnaires, and program to analyze the results are virtually the same. The 2000 and 2010 surveys in Cambodia were implemented by the National Institute of Statistics (NIS) of the Ministry of Planning and the Directorate General for Health (DGH) of the Ministry of Health. The 2005 survey was carried out by the NIS and the National Institute of Public Health and Research (NIPH) of the Ministry of Health. Table 1 presents information on dates of fieldwork and sample sizes for the households and women interviewed in the CDHS.

**Table 1. Description of the Cambodia Demographic and Health Surveys (CDHS) included in the analysis**

| Year | Date of fieldwork | Implementing organization | Number of Households interviewed | Number of women aged 15-49 interviewed |
|---|---|---|---|---|
| 2000 | February-July 2000 | NIS[1] & DGH[2] | 12,236 | 15,351 |
| 2005 | September 2005-March 2006 | NIS & NIPH[3] | 14,243 | 16,823 |
| 2010 | July 2010-January 2011 | NIS & DGH | 15,667 | 18,754 |

[1]NIS: National Institute of Statistics (Ministry of Planning)
[2]DGH: Directorate General for Health (Ministry of Health)
[3]NIPH: National Institute of Public Health and Research (Ministry of Health)

### 2.2. Methods

*Calculation of mortality*: The CDHS recorded the total number of children ever born and a complete maternal birth history for all eligible women age 15-49 in the women's questionnaire. For every live birth, the questionnaire recorded the date of birth, survival status, current age for surviving children, and age at death for deceased children. Age at death was recorded 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. Inconsistencies in the 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, 48-59 months. The analysis in this report uses the following three indices of childhood mortality:

*Neonatal mortality:* Death at age 0-30 days (also includes death reported at age 0 months)

*Infant mortality*: Death at age 0-11 months (also includes death reported at age 0 years)

*Under-five mortality*: Death at age 0-5 years (also includes death reported at age 0-59 months)

These calculations, based on all birth data from the 2000, 2005, and 2010 CDHS, show trends at the national level of neonatal mortality, infant mortality, and under-five mortality (five-year rates) from 2000 to 2005 (Figure 1). Calculation of under-five mortality (ten-year rates) on all birth data from the

2000, 2005, and 2010 surveys provides descriptive analysis on levels, trends, and differentials according to selected characteristics.

*Survival analysis*: The study uses data for all births in the five years preceding the 2010 CDHS to create a synthetic cohort life table for survival analysis, using Weibull hazard regression. This analysis determines factors associated with risk of dying (expressed in hazard ratios with a significant level) before age 5 (under-five mortality).

The reason for using data for all births in the last five years is that the survey asked about variables related to health services and programs, such as antenatal care and delivery services only for all births in the last five years. Questions on health status and health services such as vaccinations were only asked for surviving children (rather than all children) born in the five years before the survey and thus are not applicable in the multivariate model. Symptoms of acute respiratory infection (ARI), fever, and diarrhea and their treatment were limited only to the period two weeks before the interview among surviving children born in the last five years, and thus also are not applicable.

## 2.3. Data Quality

Data in the birth history used to calculate mortality rates necessarily depend on women's memories and thus are subject to recall bias. Recall bias could affect the calculation of mortality rates in many ways, such as omissions of birth or deaths, incomplete information on date of birth or death, displacement of the date of birth or date of death, and misreporting age at death. These biases inevitably occur in retrospectively collected data. If the biases are minimal they will not significantly affect the calculation of mortality rates. If the biases are large, however, they will severely affect the calculation of mortality rates. For an evaluation of these biases in birth history data, see Johnson, Rutstein, and Govindasamy (2005).

*Omissions of births or deaths:* Bias due to omission of deaths or births can be assessed by examining the ratio of early neonatal mortality (deaths within 0-6 days of birth) to all neonatal mortality the ratio of neonatal mortality to infant mortality; and the ratio of male to female births.

Sullivan et al. (1990) suggested that about 70 percent of neonatal deaths occur during the early neonatal period. If the ratio of early neonatal mortality to all neonatal mortality is less than 70 percent, there may be omission of neonatal deaths. This ratio tends to decrease if overall mortality increases.

**Table 2. Ratio of early neonatal (ENN) deaths to neonatal (NN) deaths (weighted), CDHS 2000, 2005, 2010**

| Year | ENN deaths | NN deaths | Ratio ENN:NN |
|---|---|---|---|
| 2000 | 212 | 303 | 70.1 |
| 2005 | 167 | 211 | 79.0 |
| 2010 | 177 | 219 | 80.9 |

Table 2 shows, for each of the three CDHS, the number of children who died within early neonatal period and within neonatal period, and their ratios. The ratio for the 2000 CDHS is 70 percent. The ratio for the 2005 and 2010 surveys is 79 percent and 81 percent, respectively, well above the norm, indicating no omission of neonatal deaths.

**Table 3. Ratio of neonatal (NN) deaths to infant (INF) deaths (weighted), CDHS 2000, 2005, 2010**

| Year | NN deaths | INF deaths | Ratio NN:INF |
|---|---|---|---|
| 2000 | 303 | 728 | 41.6 |
| 2005 | 211 | 457 | 46.2 |
| 2010 | 219 | 357 | 61.3 |

Table 3 shows the number of neonatal deaths and infant deaths, and the ratio of neonatal deaths to infant deaths. This ratio tends to increase if overall childhood mortality decreases. The ratio increases consistently between 2000 and 2010, consistent with the decrease in childhood mortality during that period.

**Table 4. Ratio of male (M) births to 100 female (F) births (weighted), CDHS 2000, 2005, 2010**

| Year | M | F | Ratio M:F |
|---|---|---|---|
| 2000 | 4,161 | 4,014 | 103.7 |
| 2005 | 3,901 | 3,887 | 100.4 |
| 2010 | 4,245 | 3,955 | 107.3 |

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 of deaths by sex of the children. Table 4 shows that the sex ratios at birth for the 2000 and 2010 CDHS (at 104 and 107, respectively) are within the range considered normal range (104 and 107, respectively). The sex ratio for the 2005 survey is slightly below the normal range (100), but is considered acceptable.

**Table 5. Completeness of reporting on data of births (weighted), CDHS 2000, 2005, 2010**

| | 2000 | | 2005 | | 2010 | |
|---|---|---|---|---|---|---|
| Data reported | N | % | N | % | N | % |
| Month and year reported | 8,162 | 99.8 | 7,762 | 99.7 | 8,200 | 100.0 |
| Year and age reported, month imputed | 4 | 0.1 | 12 | 0.2 | — | — |
| Year and age reported, year ignored | 9 | 0.1 | 15 | 0.2 | — | — |
| Year reported, age and month imputed | — | — | — | — | — | — |
| Age reported, year calculated, month imputed | — | — | — | — | — | — |
| No data reported, all imputed | — | — | — | — | — | — |
| Total | 8,175 | 100.0 | 7,789 | 100.0 | 8,200 | 100.0 |

*Incomplete information:* A woman is unlikely to misreport the number of births and deaths among her children, but she may not remember the exact dates of these events. When necessary, a data processing algorithm imputes the missing dates. Table 5 shows that year and month of birth were reported for virtually all births. A very small percentage required imputation in 2000 and 2005.

*Displacement of birth date:* Birth dates may be displaced so that eligible children will be moved outside the range of eligibility (born within the past five years) for certain sections of the DHS questionnaire. By reducing the number of eligible children, interviewers can reduce their workload of collecting information from the mothers of those children**.**

Systematically displacing the date of birth directly affects the calculation of mortality rates. This bias can be detected by calculating the displacement ratio of births. This displacement ratio of births is

represented by the following equation, where $B_x$ is the number of births reported in year x. A ratio below 100 indicates that fewer births are reported for year x:

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

Table 6 presents the displacement ratios for all births and births of deceased children for the last year when a child is eligible for the maternal and child health sections of the survey and for the year before that. The last year of eligibility is the full fifth year preceding the survey. If there is displacement out of the eligible date range, the ratio will be low for the last year of eligibility and high for the year before that. There is evidence of displacement for all children and for dead children in all three CDHS. Evidence of displacement for all children and for dead children is greater in the 2000 survey than in the 2005 and 2010 surveys.

**Table 6. Displacement of events: displacement ratios of all births, and births of children who died (Displacement ratio = $100*(2B_x/(B_{x-1}+B_{x+1}))$, weighted), CDHS 2000, 2005, 2010**

| | x=Last year of eligibility | | x=Year before last year of eligibility | |
|---|---|---|---|---|
| Year | All births | Births of children who died | All birth | Births of children who died |
| 2000 | 73.3 | 67.3 | 131.8 | 147.0 |
| 2005 | 107.5 | 99.3 | 101.9 | 117.9 |
| 2010 | 92.8 | 78.6 | 110.4 | 105.9 |

*Misreported age at death:* For children who died, the mother was asked to report age at death 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. It is known that mothers may round the age at death to an approximate higher level of time unit rather giving 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), even if the actual age at death was a little below these thresholds. This misreporting of age at death is called heaping, and is particularly serious when it happens at age 12 months. In the DHS the infant mortality rate is calculated based on deaths at completed age 0-11 months, while the child mortality rate is calculated based on deaths at 12 completed months. Rounding the reported age at death up to 12 months will cause an underestimate 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, 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 7. Heaping of reported age at death from month 12 (Heaping ratio=$3*D_{12}/(D_{11}+D_{12}+D_{13})$), CDHS 2000, 2005, 2010**

| Year | Heaping ratio |
|---|---|
| 2000 | 2.7 |
| 2005 | 2.7 |
| 2010 | 2.4 |

Table 7 presents the heaping ratios for reported age at death in month 12 (x=12 months). There is evidence of substantial heaping of this type in all three surveys, ranging from 240 percent to 270 percent. Nonetheless, the misreporting of age has not significantly impacted the estimates of infant mortality, for the following reasons: 1) A downward 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 (downward 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 months 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 five deaths per thousand live births. Therefore, there appears to be little impact on infant mortality trends and no impact at all on estimates of under-five mortality in the CDHS.

## 3. TRENDS IN SOCIOECONOMIC AND HEALTH INDICATORS

Socioeconomic characteristics, health care, and the health status of a population are believed to affect early childhood mortality. Table 8 presents a list of socioeconomic, health status, and health service indicators, based on the CDHS in 2000, 2005, and 2010.

The proportion of households with access to improved toilet facilities increased by about a factor of five, from 6 percent in 2000 to 34 percent in 2010. Access to improved sources of drinking water nearly tripled between 2000 and 2005, from 19 percent to 56 percent, but increased only slightly in the next five years, to 59 percent in 2010. The proportion of women with secondary education or higher doubled between 2000 and 2010, from 17 percent to 35 percent.

The percentage of children under age 5 who had diarrhea during the two weeks before the survey dropped from 20 percent to 15 percent between 2005 and 2010, after changing little between 2000 and 2005. The prevalence of ARI declined from 20 percent in 2000 to 6 percent in 2010. The nutritional status of children improved moderately between 2000 and 2010; the proportion of children with chronic malnutrition declined from 50 percent to 40 percent, and the proportion of under-weight children dropped from 39 percent to 28 percent. The proportion of women who are malnourished (body mass index (BMI) less than 18.5 $kg/m^2$) remained virtually unchanged across the three surveys, at about one woman in every five.

The percentage of births with a short preceding birth interval (less than 24 months), which is associated with increased risk of mortality, decreased from 21 percent in 2000 to 18 percent in 2005 and to 16 percent in 2010. The percentage of birth intervals of 36 months or longer, as recommended, increased from 45 percent to 58 during the ten-year period.

Children should be fully immunized against the common childhood infections: tuberculosis, diphtheria, whooping cough, tetanus, polio, and measles. In Cambodia the percentage of children receiving all six recommended vaccines (fully immunized) was low in 2000, at 40 percent, but increased consistently over the survey period to 67 percent in 2005 and to 79 percent in 2010.

Diarrhea and ARI that do not receive proper medical attention may cause severe complications leading to death. In 2000 only 22 percent of children with diarrhea and 35 percent of children with ARI were taken for treatment in a health facility or by a health care professional. These percentages rose over the decade to 58 percent for diarrhea treatment and 64 percent for ARI treatment in 2010.

Problems related to pregnancy such as anemia and infections can be diagnosed and treated during antenatal care (ANC) visits. The results indicate that in 2000 only 38 percent of Cambodian women made at least one antenatal care visit, rising to 69 percent in 2005 and 89 percent in 2010.

Neonatal tetanus, which is common among newborns delivered in poor hygienic conditions without properly sterilized equipment, can be prevented by giving the pregnant woman at least two doses of tetanus toxoid (TT) injections. If a woman was 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 the 2000 CDHS only 30 percent of pregnant women received two or more TT injections, increasing to 54 percent in 2005 and 61 percent in 2010.

**Table 8. Trends in selected health and socioeconomic indicators that could have influenced early childhood mortality, CDHS 2000, 2005, 2010**

| | Denominator | Percent | | |
|---|---|---|---|---|
| | | 2000 | 2005 | 2010 |
| **Socioeconomic indicators** | | | | |
| Access to improved (not shared) toilet | Households | 6.1 | 21.5 | 33.6 |
| Access to improved source of water (dry season) | Households | 19.2 | 55.6 | 58.8 |
| Primary education | women aged 15-49 | 54.6 | 55.8 | 49.4 |
| Secondary or higher education | women aged 15-49 | 17.1 | 24,8 | 34.8 |
| **Health indicators** | | | | |
| Had diarrhea in past 2 weeks | children <5 years (women's birth history) | 18.9 | 19.5 | 14.9 |
| Had ARI in past 2 weeks | children <5 years (women's birth history) | 19.8 | 8.5 | 6.4 |
| Stunting (height-for age < -2SD) | children <5 years (household schedule) | 49.8 | 42.7 | 39.9 |
| Wasting (weight-for height <-2SD) | children <5 years (household schedule) | 16.8 | 8.4 | 10.9 |
| Underweight (weight-for age <-2SD) | children <5 years (household schedule) | 38.5 | 28.1 | 28.3 |
| BMI (<18.5kg/m2) | women aged 15-49 (exclude pregnant) | 20.7 | 20.3 | 19.1 |
| Birth interval < 24 months | non-first births in the five years | 21.2 | 18.2 | 16.1 |
| Birth interval 24-35 months | non-first births in the five years | 33.4 | 29.6 | 26.3 |
| Birth interval 36+ months | non-first births in the five years | 45.3 | 52.3 | 57.6 |
| **Health service indicators** | | | | |
| Fully immunized | children age 12-23 months | 39.9 | 66.6 | 78.8 |
| Modern contraceptive prevalence | married women (15-49) | 18.5 | 27.2 | 34.9 |
| Diarrhea: taken for treatment | children with diarrhea | 21.6 | 37.0 | 58.4 |
| ARI: taken for treatment | children with ARI | 34.5 | 48.3 | 64.2 |
| Antenatal care from health care professional | women (15-49) with live birth (last 5 years) | 37.7 | 69.3 | 89.1 |
| 2+ tetanus toxoid injections | women (15-49) with live birth (last 5 years) | 30.0 | 54.2 | 60.6 |
| Delivery by health care professional | Births in the last 5 years | 31.8 | 43.8 | 53.8 |
| Delivery in health care facility | Births in the last 5 years | 9.9 | 21.5 | 53.8 |

Delivery at home and without assistance from a provider can be life threatening to the mother and her baby. Nonetheless, in 2010 nearly half of all births in the past five years in Cambodia were delivered somewhere other than in a health facility or were unattended by a health care professional. In 2000, only one-tenth of births were delivered in a health facility, although up to 32 percent were assisted by a health professional during delivery. In 2010, 54 percent of births were delivered in a facility or were assisted by a health care professional, most often a skilled birth attendant. However, some births were delivered in a health facility because they were referred there for complications. For these births, delivery in a health facility is associated with a higher risk of neonatal mortality.

## 4. TRENDS AND DIFFERENTIALS IN UNDER-FIVE MORTALITY

**Figure 1. Neonatal, infant, and under-five mortality, five year rates, CDHS 2000, 2005, and 2010**

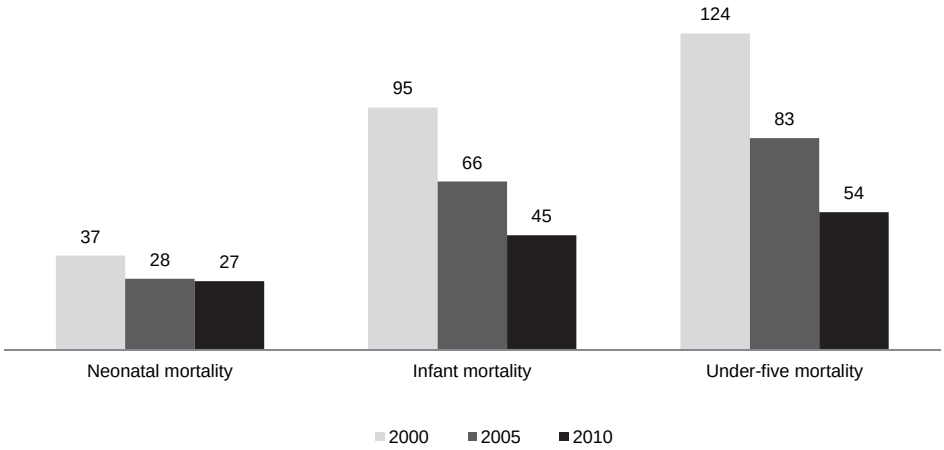



Figure 1 shows the trends in early childhood mortality in Cambodia. Infant mortality rates and under-five mortality rates declined consistently from 2000 to 2010. Their levels in 2010 represent more than a 50 percent reduction from the levels in 2000. The neonatal mortality rate dropped from 37 deaths per 1,000 live births in 2000 to 28 per 1,000 in 2005 but has remained virtually unchanged since 2005.

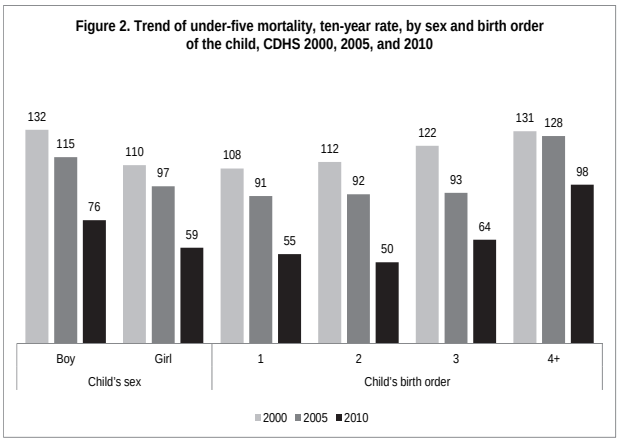
This section presents differentials in under-five mortality and trends from 2000 to 2005 and to 2010 by characteristics of the child, mother, and household. The characteristics of the child include sex, multiplicity of birth, birth order, and preceding birth interval. The characteristics of the mother include age at child's birth, marital status, education, and contraceptive use. The characteristics of the household include urban-rural residence, access to improved source of water, access to improved toilet facility, and wealth index quintile.

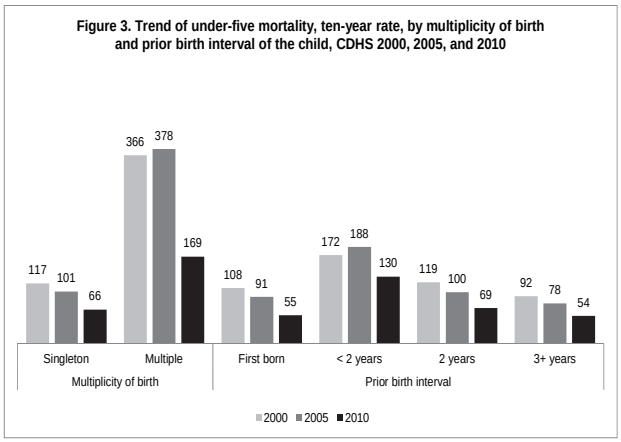
Table 9 and Figures 2-7 show differentials and trends by selected characteristics. The under-five mortality rate was higher among boys than girls in all three surveys (differentials), and it declined similarly among both groups during the study period (trends). Children of the fourth or higher birth order had a higher under-five mortality rate and a slower mortality decline than children of lower birth order. Twins and triplets experienced greater risk of dying before their fifth birthday than singletons, particularly in 2000 and 2005. The under-five mortality rate dropped more sharply between 2005 and 2010 among multiple births than among singletons. In all three surveys children born less than 24 months after their elder sibling were at higher risk of mortality compared with other groups of children, although their mortality rate fell during the last five years, from 188 deaths per 1,000 live births in 2005 to 130 per 1,000 in 2010.

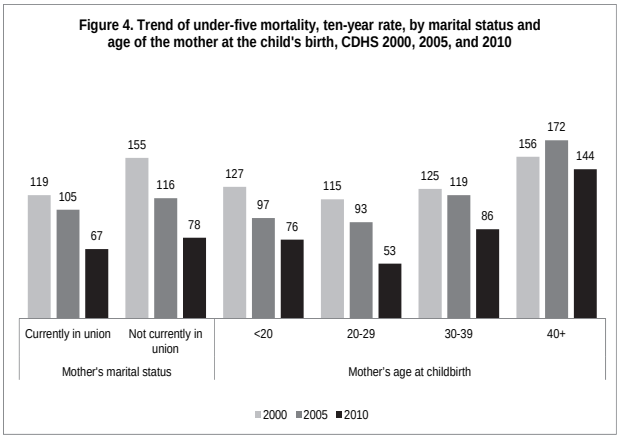
**Table 9. Under-five mortality rate (ten-year rate), by selected characteristics, CDHS 2000, 2005, 2010**

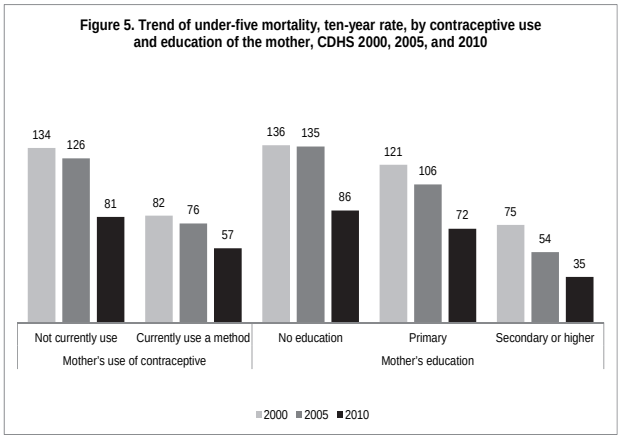
| Background characteristic | Under-five mortality rate | | |
|---|---|---|---|
| | 2000 | 2005 | 2010 |
| **Child characteristics** | | | |
| Child's sex | | | |
| Boy | 132 | 115 | 76 |
| Girl | 110 | 97 | 59 |
| Multiplicity of birth | | | |
| Single | 117 | 101 | 66 |
| Multiple | 366 | 378 | 169 |
| Child's birth order | | | |
| 1 | 108 | 91 | 55 |
| 2 | 112 | 92 | 50 |
| 3 | 122 | 93 | 64 |
| 4+ | 131 | 128 | 98 |
| Preceding birth interval | | | |
| First born | 108 | 91 | 55 |
| < 24 months | 172 | 188 | 130 |
| 24-35 months | 119 | 100 | 69 |
| 36+ months | 92 | 78 | 54 |
| **Mother characteristics** | | | |
| Mother's age at childbirth | | | |
| <20 | 127 | 97 | 76 |
| 20-29 | 115 | 93 | 53 |
| 30-39 | 125 | 119 | 86 |
| 40+ | 156 | 172 | 144 |
| Mother's marital status | | | |
| Currently in union | 119 | 105 | 67 |
| Not currently in union | 155 | 116 | 78 |
| Mother's education | | | |
| No education | 136 | 135 | 86 |
| Primary | 121 | 106 | 72 |
| Secondary or higher | 75 | 54 | 35 |
| Mother's use of contraception | | | |
| Not currently using | 134 | 126 | 81 |
| Currently using a method | 82 | 76 | 57 |
| **Household characteristics** | | | |
| Residence | | | |
| Urban | 93 | 76 | 29 |
| Rural | 126 | 110 | 75 |
| Access to improved source of water | | | |
| No | 128 | 111 | 74 |
| Yes | 106 | 101 | 62 |
| Access to improved toilet facility | | | |
| No | nc | 117 | 77 |
| Yes | nc | 49 | 43 |
| Household wealth index quintile | | | |
| Lowest | 155 | 126 | 91 |
| Lower | 137 | 128 | 82 |
| Middle | 114 | 113 | 67 |
| Higher | 113 | 92 | 48 |
| Highest | 63 | 43 | 30 |
| Total | 121 | 106 | 68 |
| Number of children | 40,990 | 40,457 | 37,511 |

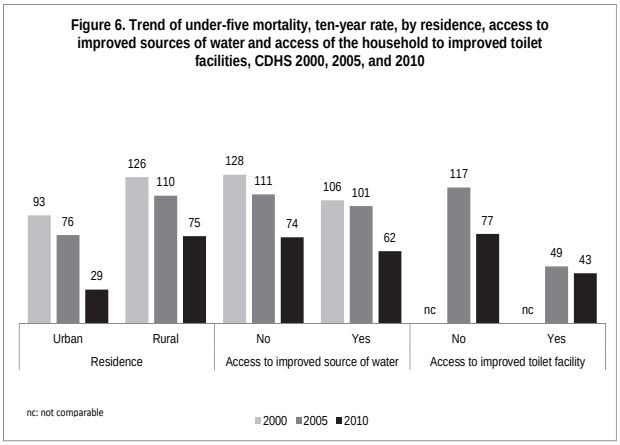
nc: not comparable

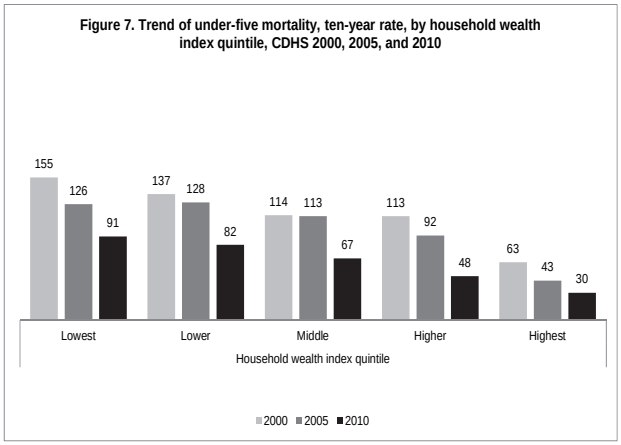



In all three surveys the under-five mortality rate was higher among children raised by single mothers than those raised by mothers in union. The rate declined consistently among both groups over the ten-year period. The risk of under-five mortality was higher for children of mothers who were under age 20 ("too young") or were age 40 or older ("too old") when they gave birth. Over the ten-year period the under-five mortality rate declined consistently among all maternal age groups except age 40 or older.

Under-five mortality was lower among children of mothers who used contraception and mothers who had a higher level of education. The differentials and trends in under-five mortality by these characteristics are consistent in all three surveys. Children in rural areas, children in households with no

access to improved sources of water, and children without improved toilet facilities were at higher risk of dying before their fifth birthday. Mortality rates declined among children in all categories, especially among urban children. In all three surveys the under-five mortality rate was highest among the poorest children (lowest household wealth index quintile) and lowest among the richest children (highest household wealth index quintile). Even though the mortality rate improved over the study period in all wealth quintiles, a gap between the poorest and wealthiest remained.

# 5. MULTIVARIATE ANALYSIS

## 5.1. Confounding Effects of the Determinants and Significant Association with Under-Five Mortality

This study carried out multivariate analyses to identify the characteristics of the children, mothers, households, and indicators of health status and health care that are significantly associated with under-five mortality in Cambodia in 2010, and to sort out the confounding effects of these characteristics. In the multivariate analysis all selected characteristics are included in the same model. In the model, interaction between characteristics or their confounding effects are neutralized. The characteristics or determinants (independent variables) that are included in the multivariate models are:

*Child's characteristics:*

- Child's sex: Whether the child is a boy or girl.
- Multiplicity of birth: Whether the birth was multiple or single.
- Birth order: Whether the child is first-born or second-born, third-born, or fourth or higher.
- Preceding birth interval: Interval between births, classified into less than 24 months after the previous birth, 24 to 35 months, and more than 35 months. In order to include all children in the analysis, first-born children are treated separately, since these births have no preceding interval.

*Mother's characteristics:*

- Mother's age at birth: Mother's age at the birth of her child, classified into under age 20, age 20-29, age 30-39, and age 40 or older.
- Marital status: Measured in two categories: not currently in union, and currently in union. Marital status is measured at the time of the survey and may not necessarily be the same as at the time of the child's birth.
- Mother's level of education: The categories are: no education, primary education, and secondary or higher.
- Mother's use of contraceptives: The categories are: not currently using contraception, and currently using contraception.

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

- Type of area of residence: Whether urban or rural.
- Region: **Phnom Penh** city is considered as a separate region; **Plain** region includes the provinces of Kampong Cham, Kandal, Prey Veng, Svay Rieng and Takeo; **Great Lake** region includes the provinces of Banteay Mean Chey, Bat Dambang, Kampong Chhnang, Kampong Thom, Pousat and Siem Reap; **Coastal** region includes the provinces of Kampot, Koh Kong, Kep City and Preah Sihanouk City; and **Plateau/Mountain** region includes the provinces of Kampong Speu, Kracheh, Mondol Kiri, Preah Vihear, Rattanak Kiri, Stung Traeng, Otdor Mean Chey, and Pailin City.

- Improved source of drinking water: Improved sources are: piped/tap water, tube/piped wells or boreholes, protected wells, spring[1], and rainwater. Other sources are classified as non-improved.
- Improved toilet facility: Includes flush toilet connected to sewage or septic tank and ventilated/improved latrine or toilet. Other types of toilet, or no toilet, are considered non-improved.

*Health and health and care indicators:*

- Antenatal care: Whether or not the mother received one or more antenatal check-ups from a health care professional during the pregnancy of her last-born child (living or dead) within the last five years.
- Tetanus toxoid vaccination: Whether the mother received tetanus toxoid vaccine (not received, received one dose, received two or more doses) during the pregnancy of her last-born child (living or dead) within the last five years.
- Delivery by health care professional: Whether or not the child was delivered by a health care professional.
- Health insurance: Whether or not the child's household was covered by health insurance (in any form).

The dependent variable is under-five mortality during the five-year period preceding the CDHS. Not all children born during the period were exposed to the risk of death for the whole time, since some may have been born later in the period, that is, exposed to risk for less than the full five years. Therefore, the Weibull hazard regression (a multivariate life-table procedure) is used to adjust for the incomplete exposure to mortality.

Table 10 shows both the unadjusted hazard ratios (without controlling for interactions or confounding effects) and adjusted hazard ratios (controlling for interaction and confounding effects) for each of the variables and their respective p-value. A hazard ratio (HR) greater than 1 indicates higher risk of mortality, and HR smaller than 1 indicates lower risk of mortality. A p-value of less than 0.050 for each respective HR indicates statistical significance, i.e. that the relationships are likely to be real and not the result of chance alone.

Results from the unadjusted model show that multiplicity of birth, fourth birth order or higher, mother's age at birth age 40 or older, rural residence, and residence in a region other than Phnom Penh are significantly associated with higher risk of under-five mortality. However, the model shows that children with health insurance are associated with higher mortality, a finding that contradicts a common belief that insured children having better access to health services and thus should have lower risk of mortality. About 14 percent of children studied were insured but 12 percent were insured with the equity fund, which is provided only to the most destitute and vulnerable children. Consequently, the higher risk of mortality is associated with the preconditions for being insured and is not a consequence of being insured.

[1] Spring water can be classified into protected and unprotected. This analysis grouped both sources and classified them as improved source, for the following two reasons: 1) the 2005 and 2010 CDHS collected data for both categories while the 2000 CDHS collected data for a single combined category of "spring water;" 2) the percentage of households with access to spring water is very small.

**Table 10. Unadjusted and adjusted effects of selected factors on under-five mortality among children who were born in the five-year period preceding the survey, CDHS 2010**

| | Unadjusted | | Adjusted | |
|---|---|---|---|---|
| **Background characteristic** | **Hazard ratio** | **P-value** | **Hazard ratio** | **P-value** |
| **Child characteristic** | | | | |
| Child's sex | | | | |
| Boy | 1.00 | — | 1.00 | — |
| Girl | 0.90 | 0.381 | 0.92 | 0.509 |
| Multiple birth | | | | |
| Single | 1.00 | — | 1.00 | — |
| Multiple | 3.25 | 0.000 | 2.08 | 0.029 |
| Child's birth order | | | | |
| 1 | 1.00 | — | 1.00 | — |
| 2 | 0.86 | 0.406 | 1.62 | 0.022 |
| 3 | 0.72 | 0.128 | 1.28 | 0.363 |
| 4+ | 1.91 | 0.000 | 2.04 | 0.004 |
| Prior birth interval | | | | |
| First born/< 24 months | 1.00 | — | 1.00 | — |
| 24-35 months | 0.70 | 0.053 | 0.41 | 0.000 |
| 36+ months | 0.82 | 0.144 | 0.51 | 0.000 |
| **Mother characteristic** | | | | |
| Mother's age at childbirth | | | | |
| <20 | 1.00 | — | 1.00 | — |
| 20-29 | 0.71 | 0.096 | 0.94 | 0.797 |
| 30-39 | 1.19 | 0.436 | 1.45 | 0.185 |
| 40+ | 3.20 | 0.000 | 3.60 | 0.000 |
| Mother's marital status | | | | |
| Not currently in union | 1.00 | — | 1.00 | — |
| Currently in union | 0.75 | 0.284 | 0.91 | 0.738 |
| Mother's education | | | | |
| No education | 1.00 | — | 1.00 | — |
| Primary | 0.77 | 0.066 | 1.11 | 0.506 |
| Secondary or higher | 0.53 | 0.001 | 1.28 | 0.293 |
| Mother's use of contraceptive | | | | |
| Not currently use | 1.00 | — | 1.00 | — |
| Currently use a method | 0.56 | 0.000 | 0.71 | 0.013 |
| **Household characteristics** | | | | |
| Residence | | | | |
| Urban | 1.00 | — | 1.00 | — |
| Rural | 2.78 | 0.000 | 1.46 | 0.094 |
| Region | | | | |
| Phnom Penh | 1.00 | — | 1.00 | — |
| Plain | 5.91 | 0.000 | 3.27 | 0.021 |
| Great Lake | 5.74 | 0.000 | 2.70 | 0.055 |
| Coastal | 7.28 | 0.000 | 3.90 | 0.011 |
| Plateau/Mountain | 6.92 | 0.000 | 2.81 | 0.048 |

**(Continued...)**

**Table 10. – *Continued***

| Background characteristic | Unadjusted | | Adjusted | |
|---|---|---|---|---|
| | Hazard ratio | P-value | Hazard ratio | P-value |
| Access to improved sources of water (dry season) | | | | |
| No | 1.00 | — | 1.00 | — |
| Yes | 0.74 | 0.013 | 0.93 | 0.621 |
| Access to improved (not shared) toilet facility | | | | |
| No | 1.00 | — | 1.00 | — |
| Yes | 0.56 | 0.000 | 0.99 | 0.948 |
| **Health and health care indicator** | | | | |
| Mother had antenatal care by health professional for the last birth with the last 5 years | | | | |
| No | 1.00 | — | 1.00 | — |
| Yes | 0.27 | 0.000 | 0.44 | 0.000 |
| Mother received tetanus toxoid vaccine during pregnancy of the last birth within the last 5 years | | | | |
| No | 1.00 | — | 1.00 | — |
| 1 doses | 0.42 | 0.000 | 0.73 | 0.221 |
| 2+ dose | 0.28 | 0.000 | 0.59 | 0.006 |
| Delivered by health care professional | | | | |
| No | 1.00 | — | 1.00 | — |
| Yes | 0.52 | 0.000 | 0.84 | 0.292 |
| Covered by a health insurance | | | | |
| No | 1.00 | — | 1.00 | — |
| Yes | 1.44 | 0.007 | 1.09 | 0.521 |
| Number of children | 8,232 | | 8,232 | |

Children whose mothers have secondary education or higher, who use contraception, mothers who had antenatal care by health professional for their last birth, mothers who received tetanus toxoid vaccine during pregnancy of the last birth, either one or two doses, and children who were delivered by a health care professional are less likely to die before their fifth birthday. Moreover, children living in households with access to improved sources of water and children in households with improved toilet facilities have a better chance of survival beyond 59 months of age. The unadjusted model shows no significant relationship between under-five mortality and the sex or prior birth interval of the child, or the mother's marital status.

When controlling for confounding effects of all variables, the adjusted model shows that sex of the child, mother's marital status, and mother's level of education do not significantly affect under-five morality. Similarly, the risk of mortality does not vary significantly by place of residence, source of water, and type of toilet facility of the household. Delivery by a health professional remains a protecting factor but is not statistically significant. In the adjusted model health insurance does not have a significant effect on child survival. Twins and triplets are twice as likely as a singleton to die before their fifth birthday. The risk of under-five mortality among children of fourth or higher birth order is twice as the risk for first-born children. Children who were born 24-35 months after their preceding sibling, and children born more than 35 months after, are significantly less likely to die before age 5 than children with a preceding birth interval less than 24 months, and than first-born children. The risk of mortality is 2.7 to 3.9 times higher for children in other regions of Cambodia compared with Phnom Penh. Antenatal care and receiving two or more doses of tetanus toxoid among mothers are both associated with significantly lower risk of under-five mortality.

## 5.2. Changes in Significant Determinants and Their Associations with Under-Five Mortality

The results of multivariate analyses for under-five mortality are presented in Table 10 as hazard ratios (HRs). HR is the exponentiated coefficient. A coefficient is the percentage increase or decrease in the risk of dying for children in each specific category of a variable in the model when compared to the reference category for that variable.

The procedure for determining how much of the change in under-five mortality between the surveys is due to measured changes of the determinants is as follows: First, a multivariate analysis of mortality is executed using data from the 2010 survey similar to the data in Table 10, but the analysis produces coefficients (using a STATA command) instead of hazard ratios. Changes in the distribution of determinants (indicators or covariates) between surveys (2010 compared with 2000, and 2010 compared to 2005) are multiplied by the coefficients (of variables) obtained from the multivariate analysis. These products are then summed and the sum is exponentiated to get the change in mortality due to changes in the value of the indicators or covariates between surveys (Hong et al., 2009).

Table 11 shows the impacts of changing health conditions on under-five mortality. Reference categories with coefficients equal to 1 are not included; they are not presented in the coefficient column. Also non-significant results are omitted from the coefficient columns.

Multiplicity of birth, birth order, birth interval, age of the mother, mother's use of contraception, geographic region, antenatal care, and tetanus toxoid during antenatal care are significant determinants of under-five mortality in the 2010 CDHS. The decline in under-five mortality between 2000 and 2010 is significantly positively related to a decrease in multiple births, a decrease of births of fourth or higher order (due to the decline in fertility over this period), an increase of birth interval >35 months, a decrease in the proportion of mothers age 40 or older, an increase in contraceptive use, an increase in antenatal care, and an increase in receiving two doses of tetanus injection during antenatal visits. The decline in under-five mortality is offset by an increasing proportion of second-order births (relatively to a decrease in births of third-order or of fourth order birth or higher), and by a decrease in birth interval 24-35 months (relatively to an increase of birth interval >35 months). Some changes occurred in the proportion of live births by geographic region that significantly affect the change in under-five mortality, in both directions. Between 2005 and 2010 all determinants significantly associated with under-five mortality changed in the same direction as between 2000 and 2010. The determinants that affect the decline in under-five mortality are the same for both periods and show similar relationships.

Between 2000 and 2010, the under-five mortality rate declined by 56 percent [(124-54)/124]. The model explains 48 percent [(1-0.52) x 100] of this decline. Thus the determinants that are significantly associated with under-five mortality for this period are responsible for 84 percent [(48/56) x 100)] of the overall decline in under-five mortality between 2000 and 2010. Between 2005 and 2010, the under-five mortality rate declined by 35 percent ((83-54)/83). The model explains 23 percent of this decline [(1-0.77) x 100]. Thus the determinants that are significantly associated with this are responsible for 67 percent [(23/35) x 100)] of the decline in under-five mortality between 2005 and 2010.

**Table 11. Expected change in under-five mortality rate, CDHS 2000, 2005, 2010**

| | Proportions | | | Change in proportions | | Model | | U5MR by change in proportions | |
|---|---|---|---|---|---|---|---|---|---|
| **Characteristic** | **2000** | **2005** | **2010** | **2010-2005** | **2010-2000** | **Coefficient** | **P-value** | **2010-2005** | **2010-2000** |
| Girl | 0.4910 | 0.4991 | 0.4824 | -0.0167 | -0.0086 | -0.0823235 | 0.509 | | |
| Multiple birth | 0.0211 | 0.0161 | 0.0156 | -0.0005 | -0.0055 | 0.7338666 | 0.029 | -0.0003669 | -0.0040363 |
| Birth order 2nd | 0.1959 | 0.2290 | 0.2658 | 0.0368 | 0.0699 | 0.4805125 | 0.022 | 0.0176829 | 0.0335878 |
| Birth order 3rd | 0.1667 | 0.1643 | 0.1631 | -0.0012 | -0.0036 | 0.2433006 | 0.363 | | |
| Birth order 4th+ | 0.4472 | 0.3320 | 0.2322 | -0.0998 | -0.2150 | 0.7128371 | 0.004 | -0.0711411 | -0.1532600 |
| Birth with birth interval 24-35 months | 0.2705 | 0.2141 | 0.1733 | -0.0408 | -0.0972 | -0.8936556 | 0.000 | 0.0364611 | 0.0868633 |
| Birth with birth interval >35 | 0.3665 | 0.3782 | 0.3789 | 0.0007 | 0.0124 | -0.6697958 | 0.000 | -0.0004689 | -0.0083055 |
| Mother age 20-29 at childbirth | 0.4900 | 0.5179 | 0.6265 | 0.1086 | 0.1365 | -0.0587962 | 0.797 | | |
| Mother age 30-39 at childbirth | 0.3610 | 0.3224 | 0.2340 | -0.0884 | -0.1270 | 0.3713696 | 0.185 | | |
| Mother age 40+ at childbirth | 0.0596 | 0.0530 | 0.0412 | -0.0118 | -0.0184 | 1.2797950 | 0.000 | -0.0151016 | -0.0235482 |
| Mother currently in union | 0.9487 | 0.9523 | 0.9579 | 0.0056 | 0.0092 | -0.0973092 | 0.738 | | |
| Mother had primary education | 0.5357 | 0.5900 | 0.5656 | -0.0244 | 0.0299 | 0.1026678 | 0.506 | | |
| Mother had secondary education | 0.1358 | 0.1679 | 0.2488 | 0.0809 | 0.1130 | 0.2494128 | 0.293 | | |
| Mother currently use a contraceptive method | 0.2149 | 0.3856 | 0.5187 | 0.1331 | 0.3038 | -0.3459128 | 0.013 | -0.0460410 | -0.1050883 |
| Rural residence | 0.8683 | 0.8597 | 0.8438 | -0.0159 | -0.0245 | 0.3756037 | 0.094 | | |
| Plain | 0.4120 | 0.4247 | 0.4303 | 0.0056 | 0.0183 | 1.1839970 | 0.021 | 0.0066304 | 0.0216671 |
| Great Lake | 0.3284 | 0.2739 | 0.2738 | -0.0001 | -0.0546 | 0.9938139 | 0.055 | | |
| Coastal | 0.0751 | 0.0762 | 0.0666 | -0.0096 | -0.0085 | 1.3613780 | 0.011 | -0.0130692 | -0.0115717 |
| Plateau/mountainous | 0.1315 | 0.1465 | 0.1504 | 0.0039 | 0.0189 | 1.0338390 | 0.048 | 0.0040320 | 0.0195396 |

**(Continued...)**

**Table 11. – *Continued***

| Characteristic | Proportions | | | Change in proportions | | Model | | U5MR by change in proportions | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2010-2005 | 2010-2000 | Coefficient | P-value | 2010-2005 | 2010-2000 |
| Access to improved sources of water | 0.1564 | 0.5790 | 0.5594 | -0.0196 | 0.4030 | -0.0692100 | 0.621 | | |
| Access to improved and unshared toilet facility | 0.0365 | 0.1617 | 0.2825 | 0.1208 | 0.2460 | -0.0118557 | 0.948 | | |
| Last birth (5 years) received antenatal care by qualified provider | 0.2632 | 0.5217 | 0.7032 | 0.1815 | 0.4400 | -0.8149716 | 0.000 | -0.1479173 | -0.3585875 |
| Mother received 1 dose of TT when pregnant with last child | 0.1036 | 0.1610 | 0.1614 | 0.0004 | 0.0578 | -0.3167777 | 0.221 | | |
| Mother received 2+ dose of TT when pregnant with last child | 0.2095 | 0.4083 | 0.4784 | 0.0701 | 0.2689 | -0.5310237 | 0.006 | -0.0372248 | -0.1427923 |
| Delivery assisted by qualified provider | 0.3183 | 0.6023 | 0.7103 | 0.1080 | 0.3920 | -0.1685617 | 0.292 | | |
| Have had a health insurance | na | na | 0.1449 | na | na | 0.0899472 | 0.521 | | |
| Constant | - | - | - | - | - | -4.8723880 | 0.000 | | |
| | | | | | | sum | | -0.266524479 | -0.6455319 |
| | | | | | | exp(sum)=**rel. risk** | | **0.766037251** | **0.524383555** |

Note: Reference categories are not presented; na = Not applicable, the question was not asked

# 6. DISCUSSION AND CONCLUSION

## 6.1. Discussion

This further analysis of the CDHS shows that under-five mortality in Cambodia declined significantly between 2000 and 2010. The analysis indicates that some changes in women's demographic characteristics, and primarily changes in health care, have significantly contributed to the decline of under-five mortality.

Multiple births are relatively rare compared to singleton births but contribute substantially to early childhood mortality (Alam, van Ginneken, and Bosch 2007), particularly in developing countries, where medical care and technology to treat high-risk births often are available only in big cities. While a decrease in the proportion of multiple births contributes to a decline in under-five mortality rates, multiple births are a natural biological phenomenon and thus are not subject to program interventions to improve child survival.

Births of fourth or higher order also are associated with higher mortality, an association that has been discussed elsewhere (Gubhaju 1985, Zenger 1993). A decrease in the proportion of higher order births has reduced mortality in recent years. Birth order can be interpreted as an indicator of the level of fertility. A reduction in child mortality is often seen as a cause of a reduction in fertility, and not a result. Because DHS data are cross-sectional, however, we cannot draw a definitive conclusion on cause and effect in this relationship.

Using DHS data from 17 developing countries to examine the effects of preceding birth intervals on neonatal, infant, and under-five year mortality and nutritional status, Rutstein (2005) concluded that the longer the birth interval, the lower the risk of mortality. In the multivariate model in our analysis, birth intervals of 24-35 months and >35 months are associated with a lower risk of under-five mortality. The increased proportion of births with birth intervals of >35 months contributed to the decline in under-five mortality during the study period. The proportion of births with intervals of 24-35 months declined from 2000 to 2005, and from 2005 to 2010, somewhat offsetting the overall decline in under-five mortality.

Older maternal age is known to be a risk factor for childhood mortality in both developed and developing countries (Friede et al. 1988; Hong and Ruiz-Beltran 2007). Consequently, if fewer women give birth at older maternal ages, then childhood mortality will decline. The proportion of Cambodian women giving birth after their prime reproductive age declined steadily between 2000 and 2010, largely as the result of strong programs for safe motherhood, reproductive health, and family planning.

An increase in contraceptive prevalence among married women in Cambodia over the past decade, from 19 percent in 2000 to 35 percent in 2010, has contributed to the reduction of under-five mortality rates. Use of contraception is significantly negatively associated with under-five mortality. Family planning allows women to space and limit their childbearing and to avoid unwanted pregnancy. Family planning therefore acts as a precursor for some of the demographic determinants discussed in this report. For example, women using contraception can avoid bearing children at higher-risk maternal ages (too young or too old), having births too close to one another (short birth intervals), and can limit the number of births over the reproductive years (high birth order). The use of family planning to space or limit births is influenced by many factors, including women's health, education, economic status, access to contraception, social and cultural norms (Bonggarts 1987, WHO 2002).

Among program-related influences on under-five mortality, more women received antenatal care from a qualified provider in 2010 than in 2000 or 2005. The association of antenatal care with lower

childhood mortality has been discussed in previous studies (Hellingera 1985; Hong and Ruiz-Beltran 2007). In Cambodia more women receiving antenatal care helped reduce under-five mortality over the study period. Such care affects childhood mortality in many ways. The objective of antenatal care is to have the pregnancy end with a healthy baby and mother, by identifying risk factors for pregnancy complications or other maternal health concerns that need to be addressed and by optimizing pregnancy outcomes. The results also show that the proportion of women receiving at least two doses of tetanus toxoid vaccine during antenatal care visit increased substantially over the past 10 years, especially between 2000 and 2005, and this change significantly reduced under-five mortality during the same period. At least two doses of tetanus toxoid are recommended during the first pregnancy and a minimum of five doses for lifetime protection.

Three of four geographic regions are significantly associated with higher mortality compared with Phnom Penh in the multivariate model. A decline in the proportion of live births in the Coastal region, both over the ten-year period 2000-2010 and the five-year period 2005-2010, contributed to the decline in mortality in these two periods. However, an increase in the proportion of live births in Plain and Plateau/Mountain in both periods tended to offset the decline of mortality. The effect of geographic region on mortality may be less important than the effects of health and health service indicators in terms of public health program intervention.

*Limitations:*

This analysis is limited to variables that were included in the DHS dataset and were collected for live births during the five years preceding the surveys. Changes in other socioeconomic and health indicators may also help to explain the declines in childhood mortality in recent years but were not available for the analysis. For example, changes in the morbidity of different types of accidents may affect mortality, but these data were not available. Other health indicators such as fever, diarrhea, and ARI, and the treatment of these conditions were collected only for the two weeks preceding the interview among children born in the five years preceding the survey, and were asked only about living children.

Another limitation is that the data are cross-sectional and retrospective, rather than panel data designed for a prospective longitudinal analysis. The CDHS was conducted at five-year intervals, and completely different women were sampled in the 2000, 2005, and 2010 surveys. The mortality data are retrospective cohort data—for example, in 2010 mortality rates were calculated on all live births and deaths between July 2005 and January 2011. Some of the covariates are associated directly with the time of the child's birth and not the time of death (multiplicity of birth, delivery assistance, mother's age at childbirth, etc…). Others reflect conditions at the time of survey not at the time of the child's birth or death (mother's level of education, marital status, use of contraceptive, household sources of water, type of toilet, etc…).

To overcome this limitation, the analysis used changes (differences) in covariates between two surveys as the predictors—changes between 2005 and 2010, and changes between 2000 and 2010. Moreover, even though data are not panel data designed for longitudinal analysis, all samples are very large and representative at national, urban-rural, and regional levels, with statistical power sufficient for the finding to be generalized.

## 6.2. Conclusion

The CDHS and this further analysis show that there is no doubt that under-five mortality rates in Cambodia dropped significantly from 2000 to 2005 and declined further between 2005 and 2010. This decline resulted in large part from the substantial improvements in public health services between 2000 and 2010. Important improvements were made in maternal and child health, specifically in antenatal care

by qualified health professionals and in tetanus toxoid vaccine injections given during pregnancy, and also in reproductive health and family planning. It is evident from this analysis that programs and policies that support the provision of services for maternal and child health, reproductive health, and family planning continue to improve child survival in Cambodia.

## REFERENCES


Alam, N., J.K. van Ginneken, and A.M. Bosch. 2007. "Infant Mortality among Twins and Triplets in Rural Bangladesh in 1975–2002." *Tropical Medicine and International Health* 12(12): 1506-1514.

Bongaarts, J. 1987. "Does Family Planning Reduce Infant Mortality?" *Population and Development Review* 13(2): 323-334.

Friede, A., W. Baldwin, P.H. Rhodes, J.W. Buehler, and L.T. Strauss. 1988. "Older Maternal Age and Infant Mortality in the United States." *Obstetric & Gynecology* 72(2): 152-7.

Hellingera, F.J. 1985. "Prenatal Care, Neonatal Intensive Care, and Infant Mortality." *International Journal of Technology Assessment in Health Care* 1(4): 934-944.

Hong, R., M. Ayad, S. Rutstein, and R. Ren. 2009. *Childhood Mortality: Levels, Trends, and Differentials, Rwanda 1992-2008; Further Analysis of Demographic and Health Surveys Data #66.* Calverton, Maryland, USA: ICF Macro.

Hong, R., and M. Ruiz-Beltran. 2007 "Impact of Prenatal Care on Infant Survival in Bangladesh." *Matern Child Health Journal* 11(2): 199-206.

Gubhaju, B.B. 1985. "Effects of Birth Order and Maternal Age on Infant and Child Mortality in Rural Nepal." *Journal of Biology and Society* 2(1): 15-22.

Rutstein, S.O. 2005. "Effects of Preceding Birth Intervals on Neonatal, Infant and Under-Five Years Mortality and Nutritional Status in Developing Countries: Evidence from the Demographic and Health Surveys." *International Journal of Gynaecology and Obstetric* 89(Suppl 1): S7-24.

World Health Organization (WHO). 2002. *Family Planning. Fact Sheet Number 351*. Geneva, Switzerland: WHO.

Zenger, E.A. 1993. "Infant Mortality, Birth Order, and Sibship Size: The Role of Heterogeneous Risk and the Previous-Death Effect." *Mathematical Population Studies* 4(2): 103-116.